INTERNATIONAL STANDARDS
AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

ANNEX 10
TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME III — COMMUNICATION SYSTEMS

(PART I — DIGITAL DATA COMMUNICATION SYSTEMS;
PART II — VOICE COMMUNICATION SYSTEMS)

FIRST EDITION — JULY 1995

The first edition of Annex 10, Volume III was adopted by the Council on 20 March 1995 and becomes applicable on 9 November 1995.

For information regarding the applicability of the Standards and Recommended Practices, *see* Foreword.

INTERNATIONAL CIVIL AVIATION ORGANIZATION

AMENDMENTS

The issue of amendments is announced regularly in the *ICAO Journal* and in the monthly *Supplement to the Catalogue of ICAO Publications and Audio-visual Training Aids*, which holders of this publication should consult. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS			
No.	Date applicable	Date entered	Entered by
71	7/11/96	—	ICAO
72	6/11/97	—	ICAO
73	5/11/98	—	ICAO
74	4/11/99	—	ICAO
75	2/11/00	—	ICAO
76	1/11/01	—	ICAO
77	28/11/02	—	ICAO
78	27/11/03	—	ICAO
79	25/11/04	—	ICAO

CORRIGENDA			
No.	Date of issue	Date entered	Entered by

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FOREWORD

Historical background

Standards and Recommended Practices for Aeronautical Telecommunications were first adopted by the Council on 30 May 1949 pursuant to the provisions of Article 37 of the Convention on International Civil Aviation (Chicago 1944) and designated as Annex 10 to the Convention. They became effective on 1 March 1950. The Standards and Recommended Practices were based on recommendations of the Communications Division at its Third Session in January 1949.

Up to and including the Seventh Edition, Annex 10 was published in one volume containing four Parts together with associated attachments: Part I — Equipment and Systems, Part II — Radio Frequencies, Part III — Procedures, and Part IV — Codes and Abbreviations.

By Amendment 42, Part IV was deleted from the Annex; the codes and abbreviations contained in that Part were transferred to a new document, Doc 8400.

As a result of the adoption of Amendment 44 on 31 May 1965, the Seventh Edition of Annex 10 was replaced by two volumes: Volume I (First Edition) containing Part I — Equipment and Systems, and Part II — Radio Frequencies, and Volume II (First Edition) containing Communication Procedures.

As a result of the adoption of Amendment 70 on 20 March 1995, Annex 10 was restructured to include five volumes: Volume I — Radio Navigation Aids; Volume II — Communication Procedures; Volume III — Communication Systems; Volume IV — Surveillance Radar and Collision Avoidance Systems; and Volume V — Aeronautical Radio Frequency Spectrum Utilization. By Amendment 70, Volumes III and IV were published in 1995 and Volume V was planned for publication with Amendment 71.

Table A shows the origin of Annex 10, Volume III subsequent to Amendment 70, together with a summary of the principal subjects involved and the dates on which the Annex and the amendments were adopted by Council, when they became effective and when they became applicable.

Action by Contracting States

Notification of differences. The attention of Contracting States is drawn to the obligation imposed by Article 38 of the Convention by which Contracting States are required to notify the Organization of any differences between their national regulations and practices and the International Standards contained in this Annex and any amendments thereto. Contracting States are invited to extend such notification to any differences from the Recommended Practices contained in this Annex and any amendments thereto, when the notification of such differences is important for the safety of air navigation. Further, Contracting States are invited to keep the Organization currently informed of any differences which may subsequently occur, or of the withdrawal of any differences previously notified. A specific request for notification of differences will be sent to Contracting States immediately after the adoption of each amendment to this Annex.

The attention of States is also drawn to the provisions of Annex 15 related to the publication of differences between their national regulations and practices and the related ICAO Standards and Recommended Practices through the Aeronautical Information Service, in addition to the obligation of States under Article 38 of the Convention.

Promulgation of information. The establishment and withdrawal of and changes to facilities, services and procedures affecting aircraft operations provided in accordance with the Standards, Recommended Practices and Procedures specified in Annex 10 should be notified and take effect in accordance with the provisions of Annex 15.

Use of the text of the Annex in national regulations. The Council, on 13 April 1948, adopted a resolution inviting the attention of Contracting States to the desirability of using in their own national regulations, as far as practicable, the precise language of those ICAO Standards that are of a regulatory character and also of indicating departures from the Standards, including any additional national regulations that were important for the safety or regularity of air navigation. Wherever possible, the provisions of this Annex have been deliberately written in such a way as would facilitate incorporation, without major textual changes, into national legislation.

Status of Annex components

An Annex is made up of the following component parts, not all of which, however, are necessarily found in every Annex; they have the status indicated:

1.— *Material comprising the Annex proper*:

a) *Standards* and *Recommended Practices* adopted by the Council under the provisions of the Convention. They are defined as follows:

Standard: Any specification for physical characteristics, configuration, matériel, performance, personnel or procedure, the uniform application of which is recognized as necessary for the safety or regularity of international air navigation and to which Contracting States will conform in accordance with the Convention; in the event of impossibility of compliance, notification to the Council is compulsory under Article 38.

Recommended Practice: Any specification for physical characteristics, configuration, matériel, performance, personnel or procedure, the uniform application of which is recognized as desirable in the interest of safety, regularity or efficiency of international air navigation, and to which Contracting States will endeavour to conform in accordance with the Convention.

b) *Appendices* comprising material grouped separately for convenience but forming part of the Standards and Recommended Practices adopted by the Council.

c) *Definitions* of terms used in the Standards and Recommended Practices which are not self-explanatory in that they do not have accepted dictionary meanings. A definition does not have independent status but is an essential part of each Standard and Recommended Practice in which the term is used, since a change in the meaning of the term would affect the specification.

d) *Tables* and *Figures* which add to or illustrate a Standard or Recommended Practice and which are referred to therein, form part of the associated Standard or Recommended Practice and have the same status.

2.— *Material approved by the Council for publication in association with the Standards and Recommended Practices*:

a) *Forewords* comprising historical and explanatory material based on the action of the Council and including an explanation of the obligations of States with regard to the application of the Standards and Recommended Practices ensuing from the Convention and the Resolution of Adoption;

b) *Introductions* comprising explanatory material introduced at the beginning of parts, chapters or sections of the Annex to assist in the understanding of the application of the text;

c) *Notes* included in the text, where appropriate, to give factual information or references bearing on the Standards or Recommended Practices in question, but not constituting part of the Standards or Recommended Practices;

d) *Attachments* comprising material supplementary to the Standards and Recommended Practices, or included as a guide to their application.

Disclaimer regarding patents

Attention is drawn to the possibility that certain elements of Standards and Recommended Practices in this Annex may be the subject of patents or other intellectual property rights. ICAO shall not be responsible or liable for not identifying any or all such rights. ICAO takes no position regarding the existence, validity, scope or applicability of any claimed patents or other intellectual property rights, and accepts no responsibility or liability therefore or relating thereto.

Selection of language

This Annex has been adopted in four languages — English, French, Russian and Spanish. Each Contracting State is requested to select one of those texts for the purpose of national implementation and for other effects provided for in the Convention, either through direct use or through translation into its own national language, and to notify the Organization accordingly.

Editorial practices

The following practice has been adhered to in order to indicate at a glance the status of each statement: *Standards* have been printed in light face roman; *Recommended Practices* have been printed in light face italics, the status being indicated by the prefix **Recommendation**; *Notes* have been printed in light face italics, the status being indicated by the prefix *Note*.

The following editorial practice has been followed in the writing of specifications: for Standards the operative verb "shall" is used, and for Recommended Practices the operative verb "should" is used.

The units of measurement used in this document are in accordance with the International System of Units (SI) as specified in Annex 5 to the Convention on International Civil Aviation. Where Annex 5 permits the use of non-SI alternative units these are shown in parentheses following the basic units. Where two sets of units are quoted it must not be assumed that the pairs of values are equal and interchangeable. It may, however, be inferred that an equivalent level of safety is achieved when either set of units is used exclusively.

Any reference to a portion of this document, which is identified by a number and/or title, includes all subdivisions of that portion.

Table A. Amendments to Annex 10, Volume III

Amendment	*Source(s)*	*Subject(s)*	*Adopted* *Effective* *Applicable*
70	Air Navigation Commission, Third Meeting of the Aeronautical Mobile Communications Panel (AMCP)	Introduction of new Volume III and SARPs related to the Aeronautical Mobile-Satellite Service (AMSS)	20 March 1995 24 July 1995 9 November 1995
71	Air Navigation Commission; SP COM/OPS/95 Divisional Meeting (1995); fifth meeting of the Secondary Surveillance Radar Improvements and Collision Avoidance Systems Panel (SICASP); third meeting of the Aeronautical Mobile Communications Panel (AMCP)	Addition of specifications for the Mode S subnetwork of ATN; addition of material relating to the introduction of 8.33 kHz channel spacing; changes to material related to the protection of air-ground communications in the VHF band; addition of technical specifications relating to the RF characteristics for the VHF digital link (VDL).	12 March 1996 15 July 1996 7 November 1996
72	Air Navigation Commission; fourth meeting of the Aeronautical Mobile Communications Panel (AMCP)	Introduction of SARPs and guidance material for VHF digital link (VDL); definition for VDL and deletion of obsolete material on air/ground data interchange.	12 March 1997 21 July 1997 6 November 1997
73	Air Navigation Commission; second meeting of the Aeronautical Telecommunication Network Panel (ATNP); sixth meeting of the Secondary Surveillance Radar Improvements and Collision Avoidance Systems Panel (SICASP)	Introduction of material relating to the ATN; changes to specifications of the Mode S subnetwork.	19 March 1998 20 July 1998 5 November 1998
74	Fifth meeting of the Aeronautical Mobile Communications Panel (AMCP); Air Navigation Commission	Introduction of: a) specifications for HF data link; and b) changes to the specifications for emergency locator transmitters.	18 March 1999 19 July 1999 4 November 1999
75	Sixth meeting of the Aeronautical Mobile Communications Panel (AMCP); Air Navigation Commission	Changes to the AMSS SARPs introducing a new antenna type, a new voice channel type and enhanced provisions for interoperability among AMSS systems; changes to the VDL SARPs to reduce potential interference to current VHF voice communication systems caused by VDL transmitters; changes to the VHF voice communication SARPs to enhance immunity to interference from VDL transmitters on board the same aircraft.	13 March 2000 17 July 2000 2 November 2000
76	Third meeting of the Aeronautical Telecommunication Network Panel (ATNP); seventh meeting of the Aeronautical Mobile Communications Panel (AMCP); the Secretariat assisted by the ATS Voice Switching and Signalling Study Group (AVSSSG)	Aeronautical telecommunication network (ATN) system management, security and directory services; removal of detailed material relating to CIDIN; integrated voice and data link system (VDL Mode 3); data link satisfying surveillance applications (VDL Mode 4); deletion of all the provisions for VDL Mode 1; removal of the detailed technical specifications for VDL Mode 2; aeronautical speech circuits; update of references to the ITU Radio Regulations.	12 March 2001 16 July 2001 1 November 2001

Amendment	*Source(s)*	*Subject(s)*	*Adopted Effective Applicable*
77	Secondary Surveillance Radar Improvements and Collision Avoidance Systems Panel (SICASP)	Mode S subnetwork (Part I), aircraft addressing system (Part I).	27 February 2002 15 July 2002 28 November 2002
78	Air Navigation Commission	Changes to technical specifications relating to radio frequency channels; introduction of registration requirement for ELTs; incorporation of VDL Modes 3 and 4 in the table of ATN subnetwork priorities (Table 3-3); editorial amendments.	5 March 2003 14 July 2003 27 November 2003
79	Eighth meeting of the Aeronautical Mobile Communications Panel (AMCP)	Changes to technical specifications relating to high frequency data link (HFDL) to align them with relevant provisions of ITU RR; introduction of FM immunity characteristics for VDL Mode 4; deletion of the note indicating that VDL Mode 4 SARPs apply to surveillance applications.	23 February 2004 12 July 2004 25 November 2004

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

PART I — DIGITAL DATA COMMUNICATION SYSTEMS

CHAPTER 1. DEFINITIONS

Note 1.— All references to "Radio Regulations" are to the Radio Regulations published by the International Telecommunication Union (ITU). Radio Regulations are amended from time to time by the decisions embodied in the Final Acts of World Radiocommunication Conferences held normally every two to three years. Further information on the ITU processes as they relate to aeronautical radio system frequency use is contained in the Handbook on Radio Frequency Spectrum Requirements for Civil Aviation including statement of approved ICAO policies *(Doc 9718).*

Note 2.— This Part of Annex 10 includes Standards and Recommended Practices for certain forms of equipment for communication systems. While the Contracting State will determine the necessity for specific installations in accordance with the conditions prescribed in the relevant Standard or Recommended Practice, review of the need for specific installation and the formulation of ICAO opinion and recommendations to Contracting States concerned, is carried out periodically by Council, ordinarily on the basis of recommendations of Regional Air Navigation Meetings (Doc 8144, Directives to Regional Air Navigation Meetings and Rules of Procedure for their Conduct*).*

Note 3.— This chapter contains general definitions relevant to communication systems. Definitions specific to each of the systems included in this volume are contained in the relevant chapters.

Note 4.— Material on secondary power supply and guidance material concerning reliability and availability for communication systems is contained in Annex 10, Volume I, 2.9 and Volume I, Attachment F, respectively.

Aeronautical telecommunication network (ATN). An internetwork architecture that allows ground, air-ground and avionic data subnetworks to interoperate by adopting common interface services and protocols based on the International Organization for Standardization (ISO) Open Systems Interconnection (OSI) reference model.

Aircraft address. A unique combination of twenty-four bits available for assignment to an aircraft for the purpose of air-ground communications, navigation and surveillance.

Aircraft earth station (AES). A mobile earth station in the aeronautical mobile-satellite service located on board an aircraft (see also "GES").

Bit error rate (BER). The number of bit errors in a sample divided by the total number of bits in the sample, generally averaged over many such samples.

Carrier-to-multipath ratio (C/M). The ratio of the carrier power received directly, i.e. without reflection, to the multipath power, i.e. carrier power received via reflection.

Carrier-to-noise density ratio (C/N_0). The ratio of the total carrier power to the average noise power in a 1 Hz bandwidth, usually expressed in dBHz.

Channel rate. The rate at which bits are transmitted over the RF channel. These bits include those bits used for framing and error correction, as well as the information bits. For burst transmission, the channel rate refers to the instantaneous burst rate over the period of the burst.

Channel rate accuracy. This is relative accuracy of the clock to which the transmitted channel bits are synchronized. For example, at a channel rate of 1.2 kbits/s, maximum error of one part in 10^6 implies the maximum allowed error in the clock is $\pm 1.2 \times 10^{-3}$ Hz.

Circuit mode. A configuration of the communications network which gives the appearance to the application of a dedicated transmission path.

Doppler shift. The frequency shift observed at a receiver due to any relative motion between transmitter and receiver.

End-to-end. Pertaining or relating to an entire communication path, typically from (1) the interface between the information source and the communication system at the transmitting end to (2) the interface between the communication system and the information user or processor or application at the receiving end.

End-user. An ultimate source and/or consumer of information.

Energy per symbol to noise density ratio (E_s/N_0). The ratio of the average energy transmitted per channel symbol to the average noise power in a 1 Hz bandwidth, usually expressed in dB. For A-BPSK and A-QPSK, one channel symbol refers to one channel bit.

Equivalent isotropically radiated power (e.i.r.p). The product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna *(absolute or isotropic gain).*

Forward error correction (FEC). The process of adding redundant information to the transmitted signal in a manner which allows correction, at the receiver, of errors incurred in the transmission.

Gain-to-noise temperature ratio. The ratio, usually expressed in dB/K, of the antenna gain to the noise at the receiver output of the antenna subsystem. The noise is expressed as the temperature that a 1 ohm resistor must be raised to produce the same noise power density.

Ground earth station (GES). An earth station in the fixed satellite service, or, in some cases, in the aeronautical mobile-satellite service, located at a specified fixed point on land to provide a feeder link for the aeronautical mobile-satellite service.

Note.— This definition is used in the ITU's Radio Regulations under the term "aeronautical earth station." The definition herein as "GES" for use in the SARPs is to clearly distinguish it from an aircraft earth station (AES), which is a mobile station on an aircraft.

Mode S subnetwork. A means of performing an interchange of digital data through the use of secondary surveillance radar (SSR) Mode S interrogators and transponders in accordance with defined protocols.

Packet. The basic unit of data transfer among communications devices within the network layer.

Packet layer protocol (PLP). A protocol to establish and maintain a connection between peer level entities at the network layer, and to transfer data packets between them. In the context of this standard, the term refers to the protocol defined by the ISO 8208 standard used in this document.

Point-to-point. Pertaining or relating to the interconnection of two devices, particularly end-user instruments. A communication path of service intended to connect two discrete end-users; as distinguished from broadcast or multipoint service.

Slotted aloha. A random access strategy whereby multiple users access the same communications channel independently, but each communication must be confined to a fixed time slot. The same timing slot structure is known to all users, but there is no other co-ordination between the users.

Switched virtual circuit (SVC). The primary circuit management technique provided within the ISO 8208 protocol. The network resources are dynamically allocated when needed and released when no longer required.

Time division multiplex (TDM). A channel sharing strategy in which packets of information from the same source but with different destinations are sequenced in time on the same channel.

Time division multiple access (TDMA). A multiple access scheme based on time-shared use of an RF channel employing: (1) discrete contiguous time slots as the fundamental shared resource; and (2) a set of operating protocols that allows users to interact with a master control station to mediate access to the channel.

Transit delay. In packet data systems, the elapsed time between a request to transmit an assembled data packet and an indication at the receiving end that the corresponding packet has been received and is ready to be used or forwarded.

VHF digital link (VDL). A constituent mobile subnetwork of the aeronautical telecommunication network (ATN), operating in the aeronautical mobile VHF frequency band. In addition, the VDL may provide non-ATN functions such as, for instance, digitized voice.

CHAPTER 2. GENERAL

[to be developed]

CHAPTER 3. AERONAUTICAL TELECOMMUNICATION NETWORK

3.1 DEFINITIONS

Note 1.— The following definitions were taken from ISO/IEC 7498-1, Information technology — Open Systems Interconnection — Basic Reference Model *(Reference: ITU-T Rec. X.200 (1994)) and from ICAO Doc 9705 —* Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN).

Note 2.— ICAO Doc 9705 has evolved through multiple editions. Each sub-volume of that document indicates the evolution of the provisions between successive editions.

Note 3.— Sub-volume I of ICAO Doc 9705 provides a cross-reference chart between versions (i.e. embedded software capabilities) and editions (i.e. technical provisions).

Accounting management. An ATN systems management facility to monitor users for use of network resources and to limit the use of those resources.

ADS application. An ATN application that provides ADS data from the aircraft to the ATS unit(s) for surveillance purposes.

Aeronautical administrative communication (AAC). Communication used by aeronautical operating agencies related to the business aspects of operating their flights and transport services. This communication is used for a variety of purposes, such as flight and ground transportation, bookings, deployment of crew and aircraft or any other logistical purposes that maintain or enhance the efficiency of over-all flight operation.

Aeronautical operational control (AOC). Communication required for the exercise of authority over the initiation, continuation, diversion or termination of flight for safety, regularity and efficiency reasons.

Aeronautical passenger communication (APC). Communication relating to the non-safety voice and data services to passengers and crew members for personal communication.

AIDC application. An ATN application dedicated to exchanges between ATS units (ATSUs) of air traffic control (ATC) information in support of flight notification, flight coordination, transfer of control, transfer of communication, transfer of surveillance data and transfer of general data.

Air traffic service. A generic term meaning variously, flight information service, alerting service, air traffic advisory service, air traffic control service (area control service, approach control service or aerodrome control service).

Application. The ultimate use of an information system, as distinguished from the system itself.

Application entity (AE). Part of an application process that is concerned with communication within the OSI environment. The aspects of an application process that need to be taken into account for the purposes of OSI are represented by one or more AEs.

Application information. Refers to the application names (e.g. AE qualifiers such as ADS and CPC), version numbers, and addresses (the long or short TSAP, as required) of each application.

ATIS application. A FIS application that supports the D-ATIS.

ATN directory services (DIR). A service which provides the capability for an application entity or user in the ATN community to query a distributed directory data base and retrieve addressing, security and technical capabilities information relating to other users or entities within the ATN community.

ATN security services. A set of information security provisions allowing the receiving end system or intermediate system to unambiguously identify (i.e. authenticate) the source of the received information and to verify the integrity of that information.

ATN systems management (SM). A collection of facilities to control, coordinate and monitor the resources which allow communications to take place in the ATN environment. These facilities include fault management, accounting management, configuration management, performance management and security management.

ATSC class. The ATSC class parameter enables the ATSC user to specify the quality of service expected for the offered data. The ATSC class value is specified in terms of ATN end-to-end transit delay at 95 per cent probability.

ATS communications (ATSC). Communication related to air traffic services including air traffic control, aeronautical and meteorological information, position reporting and services related to safety and regularity of flight. This communication involves one or more air traffic service administrations. This term is used for purposes of address administration.

ATS interfacility data communication (AIDC). Automated data exchange between air traffic services units, particularly in regard to co-ordination and transfer of flights.

ATS message handling services (ATSMHS). Procedures used to exchange ATS messages over the ATN such that the conveyance of an ATS message is in general not correlated with the conveyance of another ATS message by the service provider.

ATS unit (ATSU). A generic term meaning variously, air traffic control unit, flight information centre or air traffic services reporting office.

Authentication. A process used to ensure the identity of a person/user/network entity.

Authorized path. A communication path that the administrator(s) of the routing domain(s) has pre-defined as suitable for a given traffic type and category.

Automatic dependent surveillance (ADS). A surveillance technique in which aircraft automatically provide, via a data link, data derived from on-board navigation and position-fixing systems, including aircraft identification, four-dimensional position, and additional data as appropriate.

Automatic terminal information service (ATIS). The automatic provision of current, routine information to arriving and departing aircraft throughout 24 hours or a specified portion thereof.

Data link-automatic terminal information service (D-ATIS). The provision of ATIS via data link.

Voice-automatic terminal information service (Voice-ATIS). The provision of ATIS by means of continuous and repetitive voice broadcasts.

Configuration management. An ATN systems management facility for managers to change the configuration of remote elements.

Context management (CM) application. An ATN application that provides a log-on service allowing initial aircraft introduction into the ATN and a directory of all other data link applications on the aircraft. It also includes functionality to forward addresses between ATS units.

Note.— Context management is a recognized OSI presentation layer term. The OSI use and the ATN use have nothing in common.

Context management (CM) server. An ATS facility that is capable of providing application information relating to other ATSUs to requesting aircraft or ATSUs.

Controller pilot data link communication (CPDLC). A means of communication between controller and pilot, using data link for ATC communications.

CPDLC application. An ATN application that provides a means of ATC data communication between controlling, receiving or downstream ATS units and the aircraft, using air-ground and ground-ground subnetworks, and which is consistent with the ICAO phraseology for the current ATC voice communication.

Data integrity. The probability that data has not been altered or destroyed.

D-METAR. The symbol used to designate data link aviation weather report service.

End system (ES). A system that contains the OSI seven layers and contains one or more end user application processes.

End-to-end. Pertaining or relating to an entire communication path, typically from (1) the interface between the information source and the communication system at the transmitting end to (2) the interface between the communication system and the information user or processor or application at the receiving end.

Entity. An active element in any layer which can be either a software entity (such as a process) or a hardware entity (such as an intelligent I/O chip).

Fault management. An ATN systems management facility to detect, isolate and correct problems.

FIS application. An ATN application that provides to aircraft information and advice useful for the safe and efficient conduct of flights.

Flight information service (FIS). A service provided for the purpose of giving advice and information useful for the safe and efficient conduct of flights.

Inter-centre communications (ICC). ICC is data communication between ATS units to support ATS, such as notification, coordination, transfer of control, flight planning, airspace management and air traffic flow management.

Intermediate system (IS). A system which performs relaying and routing functions and comprises the lowest three layers of the OSI reference model.

Internet communications service. The internet communications service is an internetwork architecture which allows ground, air-to-ground and avionics data subnetworks to interoperate by adopting common interface services and protocols based on the ISO/OSI reference model.

METAR application. A FIS application that supports the D-METAR.

Open systems interconnection (OSI) reference model. A model providing a standard approach to network design introducing modularity by dividing the complex set of functions into seven more manageable, self-contained, functional layers. By convention these are usually depicted as a vertical stack.

Note.— The OSI reference model is defined by ISO/IEC 7498-1.

Performance management. An ATN systems management facility to monitor and evaluate the performance of the systems.

Security management. An ATN systems management facility for access control, authentication and data integrity.

Subnetwork. An actual implementation of a data network that employs a homogeneous protocol and addressing plan and is under control of a single authority.

System level requirement. The system level requirement is a high-level technical requirement that has been derived from operational requirements, technological constraints and regulatory constraints (administrative and institutional). The system level requirements are the basis for the functional requirements and lower-level requirements.

Transit delay. In packet data systems, the elapsed time between a request to transmit an assembled data packet and an indication at the receiving end that the corresponding packet has been received and is ready to be used or forwarded.

Upper layers (UL) communications service. A term pertaining to the session, presentation and application layers of the OSI reference model.

3.2 INTRODUCTION

3.2.1 The aeronautical telecommunication network (ATN) comprises application entities and communication services which allow ground, air-to-ground and avionics data subnetworks to interoperate by adopting common interface services and protocols based on the International Organization for Standardization (ISO) open systems interconnection (OSI) reference model. The conceptual model of the ATN is shown in Figure 3-1.*

* All figures are located at the end of this chapter.

3.2.2 The ATN and the associated application processes have been designed in support of the communications, navigation, surveillance and air traffic management (CNS/ATM) systems. The ATN:

a) is specifically and exclusively intended to provide data communications services to air traffic service provider organizations and aircraft operating agencies supporting the following types of communications traffic:

   1) air traffic services communication (ATSC);

   2) aeronautical operational control (AOC);

   3) aeronautical administrative communication (AAC); and

   4) aeronautical passenger communication (APC);

b) provides, in a manner transparent to the user, a reliable end-to-end communications service essential to support the provision of safe and efficient air traffic services, between:

   1) airborne systems and ground systems; and

   2) multiple ground systems;

c) provides a data communication service which is capable of meeting the security and safety requirements of the users;

d) is based on internationally recognized data communications standards which will facilitate the development of compliant systems and encourage the competitive provision of network services;

e) accommodates differing types/categories/classes of service (including preferred/selected air-ground subnetwork) required by the various applications;

f) defines an architecture that enables the integration of public and private subnetworks, both air-ground and ground-ground. This allows the use of existing/planned infrastructure and network technologies, as well as giving implementors the freedom to scale the network to meet the increasing needs of the users; and

g) efficiently uses the bandwidth limited air-ground subnetworks and consequently reduces the associated costs.

3.2.3 The ATN applications presently defined have been developed to provide aeronautical communication, surveillance, and information services. These applications are intended to support the following air traffic management services:

a) air traffic services (ATS);

  1) air traffic control service;

  2) flight information service (FIS); and

  3) alerting service.

b) air traffic flow management (ATFM); and

c) airspace management.

3.2.4 This chapter contains broad and general provisions for the ATN. The detailed technical provisions are found in Doc 9705. The remainder of this chapter is organized to address the following requirements and functions:

a) general;

b) system level requirements;

c) ATN applications requirements;

d) ATN communications service requirements;

e) ATN naming and addressing;

f) ATN systems management requirements; and

g) ATN security requirements.

3.3 GENERAL

3.3.1 The aeronautical telecommunication network (ATN) shall provide data communication services and application entities in support of:

a) the delivery of air traffic services (ATS) to aircraft;

b) the exchange of ATS information between ATS units; and

c) other applications such as aeronautical operational control (AOC) and aeronautical administrative communication (AAC).

Note 1.— Provisions have been made to accommodate the exchange of information such as weather, flight plans, notices to airmen and dynamic real time air traffic flow management between aircraft operating agencies' ground-based systems and ATS units.

Note 2.— Provisions have also been made to accommodate aeronautical passenger communication (APC).

3.3.2 When the ATN is used in support of air traffic services, it shall conform with the provisions of this chapter.

3.3.3 Requirements for use of the ATN shall be made on the basis of regional air navigation agreements.

3.3.4 **Recommendation.—** *Civil aviation authorities should co-ordinate, with national authorities and aeronautical industry, those implementation aspects of the ATN which will permit its world-wide safety, interoperability and efficient use, as appropriate.*

3.4 SYSTEM LEVEL REQUIREMENTS

Note.— The system level requirements are high-level technical requirements that have been derived from operational requirements, technological constraints and regulatory constraints (administrative and institutional). These system level requirements are the basis for the functional requirements and lower-level requirements.

3.4.1 The ATN shall use International Organization for Standardization (ISO) communication standards for open systems interconnection (OSI).

3.4.2 The ATN shall provide a means to facilitate migration to future versions of application entities and/or the communication services.

Note.— It is an objective that the evolution towards future versions facilitates the backward compatibility with previous versions.

3.4.3 The ATN shall enable the transition of existing AFTN/CIDIN users and systems into the ATN architecture.

Note.— The transition from the AFTN or from the CIDIN to the ATN is handled by AFTN/AMHS and CIDIN/AMHS gateways respectively, which are defined in Doc 9705, Sub-volume III.

3.4.4 The ATN shall make provisions whereby only the controlling ATS unit may provide ATC instructions to aircraft operating in its airspace.

Note.— This is achieved through the current and next data authority aspects of the controller-pilot data link communications (CPDLC) application entity.

3.4.5 The ATN shall accommodate routing based on a pre-defined routing policy.

3.4.6 The ATN shall provide means to define data communications that can be carried only over authorized paths for the traffic type and category specified by the user.

3.4.7 The ATN shall offer ATSC classes in accordance with the criteria in Table 3-1.*

* All tables are located at the end of this chapter.

Note 1.— When an ATSC class is specified by an ATN application, packets will be forwarded in the ATN internet communications service on a best effort basis. Best effort basis means that when a route is available of the requested ATSC class, the packet is forwarded on that route. When no such route is available, the packet will be forwarded on the first known route of the ATSC class higher than that requested, or if there is no such route, first known route of the ATSC class lower than that requested.

Note 2.— The ATN communications service will not inform application entities if the requested ATSC class was not achieved. It is the responsibility of the application entity to determine the actual transit delay achieved by local means such as time stamping.

3.4.8 The ATN shall operate in accordance with the communication priorities defined in Table 3-2 and Table 3-3.

3.4.9 The ATN shall enable exchange of application information when one or more authorized paths exist.

3.4.10 The ATN shall notify the appropriate application processes when no authorized path exists.

3.4.11 The ATN shall provide means to unambiguously address all ATN end and intermediate systems.

3.4.12 The ATN shall enable the recipient of a message to identify the originator of that message.

3.4.13 The ATN addressing and naming plans shall allow States and organizations to assign addresses and names within their own administrative domains.

3.4.14 The ATN shall support data communications to fixed and mobile systems.

3.4.15 The ATN shall accommodate ATN mobile subnetworks as defined in this Annex.

3.4.16 The ATN shall make provisions for the efficient use of limited bandwidth subnetworks.

3.4.17 The ATN shall enable an aircraft intermediate system to be connected to a ground intermediate system via concurrent mobile subnetworks.

3.4.18 The ATN shall enable an aircraft intermediate system to be connected to multiple ground intermediate systems.

3.4.19 The ATN shall enable the exchange of address information between application entities.

3.4.20 The ATN shall support the context management (CM) application when any of the other air-ground applications are supported.

3.4.21 The ATN shall be capable of establishing, maintaining, releasing and aborting peer-to-peer application associations for the context management (CM) application.

3.4.22 The ATN shall be capable of establishing, maintaining, releasing and aborting peer-to-peer application associations for the automatic dependent surveillance (ADS) application.

3.4.23 The ATN shall be capable of establishing, maintaining, releasing and aborting peer-to-peer application associations for the controller-pilot data link communications (CPDLC) application.

3.4.24 The ATN shall be capable of establishing, maintaining, releasing and aborting peer-to-peer application associations for the automatic terminal information service (ATIS) application.

3.4.25 The ATN shall be capable of establishing, maintaining, releasing and aborting application associations for the ATS message handling services (ATSMHS) application.

3.4.26 The ATN shall be capable of establishing, maintaining, releasing and aborting peer-to-peer application associations for the ATS interfacility data communication (AIDC) application.

3.4.27 Where the absolute time of day is used within the ATN, it shall be accurate to within 1 second of coordinated universal time (UTC).

Note.— A time accuracy value may result in synchronization errors of up to two times the stated accuracy value.

3.4.28 The end system shall make provisions to ensure that the probability of not detecting a 255-octet message being mis-delivered, non-delivered or corrupted by the internet communication service is less than or equal to 10^{-8} per message.

Note.— It is assumed that ATN subnetworks will ensure data integrity consistent with this system level requirement.

3.4.29 ATN end systems supporting ATN security services shall be capable of authenticating the identity of peer end systems, authenticating the source of application messages and ensuring the data integrity of the application messages.

Note.— Application messages in this context include messages related to ATS, systems management and directory services.

3.4.30 ATN ground and air-ground boundary intermediate systems supporting ATN security services shall be capable of authenticating the identity of peer boundary intermediate systems, authenticating the source of routing information and ensuring the data integrity of routing information.

3.4.31 The ATN shall be capable of establishing, maintaining, releasing and aborting peer-to-peer application associations for the exchange of directory information.

3.4.32 ATN systems supporting ATN systems management shall facilitate enhanced continuity of ATN operations, including the monitoring and maintenance of the quality of the communications service.

3.4.33 The ATN shall be capable of establishing, maintaining, releasing and aborting peer-to-peer application associations for the systems management (SM) application.

3.4.34 The ATN shall be capable of establishing, maintaining, releasing and aborting peer-to-peer application associations for the aviation routine weather report service (METAR) application.

3.5 ATN APPLICATIONS REQUIREMENTS

Note 1.— Implementation of ATN application(s) within a State or region does not imply implementation of all of the ATN applications defined below.

Note 2.— The implementation of pre-defined subsets of the ATN application technical provisions are allowed as detailed in Doc 9705.

3.5.1 System applications

Note.— System applications provide services that are necessary for operation of the ATN air-ground applications, ground-ground applications and/or ATN communication services.

3.5.1.1 CONTEXT MANAGEMENT (CM) APPLICATION

Note.— The CM application provides the capability for an aircraft to log on with an ATS ground system; in some instances the ground system will request the aircraft to contact a specific ground system. Once an appropriate connection is established, CM provides for the exchange of information on each supported ATN application including the network address of each, as appropriate. For ATN systems supporting security services, CM also obtains and exchanges key and key usage information. CM also provides the capability to update log-on information and the capability for an ATS ground system to forward log-on information to another ATS ground system. The registration function of the CM allows the sharing of information with other applications on the ground or on the aircraft.

3.5.1.1.1 The ATN shall be capable of supporting the following CM application functions:

a) log-on;

b) contact;

c) update;

d) CM server query;

e) CM server update;

f) ground forwarding; and

g) registration.

Note.— The technical provisions for the CM application are defined in Doc 9705, Sub-volume II.

3.5.1.2 ATN DIRECTORY SERVICES (DIR)

3.5.1.2.1 The ATN shall be capable of supporting the following DIR application functions:

a) directory bind;

b) directory information retrieval; and

c) directory information change.

Note 1.— The ATN Directory Service provides a capability for an application or user to query a distributed directory data base and to retrieve addressing, security and technical capabilities information. Directory Service provides a capability to special, authorized users to add, delete and modify parts of the directory data base for which they are responsible. The Directory Service is offered over the ATN to all applications and users complying with the technical provisions of Doc 9705, Sub-volume VII .

Note 2.— Directory bind is the function of establishing an association between two directory components that support other directory functions. Directory bind sets up the application contexts and underlying communications connections for use in other directory functions.

3.5.1.3 OTHER SYSTEM APPLICATIONS

(to be developed)

3.5.2 Air-ground applications

Note.— The ground components of air-ground applications include functionality to support the forwarding of the contents of air-to-ground messages along ground-ground communications paths.

3.5.2.1 AUTOMATIC DEPENDENT SURVEILLANCE (ADS) APPLICATION

Note.— The ADS application comprises an airborne and ground component. The airborne ADS application component is capable of automatically providing, via the ATN communications service, to the ground component data derived from on-board navigation systems (e.g. aircraft identification, four-dimensional position, intent, and additional data as appropriate). The ADS application provides service based on contracts established between its air and ground components (i.e. demand contract, periodic contract, event contract and emergency contract) and between two ADS ground components (i.e. forward contract).

3.5.2.1.1 The ATN shall be capable of supporting the following ADS application functions:

a) demand contracts;

b) periodic contracts;

c) event contracts;

d) emergency contracts; and

e) forward contracts.

Note.— The technical provisions for the ADS application are defined in Doc 9705, Sub-volume II.

3.5.2.2 CONTROLLER-PILOT DATA LINK COMMUNICATIONS (CPDLC) APPLICATION

Note.— The CPDLC application, comprising an airborne and ground component, provides capability for data link communications between ATS units and aircraft under their control and/or aircraft about to come under their control. The CPDLC application has the capability to establish, manage, and terminate CPDLC dialogues for controller-pilot message exchange and for ground message forwarding.

3.5.2.2.1 The ATN shall be capable of supporting the following CPDLC application functions:

a) controller-pilot message exchange;

b) transfer of data authority;

c) downstream clearance; and

d) ground forward.

Note.— The technical provisions for the CPDLC application are defined in Doc 9705, Sub-volume II.

3.5.2.3 FLIGHT INFORMATION SERVICE (FIS) APPLICATIONS

Note.— FIS applications provide flight information services to airspace users from ground FIS systems.

3.5.2.3.1 *AUTOMATIC TERMINAL INFORMATION SERVICE (ATIS) APPLICATION*

3.5.2.3.1.1 The ATN shall be capable of supporting the following ATIS application functions:

a) aircraft-initiated FIS demand contracts;

b) aircraft-initiated FIS update contracts; and

c) both an aircraft- and ground-initiated FIS cancellation of contracts.

Note.— The technical provisions for the ATIS application are defined in Doc 9705, Sub-volume II.

3.5.2.3.2 *AVIATION ROUTINE WEATHER REPORT SERVICE (METAR) APPLICATION*

3.5.2.3.2.1 The ATN shall be capable of supporting the METAR application function for aircraft-initiated FIS demand contracts.

Note.— The technical provisions for the METAR application are defined in Doc 9705, Sub-volume II.

3.5.2.3.3 *OTHER FIS APPLICATIONS*

(to be developed)

3.5.2.4 OTHER AIR-GROUND APPLICATIONS

(to be developed)

3.5.3 Ground-ground applications

Note.— Ground-ground applications are defined as those ATN applications resident in ground-based systems which solely exchange information with peer applications also resident in ground-based systems.

3.5.3.1 INTER-CENTRE COMMUNICATIONS (ICC)

Note.— The inter-centre communications applications set enables the exchange of information between air traffic service units.

3.5.3.1.1 *ATS INTERFACILITY DATA COMMUNICATION (AIDC)*

Note.— AIDC is an ATN application that is used by two air traffic service units to enable the exchange of ATS information for active flights related to flight notification, flight coordination, transfer of control, surveillance data and free (i.e. unstructured) text data.

3.5.3.1.1.1 The ATN shall be capable of supporting the following AIDC application functions:

a) flight notification;

b) flight coordination;

c) transfer of control;

d) transfer of communications;

e) transfer of surveillance data; and

f) transfer of general data.

Note.— The technical provisions for the AIDC application are defined in Doc 9705, Sub-volume III.

3.5.3.2 ATS MESSAGE HANDLING SERVICES (ATSMHS) APPLICATION

Note.— The ATS message handling services (ATSMHS) application comprises a main function named the ATS message service function. The ATS message service function enables ATS messages to be exchanged between service users through the provision of generic message services. The ATSMHS application includes the definition of AFTN/ATN and CIDIN/ATN gateways.

3.5.3.2.1 The ATN shall be capable of supporting the ATS message service of the ATS message handling services application (ATSMHS).

Note.— The technical provisions for the ATSMHS application are defined in Doc 9705, Sub-volume III.

3.5.3.3 OTHER GROUND-GROUND APPLICATIONS

(to be developed)

3.6 ATN COMMUNICATION SERVICE REQUIREMENTS

Note.— The ATN communication service requirements define the requirements for layers 3 through 6, as well as part of layer 7, of the OSI reference model. These services take information produced by one of the individual ATN applications and perform the end-to-end communication service using standard protocols. These communication service requirements are divided into two parts. The upper layer communications service defines the standards for layers 5 through 7. The Internet communications service defines standards for layers 3 and 4. The requirements for layers 1 and 2 are outside the scope of ATN SARPs.

3.6.1 Upper layer communications service

3.6.1.1 The upper layer communications service shall include the:

a) session layer;

b) presentation layer;

c) application entity structure;

d) association control service element (ACSE);

e) security application service object (ASO), for ATN systems supporting security services; and

f) control function (CF).

Note 1.— The technical provisions for the upper layer communications service for all ATN applications, except the ATS message service function of the ATSMHS application, are defined in Doc 9705, Sub-volume IV.

Note 2.— The technical provisions for the upper layer communications service for the ATS message service function of the ATSMHS application are defined in Doc 9705, Sub-volume III.

3.6.2 ATN Internet communications service

Note.— The ATN Internet communications service requirements are applicable to the end system and intermediate system functional entities which together provide the ATN Internet communications service. The ATN Internet communications service is provided to its user (i.e. the upper layers) via the transport layer service interface.

3.6.2.1 An ATN end system (ES) shall be capable of supporting the ATN Internet including the:

a) transport layer; and

b) network layer.

3.6.2.2 An ATN intermediate system (IS) shall support the ATN network layer provisions as appropriate to the class of ATN IS under consideration.

Note.— A number of different classes of ATN intermediate systems for which network layer profiles are defined are contained in Doc 9705, Sub-volume V.

3.7 ATN NAMING AND ADDRESSING REQUIREMENTS

Note.— The ATN naming and addressing scheme supports the principles of unambiguous identification of information objects and global address standardization.

3.7.1 The ATN shall provide provisions for application entity naming.

3.7.2 The ATN shall provide provisions for network and transport addressing.

Note.— The technical provisions for ATN application entity naming are defined in Doc 9705, Sub-volume IV, the provisions for network and transport addressing are defined in Sub-volume V, and the provisions for registration services are defined in Sub-volume IX of the same document.

3.8 ATN SYSTEMS MANAGEMENT REQUIREMENTS

Note 1.— The ATN systems management (SM) application provides the capability for an SM manager to exchange information with an SM agent and/or another SM manager.

Note 2.— Support for the ATN SM services technical provisions may be required on a State or regional basis.

3.8.1 The ATN shall be capable of supporting the following systems management application functions:

a) fault management;

b) configuration management;

c) accounting management;

d) performance management; and

e) security management.

Note.— The technical provisions for ATN Systems Management are defined in Doc 9705, Sub-volume VI.

3.8.1.1 ATN end systems and intermediate systems that support the ATN systems management application and SM managers shall support access to managed objects.

Note.— The SM application managed object definitions and access provisions are defined in Doc 9705, Sub-volume VI.

3.9 ATN SECURITY REQUIREMENTS

3.9.1 The security of the ATN shall be achieved based on a combination of technical provisions, local physical security measures, and procedural security measures.

Note 1.— The technical provisions for ATN security are defined in Doc 9705, and the physical and procedural security measures are defined in Annex 17 and the Security Manual.

Note 2.— Support for the ATN security services technical provisions may be required on a State or regional basis.

3.9.1.1 **Recommendation.—** *The following physical and procedural techniques should be used to provide security for ATN end systems, intermediate systems, network managers, directory servers and subnetworks:*

a) restricted physical access to ATN end systems, intermediate systems, SM workstations, directory servers and subnetwork switches, network managers, and other essential network sub-systems;

b) restricted user access to ATN end systems, intermediate systems, directory servers and SM workstations to only authorized personnel; and

c) non-use, or restricted use, of remote access to ATN ground end system, intermediate systems and SM workstations.

3.9.2 ATN security policy

Note.— Communication monitoring and third party traffic analysis do not constitute safety hazards and are not considered security threats for the ATSC. However, some ATS and/or non-ATS users and applications may have local, or organizational, policies wherein communication monitoring and third party traffic analysis would be considered security threats based on other concerns, such as economic considerations.

3.9.2.1 ATS messages shall be protected from masquerade, modification and replay.

Note 1. — This means that for data messages exchanged among ATN entities there will be a high level of assurance that a message comes from where it claims, has not been tampered with, and is not a repeat of an obsolete message.

Note 2. — The level of protection may vary by the type of security threat and by the level of ATN security service selected by the user or application process.

3.9.2.2 A request for protection of ATS messages shall be honoured.

Note.— A request for non-use of protection may be honoured. This means that the use of security is the default and negotiation to non-use is based on local policy.

3.9.2.3 The ATN services that support messages to and from the aircraft shall be protected against denial of service attacks to a level of probability consistent with the required application service availability as determined by local policies.

Note 1.— The term "denial of service" describes a condition where legitimate access to information or other ATN resources is deliberately impeded.

Note 2.— This may mean having alternative communications paths available in case one path is subject to denial of service.

TABLES FOR CHAPTER 3

Table 3-1. Transit delays for ATSC Classes

Maximum one-way ATN end-to-end transit delay at 95% probability (seconds)	*ATSC Class*
Reserved	A
4.5	B
7.2	C
13.5	D
18	E
27	F
50	G
100	H
No value specified	no preference

Note 1.— The value for the ATN end-to-end transit delay represents approximately 90% of the value for the total end-to-end transit delay between the ultimate users of the system.

Note 2.— The 95% probability is based on the availability of a route conforming to the requested ATSC class.

Table 3-2. Mapping of ATN communication priorities

Message categories	*ATN application*	*Corresponding protocol priority*	
		Transport layer priority	*Network layer priority*
Network/systems management	SM	0	14
Distress communications		1	13
Urgent communications		2	12
High-priority flight safety messages	CPDLC, ADS	3	11
Normal-priority flight safety messages	AIDC, ATIS	4	10
Meteorological communications	METAR	5	9
Flight regularity communications	CM, ATSMHS	6	8
Aeronautical information service messages		7	7
Network/systems administration	SM, DIR	8	6
Aeronautical administrative messages		9	5
<unassigned>		10	4
Urgent-priority administrative and U.N. Charter communications		11	3
High-priority administrative and State/Government communications		12	2
Normal-priority administrative communications		13	1
Low-priority administrative communications and aeronautical passenger communications		14	0

Note.— The network layer priorities shown in the table apply only to connectionless network priority and do not apply to subnetwork priority.

Table 3-3. Mapping of ATN network priority to mobile subnetwork priority

Message categories	*ATN network layer priority*	*Corresponding mobile subnetwork priority (see Note 4)*					
		AMSS	*VDL Mode 2*	*VDL Mode 3*	*VDL Mode 4 (see Note 5)*	*SSR Mode S*	*HFDL*
Network/systems management	14	14	see Note 1	3	high	high	14
Distress communications	13	14	see Note 1	2	high	high	14
Urgent communications	12	14	see Note 1	2	high	high	14
High-priority flight safety messages	11	11	see Note 1	2	high	high	11
Normal-priority flight safety messages	10	11	see Note 1	2	high	high	11
Meteorological communications	9	8	see Note 1	1	medium	low	8
Flight regularity communications	8	7	see Note 1	1	medium	low	7
Aeronautical information service messages	7	6	see Note 1	0	medium	low	6
Network/systems administration	6	5	see Note 1	0	medium	low	5
Aeronautical administrative messages	5	5	not allowed	not allowed	not allowed	not allowed	not allowed
<unassigned>	4	unassigned	unassigned	unassigned	unassigned	unassigned	unassigned
Urgent-priority administrative and U.N. Charter communications	3	3	not allowed	not allowed	not allowed	not allowed	not allowed
High-priority administrative and State/Government communications	2	2	not allowed	not allowed	not allowed	not allowed	not allowed
Normal-priority administrative communications	1	1	not allowed	not allowed	not allowed	not allowed	not allowed
Low-priority administrative communications and aeronautical passenger communications	0	0	not allowed	not allowed	not allowed	not allowed	not allowed

Note 1.— VDL Mode 2 has no specific subnetwork priority mechanisms.

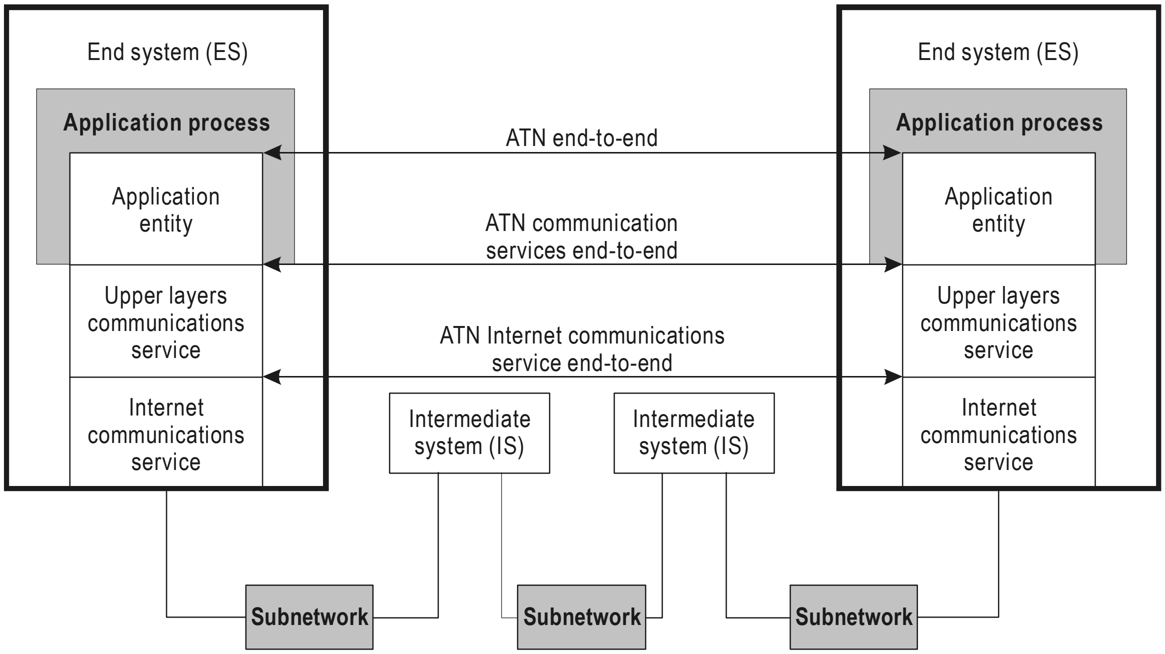
Note 2.— The AMSS SARPs specify mapping of message categories to subnetwork priority without explicitly referencing ATN network layer priority.

Note 3.—The term "not allowed" means that only communications related to safety and regularity of flight are authorized to pass over this subnetwork as defined in the subnetwork SARPs.

Note 4.— Only those mobile subnetworks are listed for which subnetwork SARPs exist and for which explicit support is provided by the ATN boundary intermediate system (BIS) technical provisions.

Note 5.— The VDL Mode 4 subnetwork provides support for surveillance applications (e.g. ADS).

FIGURE FOR CHAPTER 3



Note 1.— Shading indicates elements outside the scope of these SARPs. User requirements define the interface between the application entity and the user and ensure the functionality and interoperability of the ATN.

Note 2.— The figure represents a simplified model of the ATN and does not depict all of its capabilities (e.g. the store and forward capability which is provided for ATS message handling service).

Note 3.— Various end-to-end points have been defined within the ATN to specify certain end-to-end performance requirements. It may be necessary, however, to define different end-to-end points to facilitate the qualification of implementations to those performance requirements. In such cases, the end-to-end points should be clearly defined and correlated with the end-to-end points shown in the figure.

Note 4.— An IS is a conceptual representation of functionality and does not correspond precisely to a router. A router which implements the system management application requires the protocols of an end system and when using the system management application is also acting as an end system.

Figure 3-1. Conceptual model of the ATN

CHAPTER 4. AERONAUTICAL MOBILE-SATELLITE SERVICE

4.1 DEFINITIONS AND DESCRIPTIONS OF CHANNEL TYPES; GENERAL; SYSTEM CAPABILITIES

4.1.1 Definitions and descriptions of channel types

4.1.1.1 DEFINITIONS

Application. The ultimate use of an information system, as distinguished from the system itself.

Aviation-BPSK (A-BPSK). The particular form of binary phase shift keyed modulation which is used in AMSS for channel rates of 2.4, 1.2 and 0.6 kbits/s. A-BPSK is a modulation technique which maps a "0" to a phase shift of –90° and "1" to a phase shift of +90°. The phase-encoded A-BPSK data stream is then filtered with a filter which satisfies the amplitude and phase versus frequency limits defined by Tables A1-1 and A1-2 in Appendix 1 to Chapter 4.

Aviation-QPSK (A-QPSK). The particular form of offset quaternary phase shift keyed modulation which is used in AMSS for channel rates greater than 2 400 bits/s. A-QPSK is a modulation technique which maps a "0" into a 0 degrees and "1" into a 180 degrees, or "0" into 90 degrees and "1" into 270 degrees, alternating between the two options on successive bits. The encoded A-QPSK data stream is then filtered such that the modulated spectrum meets the amplitude mask of Table A1-3 and the phase mask defined in Table A1-2 in Appendix 1 to Chapter 4.

Burst. A time-defined, contiguous set of one or more related signal units which may convey user information and protocols, signalling, and any necessary preamble.

Cyclic redundancy check. The last two bytes of each signal unit form a cyclic redundancy check of the whole signal unit as follows. The check bits for error detection are calculated from the first 10 octets of a standard length signal unit, or from the first 17 octets of an extended length signal unit or from the first 4 octets of the burst identifier, using the following generator polynomial:

$$x^{16} + x^{12} + x^5 + 1$$

Note.— See CCITT (Red Book) Recommendation X.25, Section 2.2.7 for the method of calculation and the bit order.

Direct link service (DLS). A data communications service which makes no attempt to automatically correct errors, detected or undetected, at the link layer of the air-ground communications path. (Error control may be effected by end-user systems.)

Epoch. A span of time related to the beginning and end, or lifetime, of an event or a sequence of associated events.

Frame. A structured, repeating time-segment of a communication link architecture that provides for time-predictable communication activities between its beginning and end.

Global beam. Satellite antenna directivity whose main lobe encompasses the entire earth's surface that is within line-of-sight view of the satellite.

Initial signal unit (ISU). The first of the series of signal units followed by SSUs.

Link interface control information (LICI). The control information exchanged between the link layer and any of its service users as part of the link interface data unit (LIDU).

Link interface data unit (LIDU). The total information transferred in a single interaction across the interface between the link layer and a link service user. Each LIDU contains link interface control information (LICI) and may also contain a single link service data unit (LSDU).

Link service data unit (LSDU). A part of the link interface data unit (LIDU) and is the same as the subnetwork protocol data unit (SNPDU).

Lone signal unit (LSU). A single signal unit comprising the total message.

Near-geostationary orbits. Satellites operating in near-geostationary orbits have an orbit period of 24 hours with an inclination of up to five degrees from the equatorial plane.

Network co-ordination station (NCS). The entity of the over-all AMS(R)S system that has functional responsibilities to: co-ordinate communications traffic and satellite connectivity within its satellite region; and provide inter-system co-ordination with adjacent satellite regions served by other satellites.

P channel synchronization. The state of the P channel demodulator when the P channel unique word is reliably detected.

P channel degradation/loss. A declaration that is made when the P channel bit error rate rises above 10^{-4} over an averaging period of 3 minutes, or more than 10 short-term interruptions (loss of P channel synchronization for less than 10 seconds) are experienced in any 3-minute period; or when the P channel synchronization is lost for more than 10 seconds.

Q number, Q level, Q precedence. A definition of the transmission precedence of a message or signalling sequence, using numbers from 0 to 15 (with 15 transmitted first).

Reliable link service (RLS). A data communications service provided by the subnetwork which automatically provides for error control over its link through error detection and requested retransmission of signal units found to be in error.

Satellite region. A geographically defined sub-area within the view of a satellite within which services can be provided by that satellite.

Satellite service area. A geographically defined sub-area within the view of a satellite within which services are provided by that satellite. Note that a satellite service area might be sub-divided in terms of operational characteristics, conditions, or limitations for a variety of reasons.

Signal unit (SU). A time-ordered, contiguous set of data octets used for signalling and control, and for user packet data transmissions. Standard-length SUs are 96 bits (12 octets) used in P, T and C channels. R channel SUs are 152 bits (19 octets), and the T channel uses a header SU of 48 bits (6 octets).

Spot beam. Satellite antenna directivity whose main lobe encompasses significantly less than the earth's surface that is within line-of-sight view of the satellite. May be designed so as to improve system resource efficiency with respect to geographical distribution of user earth stations.

Subsequent signal unit (SSU). In a series of SUs, the signal unit(s) following the initial signal unit.

Superframe. A recurring, time-structured set of data transmission frames, which also includes a superframe marker (see also the definition of "frame").

4.1.1.2 DESCRIPTION OF CHANNEL TYPES

4.1.1.2.1 *P channel.* Packet mode time division multiplex(TDM) channel transmitted continuously from the aeronautical ground earth station (GES) in the to-aircraft direction to carry signalling and user data. A P channel being used for system management functions is designated P_{smc}, while a P channel being used for other functions is designated by P_d. The functional designations P_{smc} and P_d do not necessarily apply to separate physical channels.

4.1.1.2.2 *R channel.* Random access (slotted Aloha) channel, used in the from-aircraft direction to carry signalling and user data. An R channel being used for system management functions is designated R_{smc}, while an R channel being used for other functions is designated R_d. The functional designations R_{smc} and R_d do not necessarily apply to separate physical channels.

4.1.1.2.3 *T channel.* Reservation time division multiple access (TDMA) channel, used in the from-aircraft direction only. The receiving GES reserves time slots for transmissions requested by aircraft earth stations (AESs) according to message length. The sending AES transmits the message in the reserved time slots according to priority.

4.1.1.2.4 *C channel.* Circuit-mode single channel per carrier (SCPC) channel, used in both to-aircraft and from-aircraft directions. This channel is time division multiplexed to provide a primary channel for voice or data traffic and a sub-band channel for signalling, supervision and data messages. The use of the channel is controlled by assignment and release signalling at the start and end of each transaction.

4.1.2 General

4.1.2.1 When aeronautical mobile-satellite service (AMSS), using near-geostationary orbiting satellites, is installed and maintained in operation as an aid to air traffic services, it shall conform with the provisions of 4.1 to 4.10.

4.1.2.2 Requirements for mandatory carriage of AMSS equipment including the level of system capability shall be made on the basis of regional air navigation agreements which specify the airspace of operation and the implementation time-scales for the carriage of equipment.

4.1.2.3 The agreements indicated in 4.1.2.2 shall provide at least two years' notice of mandatory carriage of airborne systems.

4.1.2.4 **Recommendation.—** *Civil aviation authorities should co-ordinate, with national authorities and service providers, those implementation aspects of AMSS which will permit its world-wide interoperability and optimum use, as appropriate.*

Note.— Provisions on the allocation and assignment of 24-bit aircraft addresses for use by the AMSS are contained in Chapter 9.

4.1.3 System capabilities

Note.— A system providing aeronautical mobile-satellite service (AMSS) comprises the AES, the satellite and the GES. A Level 1 (2, 3 or 4) system consists of an AES with Level 1 (2, 3 or 4) capability with one or more satellites and one or more GESs having the capabilities to operate compatibly with all capabilities of the AES. Multiple service providers of such systems may coexist. A basic level of interoperability among different systems is provided.

4.1.3.1 *Scope.* A level of system capability shall include the performance of the AES, the satellite and the GES. All AESs, as a minimum, shall have a Level 1 capability and shall continuously monitor the P channel after log-on to the GES. Each GES shall provide at all times when operating AMS(R)S, a Level 1 capability as a minimum.

4.1.3.1.1 There shall be a P channel and an R channel P_{smc} and R_{smc} capability which perform system management functions for each satellite service area.

4.1.3.1.2 For the case where there is one transmit channel unit shared between the R and T channels, R channel transmissions shall be delayed, whenever necessary, to avoid interrupting a T channel transmission.

4.1.3.2 *Level 1.* An AES with Level 1 capability shall have the capabilities for:

a) receiving and processing data on one P channel at channel rates of 0.6 and 1.2 kbits/s; and

b) processing and transmitting data on one R channel and on one T channel at channel rates of 0.6 and 1.2 kbits/s.

Simultaneous transmission on the R channel and the T channel shall not be required.

4.1.3.2.1 An AES with Level 1 capability shall receive and process continuously the assigned P channel once logged on with the GES to enable receipt of AES-addressed messages and respond to GES commands.

4.1.3.2.2 **Recommendation.—** *An AES with Level 1 capability should have the capabilities described in 4.1.3.2 for the additional channel rate of 2.4 kbits/s.*

Note.— An AES with Level 1 capability provides basic packet mode data communications based on the open system interconnection model to support aviation safety communications. An AES with Level 1 capability requires one receive channel and one transmit channel.

4.1.3.3 *Level 2.* An AES with Level 2 capability shall have the capabilities for:

a) receiving and processing data on one P channel at channel rates of 0.6 and 10.5 kbits/s; and

b) processing and transmitting data on one R channel and on one T channel at channel rates of 0.6 and 10.5 kbits/s.

Simultaneous transmission on the R channel and the T channel shall not be required. Simultaneous reception on more than one P channel shall not be required.

4.1.3.3.1 **Recommendation.—** *An AES with Level 2 capability should have the capabilities described in 4.1.3.3 a) for the additional channel rate of 4.8 kbits/s.*

4.1.3.4 *Level 3.* An AES with Level 3 capability shall provide the capabilities for:

a) an AES with Level 2 capability; and

b) receiving, processing and transmitting digital information on one C channel at a channel rate of 8.4 or 21.0 kbits/s.

Simultaneous operation of the C channel with either the R channel or the T channel shall not be required.

4.1.3.4.1 **Recommendation.—** *Level 3 channel capability should be provided at channel rates of 5.25, 6.0 and 10.5 kbits/s.*

Note.— An AES with Level 3 capability provides digitized voice capability on a C channel in addition to the Level 2 packet mode data capability. Pre-emption requirements are described in Sections 4.8 and 4.9. Two receive channels and one transmit channel are required.

4.1.3.5 *Level 4.* An AES with Level 4 capability shall provide the capabilities for:

a) an AES with Level 3 capability;

b) simultaneous operation of a C channel with the R channel; and

c) simultaneous operation of the C channel with the T channel.

Simultaneous operation of the three channels (C, R and T) shall not be required.

4.1.3.5.1 **Recommendation.—** *Level 4 channel capability should be provided at channel rates of 5.25, 6.0 and 10.5 kbits/s.*

Note.— An AES with Level 4 capability provides digitized voice capability on a C channel simultaneously with packet mode data capability on the R channel or the T channel. Two receive channels and two transmit channels are required.

4.1.3.5.2 **Recommendation.—** *A Level 4 AES should be capable of simultaneous R and T channel transmissions whenever the C channel is not in use.*

4.2 BROADBAND RF CHARACTERISTICS

4.2.1 Frequency bands

4.2.1.1 USE OF AMS(R)S BANDS

Note.— Categories of messages, and their relative priorities within the aeronautical mobile (R) service, are given in Annex 10, Volume II, 5.1.8. These categories and priorities are equally valid for the aeronautical mobile-satellite (R) service (see ITU Radio Regulations Article S44).

4.2.1.1.1 Every aircraft earth station and ground earth station shall be designed to ensure that messages defined in Annex 10, Volume II, 5.1.8 are not delayed by the transmission and/or reception of other types of messages employing frequencies within the bands stated in 4.2.1.2 and 4.2.1.3 or other frequencies to which the station can tune. Message types not defined in Annex 10, Volume II, 5.1.8 shall be terminated if necessary, and without warning, to allow Annex 10, Volume II, 5.1.8 type messages to be transmitted and received.

Note.— See ITU Radio Regulations No. S5.357A.

4.2.1.2 TO-AIRCRAFT

4.2.1.2.1 The aircraft earth station shall be capable of receiving in the frequency band 1 544 to 1 555 MHz.

Note.— Use of the band 1 544 to 1 545 MHz by mobile satellite services is limited to distress and safety operations.

4.2.1.2.2 **Recommendation.—** *The aircraft earth station should be capable of receiving in the frequency band 1 555 to 1 559 MHz.*

Note.— The band 1 555 to 1 559 MHz may be protected and utilized by some States for national and international AMS(R)S purposes.

4.2.1.2.3 **Recommendation.—** *The aircraft earth station should also be capable of receiving in the frequency band 1 525 to 1 544 MHz.*

Note.— The band 1 525 to 1 544 MHz may be used to communicate for purposes of distress and public correspondence with stations of the maritime mobile-satellite service in accordance with ITU Radio Regulations Article S41.

4.2.1.3 FROM-AIRCRAFT

4.2.1.3.1 The aircraft earth station shall be capable of transmitting in the frequency band 1 645.5 to 1 656.5 MHz.

Note.— Use of the band 1 645.5 to 1 646.5 MHz by mobile-satellite services is limited to distress and safety operations.

4.2.1.3.2 **Recommendation.—** *The aircraft earth station should be capable of transmitting in the frequency band 1 656.5 to 1 660.5 MHz.*

Note.— The band 1 656.5 to 1 660.5 MHz may be protected and utilized by some States for national and international AMS(R)S purposes.

4.2.1.3.3 **Recommendation.—** *The aircraft earth station should also be capable of transmitting in the frequency band 1 626.5 to 1 645.5 MHz.*

Note.— The band 1 626.5 to 1 645.5 MHz may be used to communicate for purposes of distress and public correspondence with stations of the maritime mobile-satellite service in accordance with ITU Radio Regulations Article S41.

4.2.1.4 TUNING INCREMENTS

4.2.1.4.1 Channels shall be allocated throughout the bands in increments of 2.5 kHz, for the to- and from-aircraft transmission path.

4.2.1.4.2 Channel assignment and tuning of the aircraft earth station shall be achieved under control from the GES.

4.2.1.5 CHANNEL NUMBERING

4.2.1.5.1 The channel number (Ct) shall be defined with respect to the centre frequency on the to-aircraft transmission path by the formula:

$$Ct = \frac{\text{frequency of transmission (MHz)} - 1\,510.0}{0.0025}$$

4.2.1.5.2 The channel number (Cf) shall be defined with respect to the centre frequency on the from-aircraft transmission path by the formula:

$$Cf = \frac{\text{frequency of transmission (MHz)} - 1\,611.5}{0.0025}$$

4.2.2 Frequency accuracy

The frequency of transmission from the aircraft earth station, as would be received at the satellite, shall not vary from the nominal channel frequency by more than ±383 Hz due to all causes.

Note.— The frequency of transmissions received by a subsonic aircraft should not vary from the nominal channel frequency by more than ±2.18 kHz due to all causes.

4.2.3 Aircraft earth stations RF characteristics

Note.— The following requirements apply over the entire transmit and receive frequency bands.

4.2.3.1 GENERAL ANTENNA CHARACTERISTICS

4.2.3.1.1 *Reference coverage volume.* Antenna systems shall be installed to meet performance requirements for transmitting and receiving over a coverage volume of 360 degrees of azimuth and from 5 to 90 degrees in elevation from a horizontal plane for aircraft in straight and level flight.

4.2.3.1.1.1 **Recommendation.—** *To the maximum extent possible, antenna systems should be installed to meet performance requirements for transmitting and receiving over a coverage volume of 360 degrees in azimuth and from 5 to 90 degrees in elevation from a horizontal plane for aircraft attitudes of +20/–5 degrees of pitch and ±25 degrees of roll.*

4.2.3.1.2 *Polarization.* The polarization shall be right-hand circular for both receiving and transmitting, in accordance with the definition of ITU Radio Regulations No. S1.154.

4.2.3.1.3 *Antenna switching.* Aircraft earth stations that require more than one antenna shall be capable of switching from one antenna to another in the same antenna sub-system so as to introduce a signal interruption of not more than 40 ms.

Note.— 4.2.3.2, 4.2.3.2 bis *and 4.2.3.3 outline the requirements for high gain, intermediate gain and low gain antennas only. This does not preclude the future introduction of other gain antennas; however, some of the considerations which must be made before such an introduction are described in the guidance material contained in Attachment A to Part I of Annex 10, Volume III.*

4.2.3.2 LOW GAIN ANTENNA SUB-SYSTEMS

4.2.3.2.1 *Gain-to-noise temperature ratio.* Receiving sub-systems employing low gain antennas shall achieve a gain-to-noise temperature ratio (G/T) of not less than –26 dB/K over not less than 85 per cent of the reference coverage volume defined in 4.2.3.1.1; and not less than –31 dB/K over the remaining 15 per cent of the reference coverage volume. The only exception to this is the region greater than 70 degrees in elevation from the horizontal plane where the G/T shall be not less than –28 dB/K.

4.2.3.2.2 *Axial ratio.* The axial ratio shall be less than 6 dB for elevation angles of 45 to 90 degrees and less than 20 dB for elevation angles of 5 to 45 degrees or the AES antenna shall have sufficient gain to compensate for additional polarization loss in excess of that caused by the axial ratios. The condition for including the compensation shall assume the satellite axial ratio to be 2.5 dB, with major axes of the polarization ellipses orthogonal.

4.2.3.2.3 **Recommendation.—** *To the maximum extent possible, the G/T should be not less than –26 dB/K and the axial ratio should be less than 6 dB over 100 per cent of the reference coverage volume.*

4.2.3.2 *bis* INTERMEDIATE GAIN ANTENNA SUB-SYSTEMS

See paragraph 4.2.3.6.

4.2.3.3 HIGH GAIN ANTENNA SUB-SYSTEMS

4.2.3.3.1 *Gain-to-noise temperature ratio.* Receiving sub-systems employing high gain antennas shall achieve a gain-to-noise temperature ratio (G/T) of not less than –13 dB/K over not less than 75 per cent of the reference coverage volume and shall be not less than –25 dB/K over the remaining 25 per cent of the reference coverage volume defined in 4.2.3.1.1.

4.2.3.3.2 *Axial ratio.* The axial ratio shall be less than 6 dB over the 75 per cent of the reference coverage volume referred to in 4.2.3.3.1 where the G/T must exceed –13 dB/K or the AES antenna shall have sufficient gain to compensate for additional polarization loss in excess of that caused by this axial ratio. The condition for including the compensation shall assume the satellite axial ratio to be 2.5 dB, with the major axes of the polarization ellipses orthogonal.

4.2.3.3.3 **Recommendation.—** *To the maximum extent possible, the G/T should be not less than –13 dB/K and the axial ratio should be less than 6 dB over 100 per cent of the reference coverage volume.*

4.2.3.3.4 *Discrimination.* The antenna gain pattern for both transmit and receive functions shall discriminate by not less than 13 dB between the directions of wanted and unwanted satellites spaced 45 degrees or greater in longitude over not less than 75 per cent of the reference coverage volume defined in 4.2.3.1.1.

4.2.3.3.4.1 **Recommendation.—** *The antenna gain pattern for both transmit and receive functions should discriminate by not less than 13 dB between the directions of wanted and unwanted satellites spaced 45 degrees or greater in longitude over 100 per cent of the reference coverage volume defined in 4.2.3.1.1.*

4.2.3.3.5 *Phase discontinuity.* Beam steering transitions between adjacent beam positions of a switched beam antenna shall not cause RF phase transitions greater than 12 degrees in the transmitted signal for 99 per cent of all possible adjacent beam combinations.

4.2.3.3.5.1 **Recommendation.—** *Beam steering transitions between adjacent beam positions of a switched beam antenna should not cause RF phase transitions greater than 12 degrees in the transmitted signal for 100 per cent of all possible adjacent beam combinations.*

Note.— This requirement only applies to individual array performance in the case of multiple array antennas.

4.2.3.4 RECEIVER REQUIREMENTS

4.2.3.4.1 *Receiver spurious and linearity performance.* The required performance defined in 4.4.2.3 and 4.4.5.4 shall be achieved when the receiving antenna is illuminated in the direction of maximum gain by a power flux density of -100 dBW/m^2 distributed across the 1 525 to 1 559 MHz band.

4.2.3.4.2 *Receiver out-of-band performance.* The required performance defined in 4.4.2.3 and 4.4.5.4 shall be achieved in the presence of out-of-band interference at levels typical of normal operating conditions.

4.2.3.4.3 *Received phase noise.* The design of the receiver and the demodulators shall be such as to ensure full compliance with the performance requirements whenever the received signal phase noise characteristic does not exceed the mask defined in Table 4-1.*

4.2.3.4.4 *Capture range.* The receiver shall be capable of acquiring and maintaining lock to signals with a frequency offset from nominal of up to ±2.180 kHz at carrier-to-noise levels as shown in Table 4-2.

4.2.3.4.5 *Receiver Doppler rate.* The receiver shall be capable of acquiring and maintaining performance per 4.3.3 with a rate of change of frequency of 30 Hz per second.

4.2.3.5 TRANSMITTER REQUIREMENTS

4.2.3.5.1 *EIRP LIMITS*

4.2.3.5.1.1 For low gain antenna operation, the minimum value of EIRP per carrier in the direction of the satellite, when commanded to the maximum setting, shall be 13.5 dBW. The EIRP radiated in any direction shall not exceed 22.8 dBW.

4.2.3.5.1.1 *bis* For intermediate gain antenna operation, the minimum value of EIRP per carrier in the direction of the satellite, when commanded to the maximum setting, shall be 12.5 dBW. The EIRP radiated in any direction shall not exceed 34.8 dBW at the maximum setting.

4.2.3.5.1.2 For high gain antenna operation, the minimum value of EIRP per carrier in the direction of the satellite, when commanded to the maximum setting, shall be 25.5 dBW. The EIRP radiated in any direction shall not exceed 34.8 dBW at the maximum setting.

4.2.3.5.1.3 At settings less than the maximum setting, the EIRP per carrier radiated in any direction shall not exceed the EIRP radiated toward the wanted satellite by more than 5 dB.

4.2.3.5.1.4 For multicarrier operation, the maximum allowable operating EIRP shall be the level at which:

a) the total intermodulation product contribution from active sources is the maximum permitted in 4.2.3.5.7 (in-band intermodulation products), or

b) the gain-to-noise temperature ratio is the minimum permitted in 4.2.3.2.1 or 4.2.3.3.1, as applicable.

4.2.3.5.2 *EIRP control.* The EIRP per carrier in the direction of the wanted satellite shall be adjustable over a range of 15 dB in steps of 1 dB by command from the GES.

4.2.3.5.3 **Recommendation.—** *The minimum EIRP of the power control range should be a function of the channel rate and the satellite beam characteristics to minimize the interference potential.*

4.2.3.5.4 *Carrier-off level.* The EIRP in any direction, summed across the 1 626.5 to 1 660.5 MHz band, when all carriers are commanded off shall be –24.5 dBW or less.

4.2.3.5.5 *Log-on EIRP.* When logging on to a GES, the EIRP of the AES shall be at least 12.5 dBW.

4.2.3.5.6 *In-band spurious EIRP.* When transmitting a modulated carrier at any level up to the maximum allowable operating EIRP, the composite radiated in-band spurious and noise EIRP (excluding intermodulation products) referenced to a 4 kHz band shall not exceed –55 dBc. This requirement shall not apply to the frequency band on either side of the carrier centre frequency which is described in 4.3.2.1.

4.2.3.5.7 *INTERMODULATION PRODUCTS*

4.2.3.5.7.1 For multicarrier AES, the radiated intermodulation products shall not cause harmful interference to satellite navigation receiver operation where such receiver is operated on the same aircraft when transmitting two equal carriers with a total power equal to the maximum allowable operating EIRP of the AES.

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* All tables are located at the end of this chapter.

4.2.3.5.7.2 The AES transceiver shall not transmit on a newly assigned frequency that would produce a fifth-order intermodulation product at a frequency below 1 610.0 MHz.

4.2.3.5.7.3 Frequency management techniques shall be used to preclude 5th and lower order intermodulation products below 1 610 MHz being radiated by the AES.

4.2.3.5.8 *Out-of-band EIRP density levels.* When transmitting a carrier at any level up to the maximum power level as described in 4.2.3.5.1, the out-of-band EIRP including spurious, harmonics and noise generated by the AES in any direction shall not exceed the levels shown in Table 4-3.

4.2.3.5.8.1 **Recommendation.**— *The EIRP density should not exceed –140 dBc/1 MHz from 1 605 to 1 610 MHz.*

4.2.3.5.9 *Phase noise.* The phase noise induced on a modulated carrier shall have a power spectral density not exceeding the envelope defined in Table 4-4.

4.2.3.5.10 *Transmitter Doppler rate.* The maximum rate of change of the frequency of the transmitted signal when compensated for aircraft acceleration in the direction of the satellite shall not exceed 15 Hz per second. The Doppler adjustment resolution shall not exceed 10 Hz and the associated frequency changes shall be made without introducing phase discontinuity into the transmitted signal.

4.2.3.5.11 AMSS transmissions shall not cause harmful interference to satellite navigation receiver operation where such receiver is operated on the same aircraft as the AES.

4.2.3.6 INTERMEDIATE GAIN ANTENNA SUB-SYSTEMS

4.2.3.6.1 *Gain-to-noise temperature ratio.* Receiving sub-systems employing intermediate gain antennas shall achieve a gain-to-noise temperature ratio (G/T) of not less than –19 dB/K over not less than 85 per cent of the reference coverage volume defined in 4.2.3.1.1. The only exception to this is the region greater than 70 degrees in elevation from the horizontal plane where the G/T shall be not less than –21 dB/K.

4.2.3.6.2 *Axial ratio.* The axial ratio shall be less than 6 dB over 85 per cent of the reference coverage volume referred to in 4.2.3.1.1 where the G/T must exceed –19 dB/K or the AES antenna shall have sufficient gain to compensate for the additional polarization loss in excess of that caused by this axial ratio. The condition for including the compensation shall assume the satellite axial ratio to be 2.5 dB, with the major axes of the polarization ellipses orthogonal.

4.2.3.6.3 **Recommendation.**— *The G/T should be not less than –19 dB/K and the axial ratio should be less than 6 dB over 100 per cent of the reference coverage volume.*

4.2.3.6.4 *Discrimination.* The antenna gain pattern for both transmit and receive functions shall discriminate by not less than 7 dB between the directions of wanted and unwanted satellites spaced 80 degrees or greater in longitude over not less than 85 per cent of the reference coverage volume defined in 4.2.3.1.1.

4.2.3.6.5 **Recommendation.**— *The antenna gain pattern for both transmit and receive functions should discriminate by not less than 7 dB between the directions of wanted and unwanted satellites spaced 80 degrees or greater in longitude over 100 per cent of the reference coverage volume defined in 4.2.3.1.1.*

4.2.3.6.6 *Phase discontinuity.* Beam steering transitions between adjacent beam positions of a switched beam antenna shall not cause RF phase transitions greater than 30 degrees in the phase of the receive and transmit signal for 99 per cent of all possible adjacent beam combinations.

4.2.3.6.7 **Recommendation.**— *Beam steering transitions between adjacent beam positions of a switched beam antenna should not cause RF phase transitions greater than 30 degrees in the received and transmitted signal for 100 per cent of all possible adjacent beam combinations.*

4.3 RF CHANNEL CHARACTERISTICS

4.3.1 Modulation

4.3.1.1 *Modulation for channel rates 2.4 kbits/s and below.* For channel rates of 2.4, 1.2 and 0.6 kbits/s, the modulation shall be aviation binary phase shift keying (A-BPSK).

4.3.1.2 *Modulation for channel rates above 2.4 kbits/s.* For channel rates above 2.4 kbits/s the modulation shall be aviation quadrature phase shift keying (A-QPSK).

4.3.2 *Radiated power spectral density.* The following bounds on radiated power spectral density shall apply in any direction normalized to the peak spectral density in that direction. The bounds shall apply to a single carrier and shall be centred at the carrier frequency. The lower bound shall not apply when the AES is transmitting the unmodulated preamble at the beginning of a burst.

4.3.2.1 *From-aircraft.* The power spectrum radiated by the AES shall fall within the mask defined by Table 4-5.

4.3.2.2 *To-aircraft.* The power spectrum received by the AES shall be within the mask defined by Table 4-6 for A-BPSK and, Table 4-7 and Table 4-7A for A-QPSK.

4.3.3 *Demodulator performance.* Where the channel rates are implemented as defined in 4.1, the bit error rate (BER) performance of the channel demodulators after descrambling shall be equal to or better than that shown in Table 4-8. This performance shall be attained under the following conditions:

a) in the presence of two adjacent interfering carriers on either side of the wanted carrier at a level of 5 dB higher than the wanted carrier with a frequency uncertainty from the nominal carrier spacing as specified and for the AES demodulator, with the AES operating up to its maximum allowable operating EIRP;

b) while receiving a signal transmitted with the maximum phase noise characteristics described in 4.2.3.5.9;

c) during 12° RF phase discontinuities occurring at the rate of one per second; and

d) under Rician channel conditions for fading bandwidths of 20, 60 and 100 Hz with a carrier to multipath ratio of 7 dB for systems using a low gain antenna or low and high gain antennas; or 10 dB for systems using only a high gain antenna.

Note.— Bit error performance objectives for AMS(R)S radio link are contained in ITU-R Recommendation M.1037.

4.3.4 Acquisition performance

4.3.4.1 *Time to acquire superframe synchronization.* The period from the command to the antenna to acquire the satellite to superframe synchronization shall not exceed 16 seconds.

Note.— This assumes the AES is within the satellite service area of that P channel.

4.3.4.2 **Recommendation.—** *The period from the command to the antenna to acquire the satellite to superframe synchronization should be as small as possible.*

4.3.4.3 C CHANNEL AES DEMODULATOR ACQUISITION

4.3.4.3.1 *CHANNEL RATE OF 21.0 KBITS/S*

4.3.4.3.1.1 *Frame lock.* The probability of failing to achieve frame lock on the first unique word following the burst preamble shall be less than one in 10^4 at an E_s/N_0 of 1.2 dB in a Gaussian channel, including conditions of 4.3.3 a) and b), and with a maximum burst-to-burst frequency uncertainty of ±30 Hz and maximum channel rate accuracy deviation of 4.4.5.1.

4.3.4.3.1.2 *False frame lock.* The probability of false frame lock shall be less than one in 10^5 for an E_s/N_0 of 0 dB in a Gaussian channel, including conditions of 4.3.3 a) and b), and with a maximum burst-to-burst frequency uncertainty of ±30 Hz and maximum channel rate accuracy deviation of 4.4.5.1.

4.3.4.3.1.3 *Reacquisition of frame lock.* Upon the loss of frame lock, it shall be acquired within 3.0 seconds for 99 per cent of the time, at an E_s/N_0 of 0 dB in a Gaussian channel, including conditions of 4.3.3 a) and b), and with a maximum burst-to-burst frequency uncertainty of ±30 Hz and maximum channel rate accuracy deviation of 4.4.5.1.

4.3.4.3.2 *CHANNEL RATE OF 8.4 KBITS/S*

4.3.4.3.2.1 *Frame lock.* The probability of failing to achieve frame lock on the first unique word shall be less than one in 10^3 at an E_s/N_0 of 4.1 dB in a Gaussian channel, including conditions of 4.3.3 a) and b), and with a maximum burst-to-burst frequency uncertainty of ±30 Hz and maximum channel rate accuracy deviation of 4.4.5.1.

4.3.4.3.2.2 *False frame lock.* The probability of false frame lock shall be less than one in 10^4 for an E_s/N_0 of 4.1 dB in a Gaussian channel, including conditions of 4.3.3 a) and b), and with a maximum burst-to-burst frequency uncertainty of ±30 Hz and maximum channel rate accuracy deviation of 4.4.5.1.

4.3.4.3.2.3 *Reacquisition of frame lock.* Upon the loss of frame lock, it shall be acquired within 0.5 seconds at an E_s/N_0 of 4.1 dB, in 90 per cent of all cases, in a Gaussian channel, including conditions of 4.3.3 a) and b), and with a maximum burst-to-burst frequency uncertainty of ±30 Hz and maximum channel rate accuracy deviation of 4.4.5.1.

4.3.4.4 C CHANNEL GES DEMODULATOR ACQUISITION

4.3.4.4.1 *Channel rate of 21.0 kbits/s.* In a Gaussian channel, and under the conditions of 4.3.3 a) and b), with a frequency offset of ±600 Hz, and a clock frequency offset of ±0.5 Hz, the probability of failing to achieve frame lock on the first unique word shall be less than 1 in 10^3 at an E_s/N_0 of 1.7 dB. The probability of false frame lock shall be less than 1 in 10^5 at an E_s/N_0 of 1.7 dB. Should frame lock be lost, it shall be reacquired within 3.0 seconds, for 99 per cent of the time, at an E_s/N_0 of 1.7 dB.

4.3.4.4.1 *bis* *Channel rate of 8.4 kbits/s.* In a Gaussian channel, and under the conditions of 4.3.3 a) and b), with a frequency offset of ±600 Hz, and a clock frequency offset of ±0.5 Hz, the probability of failing to achieve frame lock on the first unique word shall be less than 1 in 10^3 at an E_s/N_0 of 4.4 dB. The probability of false frame lock shall be less than 1 in 10^4 at an E_s/N_0 of 4.4 dB. Should frame lock be lost, it shall be reacquired within 0.5 seconds, 90 per cent of the time, at an E_s/N_0 of 4.4 dB.

4.3.4.4.2 *Other C channel rates.* The probability of the GES demodulator failing to achieve frame lock within 0.75 seconds of the start of C channel transmission shall be less than one in 10^2.

4.3.4.4.3 **Recommendation.—** *The GES demodulator should achieve C channel frame lock as soon as possible after the start of C channel transmission.*

4.4 CHANNEL FORMAT TYPES AND RATES

4.4.1 General

4.4.1.1 *Aircraft system-timing reference point.* The reference timing point for signals generated and received by the AES shall be at the antenna.

4.4.1.2 *Channel rates.* The channel rates as applicable to the system capability levels defined in 4.1.3 shall be as shown in Table 4-9.

4.4.1.3 *Signal units (SUs).* All information to be transmitted over the P, R, T and sub-band C channels shall be in the format of signal units. For the P, T and sub-band C channel each signal unit shall consist of 96 bits. For the R channel each signal unit shall consist of 152 bits. The signal unit formats shall be as specified in Appendix 2.

4.4.1.3.1 *Cyclic redundancy check (CRC).* The last two bytes of each SU shall form a CRC of the SU. Any received SU which fails the CRC shall be discarded.

4.4.1.3.2 *Signal quality estimation.* The AES shall make information such as P channel degradation/loss and C channel bit error rate available to the AES management functions and GES management functions as appropriate.

4.4.2 P channel

4.4.2.1 *Channel rate accuracy.* The channel rate error shall not exceed one part in 10^6.

4.4.2.2 FRAME FORMAT

4.4.2.2.1 *General characteristics.* All P channel frames shall be either 500 ms, or a multiple of 500 ms to provide simple derivation of an 8-second superframe which shall be used for R channel and T channel slot allocation. Each P channel frame shall consist of five fields identified as: format identifier, superframe boundary marker, dummy field (for data rates greater than 2.4 kbits/s), information field and unique word, as shown in Figure 4-1* for channel rates of 2.4 kbits/s and less, and in Figure 4-2 for channel rates greater than 2.4 kbits/s.

4.4.2.2.2 *Format identifier.* This field shall consist of the 4 bits: 0001. Other values for this field are reserved for future use.

4.4.2.2.3 *Superframe boundary marker.* This field shall consist of 12 bits.

- — 4 bits to indicate the start of a new superframe
  - 1111 for frame 0 in a superframe of 8 seconds
  - 0000 for all remaining frames in the superframe
- — 4 bits to indicate frame of superframe
  - 0000,0001,0010,0011 at 0.6 kbits/s
  - 0000,0001,....,0111 at 1.2 kbits/s
  - 0000,0001,....,1111 at 2.4 kbits/s and above
- — 4 bits which repeat the previous 4 bits.

4.4.2.2.4 *Dummy field.* For channel rates above 2.4 kbits/s this field shall be:

16 bits for 4.8 kbits/s
178 bits for 10.5 kbits/s

The dummy field shall consist of the sequence 0001 repeated until the required number of bits is obtained.

Note.— The dummy field is included to make each frame 0.5 seconds long. There is no dummy field required for data rates of 2.4 kbits/s and below.

4.4.2.2.5 *Information field.* The information field shall contain multiple signal units which are scrambled, coded and interleaved, in that order. The number of bits in the information field shall be as indicated in Table 4-10.

Note.— The number of bits in the information field is dependent on the data rate and the number of interleaver blocks in the field.

4.4.2.2.5.1 *Scrambling.* A scrambler with a 15-stage generator register shall be used for data scrambling before FEC coding. The polynomial for the generator register of the scrambler and the descrambler shall be $1 + X + X^{15}$. The scrambler and descrambler shall be clocked at the information rate with the first scrambled bit output before the first shift. In the absence of programming commands, the shift register shall be initialized to 1101 0010 1011 001 (leftmost bit in shift register stage 1) at the beginning of the information field of each frame. The scrambler and descrambler functions shall be as illustrated in Figure 4-3. The scrambler shall be re-initialized at the beginning of the information field of each frame.

Note.— The concept of a scrambler is explained in ITU-R Recommendation S.446-4, Annex I, Section 4.3.1 Method 1.

4.4.2.2.5.2 *Forward error correction (FEC).* The Standard in 4.4.5.3.3.5.2 shall apply.

Note.— There are no flush bits on the P channel.

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* All figures are located at the end of this chapter.

4.4.2.2.5.3 *Interleaving.* All P channels shall employ block interleaving. The column depth (number of rows) of the interleaver shall be 64 transmission bits, while the number of columns shall depend on the transmission rate as shown in Table 4-11. At the transmitter, the output of the convolutional encoder shall be written into the 64-bit columns until the prescribed number of columns are full. The rows shall then be permuted using the algorithm $Row_j = (Row_i * 27)$ modulo 64. The content of the interleaver shall then be transmitted row by row as shown in Figure 4-4. At the receiver, the soft decision data from the demodulator shall be written into the interleaver row by row, and when it is full the interleaver rows shall be permuted using the converse algorithm $Row_j = (Row_i * 19)$ modulo 64. The soft decision data shall then be read column by column into the FEC decoder.

4.4.2.2.6 *Unique word.* With A-BPSK each P channel frame shall end with the 32-bit unique word 1110 0001 0101 1010 1110 1000 1001 0011, with the leftmost bit transmitted first. With A-QPSK, the unique word shall be the A-BPSK unique word repeated in each of the in-phase and quadrature channels.

4.4.2.3 *Performance.* The over-all physical layer shall be configured and operated such that the average bit error rate is 10^{-5} or less after descrambling.

4.4.3 R channel

4.4.3.1 *Channel rate accuracy.* The channel rate error shall not exceed one part in 2R, where R is the channel rate, and one part in 10^4.

4.4.3.2 *Burst timing.* The beginning of each R channel burst shall occur within ±300 μs of the beginning of an R channel slot defined by the received P channel superframe. As shown in Figure 4-5, each P channel superframe shall define 8, 16, 32 and 64 random access slots for R channel data rates of 0.6, 1.2, 2.4 and 10.5 kbits/s, respectively.

4.4.3.3 Burst format

4.4.3.3.1 *General characteristics.* Each R channel burst shall consist of three fields: the preamble, the unique word and the information field as shown in Figure 4-6.

4.4.3.3.2 *Preamble.* The preamble for the R channel shall consist of an unmodulated carrier portion followed by a modulated portion. The length of these depend on the data rate as shown in Table 4-12. The unmodulated portion of the A-BPSK preamble shall be a signal of constant phase and the modulated portion shall consist of alternating "0" and "1" input to a standard A-BPSK modulator. The first bit of the modulated portion shall be a "0" and shall give a –90 degree phase change relative to the phase of the unmodulated signal. The unmodulated portion of the A-QPSK preamble shall be a signal of constant phase corresponding to the output of an ideal A-QPSK modulator with all "0"s at its input. The modulated portion shall consist of alternating "0" and "1" (commencing with a "0" in the first bit) on the I channel and continuous "0"s on the Q channel.

Note.— It is intended that the unmodulated portion of the preamble be used for carrier acquisition and the modulated portion for clock acquisition.

4.4.3.3.3 *Unique word.* The Standard in 4.4.2.2.6 shall apply.

4.4.3.3.4 *Information field.* The information field of each R channel burst shall consist of 160 bits and shall contain an extended signal unit plus 8 flush bits prior to convolutional encoding, where an extended SU shall have 152 bits and a Flush field shall be 0000 0000. The information field shall be scrambled, coded and interleaved, in that order.

4.4.3.3.4.1 *Scrambling.* The Standard in 4.4.2.2.5.1 shall apply, except that the flush bits are not scrambled.

4.4.3.3.4.2 *Forward error correction (FEC) coding.* The Standard in 4.4.5.3.3.5.2 shall apply, except that the encoder is re-initialized to the all 0s state at the beginning of the information field of each burst.

4.4.3.3.4.3 *Interleaving.* All R channels shall employ block interleaving. The number of rows in the interleaver shall be 64 transmission bits, while the number of columns shall be 5. Row interchanging in the interleaver shall be performed in accordance with 4.4.2.2.5.3.

4.4.3.4 *Performance.* The Standard in 4.4.2.3 shall apply.

4.4.4 T channel

4.4.4.1 *Channel rate accuracy.* The channel rate error shall not exceed one part in 2R, where R is the channel rate, and one part in 10^4.

4.4.4.2 *Timing relative to P channel.* The beginning of each T channel burst shall occur within ±300μs of the beginning of the assigned T channel slot defined by the received P channel superframe. As shown in Figure 4-7, each P channel superframe shall be divided into 16 nominal frames with 64 T channel slots in each frame. The shortest guard time between the T channel bursts of two different aircraft is under control of the GES and shall be 5 slots.

4.4.4.3 Burst structure

4.4.4.3.1 *General characteristics.* Each T channel burst shall consist of three fields: the preamble, the unique word and the information field as shown in Figure 4-8.

4.4.4.3.2 *Preamble.* The Standard in 4.4.3.3.2 shall apply.

4.4.4.3.3 *Unique word.* The Standard in 4.4.2.2.6 shall apply.

4.4.4.3.4 *Information field.* The information field of each T channel burst shall consist of a burst identifier, n SUs and 16 flush bits prior to convolutional encoding, as follows.

Burst identifier — this field has 48 bits which shall identify the originating aircraft and the destination GES,

n SUs — from 2 to 31 standard length signal units of 96 bits each, and

Flush — a field of 16 bits (all 0s) to flush out the convolutional encoder.

The information field shall be scrambled, coded and interleaved, in that order.

4.4.4.3.4.1 *Scrambling.* The Standard in 4.4.2.2.5.1 shall apply, except that the scrambler shall be re-initialized at the beginning of the information field of each burst.

4.4.4.3.4.2 *Forward error correction (FEC) coding.* The Standard in 4.4.5.3.3.5.2 shall apply, except that the convolutional encoder shall be initialized to the all 0s state at the beginning of the information field of each burst.

4.4.4.3.4.3 *Interleaving.* All T channels shall employ block interleaving. The number of rows in the interleaver shall be 64 transmission bits, while the number of columns shall depend on the data rate as shown in Table 4-13. At the transmitter the output of the convolutional encoder shall be written into the 64-bit columns, until the specified number of columns are full. The interleaver row interchange algorithm shall be in accordance with 4.4.2.2.5.3.

4.4.4.4 *Performance.* The Standard in 4.4.2.3 shall apply.

4.4.5 C channel

4.4.5.1 *Channel rate accuracy.* The channel rate error shall not exceed one part in 2R, where R is the channel rate, and one part in 10^4.

4.4.5.2 TRANSMISSION FORMATS

4.4.5.2.1 *Preamble.* The burst preamble for all the C channel rates, except the 8.4 kbits/s channel, shall consist of an unmodulated carrier portion followed by a modulated portion. The length of these shall depend on the channel rate as shown in Table 4-14 as applicable to the system capability levels defined in 4.1.3. The preamble shall be as described in the text of 4.4.3.3.2 and in Table 4-14. The 8.4 kbits/s C channel shall not have a preamble.

4.4.5.2.2 *POSTAMBLE*

4.4.5.2.2.1 *8.4 kbits/s C channel.* The postamble of the C channel shall consist of alternating "1"s and "0"s (commencing with "1") on the I channel and the Q channel. The length of the 8.4 kbits/s C channel postamble shall be equivalent to 104 bits.

4.4.5.2.2.2 *All other C channels.* The postamble of all other C channels shall consist of continuous "0"s on the I channel, and alternating "0" and "1" (commencing with "0") on the Q channel. The length of the postamble shall be equivalent to a single interleaver block for channels with interleaving, and 96 bits for channels without interleaving.

4.4.5.2.3 *TO-AIRCRAFT*

4.4.5.2.3.1 *8.4 kbits/s C channel.* The C channel shall operate in burst mode in the to-aircraft direction. In this mode, the C channel shall consist of a series of contiguous frames followed by a postamble. Each frame shall consist of two fields: the unique word and the information field as in Figure 4-9 *bis.* Each frame shall be 500 ms long.

4.4.5.2.3.2 *All other C channels.* All other C channels shall operate in burst mode in the to-aircraft direction. In this mode, the C channel burst shall consist of a preamble followed by a series of contiguous frames followed by a postamble. Each frame shall consist of three fields: the unique word, a dummy field and the information field, as in Figures 4-9 and 4-10. Each frame shall be 500 ms long.

4.4.5.2.4 *FROM-AIRCRAFT*

4.4.5.2.4.1 *8.4 kbits/s C channel.* The C channel shall operate in continuous mode in the from-aircraft direction. In this mode, the C channel shall consist of two fields: the unique word and the information field as in Figure 4-9 *bis.* Each frame shall be 500 ms long.

4.4.5.2.4.2 *All other C channels.* All other C channels shall operate in continuous mode in the from-aircraft direction. Each transmission shall begin with the preamble described in 4.4.5.2.1. In this mode, the C channel frame shall consist of three fields: the unique word, a dummy field and the information field as in Figures 4-9 and 4-10. Each frame shall be 500 ms long.

Note.— In the P, R and T channels the information field refers to the information bits after forward error correction coding. With the C channel the information field may or may not include coding depending upon the particular C channel type.

4.4.5.3 FRAME FORMAT

4.4.5.3.1 *UNIQUE WORD*

4.4.5.3.1.1 *8.4 kbits/s C channel.* The unique word shall consist of two 52-bit sequences on the I and Q channels of the A-QPSK signal:

I 1010 1011 0011 0111 0110 1001 0011 1000 1011 1100 1010 0011 0000
Q 0000 1100 0101 0011 1101 0001 1100 1001 0110 1110 1100 1101 0101

with the leftmost bit transmitted first.

4.4.5.3.1.2 *All other C channels.* The unique word shall consist of two identical 44-bit sequences on the I and Q channels of the A-QPSK signal; 0100 0010 1101 1010 1111 0011 0100 1011 1011 0001 0001, with the leftmost bit transmitted first.

4.4.5.3.2 *Dummy field.* Where the channel rates are implemented as defined in Table 4-9, and as illustrated in Figures 4-9, 4-9 *bis* and 4.10, the number of bits in the dummy field shall be:

— 62 at 10.5 kbits/s;
— 44 at 21.0 kbits/s;
— 37 at 5.25 kbits/s;
— 32 at 6.0 kbits/s; and
— 0 at 8.4 kbits/s.

The dummy bits for the 5.25, 6.0, 10.5 and 21.0 kbits/s channels shall consist of the sequence 0101 1010 0011 1100 repeated until the required number of bits is obtained. For the 8.4 kbits/s C channel there is a single dummy bit d3 added after FEC encoding. The value of bit d3 is set to 1, as shown in Figure 4-9 *bis*.

4.4.5.3.3 *INFORMATION FIELD FOR CODED CHANNELS*

4.4.5.3.3.1 At the channel rate of 8.4 kbits/s this field shall contain 4 096 bits which shall be subdivided into 16 interleaver blocks of 256 bits each. At the channel rate of 21.0 kbits/s this field shall contain 10 368 bits which shall be subdivided into 27 interleaver blocks of 384 bits each.

4.4.5.3.3.2 **Recommendation.**— *At the recommended channel rate of 6.0 kbits/s this field should contain 2 880 bits which are subdivided into 15 interleaver blocks of 192 bits each.*

4.4.5.3.3.3 *Information field structure including sub-band data.* Prior to scrambling, FEC encoding and interleaving, the information field shall consist of a fill-in field followed by 25 alternating sub-band data and transparent data (voice) sub-fields as shown in Figure 4-9 or 4-9 *bis*, as appropriate.

4.4.5.3.3.3.1 At a channel rate of 21.0 kbits/s the fill-in field shall consist of 84 zeros, each subfield shall contain 12 sub-band data bits and 192 primary bits, and the last 12 bits of the 25th sub-band data subfield shall be filled with zeros.

4.4.5.3.3.3.2 **Recommendation.**— *At the recommended channel rate of 6.0 kbits/s the fill-in field should consist of 40 zeros, each subfield should contain 8 sub-band data bits and 48 primary bits, and the last 8 bits of the 25th sub-band data subfield should be filled with zeros.*

4.4.5.3.3.3.3 At a channel rate of 8.4 kbits/s the fill-in field shall consist of a single reference bit with a value set to 1, and each subfield shall contain 12 sub-band data bits and 96 primary bits.

4.4.5.3.3.4 *Scrambling.* The Standard in 4.4.2.2.5.1 shall apply.

4.4.5.3.3.5 *Forward error correction (FEC) coding*

4.4.5.3.3.5.1 *8.4 kbits/s C channel.* The FEC consists of a punctured rate 2/3 convolutional coding of constraint length k = 7 and a soft decision Viterbi decoder. The generator polynomials for this code shall be:

$G1: 1 + X^2 + X^3 + X^5 + X^6$
$G2: 1 + X + X^2 + X^3 + X^6$

The input/output relationship of the encoder is three output bits for every two input bits; the fourth bit of every four transmitted bits is dropped. The sequence is:

Input bit	1	2
Output sequence	G1 G2	G1

4.4.5.3.3.5.2 *Other C channel rates.* The information field shall use rate ½ forward error correction coding. The FEC coding shall be implemented with a constraint length 7 rate ½ convolutional encoder. The output sequence of the encoded symbols shall be G1, G2 (as defined in 4.4.5.3.3.5.1 and as shown in Figure 4-3). The convolutional encoder shall not be initialized between frames.

4.4.5.3.3.6 *Interleaving*

4.4.5.3.3.6.1 The number of rows in the interleaver shall be 64 transmission bits. At the channel rate of 8.4 kbits/s the number of columns shall be 4. At the channel rate of 21.0 kbits/s the number of columns shall be 6.

4.4.5.3.3.6.2 **Recommendation.**— *At the recommended channel rate of 6.0 kbits/s the number of rows in the interleaver should be 64 transmission bits and the interleaver columns should be 3.*

4.4.5.3.3.6.3 At the transmitter the output of the convolutional encoder shall be written into the 64-bit columns, until the specified number of columns are full. The rows shall then be permuted using the algorithm described in 4.4.2.2.5.3.

4.4.5.3.4 *Information field for uncoded channels.* Where the channel rates are implemented as defined in 4.1, at the channel rate of 10.5 kbits/s this field shall contain 5 100 bits and at the recommended channel rate of 5.25 kbits/s this field shall contain 2 500 bits.

4.4.5.3.4.1 *Information field structure including sub-band data.* Prior to scrambling this field shall be divided into 25 alternating sub-band data and primary fields as shown in Figure 4-10. Where the channel rates are implemented as defined in 4.1.3, at the channel rate of 10.5 kbits/s each subfield shall contain 12 sub-band data bits and 192 primary bits; the last 12 bits of the 25th sub-band data subfield shall be filled with zeros. Where the channel rates are implemented as defined in 4.1.3, at the channel rate of 5.25 kbits/s each subfield shall contain 4 sub-band data bits and 96 primary bits; the last 4 bits of the 25th sub-band data subfield shall be filled with zeros.

Note.— Interleaving is not applicable at the channel rates of 10.5 and 5.25 kbits/s because the data is not forward error correction coded at these rates.

4.4.5.4 *Performance.* The C channel physical layer shall be configured and operated such that the average bit error rate is 10^{-3} or less after descrambling.

Note.— GES measurements of received BER permit GES commands to the AES for adjustment of the AES transmitted power. The GES also receives performance data measurement results made by the AES to enable GES output power adjustments.

4.5 LINK LAYER P CHANNEL AND R CHANNEL PROTOCOLS

4.5.1 General

Note.— The AMSS protocols are defined in terms of the OSI layered reference model. Section 4.5 defines the functional requirements of the link layer for P and R channels to transfer user data and signalling between the AES and the GES.

4.5.1.1 For each AES and GES, the link layer shall interface to the following:

a) the subnetwork layer;

b) the AES/GES management;

c) the circuit-mode services;

d) the physical layer.

4.5.1.2 The term link service user when used with respect to the link layer in 4.5 shall include items a), b) and c) in the list above.

4.5.2 Link interface data unit (LIDU)

4.5.2.1 The link interface data unit (LIDU) shall be the total information unit transferred across the interface between the link service user and the link layer in a single interaction. Each LIDU shall comprise link interface control information (LICI) and, if required, one LSDU.

4.5.2.2 The LIDU exchanged between the link layer and the subnetwork layer shall contain an LSDU and LICI, except that the transmission status indication LIDU (Table 4-25) passed by the link layer to the subnetwork layer at the transmitting end shall contain only LICI. The LIDU exchanged between the link layer and the AES/GES management and between the link layer and the circuit-mode services shall contain only LICI.

4.5.2.3 LINK INTERFACE CONTROL INFORMATION (LICI)

4.5.2.3.1 The LICI parameters exchanged between the link layer and the subnetwork layer shall be as defined in Table 4-11.

4.5.2.3.2 The LICI parameters exchanged between the link layer and the circuit-mode services shall be as defined in Table 4-38.

4.5.2.3.3 The LICI parameters exchanged between the link layer and the AES and GES management functions shall be as defined in 4.9.2.1.2 and Table 4-45, respectively.

4.5.2.4 LINK SERVICE DATA UNIT (LSDU)

Note.— The link service data unit (LSDU) is a part of an LIDU whose identity is preserved between the two link service users communicating with each other.

4.5.2.4.1 The link service data unit (LSDU) shall contain link service user data and shall be extracted from the LIDU received from the subnetwork layer.

4.5.2.4.2 *LINK SERVICE DATA UNIT FORMAT*

The LSDU format shall be the same as the format of satellite subnetwork protocol data units (SNPDUs) in the SSND sub-layer described in 4.7.

4.5.3 Link protocol data unit (LPDU)

4.5.3.1 The link protocol data units (LPDUs) shall be the signal units (SUs) described in 4.5.3.2.

4.5.3.2 SIGNAL UNIT (SU)

4.5.3.2.1 There shall be two lengths of SUs for the P and R channels:

a) 96 bits (12 octets): standard length SUs for P channel;

b) 152 bits (19 octets): extended length SUs for R channel.

4.5.3.2.2 Each SU shall contain control information, and may include user data depending upon the SU type.

4.5.3.2.3 *LIDU-TO-SU SET MAPPING*

4.5.3.2.3.1 Each LIDU received by the link layer, before being transmitted to the peer link layer, shall be mapped into an SU set. Each SU set shall comprise either a single signal unit called a "lone signal unit" (LSU) or more than one signal unit of which the first shall be an "initial signal unit" (ISU) and those that follow shall be "subsequent signal units" (SSUs).

4.5.3.2.3.2 *For LIDU comprised of LSDU and LICI*

4.5.3.2.3.2.1 For the P channel, an LSDU of length 2, 3 or 4 octets shall be mapped into standard length LSUs of Figures A2-37, A2-39 and A2-40 in Appendix 2 to Chapter 4, respectively. An LSDU of length greater than 4 octets, shall result in an ISU followed by a maximum of 63 SSUs. For an LSDU of length greater than 4 octets, the first two octets of the LSDU shall be mapped into the 2-octet user data field of an ISU (Appendix 2 to Chapter 4, Figure A2-37). The remaining octets shall be mapped into the 8-octet user data fields of subsequent SSUs (Appendix 2 to Chapter 4, Figure A2-38) ordered by sequence numbers (Appendix 3 to Chapter 4, Item 59). The number of SSUs shall depend upon the number of octets in the LSDU. The control information in each SU of the SU set shall be mapped from the information contained in the LICI and the information generated by the internal link layer protocol processes.

Note.— Each ISU contains information indicating the number of octets in the user data field of the last SSU of the SU set.

4.5.3.2.3.2.2 For the R channel, an LSDU shall map into a maximum of 3 extended length SUs, with the ISU of the SU set containing the first 11-octets (Appendix 2 to Chapter 4, Figure A2-44) of the LSDU in its user data field. The remaining octets shall be mapped into the 11-octet user data field of SSUs ordered by sequence indicator (Appendix 3 to Chapter 4, Item 58). The control information in each SU of the SU set shall be mapped from the information contained in the LICI and the information generated by the internal link layer protocol processes.

4.5.3.2.3.3 *For LIDU comprised of LICI only*

For an LIDU containing LICI only, the SU set shall be generated by mapping the information contained in the LICI and generated by the internal link layer protocol processes into the fields of the control information of the appropriate SU.

4.5.3.2.4 *SU SET-TO-LIDU MAPPING*

4.5.3.2.4.1 At the receiving end, an SU set shall be reassembled into an LIDU before being passed to the link service user.

4.5.3.2.4.2 For an SU set with SU(s) containing user data, the resulting LIDU shall contain LSDU and LICI. The LSDU shall be reassembled by combining the user data field of each SU of the received complete SU set. The LICI shall be generated from the control information in the SUs.

4.5.3.2.4.3 For an SU set with SU(s) containing no user data, the resulting LIDU shall contain only LICI. The LICI shall be generated from the control information in the received SUs.

4.5.3.3 SIGNAL UNIT FORMAT

4.5.3.3.1 The formats of all SUs transmitted on the P and the R channels shall be as shown in Appendix 2 to Chapter 4. The signal unit field mapping and the transmission order of the bits shall be as shown in Figure A2-1. The signal unit field coding and definitions shall be as described in Appendix 3 to Chapter 4.

4.5.3.3.2 SUs not recognized by the receiving link layer shall be ignored.

Note.— SUs not specified in Appendix 2 to Chapter 4 may be in use under mutual agreement between an AMSS service provider and an AMSS user for non-safety services.

4.5.4 LIDU routing

The receiving link layer (in either the GES or the AES) shall use the message type parameter in the LICI to route the LIDU to the appropriate link service user. The transmitting link layer (in the GES and the AES) shall use the routing parameter in the LICI received from the circuit-mode services (Table 4-38) to route the SU set corresponding to an LIDU, for transmission on the sub-band C channel or the R/P channels.

4.5.5 Precedence (Q number)

Each SU of the SU set generated from an LIDU shall be assigned a precedence (Q number) by the link layer according to the precedence parameter passed to it in the LICI by the link service user. Each link layer signalling SU shall be assigned a Q number according to its message type. A Q number shall be in the range from 0 (lowest precedence) to 15 (highest precedence).

4.5.6 DLS and RLS services

4.5.6.1 The link layer shall provide two distinct types of services, designated as direct link service (DLS) and reliable link service (RLS).

4.5.6.2 DLS shall be a link-layer service in which the SUs shall be transmitted to the peer link layer without making any provision for identification and retransmission of any lost SUs.

Note.— DLS is only available to AES/GES management functions and circuit-mode services.

4.5.6.3 RLS shall be a link-layer service that provides for the identification and retransmission of any lost SUs.

4.5.7 P channel protocol

Note.— In this subsection, the use of the terms "AES" and "GES" refer to the link layer functions for the P channel protocol within the AES and the GES.

4.5.7.1 GENERAL

The link layer functions for the P channel shall be as defined in 4.5.7.2 and 4.5.7.3.

4.5.7.2 GROUND EARTH STATION (GES)

4.5.7.2.1 Upon receipt of an LIDU, the GES shall assign an available (not currently assigned to an LIDU with the same Q number) reference number to it whenever this can be done in accordance with 4.5.7.2.2; however, the GES shall not assign a reference number to LIDUs received from the circuit-mode services and to system table broadcast LIDUs received from the GES management. If a reference number cannot be assigned to an LIDU, the LIDU shall be stored until one is assigned to it.

Note.— The circuit-mode LIDUs are assigned application reference numbers by the circuit-mode services.

4.5.7.2.2 At any Q precedence level, each assignment of a reference number to an LIDU destined to a particular AES shall be to the oldest LIDU among all the LIDUs without a reference number at that Q level destined to this AES. The GES shall not assign a reference number to an RLS LIDU if there is a reference number currently assigned to another LIDU with the same Q number and addressed to the same AES. Two consecutive reference number assignments for LIDUs of the same Q number shall not be made with the same reference number except for two DLS LIDUs which are mapped into LSUs. In the case of RLS, the reference number assigned by the GES shall not be equal to the last assigned reference number to an RLS LIDU with the same Q number and addressed to the same AES.

4.5.7.2.3 For DLS, the reference number shall be released immediately after it is assigned. For RLS, the reference number shall be released after the GES sends a transmission status indication LIDU (Table 4-25) to the link service user in the GES. The GES shall not reassign a released reference number until all the reference numbers that were available before its release have been assigned, in accordance with 4.5.7.2.2, the only exception to that shall be for a reference number that was assigned to a DLS LIDU mapping into an LSU, which may be immediately reassigned to another DLS LIDU mapping into an LSU.

4.5.7.2.4 After the assignment of a reference number to the LIDU or upon receipt of circuit-mode LIDU, an SU set shall be generated according to 4.5.3.2.3. Among all the SUs awaiting transmission, the oldest of the SUs with the highest Q number shall always be transmitted first. The ISU or the RTX SU of an SU set shall be transmitted before the SSUs, and the SSUs shall be transmitted in the descending order of their sequence numbers (Appendix 3 to Chapter 4, Item 59). After the transmission of the complete SU set, the GES shall do the following:

4.5.7.2.4.1 For RLS:

a) If a P channel acknowledgement (PACK) SU (Appendix 2 to Chapter 4, Figure A2-49) indicating no error in the SU set is received from the AES, the GES shall send a transmission status indication LIDU indicating success (Table 4-25) to the link service user in the GES.

b) If a PACK SU (Appendix 2 to Chapter 4, Figure A2-49) indicating missing SUs in the SU set is received from the AES and if another PACK SU of the PACK SU set is not received within tG2 seconds (Appendix 4 to Chapter 4) from the time the last PACK SU of the PACK SU set was received, or if no more PACK SUs identifying missing SUs are expected, the GES shall transmit a retransmission SU set. The retransmission SU set shall comprise a retransmission header (RTX) SU (Appendix 2 to Chapter 4, Figure A2-41) followed by the missing SUs identified in the received PACK SUs of the PACK SU set. The GES shall then proceed as in 4.5.7.2.4.1; however, if a PACK SU indicating missing

SUs in the SU set is received from the AES before the complete retransmission SU set has been transmitted, the GES shall discard the received PACK SU.

c) If a PACK SU (Appendix 2 to Chapter 4, Figure A2-49) requesting a complete retransmission of the SU set is received from the AES, the GES shall retransmit the entire SU set as a sequence of an ISU and SSUs. The GES shall then proceed as in 4.5.7.2.4.1

d) If no PACK SU associated with the SU set is received from the AES within tG1 seconds (Appendix 4 to Chapter 4) from the time the last SSU of the SU set (original or retransmitted) was transmitted, the GES shall transmit a request for acknowledgement (RQA) SU (Appendix 2 to Chapter 4, Figure A2-27) to the AES. The GES shall transmit the RQA SU every tG1 seconds from the time the last RQA SU was sent, until a response is received from the AES, or until the number of times the RQA SU was sent equals five. If tG1 seconds elapse after the fifth retransmission of the RQA SU without receiving any corresponding PACK SU from the AES, the GES shall send a transmission status indication LIDU indicating failure (Table 4-25) to the link service user in the GES and shall cease processing that SU set; otherwise, the GES shall proceed as in 4.5.7.2.4.1.

4.5.7.2.4.2 If a PACK SU identifying an SU set which is not present in the GES is received from an AES, the GES shall discard the received PACK SU.

4.5.7.2.5 If there are no SUs (data or signalling) to be transmitted, the GES shall transmit an AES system table broadcast SU (Appendix 2 to Chapter 4, Figures A2-30 to A2-34), if one has been generated from an LIDU received from the GES management; otherwise, the GES shall transmit a fill-in SU (Appendix 2 to Chapter 4, Figure A2-42).

4.5.7.3 AIRCRAFT EARTH STATION (AES)

4.5.7.3.1 Upon receipt of an SU set comprised of an LSU, the AES shall form an LIDU according to 4.5.3.2.4 and pass it to the appropriate link service user in the AES. For an LSU using RLS, the AES shall then send a PACK SU indicating no error to the GES. The AES shall command the selection of an R channel frequency and then shall resend that PACK SU if an RQA SU identifying this SU set is received before another SU set for this AES with the same Q number.

4.5.7.3.2 Upon receipt of SUs comprising an SU set, the AES shall reassociate the received SUs into an SU set according to their reference numbers, Q numbers and sequence numbers (Appendix 3 to Chapter 4, Items 43, 46 and 59, respectively). For such an SU set, if an SSU is received without its corresponding ISU or RTX SU having been received, the AES shall discard the SSU.

4.5.7.3.3 For an SU set comprised of multiple SUs, following receipt of an ISU the AES shall determine whether or not any more SSUs corresponding to the SU set headed by the ISU are expected from the GES in accordance with the following criterion:

No more SSUs corresponding to the SU set are expected if either the last SSU in the SU set, or an SU of lower Q number than the one awaiting completion, or an SU with the same Q number as the one awaiting completion but with a different reference number, or an AES system table broadcast SU, or a fill-in SU, is received.

Note.— To apply this criterion, the AES considers all received SUs independently of their AES ID.

4.5.7.3.3.1 When an SU set with the same Q number and AES ID as an SU set awaiting completion but with a different reference number is received from the GES, the AES shall discard the incomplete SU set awaiting completion.

4.5.7.3.3.2 The AES shall discard the received SU set if the received SU set (complete or incomplete) has the same Q number, and reference number as the last SU set that has been completed and reassembled into an LIDU at that Q number.

4.5.7.3.4 If no more SUs corresponding to the SU set are expected, the AES shall determine whether or not there are any missing SUs in the received SU set. The AES shall then do the following:

4.5.7.3.4.1 For DLS:

a) If there are no missing SUs, the AES shall reassemble the SUs into an LIDU according to 4.5.3.2.4 and pass the LIDU to the appropriate link service user in the AES.

b) If there are any missing SUs, the AES shall discard the incomplete SU set.

4.5.7.3.4.2 For RLS:

a) If there are no missing SUs in the SU set, the AES shall reassemble the SU set into an LIDU according to subsection 4.5.3.2.4 and forward it to the appropriate link service user. The AES shall then send a PACK SU indicating no errors to the GES. If subsequently an RQA SU requesting acknowledgement for that same SU set is received, the AES shall command the selection of an R channel frequency and then shall retransmit that PACK SU.

b) If the number of missing SUs is less than 43, the AES shall send to the GES one or more PACK SUs comprising the PACK SU set, identifying the missing SUs and requesting their retransmission.

Note.— A PACK SU indicating errors can identify as many as three missing SUs.

c) If more than 42 SUs in an SU set are missing, the AES shall send to the GES a PACK SU set comprised of one PACK SU requesting retransmission of the entire SU set.

4.5.7.3.4.2.1 After sending a PACK SU set requesting partial or complete retransmission to the GES, the AES shall then do the following:

a) If an RQA SU is received from the GES within tA1 seconds (Appendix 4 to Chapter 4) from the time the PACK SU set was transmitted to the GES, the AES shall command the selection of an R channel frequency and then shall retransmit the last PACK SU set to the GES and shall proceed as in 4.5.7.3.4.2.1. If an RQA SU is received from the GES before the complete PACK SU set has been transmitted, the AES shall discard the RQA SU.

b) Upon receipt of SUs headed by an RTX SU or an ISU from the GES, the AES shall determine whether or not any more SUs corresponding to the retransmitted SU set are expected in accordance with the criterion described in 4.5.7.3.3. The AES shall then determine whether or not the incomplete SU set identified in the RTX SU is present in the AES. If the incomplete SU set is not present in the AES, the AES shall discard the received SU set headed by RTX SU; otherwise, the AES shall insert the received SUs headed by RTX SU into the incomplete SU set. After inserting the received retransmitted SUs into the incomplete SU set and discarding any duplicated SUs (as required), the AES shall determine whether or not the resultant SU set is complete. The AES then shall do the following:

1) If the SU set is complete, the AES shall send a PACK SU indicating no error to the GES. Then the AES shall reassemble the complete SU set into an LIDU according to 4.5.3.2.4 and shall pass it to the appropriate link service user in the AES. If subsequently, an RQA SU requesting acknowledgement for that same SU set is received before another SU set for this AES with the same Q number, the AES shall command the selection of an R channel frequency and then shall retransmit that PACK SU.

2) If the SU set is not complete, the AES shall send to the GES one or more PACK SUs comprising a PACK SU set, in accordance with 4.5.7.3.4.2 b) and c). The AES shall then proceed as in 4.5.7.3.4.2.1.

c) If no response is received from the GES within tA1 seconds (Appendix 4 to Chapter 4) from the time the complete PACK SU set requesting retransmissions was sent, the AES shall command the selection of an R channel frequency and then shall send the PACK SU set again to the GES identifying the missing SUs. The AES shall retransmit the PACK SU set every tA1 seconds (Appendix 4 to Chapter 4), from the time the last PACK SU set was sent, until a corresponding retransmitted SU set is received from the GES, or until the number of times the PACK SU set, identifying the same missing SUs, was sent equals five. If tA1 seconds elapse after the fifth retransmission of the PACK SU set without receiving any retransmitted SUs from the GES, the AES shall discard the incomplete SU set.

4.5.7.3.5 The AES shall respond to a request for acknowledgement (RQA) SU received from the GES by sending a PACK SU requesting the retransmission of the entire SU set if the RQA SU identifies an SU set not received at the AES.

4.5.7.3.6 The AES link layer shall pass the revision number of the system table broadcast to the AES management upon receipt of the first SU of a system table broadcast sequence received on the satellite/beam-identifying P_{smc} channel. The broadcast LIDU corresponding to a series of a complete or partial broadcast sequence (see 4.10.4.5.2.2) shall be assembled and passed to the AES management after all the expected SUs of the series have been received, or after an SU of another series with a revision number equal to or greater than the series awaiting completion is received.

4.5.8 R channel protocol

Note.— In 4.5.8, the use of the terms "AES" and "GES" refers to the link layer functions for the R channel protocol within the AES and the GES.

4.5.8.1 General

4.5.8.1.1 The link layer functions associated with the R channel protocol shall be as defined in 4.5.8.2 and 4.5.8.3.

4.5.8.2 Aircraft earth station (AES)

4.5.8.2.1 Upon receipt of an LIDU for RLS, the AES shall assign a reference number (Appendix 3 to Chapter 4, Item 46) to it if there is no reference number currently assigned to an LIDU for RLS with the same Q number as the received LIDU. Upon receipt of an LIDU for DLS, the AES shall assign an available (not currently assigned to an LIDU with the same Q number) reference number to it; however, the AES shall not assign a reference number to LIDUs received from the circuit-mode services. If a reference number is not assigned to an LIDU, the LIDU shall be stored until one is assigned to it. Each assignment of a reference number shall be to the oldest received LIDU without a reference number. Two consecutive reference number assignments for LIDUs of the same Q number shall not be made with the same reference number, except for two LIDUs which are mapped into DLS LSU.

Note.— Circuit-mode services LIDUs are assigned application reference numbers by the circuit-mode services.

4.5.8.2.2 For DLS, the reference number shall be released immediately after it is assigned. For RLS, the reference number shall be released after the AES sends a transmission status indication LIDU (Table 4-25) to the link service user in the AES. The AES shall not reassign a released reference number until all the reference numbers that were available before its release have been assigned; the only exception to that is for a reference number that was assigned to a DLS LIDU mapping into an LSU, which may be immediately reassigned to another DLS LIDU mapping into an LSU.

4.5.8.2.3 After the assignment of a reference number to an LIDU or upon the receipt of a circuit-mode services LIDU, an SU set shall be generated according to 4.5.3.2.3. Among all the SUs awaiting transmission, the oldest SU of the SUs with the highest Q number shall always be transmitted first. The SUs of an SU set shall be transmitted in the ascending order of their sequence indicators (Appendix 3 to Chapter 4, Item 58).

4.5.8.2.4 *For RLS.* For each transmitted SU set, the AES shall do the following:

a) Respond to the R channel acknowledgement (RACK) SUs received from the destination GES as follows:

1) If the RACK SU (Appendix 2 to Chapter 4, Figure A2-28) indicates that the SU set has been completely received at the GES, the AES shall send a transmission status indication LIDU indicating success (Table 4-25) to the link service user in the AES.

2) If the RACK SU (Appendix 2 to Chapter 4, Figure A2-29) identifies one or more SUs that have not been received, the AES shall command the selection of an R channel frequency and retransmit the missing SUs in the ascending order of their sequence indicators. If any other RACK SU identifying missing SUs is received, the AES shall discard it if the transmission of all missing SUs identified in the previously received RACK SU is not yet completed. However, if either:

i) in addition to the first RACK SU, five more RACK SUs identifying missing SUs are received before the AES has completely transmitted any of the identified missing SUs in the first RACK SU,

or

ii) the first RACK SU identified two missing SUs, and one SU has been transmitted, and subsequent to the transmission five more RACK SUs identifying missing SUs have been received without transmitting another SU,

then, the AES shall send a transmission status indication LIDU indicating failure (Table 4-25) to the link service user in the AES and shall cease processing that SU set.

Note.— A RACK SU received at the AES would identify at most two missing SUs from an SU set.

b) If a RACK SU from the destination GES does not arrive within tA3 seconds (Appendix 4 to Chapter 4) from the time the last SU in a set (the original SU set or a retransmitted set of SUs corresponding to the original SU set) was transmitted, the AES shall command the selection of an R channel frequency from the available group of R channel frequencies and shall retransmit the set of SUs. The AES shall repeat this process until an acknowledgement from the GES is received, except that the number of times the same set of SUs was retransmitted shall not exceed 5. If a RACK SU does not arrive within tA3 seconds after the fifth repetition, the AES shall send a transmission status indication LIDU indicating failure (Table 4-25) to the link service user in the AES and shall cease processing that SU set.

4.5.8.3 GROUND EARTH STATION (GES)

4.5.8.3.1 The GES shall associate the SUs received from logged-on AESs into sets according to their AES IDs, Q numbers, reference numbers and sequence indicators (Appendix 3 to Chapter 4, Item 58).

4.5.8.3.2 *FOR RLS*

4.5.8.3.2.1 After an SU of an SU set has been received by the GES without completing the set, the GES shall send a RACK SU identifying the remaining missing SUs to the AES if any of the following is true:

a) if the received SU is either the last SU of the SU set or the last SU of the missing SUs of the SU set;

b) if a period of tG4 seconds (Appendix 4 to Chapter 4) elapses without another SU (DLS or RLS) from the same AES having been received; or

c) if the GES subsequently receives from the same AES an SU with a lower Q number or an SU, indicating DLS, of the same Q number but different reference number.

If after sending a RACK SU, identifying the missing SUs, the GES receives no SU in response within tG3 seconds, it shall retransmit the RACK SU to the AES, except that, instead of sending the RACK SU, the GES shall discard the SU set if a total of 6 identical RACK SUs have been sent and no missing SU was received within tG3 seconds since the last RACK SU was transmitted. The GES shall also discard an incomplete

SU set if an SU indicating RLS and having the same Q number but different reference number than the SUs of the set, is received from the same AES.

4.5.8.3.2.2 Whenever a complete SU set has been received, the GES shall reassemble an LIDU according to 4.5.3.2.4, shall pass it to the appropriate link service user, and shall send a RACK SU indicating no error to the AES.

4.5.8.3.2.3 After an LIDU has been formed the GES shall discard all SU sets with the same Q number and reference number subsequently received from the same AES until at least one SU with the same Q number and a different reference number has been received from the same AES, and shall retransmit, for each discarded SU set, a RACK SU indicating no error to the AES.

4.5.8.3.2.4 Whenever two or more SUs of the same Q number and reference number and sequence indicator have been received from the same AES before the corresponding LIDU has been formed, all but one shall be discarded.

4.5.8.3.3 *FOR DLS*

After an SU of an SU set has been received by the GES without completing the set, if any of the following is true, the GES shall discard the received SUs:

a) if the received SU is the last SU in the set;

b) if a period of tG4 seconds (Appendix 4 to Chapter 4) elapses without another SU (DLS or RLS) from the same AES having been received; or

c) if the GES subsequently receives from the same AES an SU with a lower Q number or an SU of the same Q number but different reference number.

If and when the SU set becomes complete, the GES shall reassemble the set into an LIDU according to 4.5.3.2.4 and shall pass it to the appropriate link service user. However, if the SUs of the complete SU set specify a different GES ID and the SU set corresponds to a circuit-mode services LIDU, the GES shall send the SU set to the GES whose ID is specified.

4.6 LINK LAYER T CHANNEL AND SUB-BAND C CHANNEL PROTOCOLS

4.6.1 General

4.6.1.1 The link layer functions for T and sub-band C channels to transfer user data and signalling shall be as defined in this section.

4.6.1.2 The P and R channels, described in 4.5, shall be used to set up T and sub-band C channels as described in 4.6.5 and 4.6.6, respectively.

4.6.2 Link interface data unit (LIDU)

4.6.2.1 The LIDU exchanged between the link layer and the subnetwork layer for transmission on the T channel shall contain link interface control information (LICI) and link service data unit (LSDU), except that the transmission status indication LIDU (Table 4-25) passed by the link layer to the subnetwork layer at the transmitting end shall contain only LICI.

4.6.2.2 The LIDU exchanged between the link layer and circuit-mode services and between the link layer and AES/GES management functions for transmission on the sub-band C channel shall contain LICI only.

4.6.2.3 LINK INTERFACE CONTROL INFORMATION (LICI)

4.6.2.3.1 The LICI parameters exchanged between the link layer and the subnetwork layer shall be as defined in Table 4-25.

4.6.2.3.2 The LICI parameters exchanged between the link layer and circuit-mode services shall be as defined in Table 4-38. The LICI parameters exchanged between the link layer and subnetwork management functions shall be as defined in Tables 4-44 and 4-45.

4.6.2.4 LINK SERVICE DATA UNIT (LSDU)

The link service data unit (LSDU) shall contain link service user data and shall be extracted from the LIDU received from the subnetwork layer.

4.6.3 Signal unit (SU)

4.6.3.1 There shall be two lengths of SUs for the T channel and one length for the sub-band C channel:

a) 48 bits (6 octets): burst identifier lone signal unit (LSU) (Appendix 2 to Chapter 4, Figure A2-43) for T channel.

b) 96 bits (12 octets): standard length SUs for T and sub-band C channels.

4.6.3.2 Each SU of the SU set corresponding to an LIDU received from the satellite subnetwork layer shall contain control information and user data. The SUs of the SU set corresponding to an LIDU received from the circuit-mode services and AES/GES management shall contain only control information.

4.6.3.3 LIDU-TO-SU SET MAPPING

4.6.3.3.1 *FOR LIDU COMPRISED OF LSDU AND LICI*

An LIDU shall be mapped into an SU set. Each SU set shall comprise an "initial signal unit" (ISU) followed by a maximum of 63 "subsequent signal units" (SSUs). The first two octets of the LSDU shall be mapped into the 2-octet user data field of the ISU (Appendix 2 to Chapter 4, Figure A2-37). The remaining octets shall be mapped into the 8-octets user data fields of the SSUs ordered by sequence numbers (Appendix 3 to Chapter 4, Item 59). The number of SSUs shall depend upon the number of octets in the LSDU. The control information in each SU of the SU set shall be mapped from the information contained in the LICI and the information generated by the internal link layer protocol processes.

4.6.3.3.2 *FOR LIDU COMPRISED OF LICI*

For an LIDU containing LICI only, the SU set shall be generated by mapping the information contained in the LICI and generated by the internal link layer processes into the fields of the control information of the appropriate SU.

4.6.3.4 SU SET-TO-LIDU MAPPING

4.6.3.4.1 An SU set shall be mapped into an LIDU before being passed to the link service user.

4.6.3.4.2 For an SU set with SU(s) containing user data, the resulting LIDU shall contain LSDU and LICI. The LSDU of the resulting LIDU shall be reassembled by combining the user data field of each SU of the received complete SU set. The associated LICI shall be generated from the control information in the SUs.

4.6.3.4.3 For an SU set with SU(s) containing no user data, the resulting LIDU shall contain only LICI. The LICI shall be generated from the control information in the received SUs.

4.6.3.5 SIGNAL UNIT FORMAT

4.6.3.5.1 The formats for all SUs transmitted on the T and sub-band C channels shall be as shown in Appendix 2 to Chapter 4. The signal unit field mapping and the transmission order of the bits shall be as shown in Figure A2-1. The signal unit field coding and definitions shall be as described in Appendix 3 to Chapter 4.

4.6.3.5.2 SUs not recognized by the receiving link layer shall be ignored.

Note.— SUs not specified in Appendix 2 to Chapter 4 may be in use under mutual agreement between an AMSS service provider and an AMSS user for non-safety services.

4.6.4 T channel transmission protocol

Note.— In 4.6.4, the use of the terms "AES" and "GES" refer to the link layer functions for the T channel transmission protocol within the AES and the GES.

4.6.4.1 GENERAL

The link layer functions for the T channel transmission protocol shall be as defined in 4.6.4.2 and 4.6.4.3.

4.6.4.2 AIRCRAFT EARTH STATION (AES)

4.6.4.2.1 Upon receiving an LIDU, the AES shall generate an SU set according to 4.6.3.3.1.

Note.— LIDUs are assigned reference numbers by the T channel reservation protocol.

4.6.4.2.2 *SU transmission.* SUs shall be transmitted on the T channel in burst reservations. Among all the SUs awaiting transmission, the oldest SU of the SUs with the highest Q number shall always be transmitted first. The ISU or the RTX SU of an SU set shall always be transmitted before the SSUs, and the SSUs shall be transmitted in the descending order of their sequence numbers (Appendix 3 to Chapter 4, Item 59). A burst identifier SU (Appendix 2 to Chapter 4, Figure A2-43) shall be transmitted at the beginning of each burst (as specified in 4.4.4.3.4). Whenever, during a burst transmission, there is no SU available for transmission, a fill-in SU (Appendix 2 to Chapter 4, Figure A2-42) shall be transmitted. However, if no SUs are available at the start of a burst reservation, the AES shall inhibit the transmission of the corresponding burst.

4.6.4.2.3 *For RLS.* For each transmitted SU set the AES shall do the following:

a) respond to each T channel acknowledgement (TACK) SU sent by the destination GES via the P channel in response to the SU set as follows:

   1) when the TACK SU (Appendix 2 to Chapter 4, Figure A2-29) indicates that the SU set has been completely received at the GES, the AES shall send a transmission status indication LIDU indicating success (Table 4-25) to the link service user;

   2) when the TACK SU (Appendix 2 to Chapter 4, Figure A2-29) indicates that the entire SU set has been lost, the AES shall retransmit the entire original SU set;

   3) when the TACK SU (Appendix 2 to Chapter 4, Figure A2-29) indicates missing SUs at the GES, if no more TACK SUs indicating more missing SUs of the same SU set are expected, or if one or more

TACK SUs are expected but none is received within tA5 seconds (Appendix 4 to Chapter 4) from the time the previous TACK SU was received, the AES shall retransmit the missing SUs as indicated in the received TACK SUs. A retransmission header (RTX) SU (Appendix 2 to Chapter 4, Figure A2-41) shall be transmitted before any retransmitted SU. Then, if any further TACK SU indicating missing SUs associated with the same SU set is received before the entire retransmission SU set has been retransmitted, the AES shall discard the received TACK SU.

However, the AES shall not transmit the same set, either the original SU set or a retransmission SU set, more than three times. If, after the third transmission, the AES receives a TACK SU that would result in a fourth transmission of the same SU set, the AES shall send a transmission status indication LIDU indicating the failure to the link service user and shall cease processing that SU set.

b) If an acknowledgement, associated with the SU set, is not received from the destination GES within tA4A seconds (Appendix 4 to Chapter 4) from the time the last SU in the set (either the original SU set or a retransmission set of SUs corresponding to the original SU set) was transmitted or, as specified in 4.6.5.2.6 b), discarded, the AES shall transmit a request for acknowledgement (RQA) SU (Appendix 2 to Chapter 4, Figure A2-48). Thereafter, the AES shall command the selection of an R channel frequency and then shall retransmit the RQA SU every tA4B seconds (Appendix 4 to Chapter 4) from the time the previous RQA SU was transmitted, until a corresponding TACK SU is received. However, if a corresponding TACK SU is not received within tA4B seconds from the time the fifth RQA SU was transmitted, the AES shall send a transmission status indication LIDU indicating failure (Table 4-25) to the link service user in the AES and shall cease processing that SU set.

4.6.4.3 GROUND EARTH STATION (GES)

4.6.4.3.1 The GES shall reassociate and reorder the SUs received from a logged-on AES according to their AES IDs, Q numbers, reference numbers and sequence numbers, defined in Appendix 3 to Chapter 4. A received SSU shall be discarded if the corresponding ISU or RTX SU has not been received.

Note.— The AES ID associated with a T channel burst could be determined either from the burst ID SU, if received, or any other SU, within the same burst, that contains an AES ID field.

4.6.4.3.2 Following the receipt of an ISU, the GES shall determine whether or not any more SSUs corresponding to the SU set headed by the received ISU are expected from the AES according to the following criterion:

No more SSUs corresponding to the SU set are expected if either the last SSU of the set, or an SU from the same AES but with a lower Q number, or an SU from the same AES with the same Q number but with a different reference number, or a fill-in SU with the same AES ID, is received.

4.6.4.3.3 When no more SUs corresponding to an SU set are expected, the GES shall determine whether or not there are any missing SUs in the received SU set. The GES then shall do the following:

a) if the SU set is complete, send a T channel acknowledgement (TACK) SU (Appendix 2 to Chapter 4, Figure A2-29) indicating that no SUs are missing, assemble an LIDU from the SU set according to 4.6.3.4, and pass it to the appropriate link service user;

b) if the SU set is incomplete, transmit one or more TACK SUs identifying the missing SUs to the AES, according to the following:

   1) if more than 42 or less than 4 SUs of the SU set are missing, only one TACK SU (Appendix 2 to Chapter 4, Figure A2-29) shall be sent. In the first case the TACK SU shall indicate a request for the retransmission of the entire SU set, while in the second case it shall indicate a request for retransmission of all missing SUs;

   2) otherwise, a maximum of 14 TACK SUs (Appendix 2 to Chapter 4, Figure A2-29) indicating all missing SUs shall be sent to the AES.

4.6.4.3.3.1 If the received SU set is a retransmission of an SU set awaiting completion at the GES, the GES shall use these sets to form a new SU set that is as complete as possible prior to sending an acknowledgement as given in 4.6.4.3.3 a) and b).

4.6.4.3.3.2 For each completed SU set, the GES shall discard all subsequent SU sets (complete or incomplete) with the same Q number, AES ID and reference number, until an SU set with the same Q number, AES ID and the paired reference number (according to the pairing scheme given in 4.6.5.2.2) is received.

4.6.4.3.4 Following the reception of an RTX SU (Appendix 2 to Chapter 4, Figure A2-41), the GES shall determine, according to the criterion described in 4.6.4.3.2, whether or not any more SUs corresponding to the retransmission set, headed by the received RTX SU, are expected from the AES. When no more SUs are still expected, the GES shall insert the retransmitted SUs into the appropriate (incomplete) SU set and shall acknowledge as specified in 4.6.4.3.3.

4.6.4.3.5 The GES shall respond to a request for acknowledgement (RQA) SU received from the AES by retransmitting the latest previously sent set of TACK SUs corresponding to the SU set indicated in the RQA SU. If the RQA SU identifies an SU set awaiting completion at the GES and for which no TACK SU has been transmitted, the GES shall send a TACK SU requesting the retransmissions of the missing SUs. If the RQA SU identifies an SU set not received at the GES, the GES shall send a TACK SU requesting the retransmission of the entire SU set.

4.6.4.3.6 If the GES receives an ISU with the same AES ID and Q number as those of an SU set awaiting completion and with a reference number equal to the reference number paired with the reference number of the SU set according to the pairing scheme given in 4.6.5.2.2, the GES shall discard the awaiting SU set.

4.6.5 T channel reservation protocol

Note.— In 4.6.5, the use of the terms "AES" and "GES" refer to the link layer functions for the T channel reservation protocol within the AES and the GES.

4.6.5.1 General

The link layer functions for the T channel reservation protocol shall be as defined in 4.6.5.2 and 4.6.5.3.

4.6.5.2 Aircraft earth station (AES)

4.6.5.2.1 Upon receipt of an LIDU containing an LSDU exceeding 33 octets, the AES shall route the LIDU to the T channel protocol.

Note.— An LIDU containing an LSDU of 33 octets or less may be routed to R channel protocol or T channel protocol.

4.6.5.2.2 Before passing the LIDU to the T channel transmission protocol, the AES shall assign an available (not currently assigned) reference number (Appendix 3 to Chapter 4, Item 46) to it. If a reference number is not assigned to an LIDU, the LIDU shall be stored until one is assigned to it. Each assignment of a reference number shall be to the oldest received LIDU without a reference number. The reference numbers for assignment to T channel LIDUs shall be defined in pairs as (0,1); (2,3); (4,5); (6,7); (8,9); (10,11); (12,13); (14,15). Once released, a reference number from a pair shall not be reassigned until the other number from the pair has been assigned and released. The AES shall not assign a reference number from a pair whose other number has just been released until a reference number from each pair that was available for assignment before the release has been assigned. The assigned reference number shall be used by both the T channel transmission protocol and the T channel reservation protocol.

4.6.5.2.3 To request a reservation for the transmission of an SU set, the AES shall send a reservation request (REQ) SU to the GES indicating the reference number, Q number and the length of the SU set to be transmitted.

4.6.5.2.4 The AES shall transmit a REQ SU on the R channel (Appendix 2 to Chapter 4, Figure A2-47) or on the T channel (Appendix 2 to Chapter 4, Figure A2-7) to the GES in accordance with the following criterion:

The T channel shall be used if the AES is currently transmitting a T channel burst and there is enough room to accommodate the REQ SU or if there is a T channel burst due to start in the next 8-second time window; otherwise, the R channel shall be used.

4.6.5.2.5 When the T channel is used for transmitting a REQ SU to the GES, the requested length shall be increased by one SU.

4.6.5.2.6 After sending a REQ SU to the GES, the AES shall do the following:

a) If the T channel was used for a REQ SU transmission, and neither a corresponding reservation (RES) SU (Appendix 2 to Chapter 4, Figure A2-23) nor a corresponding reservation forthcoming (RFC) SU (Appendix 2 to Chapter 4, Figure A2-24) is received from the GES within tA6 seconds (Appendix 4 to Chapter 4) from the time the REQ SU was sent on the T channel, the AES shall send the REQ SU again on the T or R channel, in accordance with 4.6.5.2.4, with the requested transmission length equal to the length last requested or incremented by one if T channel is used. The AES shall then proceed as in 4.6.5.2.6.

b) If the R channel was used for the REQ SU transmission, and neither a corresponding RES SU nor a corresponding RFC SU is received from the GES within tA7 seconds (Appendix 4 to Chapter 4) from the time the REQ SU was sent on the R channel, the AES shall command the selection of an R channel frequency and send the REQ SU again on the T or R channel, in accordance with 4.6.5.2.4, with the requested transmission length equal to the length last requested or incremented by one if the T channel is used. The AES shall then proceed as in 4.6.5.2.6. However, if tA7 seconds elapse after the fifth consecutive transmission of a REQ SU on the R channel without receiving any corresponding RES SU or RFC SU from the GES, the AES shall abort the reservation procedure for the corresponding LIDU and shall discard the number of SUs specified in the last transmitted REQ SU. If an ISU is amongst the SUs discarded, the AES shall then discard the complete SU set headed by the discarded ISU even if this shall result in discarding more SUs than the number of SUs specified in the REQ SU. The AES shall then send a transmission status indication LIDU (Table 4-25) indicating failure to the appropriate link service user in the AES corresponding to that completely discarded SU set. If an RTX SU is amongst the SUs discarded, the AES shall discard the complete SU set headed by the RTX SU. If a REQ SU is amongst the SUs discarded, the AES shall retransmit the REQ SU again on the R channel or the T channel in accordance with 4.6.5.2.4.

c) If a RES SU corresponding to a REQ SU is received from the GES, the AES shall pass the reservation information in the RES SU to the T channel transmission protocol. The starting frame number in the T channel burst reservation shall refer to either the current frame number or one of the 15 frames following the current frame number.

d) If an RFC SU corresponding to a REQ SU is received from the GES, the AES shall compute tA8 (Appendix 4 to Chapter 4), according to the delay specified in the RFC SU for the expected RES SU to arrive. The AES then shall do the following:

1) If no RES SU or RFC SU corresponding to that RFC SU set is received from the GES within tA8 seconds from the time the RFC SU was received, the AES shall send a REQ SU to the GES on the T or R channel in accordance with 4.6.5.2.4 with the requested length equal to the length associated with the corresponding RFC SU or incremented by one if the T channel is used and the AES shall then proceed as in 4.6.5.2.6.

2) If an RFC SU associated with the previously received RFC SU is received from the GES, the AES shall update the corresponding tA8 according to the new delay specified in the RFC SU.

3) If a RES SU corresponding to that RFC SU is received from the GES within tA8 seconds from the time the RFC SU was received, the AES shall pass the reservation information in the RES SU to the T channel transmission protocol in the AES.

4.6.5.2.7 After the T channel transmission protocol in the AES receives a TACK SU set requesting the retransmission of missing SUs, the AES shall compute tA8, according to the delay specified in the TACK SU for the expected RES SU to arrive. The AES then shall do the following:

a) If no RES SU or RFC SU corresponding to that TACK SU set is received from the GES within tA8 seconds from the time the complete SU set was received, the AES shall send a REQ SU to the GES on the T or R channel in accordance with 4.6.5.2.4 with the requested length equal to the number of missing SUs identified in the TACK SU set plus on if the R channel is used or incremented by one more if the T channel is used and the AES shall then proceed as in 4.6.5.2.6.

b) If an RFC SU associated with the previously received TACK SU set is received from the GES, the AES shall update the corresponding tA8 according to the new delay specified in the RFC SU.

c) If a RES SU is received from the GES within tA8 seconds from the time the complete TACK SU set was received, the AES shall pass the reservation information in the RES SU to the T channel transmission protocol in the AES.

Note.— The RFC flag field (Appendix 3 to Chapter 4, Item 50) in the RES or RFC SU to distinguish between the RES or RFC SUs associated with REQ SUs and those associated with TACK SUs or RFC SUs.

4.6.5.2.8 If a RES SU is received from the GES which does not correspond to any REQ SU sent by the AES or to RFC SU or TACK SU received by the AES, the AES shall pass the reservation information in the RES SU to the T channel transmission protocol.

4.6.5.2.9 If the AES is not able to transmit a T channel burst in the assigned T channel burst reservation, the AES shall send a REQ SU to the GES requesting a reservation for the not transmitted burst.

4.6.5.2.10 When an AES terminates communications with a GES as the result of a handover procedure (4.9), both the AES and the GES shall release all link layer resources which were allocated for data communication between them.

4.6.5.2.11 The reference number assigned to an LIDU shall be released when either all the expected reservations associated with the SU set corresponding to the LIDU have been received at the AES or the reservation procedure corresponding to that LIDU has been aborted, and after a transmission status indication LIDU (Table 4-25) indicating success or failure has been sent to the link service user in the AES.

4.6.5.3 GROUND EARTH STATION (GES)

4.6.5.3.1 Upon receipt of a REQ SU from the AES, the GES shall assign one or more burst reservations to the AES for the SU set identified in the REQ SU. When the GES transmits a TACK SU set indicating error to the AES, the GES shall assign one or more burst reservations for retransmission of the partial SU set comprised of an RTX SU followed by the missing SUs or retransmission of the complete SU set.

Note.— A TACK SU indicating error contains a field defining the preset delay to the forthcoming RES SU.

4.6.5.3.2 The GES shall send a RES SU to the AES at a time such that there is a subsequent maximum delay of 8 seconds before the intended SU set transmission time. If the start of the assigned reservation is outside the 8-second time window from the time the reservation was made, the GES shall send an RFC SU to the AES indicating the delay and then shall send the RES SU once the actual time is within 8 seconds of the scheduled reservation time. If a reservation associated with a TACK SU set indicating errors or RFC SU previously transmitted cannot be made within the delay specified in the TACK SU set or the RFC SU, the GES shall send an RFC SU to the AES before the delay period has elapsed. The RFC SU shall indicate a new delay to reservation. The GES shall send a RES SU to the AES early enough so that it arrives in time for the AES to begin sending an SU set at the start of burst reservation.

4.6.5.3.3 The GES shall not assign overlapping reservations on the same T channel. The interval between the end of one reservation and the beginning of the next reservation shall be sufficient to assure that the T channel bursts reserved by the GES do not overlap. A long SU set shall be assigned multiple bursts separated by intervals. The interval between the multiple burst reservations or between individual reservations for different SU sets shall be such as to allow for the transmission of at least one R channel burst every 8 seconds. The T channel burst length shall be chosen to allow the R channel and T channel transmissions to meet the performance requirements in 4.7. The length of each burst reservation shall be sufficient to accommodate the burst identifier SU which heads each T channel burst and the total reservation length shall be at least one SU longer than the requested one. The GES shall make reservations such that any given AES shall not be required to transmit at any time on more than one T channel belonging to the group of T channels assigned to the AES.

4.6.6 Sub-band C channel to-aircraft protocol

Note.— In this subsection, the use of the terms "AES" and "GES" refers to the link layer functions for the sub-band C channel to-aircraft protocol within the GES and the AES.

4.6.6.1 General

The link layer functions for an individual sub-band C channel in the to-aircraft direction shall be as specified in 4.6.6.2 and 4.6.6.3.

4.6.6.2 Ground earth station (GES)

4.6.6.2.1 Upon receipt of an LIDU from the circuit-mode link service user (Table 4-38) or the GES management (Table 4-45), the GES shall generate an SU set from the LIDU. Each SU set shall comprise either a single signal unit called a "lone signal unit (LSU)" or more than one signal unit of which the first shall be an "initial signal unit (ISU)" and those that follow shall be "subsequent signal units (SSUs)". The SU set shall be generated by mapping the information contained in the LICI and generated by the internal link layer protocol processes into the fields of the control information of the appropriate SU.

4.6.6.2.2 Among all the SUs awaiting transmission, the oldest of the SUs with the highest Q number shall always be transmitted first. The SUs of an SU set comprised of multiple SUs shall be transmitted in the descending order of their sequence numbers (Appendix 3 to Chapter 4, Item 59).

Note.— The sub-band C channel link layer in the GES does not assign a reference number to the LIDU received from the circuit-mode link service user. Instead an application reference number is assigned by the circuit-mode services and is passed to the link layer in the LICI.

4.6.6.2.3 If there are no SUs to be transmitted, the GES shall transmit fill-in SUs (Appendix 2 to Chapter 4, Figure A2-42).

4.6.6.3 Aircraft earth station (AES)

4.6.6.3.1 For an SU set comprised of an LSU, the AES shall form an LIDU containing only LICI and pass the LIDU to the appropriate link service user in the AES. The LICI shall be generated from the control information in the received LSU.

4.6.6.3.2 For an SU set comprised of multiple SUs, the AES shall reassociate and reorder the received SUs into an SU set according to their application reference number (Appendix 3 to Chapter 4, Item 4), sequence numbers (Appendix 3 to Chapter 4, Item 59) and Q numbers (Appendix 3 to Chapter 4, Item 43). Following receipt of an ISU, the AES shall determine whether or not any more SSUs corresponding to the SU set headed by the ISU are expected from the GES in accordance with the following criterion:

> No more SSUs corresponding to the SU set are expected if either the last SSU in the SU set or a fill-in SU is received, or if the channel is released.

If an ISU or an LSU with a Q number equal to the Q number of the SU set awaiting completion is received, the AES shall discard the incomplete SU set awaiting completion.

4.6.6.3.2.1 If no more SUs corresponding to a transmission of an SU set are expected, the AES shall determine whether or not there are any missing SUs. The AES shall then do the following:

a) if there are no missing SUs, the AES shall reassemble the SUs into an LIDU according to 4.6.3.4.3 and pass the LIDU to the appropriate link service user in the AES;

b) if there are any missing SUs, the AES shall not generate an LIDU from the received incomplete SU set; instead, the AES shall store the received SUs until the other missing SUs are received in a retransmission of the SU set, or until the channel is released.

4.6.6.3.3 *C channel crosstalk detection.* If a received SU or SU set contains an AES ID or application reference number which differs from that which prevailed when the C channel was established, the AES shall command the AES management to inhibit transmission on the C channel frequency and command the AES circuit-mode services to terminate the call.

4.6.7 Sub-band C channel from-aircraft protocol

Note.— In 4.6.7, the use of the terms "AES" and "GES" refers to the link layer functions for the sub-band C channel from-aircraft protocol within the AES and the GES.

4.6.7.1 GENERAL

The link layer functions for an individual sub-band C channel in the from-aircraft direction shall be as defined in 4.6.7.2 and 4.6.7.3.

4.6.7.2 AIRCRAFT EARTH STATION (AES)

4.6.7.2.1 Upon receipt of an LIDU from the circuit-mode link service user (Table 4-38) or the AES management (Table 4-44), the AES link layer shall generate the corresponding SU set according to 4.6.6.2.1.

4.6.7.2.2 Among all the SUs awaiting transmission, the oldest of the SUs with highest Q number shall always be transmitted first. The SUs of an SU set comprised of multiple SUs shall be transmitted in the descending order of their sequence numbers (Appendix 3 to Chapter 4, Item 59).

Note.— The sub-band C channel link layer in the AES does not assign a reference number to the LIDU received from the circuit-mode link service user. Instead an application reference number is assigned by the circuit-mode services and is passed to the link layer in the LICI.

4.6.7.2.3 If there are no SUs to be transmitted, the AES shall transmit fill-in SUs (Appendix 2 to Chapter 4, Figure A2-42).

4.6.7.3 GROUND EARTH STATION (GES)

4.6.7.3.1 For an SU set comprised of an LSU, the GES shall form an LIDU according to 4.6.6.3.1 and pass the LIDU to the appropriate link services user in the GES.

4.6.7.3.2 For an SU set comprised of multiple SUs, the GES shall reassociate and reorder the received SUs into an SU set according to their application reference number (Appendix 3 to Chapter 4, Item 4), sequence numbers (Appendix 3 to Chapter 4, Item 59) and Q numbers (Appendix 3 to Chapter 4, Item 43). Following receipt of an ISU, the GES shall determine whether or not any more SSUs corresponding to the SU set headed by the ISU are expected from the AES in accordance with the following criterion:

> No more SSUs corresponding to the SU set are expected if either the last SSU in the SU set or a fill-in SU is received, or if the channel is released.

If an ISU or an LSU with a Q number equal to the Q number of the SU set awaiting completion is received, the GES shall discard the incomplete SU set awaiting completion.

4.6.7.3.2.1 If no more SUs corresponding to a transmission of an SU set are expected, the GES shall determine whether or not there are any missing SUs. The GES shall then do the following:

a) if there are no missing SUs, the GES shall reassemble the SUs into an LIDU according to 4.6.3.4.3 and pass the LIDU to the appropriate link service user in the GES;

b) if there are any missing SUs, the GES shall not generate an LIDU from the received incomplete SU set; instead, the GES shall store the received SUs until the other missing SUs are received in a retransmission of the SU set, or until the channel is released.

4.7 SATELLITE SUBNETWORK LAYER

4.7.1 General provisions

4.7.1.1 ARCHITECTURE

4.7.1.1.1 The satellite subnetwork layer (SSNL) in the AES and GES shall provide connection-oriented packet data service by establishing subnetwork connections (SNCs) between subnetwork service (SNS) users. Both of the SSNL in the AES and GES shall contain the following three functions:

a) satellite subnetwork dependent (SSND) function;

b) subnetwork access (SNAc) function; and

c) interworking (IW) function.

The SSND function shall perform the SSND protocol (SSNDP) between each pair of AES and GES by exchanging subnetwork protocol data units (SNPDUs). It shall perform the SSNDP aircraft (SSNDPA) function in the AES and the SSNDP ground (SSNDPG) function in the GES. At a minimum, the SNAc function shall perform the ISO 8208 protocol between the AES or GES and the attached routers by exchanging ISO 8208 packets. It shall perform the ISO 8208 DCE function in the AES and the GES. The IW function (IWF) shall provide the necessary harmonization functions between the SSND and the SNAc functions. Figure 4-11 shows the SSND, IW and SNAc functions and the ATN satellite subnetwork protocol architecture.

4.7.1.1.2 The term DCE when used shall mean ISO 8208 DCE.

4.7.1.1.3 The SSNL shall interface with the link layer and the AES/GES management.

4.7.1.2 SERVICES

The SSNL shall provide the following services:

a) transparency of transferred information — provide for the transparent transfer of octet aligned SSNL user data and/ or control information; and

b) quality of service selection — make available to SNS users a means to request and to agree to the quality of service for the transfer of SSNL user data.

4.7.2 Packet data performance

4.7.2.1 DEFINITIONS

4.7.2.1.1 The terms used with respect to packet data performance are based on the definitions in ISO 8348 (first edition). In applying these definitions to the AMSS subnetwork layer, the word "network" and its abbreviation "N" in ISO 8348 are replaced by the word "subnetwork" and its abbreviation "SN", respectively, wherever they appear. Additional definitions are provided as follows.

4.7.2.1.2 *Data transfer delay (95 percentile).* The 95th percentile of the statistical distribution of delays for which transit delay is the average.

4.7.2.1.2 *bis Data transit delay.* In accordance with ISO 8348, the average value of the statistical distribution of data delays.

4.7.2.1.3 *Subnetwork service data unit (SNSDU).* An amount of subnetwork user data, the identity of which is preserved from one end of a subnetwork connection to the other.

Note.— Subnetwork performance depends on a number of factors, including the level of communication traffic. The performance values given here apply during peak busy hours.

4.7.2.2 SPEED-OF-SERVICE

4.7.2.2.1 *CONNECTION ESTABLISHMENT DELAY*

Note.— Connection establishment delay, as defined in ISO 8348, includes a component, attributable to the called subnetwork service user, which is the time between the SN-CONNECT indication and the SN-CONNECT response. This user component is due to actions outside the boundaries of the satellite subnetwork and is therefore excluded from the AMSS specifications.

4.7.2.2.1.1 Connection establishment delay shall not exceed the following maximum values:

Minimum channel rate in use by AES (bits/s)	Maximum connection established delay (95 percentile) (seconds)
600	70
1 200	45
2 400	25
4 800	25
10 500	25

4.7.2.2.2 *DATA TRANSIT DELAY*

Note.— In accordance with ISO 8348, data transit delay values are based on a fixed SNSDU length of 128 octets. Data transit delays are defined as average values. (4.7.2.1.2 and 4.7.2.1.2 bis *refer)*

4.7.2.2.2.1 Data transit delay shall not exceed the following maximum values:

Minimum channel rate in use by AES (bits/s)	Maximum data transit delay (seconds)		
	To-aircraft		From-aircraft
	Highest priority service	Lowest priority service	Highest priority service
600	12	40	40
1 200	8	25	30
2 400	5	12	15
4 800	4	7	13
10 500	4	5	13

Note.— In any particular AES, lower priority from-aircraft traffic may be subject to additional delay, depending on the amount and rate of from-aircraft traffic loading.

4.7.2.2.3 *DATA TRANSFER DELAY (95 PERCENTILE)*

Note.— In accordance with ISO 8348, 95 per cent data transfer delay values are based on a fixed SNSDU length of 128 octets. 95 per cent data transfer delay is defined in 4.7.2.1.2.

Data transfer delay (95 percentile) shall not exceed the following maximum values:

Minimum channel rate in use by AES (bits/s)	Maximum data transfer delay (95 percentile) (seconds)		
	To-aircraft		From-aircraft
	Highest priority service	Lowest priority service	Highest priority service
600	15	110	80
1 200	9	60	65
2 400	6	30	35
4 800	5	20	30
10 500	4	10	30

Note.— In any particular AES, lower priority from-aircraft traffic may be subject to additional delay, depending on the amount and rate of from-aircraft traffic loading.

4.7.2.2.4 *CONNECTION RELEASE DELAY*

The connection release delay (95 percentile) shall not exceed 30 seconds.

4.7.2.3 RELIABILITY OF SERVICE

4.7.2.3.1 *RESIDUAL ERROR RATE*

The residual error rate in the from-aircraft direction shall not exceed 10^{-4} per SNSDU. The residual error rate in the to-aircraft direction shall not exceed 10^{-6} per SNSDU.

Note.— Residual error rate includes the probability of undetected error, the probability of losing an SNSDU, and the probability of duplicating an SNSDU.

4.7.2.3.2 *CONNECTION RESILIENCE*

4.7.2.3.2.1 The probability of an SNC provider-invoked SNC release shall not exceed 10^{-4} over any one-hour interval.

Note.— Connection release resulting from either GES-to-GES handover or AES log-off or VC pre-emption are excluded from this specification.

4.7.2.3.2.2 The probability of an SNC provider-invoked reset shall not exceed 10^{-1} over any one-hour interval.

4.7.3 Satellite subnetwork-dependent protocol services and operations

4.7.3.1 GENERAL PROVISIONS

Since the functional differences between the SSNDPA and SSNDPG are minimal, their operations shall be described in terms of SSNDPX where X shall stand for either A or G. Where differences do occur, the SSNDPA and SSNDPG functions shall be described individually.

4.7.3.2 SATELLITE SUBNETWORK-DEPENDENT PROTOCOL ENTITIES

Note.— At least one pair of SSNDPA and SSNDPG entities exists between each pair of AES and GES. Figure 4-12 shows two pairs of SSNDPA and SSNDPG entities between two AESs and a GES.

4.7.3.2.1 The SSNDPX defined in this section shall pertain to each SSNDPX entity.

4.7.3.3 LOGICAL CHANNELS

Note.— The connections between SSNDPAs and SSNDPGs are established through logical channels. Up to 255 logical channels may be established between each pair of SSNDPX entities. Each logical channel is identified by its own logical channel number (LCN) ranging from 1 through 255. LCN 0 is reserved.

4.7.3.3.1 For a new ground-to-air connection establishment, the SSNDPG shall allocate a logical channel number in the range 1 to 127, by choosing the lowest numbered logical channel in the ready state in that range. For a new air-to-ground connection setup, the SSNDPA shall allocate a logical channel number in the range 128 to 255, by choosing the highest numbered logical channel in the ready state in that range.

4.7.3.4 OPERATIONS

The SSNDPX virtual call (VC) service shall proceed through three distinct phases:

a) connection establishment;

b) data transfer; and

c) connection release.

Note.— The SSNDPX is specified in terms of locally originated, or remotely originated operations. Locally originated specifies the procedure at the SSNDPX for handling operations originating from a local SNS user, while remotely originated specifies the procedure at the SSNDPX for handling operations originating from a remote SNS user.

4.7.3.5 CONNECTION ESTABLISHMENT

Note.— Up to 128 octets of user data may be transferred during connection establishment.

4.7.3.5.1 The connection establishment procedure shall apply independently to each establishment request.

4.7.3.5.2 User data shall be transparently forwarded in both directions.

4.7.3.5.3 *LOCALLY ORIGINATED*

4.7.3.5.3.1 *Normal operation*

4.7.3.5.3.1.1 When the SSNDPX receives a call request packet from the IWF, it shall allocate a logical channel which is in the ready state, forward the call request packet to the remote SSNDPX by means of a connection request SNPDU and place the logical channel into the IWF call request state.

4.7.3.5.3.1.2 If the call is accepted at the remote SSNDPX, a connection confirm SNPDU is received. The SSNDPX shall then place the logical channel in the data transfer/flow control state (flow control ready/no remote or local interrupt pending) and forward a call connected packet to the IWF. The call connected packet shall use default values (if any) for the facilities which are not transmitted over the satellite subnetwork, according to the SNPDU to packet mapping rules defined in 4.7.3.16.

4.7.3.5.3.1.3 If the SSNDPX does not receive either a connection confirm or connection released SNPDU from the remote SSNDPX before the timer (see tN1, Table 4-18) expires, it shall initiate a connection release procedure.

4.7.3.5.3.2 *Other operation*

If resources are not available, or a requested facility value is not allowed, then the originating SSNDPX shall send a clear indication packet to the IWF.

4.7.3.5.4 *REMOTELY ORIGINATED*

4.7.3.5.4.1 *Normal operation*

4.7.3.5.4.1.1 When the SSNDPX receives a connection request SNPDU from the remote SSNDPX, it shall place the logical channel selected in the incoming call state. The SSNDPX shall forward an incoming call packet to the IWF using default values for any facilities which are not transmitted over the satellite subnetwork (see 4.7.3.16).

4.7.3.5.4.1.2 When the SSNDPX receives a call accepted packet from the IWF, it shall forward a connection confirm SNPDU to the remote SSNDPX and place the logical channel in the data transfer/flow control state (flow control ready/no remote or local interrupt pending) when it receives from the interfacing link layer the information that the connection confirm SNPDU has been processed (receipt of fail/success LIDU).

4.7.3.5.4.2 *Other operation*

4.7.3.5.4.2.1 If the receiving SSNDPX cannot support the request, then it shall transmit a connection released SNPDU to the originating SSNDPX.

4.7.3.5.4.2.2 If a selected facility value is not allowed, then the receiving SSNDPX shall initiate a connection release procedure.

4.7.3.6 CONNECTION RELEASE

Note.— A subnetwork connection may be released at any time by any party once the logical channel is in the data transfer, IWF call request, or incoming call states. The connection released SNPDU may contain user data (128 octets maximum) provided by the IWF.

4.7.3.6.1 User data shall be transparently forwarded in both directions.

4.7.3.6.2 The SSNDPX shall guarantee in-sequence transmission between data/ interrupt SNPDUs already forwarded to the link layer and a subsequently transmitted connection released or connection release complete SNPDU.

4.7.3.6.3 *LOCALLY ORIGINATED*

4.7.3.6.3.1 When the SSNDPX receives a clear request packet from the IWF, it shall place the logical channel in the local clear request state, generate a connection released SNPDU, and forward it to the remote SSNDPX. The only SNPDUs it shall then accept, are a connection released SNPDU or a connection release complete SNPDU. It shall discard all other SNPDUs. The SSNDPX shall also consider the receipt of any packet other than a clear request packet as an error, and shall discard it.

4.7.3.6.3.2 When the SSNDPX receives a connection release complete after the connection released has been successfully sent, it shall return the logical channel to the ready state. If the SSNDPX receives a connection released SNPDU from the remote SSNDPX, it shall not expect to receive a connection release complete SNPDU.

4.7.3.6.3.3 If the SSNDPX does not receive a response from the remote SSNDPX before the associated timer (see tN6, Table 4-18) expires, it shall return the logical channel to the ready state.

4.7.3.6.4 *REMOTELY ORIGINATED*

When the SSNDPX receives a connection released SNPDU, it shall enter the remote clear request state, and forward a clear indication packet to the IWF. It shall also construct a connection release complete SNPDU, send it to the remote SSNDPX, and return the logical channel to the ready state.

4.7.3.6.5 *SSNDPX ORIGINATED*

If the SSNDPX entity needs to disconnect a connection, it shall place the logical channel in the local clear request state, send a clear indication packet to the IWF and transmit a connection released SNPDU to the remote SSNDPX. It expects to receive as a response from the remote SSNDPX a connection release complete SNPDU or connection released SNPDU, and shall return the logical channel to the ready state when the expected response is received or timing supervision expires (see tN6, Table 4-20).

4.7.3.7 DATA TRANSFER

4.7.3.7.1 The data transfer procedure shall apply independently to each logical channel which is in the data transfer/flow control state.

4.7.3.7.2 *DATA TRANSFER PROCEDURE*

4.7.3.7.2.1 Data shall be forwarded transparently and in sequence between the SNS users.

4.7.3.7.2.2 An M-bit SNPDU sequence shall consist of a sequence of one or more data SNPDUs. Each data SNPDU except the last one, shall contain the maximum 503 octets of user data and its M-bit shall be set to 1. The user data field of the last SNPDU which belongs to the sequence may have less than the maximum length and shall have its M-bit set to 0.

4.7.3.7.2.3 *Locally originated*

4.7.3.7.2.3.1 An M-bit packet sequence received from the IWF shall be forwarded as an M-bit SNPDU sequence to the remote SSNDPX.

4.7.3.7.2.3.2 Upon receipt from the IWF of one or more data packets belonging to one M-bit packet sequence, the SSNDPX shall generate one or more data SNPDUs, using the M-bit to indicate a following data SNPDU of the same sequence of data SNPDUs and shall forward them to the remote SSNDPX.

Note.— The number of data SNPDUs needed in the sequence depends on the amount of user data in the data packets which belong to the M-bit packet sequence.

4.7.3.7.2.3.3 The SSNDPX shall also assign an SNPDU number to each data SNPDU. SNPDU numbers shall be consecutive over a given connection. The sequence numbering of data SNPDUs shall be performed modulo 256 and the SNPDU numbers shall cycle through the entire range from 0 through 255. The first data SNPDU to be transmitted over the satellite link, when the logical channel has just entered the flow control ready state, shall have an SNPDU number equal to 0.

4.7.3.7.2.4 *Remotely originated*

4.7.3.7.2.4.1 An M-bit SNPDU sequence received from the remote SSNDPX shall be forwarded as an M-bit packet sequence to the IWF.

4.7.3.7.2.4.2 Upon receipt of an M-bit SNPDU sequence, the SSNDPX shall generate an M-bit packet sequence, using the M-bit to indicate a following packet of the same sequence as required and forward it to the IWF.

Note.— The number of data packets needed in the M-bit packet sequence depends on the amount of user data in the M-bit SNPDU sequence and the packet size.

4.7.3.7.2.4.3 If a data SNPDU is received which contains less than the maximum size and with M-bit = 1 and D-bit = 0, then the SSNDPX shall initiate a reset procedure (see 4.7.3.8.2.1).

4.7.3.7.3 *FLOW CONTROL*

4.7.3.7.3.1 Flow control shall be provided within the SSNDPX to prevent the overflow of data buffers.

4.7.3.7.3.2 To interrupt the flow of data, the receiving SSNDPX shall generate a flow control SNPDU with its flow control reason field set to suspend and transmit it to the remote SSNDPX. The SNPDU number in the flow control (suspend) SNPDU shall be set to the SNPDU number of the last received and accepted data SNPDU. If there are any out-of-sequence data SNPDUs in the SSNDPG, the SNPDU number in the flow control SNPDU with its reason field set to suspend shall be set to the SNPDU number of the SNPDU received and accepted before the out-of-sequence SNPDU. When subsequently the receiving SNDPX is able to resume the data transfer, it shall transmit a flow control SNPDU with its flow control reason field set to resume.

4.7.3.7.3.3 When the SSNDPX receives a flow control SNPDU with its flow control field set to suspend, it shall stop transmitting data SNPDUs on the indicated logical channel. If the SNPDU number in the flow control (suspend) SNPDU is other than that of the last data SNPDU transmitted and the data

SNPDU with SNPDU number equal to the SNPDU number in the flow control (suspend) SNPDU plus one modulo 256 is no longer in the data buffer, the SSNDPX shall initiate a reset of the logical channel. When the SSNDPX receives a flow control SNPDU with its control field set to resume, it shall restart transmitting data SNPDUs on the indicated logical channel. The first (re)transmitted data SNPDU shall have its SNPDU number equal to the SNPDU number of the previously received flow control SNPDU (suspend) plus one modulo 256, unless a reset procedure has been invoked.

4.7.3.7.3.4 If the receiving SSNDPX is not able to resume data transfer before the associated timer (see tN7 in Table 4-18 and Table 4-20) expires, it shall initiate a reset of the logical channel.

4.7.3.7.4 *EXPEDITED DATA TRANSFER*

Note.— The expedited data transfer allows an SSNDPX to transmit user data contained in an interrupt packet to the remote SSNDPX, bypassing any flow control that may have been applied by subnetwork layer entities.

4.7.3.7.4.1 The expedited data transfer procedure shall apply independently to each logical channel which is in the data transfer state and shall not be initiated when a release or reset procedure is in process.

4.7.3.7.4.2 Only one interrupt SNPDU at a time, with a maximum user data length of 32 octets, shall be permitted in each direction.

4.7.3.7.4.3 *Locally originated*

4.7.3.7.4.3.1 When the originating SSNDPX receives an interrupt packet from the IWF and provided there is no pre-existing interrupt SNPDU awaiting interrupt confirm SNPDU, the SSNDPX shall then generate an interrupt SNPDU and forward it to the remote SSNDPX, and await an interrupt confirm SNPDU; otherwise, the SSNDPX shall discard the interrupt packet.

4.7.3.7.4.3.2 Upon receipt of an interrupt confirm SNPDU, the SSNDPX shall generate an interrupt confirmation packet and forward it to the IWF.

4.7.3.7.4.3.3 If the SSNDPX does not receive the interrupt confirm SNPDU before the associated timer (see tN4 in Table 4-18 and Table 4-20) expires, it shall initiate a reset of the logical channel.

4.7.3.7.4.4 *Remotely originated*

4.7.3.7.4.4.1 When the SSNDPX receives an interrupt SNPDU, it shall forward an interrupt packet to the IWF.

4.7.3.7.4.4.2 When the SSNDPX receives an interrupt confirmation packet from the IWF, it shall construct an interrupt confirm SNPDU, and send it to the remote SSNPDX.

4.7.3.8 CONNECTION RESET

4.7.3.8.1 When the SSNDPX detects an error in the SSNDPX operation for which its action is to reset the virtual circuit (see Table 4-24), then it shall place the logical channel into the local reset state, carry out the reset procedure and transmit a reset SNPDU to the remote SSNDPX.

Note.— The cause and diagnostic codes indicate whether the reset should be carried out within the satellite subnetwork alone or should be extended to the IWF.

4.7.3.8.2 *RESET ACTION*

During the reset process, the following actions shall be taken by the SSNDPX with respect to its data transfer operation:

a) the SNPDUs which have not yet been passed to the link layer shall be discarded;

b) the SNPDUs that have been received prior to receiving/transmitting a reset SNPDU but which do not constitute an M-bit SNPDU sequence shall be flushed from the reassembly area;

c) the expected (data) SNPDU number shall be reset to 0 and subsequently transmitted data SNPDUs shall be numbered starting from 0; and

d) any outstanding interrupt SNPDU to or from the remote SSNDPX remains unconfirmed and tN4 is stopped.

4.7.3.8.3 *RESET PROCEDURES*

4.7.3.8.3.1 The reset procedures shall apply only to logical channels that are in the data transfer state.

4.7.3.8.3.2 The SSNDPX shall guarantee in sequence transmission between data/interrupt SNPDUs already forwarded to the link layer and a subsequently transmitted reset or reset confirm SNPDU.

4.7.3.8.3.3 *Locally/SSNDPX originated*

4.7.3.8.3.3.1 When the originating SSNDPX receives a reset request packet from the IWF or when it has detected an error for which its action is to reset the SVC, it shall place the logical channel into the local reset state, execute the reset action, transmit a reset SNPDU to the remote SSNDPX, and start a timer tN3 (see Table 4-18). If required by the error procedures in 4.7.3.9, the SSNDPX shall forward a reset indication packet to the IWF.

4.7.3.8.3.3.2 Upon receipt of the reset confirm SNPDU from the remote SSNDPX, it shall return the logical channel to the data transfer/flow control state.

4.7.3.8.3.3.3 If the SSNDPX does not receive a response from the SSNDPX before the associated timer (see tN3 in Table 4-18) expires, it shall initiate a connection release procedure.

4.7.3.8.3.4 *Remotely originated*

4.7.3.8.3.4.1 When the SSNDPX receives a reset SNPDU, it shall place the logical channel into the remote reset state, execute the reset action and transmit a reset indication packet to the IWF as required (see Table 4-24).

4.7.3.8.3.4.2 The SSNDPX shall transmit a reset confirm SNPDU to its remote SSNDPX and shall return the logical channel to the data transfer state when it has received from the link layer the information that the reset confirm SNPDU has been successfully transmitted.

4.7.3.8.3.5 *Simultaneous reset*

If the SSNDPX sends a reset SNPDU and subsequently receives a reset SNPDU it shall:

a) not send a reset confirm SNPDU; and

b) not expect to receive a reset confirm SNPDU.

4.7.3.9 ERROR PROCEDURES

Note.— Errors which are recognized by the SSNDPX may be the result of the following events:

- *channel degradation or loss of synchronization*
- *AES log-off*
- *a GES-to-GES handover*
- *link congestion*
- *an uncorrected transmission error*
- *a remote SSNDPX protocol error*
- *a protocol error in the IWF/SSNDPX interface procedure*

4.7.3.9.1 When an error as noted in Tables 4-22 to 4-24 is detected, the SSNDPX shall initiate either reset or release of the relevant connection.

4.7.3.9.2 Errors shall be notified to the IWF by means of cause and diagnostic parameters within the relevant packet. Errors shall be notified to the remote SSNDPX by using the corresponding fields of the SNPDUs, i.e. reset or release cause and diagnostic code.

4.7.3.9.3 The coding of the cause fields which are generated by the SSNDPX and passed to the remote SSNDPX shall be as defined in Table 4-16.

4.7.3.9.4 The coding of the corresponding SSNDPX generated diagnostic code field shall be as defined in Table 4-17.

4.7.3.9.5 *LOG-ON/LOG-OFF*

Note.— The procedures for log-on and log-off are covered in 4.7.6.

4.7.3.9.6 *ORIGINATING SSNDPX ERROR RECOVERY*

4.7.3.9.6.1 Transmission error resulting from the loss or delay of SNPDUs shall be detected either by time-out when a response is expected or by the fail LIDU reported by the link layer.

4.7.3.9.6.2 The actions the SSNDPX follows upon time-out shall be as summarized in Table 4-18.

4.7.3.9.6.3 The actions the SSNDPX shall follow when it is informed by the link layer that the transmission of an SNPDU has failed shall be as summarized in Table 4-19. Receipt of a fail (data/interrupt) LIDU while the relevant LCN is either in local/remote reset state or local/remote clear request state, shall not cause the SSND sub-layer entity to generate a (further) connection reset.

4.7.3.9.7 *PROTOCOL ERROR*

Note.— Two types of protocol error may occur at the SSNDPX. These are:

a) a syntactical error which occurs when a received SNPDU does not conform to the format specifications over the satellite subnetwork; and

b) a logical error which occurs when the SSNDPX receives from its peer entity an SNPDU that is not an acceptable input to the current state of the logical channel.

4.7.3.9.7.1 When the SSNDPX detects a protocol error, it shall respond as indicated in Tables 4-21 to 4-24. These tables are depicted for each logical channel state.

4.7.3.9.8 *OUT-OF-SEQUENCE DATA SNPDU PROCEDURE*

4.7.3.9.8.1 The SSNDPX shall process received data SNPDUs in proper sequence, according to SNPDU number to construct data packets to be forwarded to the IWF. The SSNDPX shall discard duplicate SNPDUs.

Note.— The receiving link layer at the GES may deliver SNPDUs to the SSNDPG in altered sequence. The SSNDPG assembles data SNPDUs in proper sequence before forwarding them to the IWF.

4.7.3.9.8.2 *SSNDPG actions for out-of-sequence data SNPDUs*

A data SNPDU shall be defined as out of sequence if and only if its SNPDU number does not immediately follow the SNPDU number of the last received data SNPDU that has been used in creating the last data packet.

Note.— SNPDU numbers are incremented modulo 256. Thus, SNPDU number 0 follows SNPDU number 255.

4.7.3.9.8.2.1 If an out-of-sequence data SNPDU is not a duplicate, the SSNDPG shall store the out-of-sequence data SNPDU. If no more storage is available, the SSNDPG shall place the logical channel in the reset state and extend the reset to the IWF.

4.7.3.9.8.2.2 Stored data SNPDUs shall be processed to create data packets whenever this can be done without creating an out-of-sequence condition. Data packets shall be forwarded to the IWF as soon as possible.

4.7.3.9.8.3 *SSNDPA actions for out-of-sequence SNPDUs*

If a data SNPDU is received which is not a duplicate but has an SNPDU number not immediately following the SNPDU number of the data SNPDU last received, the SSNDPA shall initiate a reset of the connection.

4.7.3.10 SNPDU FORMATS

4.7.3.10.1 *GENERAL SNPDU FORMAT*

4.7.3.10.1.1 An SNPDU shall consist of at least two octets. Octet 1 shall contain the D- and M-bits and the SNPDU type identifier field. Octet 2 shall contain the logical channel number field; depending on the particular SNPDU type, additional octets may be required. The general SNPDU format shall be as defined in Figure 4-13.

4.7.3.10.1.2 The D- and M-bits shall be bits 7 and 8, respectively, in octet 1.

4.7.3.10.1.3 The M-bit shall be used in an M-bit SNPDU sequence consisting of a sequence of data SNPDUs; it shall be set to 0 in all other SNPDUs.

Note.— The D-bit may be used for end-to-end acknowledgement (receipt confirmation).

4.7.3.10.1.4 The SNPDU type identifier field shall be bits 1-6 in octet 1. The coding of the SNPDU type identifier field shall be as defined in Table 4-15.

4.7.3.10.1.5 Octet 2 shall contain the logical channel number field.

Note.— In the following sections, fields are defined in the order they may appear in the relevant SNPDU.

4.7.3.10.2 *CONNECTION REQUEST SNPDU*

4.7.3.10.2.1 The format of connection request SNPDU shall be as defined in Figure 4-14.

4.7.3.10.2.2 *SNPDU type identifier field*

4.7.3.10.2.2.1 Bits 1, 2, 3 and 6 shall be the following indicator bits:

a) bit 1, facilities field present;

b) bit 2, called NSAP address present;

c) bit 3, calling NSAP address present; and

d) bit 6, fast select with restriction on response.

4.7.3.10.2.2.2 Bits 1, 2 and 3 shall be set to 1 if the corresponding fields are present in the connection request SNPDU; otherwise, they shall be set to 0. Bit 6 shall be set to 1 if fast select with restriction on response applies; otherwise, it shall be set to 0.

4.7.3.10.2.3 *DTE address length field*

Octet 3 shall consist of the calling- and called-DTE address length fields. Bits 8 to 5 shall specify the length of the calling-DTE address in semi-octets. Bits 4 to 1 shall specify the length of the called-DTE address in semi-octets. Each address-length field shall be binary-coded, where bit 5 or 1 shall be the low-order bit of the indicator.

4.7.3.10.2.4 *Calling- and called-DTE fields*

4.7.3.10.2.4.1 When indicated by the DTE addresses length field, the octets following the DTE addresses length field shall contain the called-DTE address followed by the calling-DTE address.

4.7.3.10.2.4.2 Each digit of an address shall be coded in a semi-octet in binary-coded decimal, where bit 5 or bit 1 shall be the low-order bit of the digit.

4.7.3.10.2.4.3 Starting from the high-order digit, a DTE address shall be coded in consecutive octets, with two digits per octet. In each octet, the higher-order digit shall be coded in bits 8 to 5. When the total number of digits in the called-plus calling-DTE fields is odd, the combined fields shall be rounded up to an integral number of octets by inserting zeros in bits 4 to 1 of the last octet of the combined fields.

4.7.3.10.2.5 *Called- and calling-NSAP address fields*

When indicated by the called- and calling-NSAP address present indicator bits, the octets following the calling- and called-DTE fields shall contain the called-NSAP address field, then the calling-NSAP address field.

4.7.3.10.2.6 *Facility field length field*

When indicated by the facilities field present indicator bit, the next octet shall contain the length of the facilities field in octets. The facility field length field shall be binary-coded, where bit 1 shall be the low-order bit of the field.

4.7.3.10.2.7 *Facilities field*

When indicated by the facilities field present indicator bit, the octets following the facility field length field shall contain the codes and parameters for the facilities.

4.7.3.10.2.8 *Call user data field*

The next octets shall be used to carry the call user data, if any. If fast select facility is not used, not more than 16 octets of data shall be present. If fast select facility is used, not more than 128 octets of data shall be present.

4.7.3.10.3 *CONNECTION CONFIRM SNPDU*

4.7.3.10.3.1 The format of the connection confirm SNPDU shall be as specified in Figure 4-15.

4.7.3.10.3.2 *SNPDU type identifier field*

4.7.3.10.3.2.1 Bits 1 and 2 shall be the following indicator bits:

a) bit 1: facilities field present; and

b) bit 2: NSAP address present.

4.7.3.10.3.2.2 These bits shall be set to 1 if the corresponding fields are present; otherwise, they shall be set to 0.

4.7.3.10.3.3 *Called-NSAP address field*

When indicated by the NSAP address present indicator bit, the octets following the logical channel number field shall consist of the called-NSAP address.

4.7.3.10.3.4 *Facility length field*

When indicated by the facilities field present indicator bit, the next octet shall contain the length of the facilities field in octets. The facility length indicator shall be binary-coded, where bit 1 shall be the low-order bit of the field.

4.7.3.10.3.5 *Facilities field*

When indicated by the facilities field present indicator bit, the octets following the facilities field shall contain the codes and parameters for the facilities.

4.7.3.10.3.6 *Called user data field*

The next octets shall be used to carry the called user data, if any. If fast select facility is used, not more than 128 octets of data shall be present.

4.7.3.10.4 *CONNECTION RELEASED SNPDU*

4.7.3.10.4.1 The connection released SNPDU format shall be as defined in Figure 4-16.

4.7.3.10.4.2 *SNPDU type identifier field*

4.7.3.10.4.2.1 Bit 2 shall be the NSAP address present indicator bit.

4.7.3.10.4.2.2 This bit shall be set to 1 if the called-NSAP address field is present; otherwise, it shall be set to 0.

4.7.3.10.4.3 *Called-NSAP address field*

This field shall have the same coding as 4.7.3.10.3.3.

4.7.3.10.4.4 *Clearing cause field*

4.7.3.10.4.4.1 The next octet shall be the clearing cause field. It shall contain the clearing cause for the release of the connection.

4.7.3.10.4.4.2 The coding of the clearing cause which may be generated by the SSNDPX shall be as given in Table 4-16.

4.7.3.10.4.5 *Diagnostic code field*

The octet following the clearing cause field shall be the diagnostic code field. It shall contain additional information on the reason for the release of the connection. The coding of the diagnostic code field shall be dependent on the clearing cause as in Table 4-16. The diagnostic code field codings when connection release has been initiated by the SSNDPX shall be as defined in Table 4-17.

4.7.3.10.4.6 *Clear user data field*

The field following the diagnostic code field shall be the user data field. If present, this field shall contain not more than 128 octets of user data.

4.7.3.10.5 *CONNECTION RELEASE COMPLETE SNPDU*

The connection release complete SNPDU format shall be as defined in Figure 4-17.

4.7.3.10.6 *DATA SNPDU*

4.7.3.10.6.1 The data SNPDU format shall be as defined in Figure 4-18.

4.7.3.10.6.2 *M-bit*

The M-bit shall be set to 1 if the SNPDU is not the last in an M-bit sequence of data SNPDUs; otherwise, it shall be set to 0.

4.7.3.10.6.3 *SNPDU number field*

Octet 3 shall contain the 8-bit SNPDU number.

4.7.3.10.6.4 *User data field*

The field following the SNPDU number field shall contain the user data. This field shall contain up to a maximum of 503 octets.

4.7.3.10.7 *INTERRUPT DATA SNPDU*

4.7.3.10.7.1 The interrupt data SNPDU format shall be as defined in Figure 4-19.

4.7.3.10.7.2 *Interrupt user data field*

The field following the logical channel number field shall be the interrupt user data field. This field shall contain up to a maximum of 32 octets.

4.7.3.10.8 *INTERRUPT CONFIRM SNPDU*

The interrupt confirm SNPDU format shall be as defined in Figure 4-20.

4.7.3.10.9 *RESET SNPDU*

4.7.3.10.9.1 The reset SNPDU format shall be as defined in Figure 4-21.

4.7.3.10.9.2 *Resetting cause*

Octet 3 shall be the resetting cause field and shall contain the reason for the reset. When the reset has been initiated by the SSNDPX, the coding of the resetting cause field in a reset SNPDU shall be as given in Table 4-16.

4.7.3.10.9.3 *Diagnostic code*

4.7.3.10.9.3.1 Octet 4 shall be the diagnostic code field and shall contain additional information on the reason for the reset. The coding of the diagnostic code field shall be dependent on the resetting cause as given in Table 4-16. The diagnostic code field codings when the reset has been initiated by the SSNDPX shall be as defined in Table 4-17.

4.7.3.10.9.3.2 If the resetting cause field indicates "IWF originated", the diagnostic code field shall have been passed unchanged from the IWF as a result of its having initiated a resetting procedure.

4.7.3.10.10 *RESET CONFIRM SNPDU*

The reset confirm SNPDU format shall be as defined in Figure 4-22.

4.7.3.10.11 *FLOW CONTROL (SUSPEND) SNPDU*

4.7.3.10.11.1 The flow control (suspend) SNPDU format shall be as defined in Figure 4-23.

4.7.3.10.11.2 *Flow control reason field*

Octet 3 shall contain the flow control reason field. This field shall be set to 11001001 (suspend).

4.7.3.10.11.3 *SNPDU number field*

Octet 4 shall contain the 8-bit SNPDU number of the last in-sequence received and accepted data SNPDU.

4.7.3.10.12 *FLOW CONTROL (RESUME) SNPDU*

4.7.3.10.12.1 The flow control (resume) SNPDU format shall be as defined in Figure 4-24.

4.7.3.10.12.2 *Flow control field*

Octet 3 shall contain the flow control reason field. This field shall be set to 11001011 (resume) to resume transmission from the peer.

4.7.3.10.13 *CONNECTION REQUEST/CONFIRM SNPDU FACILITIES FIELD*

4.7.3.10.13.1 The facilities field shall be present only when the facility field present indicator bit is set to one in the connection request, and connection confirm SNPDUs.

4.7.3.10.13.2 The facilities field shall contain one facility element for each facility or group of facilities requested. The first octet of each facility element shall be the facility code field, which shall indicate the code for the facility or facilities requested. The remaining octets of a facility element shall contain the facility parameter field.

4.7.3.10.13.3 *Recommended facilities*

Recommendation.— *The following facilities should be supported by the SSNDPX:*

a) throughput class negotiation;

b) transit delay selection and indication; and

c) fast select.

4.7.3.10.13.4 *Throughput class negotiation (TCN) facility format*

The format of the throughput class negotiation (TCN) facility field shall be as defined in Figure 4-25.

4.7.3.10.13.5 *Transit delay selection and indication (TDSAI) facility format*

The format of the transit delay selection and indication facility field shall be as defined in Figure 4-26.

4.7.3.10.13.6 *Fast select facility format*

The fast select facility format shall be as defined in Figure 4-27.

4.7.3.10.13.7 *Expedited data negotiation*

The expedited data negotiation facility format shall be as defined in Figure 4-28.

4.7.3.10.14 *DIAGNOSTIC CODES*

When connection release/reset is initiated by the SSNDPX, the coding of the diagnostic code field in the connection released and reset SNPDUs shall be as defined in Table 4-17.

4.7.3.11 TIMER VALUES

The timer values shall be as defined in Table 4-20.

4.7.3.12 STATE DIAGRAMS

State diagrams for the following states shall be given below:

a) The state diagram for connection establishment/release of a logical channel shall be as defined in Figure 4-29.

b) The state diagram for reset and flow control states within the data transfer state shall be as defined in Figure 4-30.

4.7.3.13 STATE TABLES

4.7.3.13.1 Action taken in any state of the SSNDPX shall be given by Tables 4-21 to 4-24.

4.7.3.13.2 The following conventions shall be used in the state tables:

a) action taken, which could be:

— normal, as defined in 4.7.3.5 to 4.7.3.8;

— discard the received SNPDU and take no subsequent action as a result of receiving that SNPDU;

— error, as defined in the table;

b) D = the diagnostic code contained in the diagnostic code field of the appropriate SNPDU (connection released, or reset) issued upon the detection of the indicated error.

4.7.3.14 SATELLITE SUBNETWORK DEPENDENT TO LINK LAYER INTERFACE FUNCTIONS

4.7.3.14.1 The interface functions to the link layer shall include the following:

a) generation and reception of link interface data units (LIDUs);

b) routing of received SNPDUs according to connection;

c) selection of further SNPDUs for transmission according to a cyclic order of selecting among the logical channels at a given Q number and giving precedence to interrupt SNPDUs over data SNPDUs of the same Q number; and

d) routing of local acknowledgement (success/fail) for RLS transmission status indication LIDUs.

4.7.3.14.2 The LIDUs passed between the SSNDPX and the link layer shall include the LIDUs defined in Table 4-25.

4.7.3.15 PACKET TO SNPDU MAPPING RULES

4.7.3.15.1 The rules for mapping the ISO 8208 packet fields into the corresponding fields in SNPDU shall be as specified in this section.

4.7.3.15.2 *DTE ADDRESSES*

4.7.3.15.2.1 The called-DTE address and the calling-DTE address fields in the ISO 8208 call request packet shall be directly mapped into the called-DTE address and the calling-DTE address fields in the connection request SNPDU.

4.7.3.15.2.2 The calling- and called-DTE addresses in the ISO 8208 call accepted packet shall not be transmitted across the satellite link.

4.7.3.15.3 *NSAP ADDRESS*

4.7.3.15.3.1 The called address extension and the calling address extension parameter fields in the ISO 8208 call request packet shall be directly mapped into the called NSAP address and the calling NSAP address fields in the connection request SNPDU.

4.7.3.15.3.2 If the called address extension parameter in either the ISO 8208 call accepted packet or clear request packet is equal to the called NSAP address of the corresponding connection request SNPDU, then the called address extension shall not be transmitted across the satellite link; otherwise, it shall be directly mapped into the relevant SNPDU.

4.7.3.15.4 *SUBNETWORK CONNECTION PRIORITY*

4.7.3.15.4.1 The target value for the priority of data on a connection in the ISO 8208 call request packet shall be mapped to the LIDU Q number passed to the link layer as defined in Table 4-26. This value shall be used as long as the connection setup procedure has not been completed.

4.7.3.15.4.2 The selected value for the priority of data on a connection in the ISO 8208 call accepted packet shall be mapped to the LIDU Q number passed to the link layer as defined in Table 4-26. This value shall be used for the remainder of the SNC.

4.7.3.15.4.3 If an invalid priority value is provided in the call request or call accepted packet, the SSNDPX shall reject the call. The diagnostic code in the clear indication packet shall be set to "connection rejection — requested quality of service not available — (permanent condition)".

4.7.3.15.4.4 If priority of data on a connection is not indicated in the call request packet, a default value (SNC priority = 0) shall be used.

4.7.3.15.5 *THROUGHPUT CLASS NEGOTIATION*

4.7.3.15.5.1 The throughput class negotiation shall apply independently for each direction of transfer.

4.7.3.15.5.2 *Throughput*

The throughput subparameter shall be defined as one of the values (unspecified, 75, 150, 300, 600, 1 200, 2 400, 4 800, 9 600, 19 200, 48 000, 64 000 bits/s).

4.7.3.15.6 *TRANSIT DELAY*

4.7.3.15.6.1 The negotiated transit delay shall apply to both directions of transfer.

4.7.3.15.6.2 *Aircraft-originated connection establishment*

4.7.3.15.6.2.1 The SSNDPA shall map directly the transit delay selection and indication (TDSAI) facility in the call request packet to the same facility in the connection request SNPDU.

4.7.3.15.6.2.2 If the SSNDPG receives a call accepted packet from the IWF in response to an incoming call packet with TDSAI facility, it shall forward the same facility in the connection confirm SNPDU to the SSNDPA.

4.7.3.15.6.3 *Ground-originated connection establishment*

If the SSNDPG receives a call request packet with the TDSAI facility from the IWF, the SSNDPG shall forward to the SSNDPA a mean value for the satellite subnetwork transit delay of a data SNPDU of 131 octets in the connection request SNPDU.

4.7.3.15.7 *FAST SELECT*

The fast select facility shall be treated as follows:

a) a call request packet without the fast select facility shall be mapped to a connection request with no restriction on response SNPDU with the fast select (use not permitted) facility;

b) a call request packet with the fast select facility indicating fast select requested with no restriction on response shall be mapped to a connection request with no restriction on response SNPDU without the fast select (use not permitted) facility; and

c) a call request packet with the fast select facility indicating fast select request with restriction on response shall be mapped to a connection request with restriction on response SNPDU without the fast select (use not permitted) facility.

4.7.3.15.8 *EXPEDITED DATA NEGOTIATION*

The expedited data negotiation facility in the call request or call accepted packet shall not be mapped to the corresponding connection request or connection confirm SNPDU unless the facility parameter is set to "no use of expedited data".

4.7.3.15.9 *CAUSE AND DIAGNOSTIC CODES*

4.7.3.15.9.1 Clearing cause, resetting cause and diagnostic code fields shall be transferred without modification from the packets to the corresponding SNPDUs.

4.7.3.15.9.2 If the SSNDPX has initiated the clear or reset procedure, then the clearing cause, the resetting cause and the diagnostic code fields shall be set as defined in Tables 4-16 and 4-17.

4.7.3.15.10 *DATA*

4.7.3.15.10.1 If the user data field in the data packets of an M-bit packet sequence is less than the default data SNPDU maximum user data field length, then these fields shall be concatenated to form an M-bit SNPDU sequence.

4.7.3.15.10.2 If the user data field in the data packets of an M-bit packet sequence is greater than the default data SNPDU maximum user data field length, then these fields shall be segmented to form an M-bit SNPDU sequence.

4.7.3.16 SNPDU TO PACKET MAPPING RULES

4.7.3.16.1 This section shall specify the rules for mapping the SNPDU fields into the corresponding fields in ISO 8208 packet.

4.7.3.16.2 *DTE ADDRESS*

4.7.3.16.2.1 The called DTE address and the calling DTE address fields in the connection request SNPDU shall be directly mapped into the called DTE address and the calling DTE address fields in the incoming call packet.

4.7.3.16.2.2 Both the calling and called DTE address fields shall be regenerated when forwarding a call connected packet, if they were present in the corresponding call request packet.

4.7.3.16.3 *NSAP ADDRESS*

4.7.3.16.3.1 The called NSAP address and the calling NSAP address fields in the connection request SNPDU shall be directly mapped into the called address extension and calling address extension parameter fields in the incoming call packet.

4.7.3.16.3.2 The called NSAP address field in the connection confirm or connection released SNPDU shall be mapped into the called address extension field in the call connected or clear indication packet.

4.7.3.16.4 *PRIORITY*

The Q number associated with the connection request and connection confirm SNPDUs shall be mapped into the target and selected values of the priority of data on a connection field in the priority facility in the ISO 8208 incoming call and call connected packets.

4.7.3.16.5 *THROUGHPUT CLASS NEGOTIATION*

4.7.3.16.5.1 The throughput class negotiation shall apply independently for each direction of transfer.

4.7.3.16.5.2 *Throughput*

The throughput sub-parameter shall be defined as one of the values (unspecified, 75, 150, 300, 600, 1 200, 2 400, 4 800, 9 600, 19 200, 48 000, 64 000 bits/s).

4.7.3.16.6 *TRANSIT DELAY*

4.7.3.16.6.1 The negotiated transit delay shall apply to both directions of transfer.

4.7.3.16.6.2 *Aircraft-originated connection establishment*

4.7.3.16.6.2.1 If the SSNDPG receives a connection request SNPDU from an SSNDPA with TDSAI facility, the SSNDPG shall forward to the IWF a mean value for satellite subnetwork transit delay of a data SNPDU of 131 octets in the incoming call packet.

4.7.3.16.6.2.2 The SSNDPA shall map directly the TDSAI facility in the connection confirm SNPDU to the same facility in the call connected packet.

4.7.3.16.6.3 *Ground-originated connection establishment*

4.7.3.16.6.3.1 The SSNDPA shall map directly the TDSAI facility in the connection request SNPDU to the same facility in the incoming call packet.

4.7.3.16.6.3.2 If the SSNDPG receives a connection confirm SNPDU from the SSNDPA in response to a connection request SNPDU with TDSAI facility, it shall forward the same facility in the call connected packet to the IWF.

4.7.3.16.7 *FAST SELECT*

The fast select facility shall be treated as follows:

a) a connection request with no restriction on response SNPDU with the fast select (use not permitted) facility shall be mapped into an incoming call packet without the fast select facility;

b) a connection request with no restriction on response SNPDU without the fast select (use not permitted) facility shall be mapped into an incoming call packet with the fast select facility with the "no restriction on response" parameter;

c) a connection request with restriction on response SNPDU without the fast select (use not permitted) facility shall be mapped into an incoming call packet with the fast select facility with the "restriction on response" parameter.

4.7.3.16.8 *EXPEDITED DATA NEGOTIATION*

If the expedited data negotiation facility is not present in the connection request or connection confirm SNPDU, this facility with its parameter set to "use of expedited data" shall be added to the corresponding incoming call or call connected packet; otherwise, this facility shall be mapped to the corresponding packet.

4.7.3.16.9 *CAUSE AND DIAGNOSTIC CODES*

Clearing cause, resetting cause and diagnostic code fields shall be transferred without modification from the SNPDUs to the corresponding packets.

4.7.3.16.10 *DATA*

4.7.3.16.10.1 If the user data field in the data SNPDUs of an M-bit SNPDU sequence is less than the default data packet maximum user data field length, then these fields shall be concatenated to form an M-bit packet sequence.

4.7.3.16.10.2 If the user data field in the data SNPDUs of an M-bit SNPDU sequence is greater than the default data packet maximum user data field length, then these fields shall be segmented to form an M-bit packet sequence.

4.7.3.17 CAPACITY

The SSNDPA shall support at least eight simultaneous, independent logical channels.

4.7.4 ISO 8208 DCE protocol operations

4.7.4.1 GENERAL PROVISIONS

4.7.4.1.1 The protocol between the ISO 8208 DCE and the ISO 8208 DTE shall comply with the ISO 8208 second edition.

4.7.4.1.2 *PACKET LAYER ENTITY*

Note.— Within the ISO 8208 DCE there may be more than one DCE/DTE interface, e.g. a GES may be connected to more than one ground ATN router. One such entity exists in the DCE for each DCE/DTE interface. Deciding which entity to use to reach a particular destination is a function performed external to the protocol described here. The protocol defined in 4.7.4 pertains to each packet layer entity in the DCE.

4.7.4.2 CONFORMANCE REQUIREMENTS

4.7.4.2.1 *SUPPORTED SERVICES AND CAPABILITIES*

The following services and capabilities shall be supported:

a) virtual call service;

b) a user data field of up to 128 octets in data packets; and

c) expedited data delivery, i.e. the use of interrupt packets with a user data field of up to 32 octets.

4.7.4.2.2 *SUPPORTED FACILITIES*

The following facilities shall be supported:

a) calling address extension and called address extension; and

b) priority.

Note.— The target and lowest acceptable values for the priority to gain a connection and keep a connection, and the lowest acceptable value for data on a connection, need not be supported.

4.7.4.2.3 *RECOMMENDED FACILITIES*

Recommendation.— *The following facilities should be supported:*

a) throughput class negotiation;

b) transit delay selection and indication;

c) fast select;

d) fast select acceptance.

4.7.4.3 OPERATIONS

4.7.4.3.1 *EXTERNAL INTERACTIONS*

Note.— The initiation of certain DCE procedures is directed by elements outside the ISO 8208 DCE. Likewise, the *occurrence of certain ISO 8208 DCE events are to be reported appropriately. These external interactions include:*

a) requesting of the link layer, transmission of outgoing packets;

b) receiving, from the link layer, incoming packets;

c) accepting requests from the IWF to initiate certain ISO 8208 protocol procedures including:

1) originate a virtual call,

2) accept a virtual call,

3) terminate a virtual call,

4) transfer data and interrupt information, and

5) re-initialize a logical channel.

d) reporting to the IWF the occurrence of certain ISO 8208 protocol events including:

1) receipt of an incoming request to set up a virtual call,

2) receipt of the acceptance of a virtual call setup,

3) termination of a virtual call,

4) receipt of data and interrupt information, and

5) re-initialization of a logical channel.

4.7.4.3.1.1 The ISO 8208 DCE shall accept all ISO 8208 packets from the ISO 8208 DTE without failure.

4.7.4.3.2 *LOGICAL CHANNELS*

Note.— Each virtual call and permanent virtual circuit is assigned a logical channel identifier which is a number in the range from 1 through 4 095. For each virtual call, a logical channel identifier is assigned during the call setup phase from a range of previously agreed-upon logical channel identifiers. For each permanent virtual circuit, a logical channel identifier is assigned in agreement with the DTE. A DCE's use of logical channels is agreed upon for a period of time with the DTE.

4.7.4.3.3 *STATE TRANSITIONS*

4.7.4.3.3.1 The specifications and definitions in ISO 8208 shall apply for format definitions, diagnostic and cause codes, facility registration protocols (if used), and flow control on the ISO 8208 interface.

Note 1.— The ISO 8208 DCE is defined as a state machine. An ISO 8208 packet received from the DTE can cause state transitions, as can a packet received from IWF. The next state transition (if any) that occurs when the DCE receives a packet from the DTE is specified by Tables 4-29 to 4-34. These tables are organized according to the hierarchy in Figure 4-31.

Note 2.— Upon receiving a packet, the action is classified as normal or erroneous under the entry "A =". The resulting state is shown under the entry, "S =".

4.7.4.3.3.2 If a state transition is specified, the action taken shall be as specified in Tables 4-29 to 4-34.

4.7.4.3.4 *DISPOSITION OF PACKETS*

When a packet is received from the DTE, the expressions in parentheses in Tables 4-29 to 4-34 specify whether the packet shall be forwarded or not forwarded to the IWF. If no remark in parentheses is listed or listed as not forwarded, then the packet shall be discarded. The ISO 8208 DCE shall either forward or not forward a packet from the IWF to the DTE in a manner that is compatible with ISO 8208.

4.7.4.3.5 *DIAGNOSTIC AND CAUSE CODES*

For certain conditions, Tables 4-29 to 4-34 indicate a diagnostic code that shall be included in the packet generated when entering the state indicated. The term, "D =", shall define the diagnostic code. When "A = DIAG", the action taken shall be to generate an ISO 8208 diagnostic packet and transfer it to the DTE; the diagnostic code indicated shall define the entry in the diagnostic field of the packet. In the cause field of any packet type, bit 8 of the cause field shall always be set to 0, indicating that the condition was recognized by the ISO 8208 interface.

Note.— The state Tables 4-29 to 4-34 are defined so that the SSNDPX and ISO 8208 DCE functions can operate simultaneously. While asynchronous operation is a suitable implementation strategy, it is not a requirement for the SSNDPX and ISO 8208 DCE operations.

4.7.4.3.6 *DCE TIMER*

Note.— Under certain circumstances, the DTE must respond to a packet issued from the DCE within a given time.

4.7.4.3.6.1 Table 4-35 covers these circumstances and the action that the DCE shall initiate upon the expiration of that time.

4.7.4.4 CAPACITY

The AES DCE shall support at least eight simultaneous, independent logical channels.

4.7.4.5 VC PRE-EMPTION

A logical channel of the lowest priority and the associated virtual call shall be cleared as necessary to accept a request for higher priority service.

Note.— Logical channels and virtual calls have a priority level of 0 unless the ISO 8208 priority facility was invoked during call set up.

4.7.5 Interworking function

4.7.5.1 SSNDPX/IWF INTERFACE

4.7.5.1.1 The ISO 8208 packets exchanged between the IWF and the SSNDPX shall be as defined in Table 4-36.

4.7.5.1.2 *INCOMING CALL PACKET HANDLING*

The IWF shall forward the incoming call packet with the expedited data negotiation facility and "use of expedited data" parameter to the appropriate ISO 8208 DCE entity.

Note.— If the facility parameter is "no use of expedited data", the IWF forwards the incoming call packet with or without this facility.

4.7.5.1.3 *CALL CONNECTED PACKET HANDLING*

If the parameter of the expedited data negotiation facility is set to "use of expedited data" in the call connected packet, the IWF shall forward this facility and its parameter with the packet to the appropriate ISO 8208 DCE entity. For each virtual call, the IWF shall associate the SSNDPX logical channel with the corresponding ISO 8208 DCE logical channel.

Note.— If the expedited data negotiation facility parameter is set to "no use of expedited data", the IWF forwards the call connected packet with or without this facility.

4.7.5.1.4 *CLEAR INDICATION PACKET HANDLING*

4.7.5.1.4.1 The IWF shall disassociate the SSNDPX logical channel with the corresponding ISO 8208 DCE logical channel and forward the packet to the ISO 8208 DCE entity.

4.7.5.1.5 *DATA, INTERRUPT, INTERRUPT CONFIRMATION AND RESET INDICATION PACKET HANDLING*

4.7.5.1.5.1 Data, interrupt, interrupt confirmation and reset indication packets shall be forwarded to the appropriate ISO 8208 DCE entity based on the logical channel association established after the completion of a connection establishment.

4.7.5.2 ISO 8208 DCE/IWF INTERFACE

4.7.5.2.1 The ISO 8208 packets exchanged between the IWF and the ISO 8208 DCE shall be as defined in Table 4-37.

4.7.5.2.2 *CALL REQUEST PACKET HANDLING*

If the call request packet does not contain the expedited data negotiation facility, the IWF shall add this facility with its parameter set to "no use of expedited data" to the packet and shall forward it to the appropriate SSNDPX entity; otherwise, the IWF shall forward the call request packet with this facility and parameter. If the optional called DTE address is invalid, then the IWF shall return a clear indication packet to the ISO 8208 DCE entity.

4.7.5.2.3 *CALL ACCEPTED PACKET HANDLING*

If the call accepted packet does not contain the expedited data negotiation facility, the IWF shall add this facility with its parameter set to "no use of expedited data" to the packet and shall forward it to the appropriate SSNDPX entity; otherwise, the IWF shall forward the call accepted packet with this facility and parameter. For each virtual call, the IWF shall associate the ISO 8208 DCE logical channel with the corresponding SSNDPX logical channel.

4.7.5.2.4 *CLEAR REQUEST PACKET HANDLING*

The IWF shall disassociate the ISO 8208 DCE logical channel with the corresponding SSNDPX logical channel and forward the packet to the SSNDPX entity.

4.7.5.2.5 *DATA, INTERRUPT, INTERRUPT CONFIRMATION AND RESET REQUEST PACKET HANDLING*

Data, interrupt, interrupt confirmation and reset request packets shall be forwarded to the appropriate SSNDPX entity based on the logical channel association established after the completion of a connection establishment.

4.7.5.3 (Reserved)

4.7.5.4 ISO 8208 LOGICAL CHANNEL AND SSNDPX LOGICAL CHANNEL ASSOCIATION

Note.— ISO 8208 DCE logical channel identifier and the SSNDPX logical channel number of an SNC need not be identical.

4.7.5.5 DATA TRANSFER PROCEDURES

4.7.5.5.1 *FLOW CONTROL*

Flow control shall be applied between the SSNDPX and the ISO 8208 DCE to prevent storage overflow.

4.7.5.6 CAUSE AND DIAGNOSTIC CODE

4.7.5.6.1 The IWF shall replace the cause "local procedure error" in ISO 8208 packets received from the DCE, by the cause "remote procedure error" before forwarding them to the SSNDPX. The IWF shall replace the cause "local link error" in an SNPDU received from the SSNDPX by the cause "network congestion" before forwarding them to the DCE. All other causes shall be transferred without modification.

4.7.5.6.2 Diagnostic codes shall be transferred without modification.

4.7.6 Management interface

4.7.6.1 AES MANAGEMENT INTERFACE

4.7.6.1.1 The changes in log-on status conveyed from the AES management to the SSNL shall be as defined in 4.9.2.1.1.

4.7.6.1.2 When the AES either logs-off or otherwise terminates communication with a GES, the AES SSNL shall clear all connections with this GES.

4.7.6.1.3 *CONNECTIVITY NOTIFICATION EVENT*

4.7.6.1.3.1 The CN function shall be performed by the CN entity.

4.7.6.1.3.1 *bis* *Join and leave events*

The AES shall provide join and leave event messages to the aircraft routing function to indicate that the air-ground data link is either available or not available, respectively. The join and leave messages shall include sufficient information for the routing function to determine the address(es) of the DTE(s) attached to the log-on GES.

Note.— This may be accomplished, for example, by passing the GES/satellite ID from the AES to the routing function containing a lookup table for translation to DTE address(es), or by passing the DTE address(es) directly from the AES to the routing function.

4.7.6.1.3.2 (Reserved)

4.7.6.1.3.3 (Reserved)

4.7.6.2 GES MANAGEMENT INTERFACE

4.7.6.2.1 The changes in log-on status conveyed from the GES management to the SSNL shall be as defined in 4.10.3.2.

4.7.6.2.2 When the AES logs off from the GES, the SSNL shall clear all connections associated with the AES, and shall release all resources associated with these SNCs. In addition, the GES shall provide to the attached ATN ground routers a leave event indication referencing the 24-bit ICAO aircraft identifier.

4.8 CIRCUIT-MODE SERVICES

4.8.1 AMS(R)S circuit-mode general requirements

Note.— The AMS(R)S circuit-mode service is a communications service between aircraft and ground facilities using satellite links as one of the connecting media. The AMS(R)S circuit-mode service provides a means to establish and maintain a non-shared switched circuit between aircraft and ground users on demand. The primary purpose of the circuit-mode service is to provide for safety voice communications. A switched circuit is held for the duration of the call unless automatically pre-empted in order to reassign resources for a higher priority call attempt. AMS(R)S switched circuits may be interconnected with one or more terrestrial communications facilities in tandem with the AMS(R)S subnetwork. These facilities may include safety circuit-switched networks or dedicated circuits.

4.8.1.1 *AMS(R)S circuit-mode services.* Circuit-mode AMS(R)S communications services shall be provided to Level 3 and 4 AESs and shall consist of distress, urgency, flight safety and other messages related to meteorology and flight regularity.

Note.— Non-AMS(R)S circuit switched voice and data service for non-safety communications may be supported by AMS(R)S on a not-to-interfere basis provided that the provisions of 4.8.3.2 are complied with.

4.8.1.2 *Order of importance.* AMS(R)S services for ATS communications shall have precedence over non-AMS(R)S communications.

4.8.1.3 *Non-AMS(R)S communications.* Non-AMS(R)S communications shall not interfere with AMS(R)S communications.

4.8.2 Circuit-mode system architecture

4.8.2.1 AES circuit-mode services shall be able to specify a particular GES to be used in air-origination calls and shall not be restricted to its log-on GES. Conversely, a ground originated call arriving from the terrestrial network of any GES which has current log-on information of the AES shall be completed by that GES rather than the GES to which the AES is logged on.

4.8.2.2 *Circuit-mode link layer signalling interface.* The AES and GES circuit-mode service procedures shall use the AMS(R)S link layer to exchange signalling information. This information shall be conveyed in circuit-mode — link interface data units (CM-LIDU). As a link service user, the AMS(R)S circuit-mode procedures shall use the services of the link layer interface defined in 4.5 and 4.6. Each CM-LIDU shall be comprised of specific link interface control information (LICI) parameters required by the link layer service. The CM-LIDUs and their relevant LICI parameters are defined in Table 4-38.

4.8.2.3 CIRCUIT-MODE TELEPHONY INTERWORKING INTERFACE

Note.— Guidance material on the circuit-mode telephony interworking interface is contained in Attachment A to Part I.

4.8.2.3.1 The AES and GES circuit-mode service procedures shall interwork with external telephony networks through an interworking interface comprising a standardized set of interworking telephony events which conform to ITU CCITT Recommendations Q.601 to Q.608. The set of interworking telephony events used by the circuit-mode procedures, and the requirements for mapping parameters between the events and corresponding CM-LIDUs, shall be as defined in Tables 4-39 to 4-42.

Note.— Details of ITU CCITT Recommendations Q.601 to Q.608 are contained in CCITT Blue Book, Volume VI — Fascicle VI.6.

4.8.2.4 OTHER AES CIRCUIT-MODE SYSTEM INTERFACES

4.8.2.4.1 *AES management interface.* The specific information exchanged between AES circuit-mode services and AES management shall be as defined in 4.9.

4.8.2.4.2 *AES voice codec external interface.* The AES external voice interface shall convey bi-directional voice information in a form compatible with aircraft-specific audio systems.

4.8.2.5 OTHER GES CIRCUIT-MODE SYSTEM INTERFACES

4.8.2.5.1 *GES management interface.* The specific information exchanged between GES circuit-mode services and GES management shall be as defined in 4.10.

4.8.2.5.2 *Voice codec external interface.* The GES external voice interface shall convey bi-directional voice information in a form compatible with terrestrial network audio channels.

4.8.3 AMS(R)S service requirements

4.8.3.1 *Connectivity.* The AMS(R)S service shall support the on-demand establishment of switched circuits between any aircraft within the service area of a GES and the terrestrial networks serving the GES. The AMS(R)S service shall allow a circuit switched transaction to be established between an aircraft and a terrestrial network via a GES other than the GES to which the aircraft is logged on.

4.8.3.2 *Priority and pre-emption.* AMS(R)S calls shall have priority over all non-AMS(R)S calls and shall be capable of pre-empting non-AMS(R)S calls if required to gain immediate access to the circuit-mode service. AMS(R)S calls shall be established and maintained in accordance with the priority levels defined in Table 4-43. An AMS(R)S call with a higher service priority than an AMS(R)S call in progress shall be able to preempt the lower service priority call if necessary to gain immediate access to circuit-mode service. All AMS(R)S call attempts crossing the interface between a GES and a terrestrial network shall be identified as to the associated priority category.

4.8.3.3 *Grade-of-service.* The GES shall have available sufficient C channel resources such that an air or ground-originated call attempt received at the GES shall experience a probability of blockage within the GES of no more than 0.01. Available GES C channel resources shall include all pre-emptable resources (e.g. those in use by non-safety users).

4.8.4 AMS(R)S performance requirements

4.8.4.1 CALL PROCESSING DELAYS

Note 1.— Guidance material on access delay performance requirements for the AMS(R)S subnetwork and how they impact planning of ATS terrestrial networks is contained in Attachment A to Part I.

Note 2.— Figure A5-1a) shows the "access request" CM-LIDU which is associated with one of the two different access request SUs shown in Figures A2-45 and A2-46. The first is the baseline standard, with the second providing slightly less connection establishment delay.

4.8.4.1.1 *AIR-ORIGINATIONS*

4.8.4.1.1.1 *GES signalling transit delay.* The maximum time delay for a GES to present a call origination event (FITE 18, *see* Table 4-42) to the terrestrial network interworking interface after the first arrival of all AES call information at the GES link layer shall be 1.0 second (95th percentile).

Note.— AES call information is contained within the "access request" CM-LIDU received via the R channel and in the CM-LIDU received via the C channel. Figures A2-45 and A2-46 show two access request SUs.

4.8.4.1.1.2 *GES C channel assignment delay.* The maximum time delay for a GES to enqueue a "C channel assignment" CM-LIDU for service by the P channel link layer after an "access request" CM-LIDU has arrived at the GES link layer shall be 1.5 seconds (95th percentile).

4.8.4.1.1.3 *AES C channel assignment response delay.* The maximum time delay for an AES to begin transmitting a C channel carrier after a "C channel assignment" CM-LIDU has arrived at the AES link layer shall be 1.0 second (95th percentile).

4.8.4.1.2 *GROUND-ORIGINATIONS*

4.8.4.1.2.1 *GES C channel assignment delay.* The maximum time delay for a GES to enqueue a "C channel assignment" CM-LIDU for service by the P channel link layer after a call origination event (FITE 18, see Table 4-41) has arrived at the terrestrial network interworking interface shall be 1.5 seconds (95th percentile).

4.8.4.1.2.2 *AES C channel assignment response delay.* The maximum time delay for an AES to begin transmitting a C channel carrier after both a "call announcement" CM-LIDU and a "C channel assignment" CM-LIDU have arrived at the AES link layer shall be 1.0 second (95th percentile).

Note.— The AES procedures for ground-originated calls require an AES to await the successful receipt of both CM-LIDUs before C channel transmission can begin. These procedures include error-recovery logic to handle their potential receipt out of normal order.

4.8.4.2 TRANSFER DELAY

4.8.4.2.1 The total allowable transfer delay within the AMS(R)S subnetwork on a C channel operating at 21.0 kbits/s shall be no more than 0.485 second.

4.8.4.2.2 The maximum transfer delay component that can be attributed to the AES or GES shall be 0.080 second for each.

Note 1.— Fixed transfer delay components of 0.285 second and 0.040 second are allotted to RF propagation delay (worst case path geometry) and vocoder frame emission delay respectively. Allocating 0.040 second for vocoder frame emission delay provides for worst case synchronization where the first 0.020 second vocoder speech frame is delayed by an additional C channel interleaver block.

Note 2.— Total transfer delay for the AMS(R)S subnetwork is defined as the elapsed time commencing at the instant that speech is presented to the AES or GES and concluding at the instant that the speech enters the interconnecting network of the counterpart GES or AES. This delay includes vocoder processing time, physical layer delay, RF propagation delay and any other delays within the AMS(R)S subnetwork.

4.8.4.3 MISROUTING

The probability of misrouting caused by internal processing or signalling errors within the GES shall not exceed 1 in 10^6.

Note.— Misrouting can occur if the GES misinterprets (1) the network-ID or ground address digits contained in an "access request — telephone" CM-LIDU (for air-originations) or (2) the AES-ID or terminal-ID contained in a FITE 18 received from the interworking interface with the terrestrial network (for ground-originations).

4.8.5 Circuit-mode voice encoding/decoding

4.8.5.1 *Circuit-mode voice.* For circuit-mode voice, the appropriate voice encoding/decoding algorithm for the AES and GES shall be used for each C channel as indicated below.

4.8.5.1.1 *21.0 kbits/s C channel.* A 9.6 kbits/s encoding/decoding algorithm (see Appendix 7 to Chapter 4) shall be used with a 21 kbits/s C channel (see 4.4.5).

Note.— The voice encoding algorithm is subject to BT (formerly British Telecom) patent rights and copyrights. BT has agreed to grant royalty-free non-exclusive licences under such patent rights and copyrights to all manufacturers of AES and GES implementations for civil aeronautical mobile satellite communications only (which include AMSS and AMS(R)S communications, as provided in Chapter 4). These manufacturers should enter into a royalty-free licence agreement with BT Laboratories prior to incorporating the algorithm in equipments for civil aeronautical mobile satellite communications.

4.8.5.1.2 *8.4 kbits/s C channel.* A 4.8 kbits/s encoding/decoding algorithm shall be used with an 8.4 kbits/s C channel (see 4.4.5).

Note.— Information on technical characteristics of the industry standard 4.8 kbits/s encoding/decoding algorithm is contained in the document "Low Level Description", version number 1.5, dated 3 May 1996, and developed by Digital Voice Systems Inc. (DVSI), United States.

The 4.8 kbits/s encoding/decoding technology described in the document is subject to DVSI patent rights and copyrights. Manufacturers must enter into a licence agreement with DVSI prior to obtaining a detailed description of the algorithm before incorporation in equipment operating in the AMSS service. By letter to ICAO dated 10 November 1998, DVSI confirmed its commitment to license the technology for the manufacture and sale of aeronautical equipment under reasonable terms and conditions, negotiated on a non-discriminatory basis.

4.8.6 AMS(R)S circuit-mode procedures

The AMS(R)S circuit-mode procedures comprise the following four functional areas:

a) For the AES circuit-mode services:

   i) AES outgoing logic procedure (for air-originations); and

   ii) AES incoming logic procedure (for ground-originations).

b) For the GES circuit-mode services:

   i) GES outgoing logic procedure (for ground-originations); and

   ii) GES incoming logic procedure (for air-originations).

4.8.6.1 AMS(R)S CIRCUIT-MODE PROCEDURES

Note 1.— It is assumed that an AMS(R)S circuit-mode service procedure will encode or interpret the relevant parameters of any CM-LIDU being transmitted or received without specifically stating the exact code values in the procedures contained herein. Specific requirements for parameter encoding can be found in the interworking telephony events mapping requirements defined in Appendix 5 to Chapter 4.

Note 2.— The term "C channel resources" includes all required C channel hardware and sufficient transmitter power to maintain a C channel.

4.8.6.1.1 *AES CIRCUIT-MODE LOGIC*

Note.— The requirements for mapping between interworking telephony events and CM-LIDUs by the AES outgoing and incoming procedures are defined in Appendix 5 to Chapter 4, Figures A5-1 to A5-11 and A5-12 to A5-18, respectively. Circuit-mode configuration parameters (e.g. those used in 4.8.6.1.1.1) are defined in Appendix 6 to Chapter 4.

4.8.6.1.1.1 *AES outgoing circuit-mode procedure.* Receipt of an "AMS(R)S call origination" event (FITE 18) at the interworking interface shall cause AES circuit-mode services to assign a unique application reference number to the call. AES circuit-mode services shall then do the following:

a) if sufficient AES C channel resources are not available and the blockage is attributable to calls operating at a C channel priority equal to or greater than the current call attempt, AES circuit-mode services shall return a "call unsuccessful — network congestion" event (BITE 12) to the interworking interface and terminate all activities for the call; or

b) if sufficient C channel resources are available or if at least one of the calls causing the blockage is operating at a C channel priority less than the current call attempt, AES circuit-mode services shall do the following and then await a C channel assignment from GES circuit-mode services:

   1) if the call priority is distress/urgency, AES circuit-mode services shall forward to the link layer nA21 "access request — telephone" CM-LIDUs; or

   2) if the call priority is flight safety, AES circuit-mode services shall forward to the link layer nA22 "access request — telephone" CM-LIDUs; or

   3) if the call priority is regularity/meteorological, the AES circuit-mode services shall forward to the link layer nA23 "access request — telephone" CM-LIDUs.

4.8.6.1.1.1.1 AES circuit-mode services shall do the following while awaiting a response from GES circuit-mode services:

a) if a response is not received from GES circuit-mode services within tA50 seconds after the transmission of the latest "access request — telephony" CM-LIDU, the AES shall command the selection of an R channel frequency and then shall transmit the original quantity of CM-LIDUs; provided that the total number of retransmissions of the CM-LIDU series does not exceed four. If, tA50 seconds after the fourth retransmission of the CM-LIDU series, no response has been received, AES circuit-mode services shall return a "call unsuccessful — line out of service" event (BITE 17) to the interworking interface and terminate all activities for the call; or

b) if a "clear forward" event (FITE 22) is received at the interworking interface, AES circuit-mode services shall forward to the link layer a "call progress — channel release" CM-LIDU via the R channel and terminate all activities for the call; or

c) if the call attempt is to be pre-empted by a higher priority call, AES circuit-mode services shall forward a "clear back" event (BITE 25) to the interworking interface, forward to the link layer a "call progress — channel release" CM-LIDU via the R channel, and then terminate all activities for the call; or

d) if any of the following responses are received, AES circuit-mode services shall do the following:

1) if either a "call progress — call attempt result" CM-LIDU or a "call progress — channel release" CM-LIDU are received, AES circuit-mode services shall forward a "clear back" event (BITE 25) or an appropriate "call unsuccessful" event (BITE 14, 15, 16, 17, or 20) to the interworking interface as determined by the cause location, cause class, and cause value parameters received in the CM-LIDU. AES circuit-mode services shall then terminate all activities for the call; or

2) if a "C channel assignment" CM-LIDU is received, AES circuit-mode services shall request AES management to allocate C channel resources and activate a C channel unit on the assigned frequency at the C channel Q number value as per Table 4-43.

Note.— This is to say that the Q number of the C channel is inferred from the Q number used in the initial circuit-mode call signalling at the link layer.

AES circuit-mode services shall then forward to the link layer a "call information — service address" CM-LIDU every tA29 seconds indefinitely and interconnect the C channel audio interface with that of the calling terminal.

Note.— The call information conveyed by the "call information — service address" CM-LIDU is redundant with that conveyed by the "access request" CM-LIDU, when the access request procedure used is not the "general access request" procedure. In this case, this information is used to maintain compatibility with the circuit continuity test procedure in use by those GESs which are providing AMSS services to non-AMS(R)S users; and it will not be submitted to digit analysis by a GES.

4.8.6.1.1.1.2 If no response is received from GES circuit-mode services within tA28 seconds after C channel unit activation, AES circuit-mode services shall forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band, return a "call unsuccessful — line out of service" event (BITE 17) to the interworking interface, and terminate all activities for the call; otherwise, AES circuit-mode services shall do the following:

a) if one or more "call progress — test" CM-LIDUs are received, AES circuit-mode services shall ignore them; or

b) if one or more "call progress — channel release" CM-LIDUs are received, or if a "clear forward" event (FITE 22) is received at the interworking interface, then AES circuit-mode services shall forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band, return an appropriate telephony event (BITE 14, 15, 16, 17, 20, or 25) to the interworking interface, and terminate all activities for the call; or

c) if a "call progress — connect" CM-LIDU is received, or if the CM-LIDU arrives preceded by either a "call progress — test" CM-LIDU or a "call progress — call attempt result" CM-LIDU which was previously received within tA28 seconds after C channel unit activation, AES circuit-mode services shall do the following:

1) ensure that the repetitive transmission of the "call information — service address" CM-LIDU has ceased; and

2) forward an "answer" event (BITE 22) to the interworking interface and forward to the link layer a positive "telephony acknowledge" CM-LIDU via the C channel sub-band. If any additional "call progress — connect" CM-LIDUs are received subsequent to the initial "call progress — connect" CM-LIDU, AES circuit-mode services shall respond to each by forwarding to the link layer a positive "telephony acknowledge" CM-LIDU to GES circuit-mode services; or

Note.— At this point the end-to-end call is established.

d) if a "call progress — call attempt result" CM-LIDU (encoded to indicate an "address complete" event) is received, or if it arrives preceded by a "call progress — test" CM-LIDU which was previously received within tA28 seconds after C channel unit activation, AES circuit-mode services shall do the following:

1) ensure that the repetitive transmission of the "call information — service address" CM-LIDU has ceased; and

2) forward an "address complete" event (BITE 5) to the interworking interface and forward to the link layer a positive "telephony acknowledge" CM-LIDU via the

C channel sub-band. If any additional "call progress — call attempt result" CM-LIDUs are received subsequent to the initial "call progress — call attempt result" CM-LIDU, AES circuit-mode services shall respond to each by forwarding to the link layer a positive "telephony acknowledge" CM-LIDU to GES circuit-mode services; or

e) if C channel resources are pre-empted for a higher priority call, AES circuit-mode services shall forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band, return a "clear back" event (BITE 25) to the interworking interface, and terminate all activities for the call; or

f) if the C channel sub-band link layer commands the call be terminated, AES circuit-mode services shall forward a "clear back" event (BITE 25) to the interworking interface and terminate all activities for the call.

4.8.6.1.1.2 *AES incoming circuit-mode procedure.* This procedure shall be defined by the following interrelated procedures:

a) AES incoming circuit-mode call initiation — 4.8.6.1.1.2.1;

b) AES incoming C channel continuity check — 4.8.6.1.1.2.2;

c) AES incoming aircraft completion — 4.8.6.1.1.2.3; and

d) AES incoming C channel maintenance — 4.8.6.1.1.2.4.

4.8.6.1.1.2.1 *AES incoming circuit-mode call initiation.* Upon receipt of either a "call announcement" or "C channel assignment" CM-LIDU with a unique application reference number, AES circuit-mode services shall do the following:

a) if a "C channel assignment" was received, AES circuit-mode services shall forward to the link layer a negative "telephony acknowledge" CM-LIDU (encoded to indicate that the "call announcement" CM-LIDU is missing) via the R channel and do the following:

   1) if neither a related "call announcement" CM-LIDU or a "call progress — channel release" CM-LIDU are received within tA27 seconds of the transmission of the latest negative "telephony acknowledge" CM-LIDU, AES circuit-mode services shall forward to the link layer the negative "telephony acknowledge" CM-LIDU via the R channel and await their arrival for an additional tA27 seconds; provided that the total number of repetitions of the "telephony acknowledge" CM-LIDU does not exceed four. If neither of the aforementioned CM-LIDUs are received within tA27 seconds after the fourth repetition of the "telephony acknowledge" CM-LIDU, AES circuit-mode services shall forward to the link layer a "call progress — call attempt result" CM-LIDU via the R channel and terminate all activities for the call; or

   2) if a "call progress — channel release" CM-LIDU is received within tA27 seconds after the latest transmission of the "telephony acknowledge" CM-LIDU, AES circuit-mode services shall terminate all activities for the call; or

   3) if the call attempt is to be preempted for a higher priority call, AES circuit-mode services shall forward to the link layer a "call progress — call attempt result" CM-LIDU via the R channel and terminate all activities for the call; or

   4) if the related "call announcement" CM-LIDU is received within tA27 seconds after the latest transmission of the "telephony acknowledge" CM-LIDU, AES circuit-mode services shall do the following:

      i) if the called terminal is occupied with a call at a priority higher than or equal to the current call attempt, or if C channel resources are not available, AES circuit-mode services shall forward to the link layer a "call progress — call attempt result" CM-LIDU via the R channel and terminate all activities for the call; or

      ii) if the called terminal and C channel resources are both available, AES circuit-mode services shall request AES management to allocate C channel resources and activate a C channel unit on the assigned frequency at the C channel Q number value as per Table 4-43.

      Note.— This is to say that the Q number of the C channel shall be inferred from the Q number used in the initial circuit-mode call signalling at the link layer.

      AES circuit-mode services shall then forward to the link layer a "call progress — test" CM-LIDU and perform the AES incoming C channel continuity check procedure in 4.8.6.1.1.2.2; or

b) if a "call announcement" CM-LIDU was received, AES circuit-mode services shall do the following:

   1) if a "call progress — channel release" CM-LIDU is received within tA25 seconds after receipt of the "call announcement" CM-LIDU, AES circuit-mode services shall terminate all activities for the call; or

   2) if neither a "C channel assignment" CM-LIDU or a "call progress — channel release" CM-LIDU are received within tA25 seconds after receipt of the "call announcement" CM-LIDU, AES circuit-mode

services shall forward to the link layer a negative "telephony acknowledge" CM-LIDU (encoded to indicate that the "C channel assignment" CM-LIDU is missing) via the R channel and await their arrival for an additional tA27 seconds. If neither of the CM-LIDUs arrive after tA27 seconds, AES circuit-mode services shall again forward to the link layer the negative "telephony acknowledge" CM-LIDU and await an additional tA27 seconds; provided that the total number of repetitions of the negative "telephony acknowledge" CM-LIDU does not exceed four. If neither of the CM-LIDUs are received within tA27 seconds after the fourth repetition of the negative "telephony acknowledge" CM-LIDU, AES circuit-mode services shall forward to the link layer a "call progress — call attempt result" CM-LIDU via the R channel and terminate all activities for the call; or

3) if the call attempt is to be pre-empted for a higher priority call, AES circuit-mode services shall forward to the link layer a "call progress — call attempt result" CM-LIDU via the R channel and terminate all activities for the call; or

4) if a "C channel assignment" CM-LIDU is received within either tA25 seconds after receipt of the "call announcement" CM-LIDU or tA27 seconds after receipt of the transmission of the latest negative "telephony acknowledge" CM-LIDU, AES circuit-mode services shall do the following:

   i) if the called terminal is occupied with a call at a priority higher than or equal to the current call attempt, or if C channel resources are not available, AES circuit-mode services shall forward to the link layer a "call progress — call attempt result" CM-LIDU via the R channel and terminate all activities for the call; or

   ii) if the called terminal and C channel resources are both available, AES circuit-mode services shall request AES management to allocate the resources at a C channel Q number value as per Table 4-43 and activate a C channel unit on the assigned frequency. AES circuit-mode services shall then forward to the link layer a "call progress — test" CM-LIDU and perform the AES incoming C channel continuity check procedure in 4.8.6.1.1.2.2.

4.8.6.1.1.2.2 *AES incoming C channel continuity check.* Where required elsewhere in 4.8, AES circuit-mode services shall perform a C channel continuity check by doing the following:

a) if neither a "call progress — test" CM-LIDU or a "call progress — channel release" CM-LIDU are received within tA26 seconds after the most recent "call progress — test" CM-LIDU has been forwarded, AES circuit-mode services shall forward to the link layer another "call progress — test" CM-LIDU until any of the following occur:

   1) if neither a "call progress — test" CM-LIDU or a "call progress — channel release" CM-LIDU are received within tA41 seconds after activation of the C channel unit, AES circuit-mode services shall stop forwarding "call progress — test" CM-LIDUs, shall then forward to the link layer a "call progress — call attempt result" CM-LIDU via the R channel and terminate all activities for the call; or

   2) if a "call progress — channel release" CM-LIDU is received within tA41 seconds after activation of the C channel unit, AES circuit-mode services shall terminate all activities for the call; or

   3) if the C channel is to be pre-empted for a higher priority call, AES circuit-mode services shall forward to the link layer a "call progress — call attempt result" CM-LIDU via the R channel and terminate all activities for the call; or

   4) if a "call progress — test" CM-LIDU is received within tA41 seconds after C channel unit activation, AES circuit-mode services shall enable the circuit path between the C channel unit and the forward circuit of the aircraft network. AES circuit-mode services shall then forward to the link layer a positive "telephony acknowledge" CM-LIDU via the C channel sub-band, forward an "AMS(R)S call origination" event (FITE 18) to the interworking interface and await completion of the call to the called terminal as per the AES incoming aircraft completion procedure defined in 4.8.6.1.1.2.3.

4.8.6.1.1.2.3 *AES incoming aircraft completion.* Where required elsewhere in 4.8, AES circuit-mode services shall do the following in order to complete a call across the aircraft network to the called terminal:

a) if one or more "call progress — test" CM-LIDUs are received, AES circuit-mode services shall forward to the link layer a positive "telephony acknowledge" CM-LIDU via the C channel sub-band; or

b) if an "answer" event (BITE 22) is not received from the interworking interface within tA42 seconds after forwarding the "AMS(R)S call origination" event (FITE 18), AES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface, forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band and terminate all activities for the call; or

c) if a "call progress — channel release" CM-LIDU is received within tA42 seconds after forwarding the "AMS(R)S call origination" event (FITE 18), or if the C channel is to be pre-empted for a higher priority call, then AES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface, forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band and terminate all activities for the call; or

d) if an "answer" event (BITE 22) is received from the interworking interface within tA42 seconds after forwarding the "AMS(R)S call origination" event (FITE 18), AES circuit-mode services shall forward to the link layer a "call progress — connect" CM-LIDU and perform the AES incoming C channel maintenance procedure defined in 4.8.6.1.1.2.4.

4.8.6.1.1.2.4 *AES incoming C channel maintenance.* Where required elsewhere in 4.8, AES circuit-mode services shall allow the end-to-end connection to continue while doing the following to maintain a C channel:

a) if, within tA26 seconds after transmission of the latest "call progress — connect" CM-LIDU, neither a positive "telephony acknowledge" CM-LIDU is received or a "clear back" event (BITE 25) is received from the interworking interface, AES circuit-mode services shall again forward to the link layer the "call progress — connect" CM-LIDU via the C channel sub-band; or

b) if, within tA30 seconds after transmission of the first "call progress — connect" CM-LIDU, neither a positive "telephony acknowledge" CM-LIDU is received or a "clear back" event (BITE 25) is received from the interworking interface, AES circuit-mode services shall stop forwarding the "call progress — connect" CM-LIDU, forward a "clear forward" event (FITE 22) to the interworking interface, forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band and terminate all activities for the call; or

c) if, within tA30 seconds after transmission of the first "call progress — connect" CM-LIDU, a "call progress — channel release" CM-LIDU is received, AES circuit-mode services shall stop forwarding the "call progress — connect" CM-LIDU, forward a "clear forward" event (FITE 22) to the interworking interface, forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band and terminate all activities for the call; or

d) if the C channel is to be pre-empted for a higher priority call, AES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface, forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band, and terminate all activities for the call; or

e) if one or more positive "telephony acknowledge" CM-LIDUs are received, AES circuit-mode services shall stop forwarding the "call progress — connect" CM-LIDU and do the following while allowing the C channel to function:

Note.— This is the location in the logic procedure at which the end-to-end voice channel is ready for use and the air and ground users can begin conversation.

1) if a "clear back" event (BITE 25) is received from the interworking interface, AES circuit-mode services shall forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band and terminate all activities for the call; or

2) if a "call progress — channel release" CM-LIDU is received, AES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface, forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band and terminate all activities for the call; or

3) if the C channel is to be pre-empted for a higher priority call, AES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface, forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band and terminate all activities for the call; or

Note.— The above logic transitions monitor for call clearing via either a normal call clearing action or an AES-initiated C channel pre-emption.

f) if the C channel sub-band link layer commands the call be terminated, AES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface and terminate all activities for the call.

4.8.6.1.2 *GES CIRCUIT-MODE LOGIC*

Note.— The requirements for mapping between interworking telephony events and CM-LIDUs by the GES outgoing and incoming procedures are defined in Appendix 5 to Chapter 4, Figures A5-19 to A5-27 and A5-28 to A5-40, respectively.

4.8.6.1.2.1 *GES outgoing circuit-mode procedure.* This procedure shall be defined by the following interrelated procedures:

a) GES outgoing circuit-mode call initiation — 4.8.6.1.2.1.1;

b) GES outgoing C channel establishment — 4.8.6.1.2.1.2;

c) GES outgoing C channel continuity check — 4.8.6.1.2.1.3;

d) GES outgoing C channel maintenance — 4.8.6.1.2.1.4; and

e) GES outgoing C channel release guard — 4.8.6.1.2.1.5.

4.8.6.1.2.1.1 *GES outgoing circuit-mode call initiation.* Receipt of an "AMS(R)S call origination" event (FITE 18) at the interworking interface shall cause GES circuit-mode services to assign a unique application reference number to the call. If the AES is not logged on, GES circuit-mode services shall forward a "call unsuccessful — send error indication" event (BITE 20) to the interworking interface and terminate all activities for the call; otherwise, GES circuit-mode services shall request GES management to assign C channel resources to the call at the C channel Q number value as per Table 4-43.

Note.— This is to say that the Q number of the C channel shall be inferred from the Q number used in the initial circuit-mode call signalling at the link layer.

GES circuit-mode services shall then do the following:

a) if a "clear forward" event (FITE 22) is received at the interworking interface, GES circuit-mode services shall terminate all activities for the call; or

b) if C channel resources are not available, GES circuit-mode services shall forward a "call unsuccessful — network congestion" event (BITE 12) to the interworking interface and terminate all activities for the call; or

c) if C channel resources are available, GES circuit-mode services shall forward to the link layer a "call announcement" CM-LIDU followed immediately by a "C channel assignment" CM-LIDU. GES circuit-mode services shall then request GES management to activate the previously assigned C channel unit on the assigned frequency and then establish the C channel as per 4.8.6.1.2.1.2.

4.8.6.1.2.1.2 *GES outgoing C channel establishment.* Where required elsewhere in 4.8, GES circuit-mode services shall do the following to establish a C channel for use in a ground-origination:

a) if, within tG16 seconds after the latest transmission of either the "call announcement" or "C channel assignment" CM-LIDUs, a negative "telephony acknowledge" CM-LIDU is received, GES circuit-mode services shall again forward to the link layer the missing CM-LIDU indicated in the received CM-LIDU and await an additional tG16 seconds; or

b) if nothing is received from AES circuit-mode services within tG16 seconds after the latest transmission of either the "call announcement" or "C channel assignment" CM-LIDU, GES circuit-mode services shall again forward to the link layer both of the CM-LIDUs and await an additional tG16 seconds. If, after the additional tG16 second period, nothing is received, GES circuit-mode services shall forward a "call unsuccessful — line out of service" event (BITE 17) to the interworking interface and forward to the link layer a "call progress — channel release" CM-LIDU via the P channel. If the from-aircraft carrier is not present, terminate all activities for the call; otherwise, if the C channel from-aircraft carrier does not terminate within tG23 seconds after the first "call progress — channel release" CM-LIDU was forwarded, GES circuit-mode services shall again forward the CM-LIDU. If the from-aircraft carrier terminates during either tG23 second period, GES circuit-mode services shall terminate all activities for the call. If the from-aircraft carrier does not terminate by the expiry of the second tG23 second period, GES circuit-mode services shall terminate all activities for the call; or

Note.— The status of an unterminated from-aircraft carrier should be posted to a monitoring function.

c) if a "call progress — call attempt result" CM-LIDU is received, GES circuit-mode services shall forward an appropriate "call unsuccessful" event (BITES 12, 16, or 17) to the interworking interface. Also, GES circuit-mode services shall wait tG23 seconds for the C channel from-aircraft carrier to terminate. If the from-aircraft carrier is not present, terminate all activities for the call; otherwise, if the from-aircraft carrier terminates by the end of the period, GES circuit-mode services shall terminate all activities for the call. If the from-aircraft carrier does not terminate within the same period, GES circuit-mode services shall terminate all activities for the call at the end of the period; or

Note.— The status of an unterminated from-aircraft carrier should be posted to a monitoring function.

d) if a "clear forward" event (FITE 22) is received at the interworking interface, GES circuit-mode services shall forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band followed by a "call progress — channel release" CM-LIDU via the P channel. GES circuit-mode services shall then perform the GES outgoing C channel release guard procedure defined in 4.8.6.1.2.1.5; or

e) if a "call progress — test" CM-LIDU is received, GES circuit-mode services shall forward to the link layer a "call progress — test" CM-LIDU and then perform the GES outgoing C channel continuity check procedure defined in 4.8.6.1.2.1.3.

4.8.6.1.2.1.3 *GES outgoing C channel continuity check.* When checking the circuit continuity of a C channel which is to be used for a ground-origination, GES circuit-mode services shall do the following:

a) if tG34 seconds have elapsed from the time that the first "call progress — test" CM-LIDU was sent to AES circuit-mode services, GES circuit-mode services shall forward a "call unsuccessful — line out of service" event (BITE 17) to the interworking interface and forward to the link layer a "call progress — channel release" CM-LIDU via the P channel. If the from-aircraft carrier is not present, terminate all activities for the call; otherwise, if the C channel from-aircraft carrier does not terminate within tG23 seconds after the first transmission of the "call progress — channel release" CM-LIDU, GES circuit-mode services shall again forward the CM-LIDU via the P channel and await an additional tG23 seconds. If the from-aircraft carrier terminates during either period, GES circuit-mode services shall terminate all activities for the call. If the from-aircraft carrier does not terminate by expiry of the second period, GES circuit-mode services shall terminate all activities for the call at the end of the period; or

Note.— The status of an unterminated from-aircraft carrier should be posted to a monitoring function.

b) if tG34 seconds have not elapsed since the time that the first "call progress — test" CM-LIDU was sent to AES circuit-mode services, GES circuit-mode services shall do the following while simultaneously forwarding to the link layer a "call progress — test" CM-LIDU to AES circuit-mode services every tG35 seconds:

1) if a "call progress — call attempt result" CM-LIDU is received, GES circuit-mode services shall stop forwarding "call progress — test" CM-LIDUs to AES circuit-mode services. GES circuit-mode services shall then forward an appropriate "call unsuccessful" event (BITE 12, 16 or 17) to the interworking interface and await tG23 seconds for the C channel from-aircraft carrier to terminate. If the from-aircraft carrier is not present, terminate all activities for the call; otherwise, if the from-aircraft carrier terminates by the end of the period, GES circuit-mode services shall terminate all activities for the call. If the from-aircraft carrier does not terminate by the expiry of this period, GES circuit-mode services shall terminate all activities for the call at the end of the period; or

Note.— The status of an unterminated from-aircraft carrier should be posted to a monitoring function.

2) if a "clear forward" event (FITE 22) is received at the interworking interface, GES circuit-mode services shall forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band, stop forwarding "call progress — test" CM-LIDUs and then perform the GES outgoing C channel release guard procedure defined in 4.8.6.1.2.1.5; or

3) if a "call progress — channel release" CM-LIDU is received from AES circuit-mode services, GES circuit-mode services shall forward a "clear back" event (BITE 25) to the interworking interface and stop forwarding "call progress — test" CM-LIDUs. GES circuit-mode services shall then wait tG23 seconds for the C channel from-aircraft carrier to terminate. If the from-aircraft carrier is not present, terminate all activities for the call; otherwise, if the from-aircraft carrier terminates during the period, GES circuit-mode services shall terminate all activities for the call. If the from-aircraft carrier does not terminate within this period, GES circuit-mode services shall terminate all activities for the call at the end of the period; or

Note.— The status of an unterminated from-aircraft carrier should be posted to a monitoring function.

4) if a positive "telephony acknowledge" CM-LIDU is received, GES circuit-mode services shall stop forwarding "call progress — test" CM-LIDUs. GES circuit-mode services shall then forward an "address complete" event (BITE 5) to the interworking interface and perform the GES outgoing C channel maintenance procedure defined in 4.8.6.1.2.1.4; or

5) if a "call progress — connect" CM-CIDU is received, GES circuit-mode services shall stop forwarding "call progress — test" CM-LIDUs. GES circuit-mode services shall then forward an "address complete" event (BITE 5) and an "answer" event (BITE 22) to the interworking interface, forward to the link layer a positive "telephony acknowledge" CM-LIDU via the C channel sub-band, and perform the GES outgoing C channel maintenance procedure defined in 4.8.6.1.2.1.4.

4.8.6.1.2.1.4 *GES outgoing C channel maintenance.* Where required elsewhere in 4.8, GES circuit-mode services shall enable the circuit path between the forward circuit of the terrestrial network and the C channel unit, and then do the following to maintain the C channel:

a) if a "call progress — connect" CM-LIDU is received, GES circuit-mode services shall forward to the link layer a positive "telephony acknowledge" CM-LIDU via the C channel sub-band. If an identical CM-LIDU was not received previously during the GES outgoing C channel establishment procedure defined in 4.8.6.1.2.1.2, GES circuit-mode services shall also forward an "answer" event (BITE 22) to the interworking interface; or

b) if a "clear forward" event is received at the interworking interface, GES circuit-mode services shall forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band. GES circuit-mode services shall then perform the GES outgoing C channel release guard procedure defined in 4.8.6.1.2.1.5; or

c) if the C channel from-aircraft carrier drops for more than tG19 seconds, GES circuit-mode services shall forward a "clear back" event (BITE 25) to the interworking interface. GES circuit-mode services shall then forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band and perform the GES outgoing C channel release guard procedure defined in 4.8.6.1.2.1.5; or

d) if the C channel is to be pre-empted for a higher priority call, GES circuit-mode services shall forward a "clear back" event (BITE 25) to the interworking interface. GES circuit-mode services shall then forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band and perform the GES outgoing C channel release guard procedure defined in 4.8.6.1.2.1.5; or

e) if a "call progress — channel release" CM-LIDU is received, GES circuit-mode services shall forward a "clear back" event (BITE 25) to the interworking interface and terminate all activities for the call.

4.8.6.1.2.1.5 *GES outgoing C channel release guard.* When releasing a C channel which is in use for a ground-origination, GES circuit-mode services shall do the following when required elsewhere in 4.8:

a) if the C channel from-aircraft carrier terminates within tG17 seconds after the last of the six "call progress — channel release" CM-LIDUs has been forwarded, GES circuit-mode services shall terminate all activities for the call; or

b) if the C channel from-aircraft carrier does not terminate within tG17 seconds after the last of the six "call progress — channel release" CM-LIDUs has been forwarded, GES circuit-mode services shall forward to the link layer twelve "call progress — channel release" CM-LIDUs via the C channel sub-band and one "call progress — channel release" CM-LIDU via the P channel. If the from-aircraft carrier is not present, terminate all activities for the call. Otherwise, if the C channel from-aircraft carrier terminates within tG18 seconds after the transmission of the "call progress — channel release" CM-LIDU via the P channel, GES circuit-mode services shall terminate all activities for the call. If the C channel from-aircraft carrier does not terminate within the same tG18 second period, GES circuit-mode services shall terminate all activities for the call at the end of the period; or

Note.— The status of an unterminated from-aircraft carrier should be posted to a monitoring function.

c) if a "call progress — channel release" CM-LIDU is received, GES circuit-mode services shall await the termination of the C channel from-aircraft carrier. If the from-aircraft carrier is not present, terminate all activities for the call; otherwise, if the C channel from-aircraft carrier terminates within tG18 seconds after receipt of the "call progress — channel release" CM-LIDU, GES circuit-mode services shall terminate all activities for the call. If the C channel from-aircraft carrier does not terminate within this same period, GES circuit-mode services shall terminate all activities for the call at the end of the period.

Note.— The status of an unterminated from-aircraft carrier should be posted to a monitoring function.

4.8.6.1.2.2 *GES incoming circuit-mode procedure.* This procedure shall be defined by the following interrelated procedures:

a) GES incoming circuit-mode call initiation — 4.8.6.1.2.2.1;

b) GES incoming bi-directional setup — 4.8.6.1.2.2.2;

c) GES incoming C channel establishment — 4.8.6.1.2.2.3;

d) GES incoming terrestrial completion — 4.8.6.1.2.2.4;

e) GES incoming C channel maintenance — 4.8.6.1.2.2.5; and

f) GES incoming C channel release guard — 4.8.6.1.2.2.6.

4.8.6.1.2.2.1 *GES incoming circuit-mode call initiation.* Upon receipt from an AES of an "access request — telephone" CM-LIDU with a unique application reference number, GES circuit-mode services shall request GES management to assign C channel resources at the C channel Q number value as per Table 4-43.

Note.— This is to say that the Q number of the C channel shall be inferred from the Q number used in the initial circuit-mode call signalling at the link layer.

GES circuit-mode services shall then do the following:

a) if a "call progress — channel release" CM-LIDU is received prior to GES management assigning C channel resources, GES circuit-mode services shall terminate all activities for the call; or

b) if C channel resources are not available, then GES circuit-mode services shall forward to the link layer a "call progress — call attempt result" CM-LIDU via the P channel. GES circuit-mode services shall then await tG9 seconds for the potential receipt of a repetition of the original "access request — telephone" CM-LIDU at the current application reference number. If such an additional CM-LIDU is received from AES circuit-mode services, GES circuit-mode services shall again forward the "call progress — call attempt result" CM-LIDU; otherwise, GES circuit-mode services shall terminate all activities for the call after expiry of the initial tG9 second period.

Otherwise, GES circuit-mode services shall forward to the link layer a "C channel assignment" CM-LIDU. Simultaneously, GES circuit-mode services shall request GES management to activate the previously assigned C channel unit. Any redundant "access request — telephone" CM-LIDUs (with an identical application reference number) received prior to C channel unit activation shall be ignored. GES circuit-mode services shall then perform the GES incoming bi-directional setup procedure defined in 4.8.6.1.2.2.2.

Note.— Redundant "access request — telephone" CM-LIDUs might be received, prior to C channel unit activation, as a result of the series transmission of several such CM-LIDUs by the AES. The redundant CM-LIDUs can be ignored without effect.

4.8.6.1.2.2.2 *GES incoming bi-directional setup.* Where required elsewhere in 4.8, GES circuit-mode services shall perform routing analysis of the network-ID specified in the "access request — telephone" CM-LIDU while simultaneously performing the following:

Note 1.— Routing analysis is considered to be a GES-specific procedure wherein the network-ID parameter is used to identify the specific group of voice circuits which interconnect the GES with the desired terrestrial circuit-switched voice network.

Note 2.— The logic in this subsection initiates terrestrial call completion while simultaneously initiating the establishment of the C channel.

a) if an additional "access request — telephone" CM-LIDU at the current application reference number is received from AES circuit-mode services within tG11 seconds after the latest "C channel assignment" CM-LIDU has been forwarded to the link layer, GES circuit-mode services shall again forward the "C channel assignment" CM-LIDU to AES circuit-mode services; or

b) if a "call information — service address" CM-LIDU is not received within tG11 seconds after the latest "C channel assignment" CM-LIDU has been forwarded to the link layer, GES circuit-mode services shall perform the GES incoming release guard procedure defined in 4.8.6.1.2.2.6; or

c) if a "call progress — channel release" CM-LIDU is received, GES circuit-mode services shall await the termination of the C channel from-aircraft carrier. If the from-aircraft carrier is not present, terminate all activities for the call; otherwise, if the C channel from-aircraft carrier terminates within tG24 seconds after receipt of the "call progress — channel release" CM-LIDU, GES circuit-mode services shall terminate all activities for the call. If the carrier does not terminate within the same tG24 second period, GES circuit-mode services shall terminate all activities for the call at the end of the period; or

Note.— The status of an unterminated from-aircraft carrier should be posted to a monitoring function.

d) if a "call information — service address" CM-LIDU is received within tG11 seconds after C channel unit activation, GES circuit-mode services shall send "call progress — test" CM-LIDUs every tG10 seconds indefinitely; or

e) if routing analysis indicates that completion of the call is blocked due to congestion in either the GES switching equipment or the forward circuit group leading to the terrestrial network, GES circuit-mode services shall stop forwarding "call progress — test" CM-LIDUs and then forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band. GES circuit-mode services shall then perform the GES incoming release guard procedure defined in 4.8.6.1.2.2.6; or

f) if routing analysis is successful in obtaining a forward circuit to the terrestrial network, GES circuit-mode services shall forward an "AMS(R)S call origination" event (FITE 18) to the interworking interface with the terrestrial network. If a "call information — service address" CM-LIDU has already been received, GES circuit-mode services shall then perform the GES incoming terrestrial completion procedure defined in 4.8.6.1.2.2.4; otherwise GES circuit-mode services shall await establishment of the C channel by performing the GES incoming C channel establishment procedure defined in 4.8.6.1.2.2.3.

4.8.6.1.2.2.3 *GES incoming C channel establishment.* Where required elsewhere in 4.8, GES circuit-mode services shall do the following while awaiting the establishment of the C channel:

Note.— Within this subsection, it is possible that signalling events might be received from the terrestrial network. Therefore, if any telephony interworking events are received at the interworking interface with the terrestrial network, they should be held in queue for interpretation by logic specified in subsequent subsections.

a) if an additional "access request — telephone" CM-LIDU at the current application reference number is received from AES circuit-mode services within tG11 seconds after the latest "C channel assignment" CM-LIDU has been forwarded to the link layer, GES circuit-mode services shall again forward the "C channel assignment" CM-LIDU to AES circuit-mode services; or

b) if a "call progress — channel release" CM-LIDU is received within tG11 seconds of C channel unit activation, GES circuit-mode services shall stop forwarding "call progress — test" CM-LIDUs and forward a "clear forward" event (FITE 22) to the interworking interface. (If additional "call progress — channel release" CM-LIDUs are received, GES circuit-mode services shall ignore them.) GES circuit-mode services shall then wait tG24 seconds after receipt of the "call progress — channel release" CM-LIDU for the C channel from-aircraft carrier to terminate. If the from-aircraft carrier is not present, terminate all activities for the call; otherwise, if the C channel from-aircraft carrier terminates within the tG24 second period, GES circuit-mode services shall terminate all activities for the call. If the C channel from-aircraft carrier does not terminate within the same period, GES circuit-mode services shall terminate all activities for the call at the end of the period; or

Note.— The status of the unterminated from-aircraft carrier should be posted to a monitoring function.

c) if a "call information — service address" CM-LIDU is not received within tG11 seconds after the latest "C channel assignment" CM-LIDU has been forwarded to the link layer, GES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface and perform the GES incoming release guard procedure defined in 4.8.6.1.2.2.6; or

d) if a "call information — service address" CM-LIDU is received within tG11 seconds after C channel unit activation, GES circuit-mode services shall send "call progress — test" CM-LIDUs every tG10 seconds indefinitely and perform the GES incoming terrestrial completion procedure defined in 4.8.6.1.2.2.4.

4.8.6.1.2.2.4 *GES incoming terrestrial completion.* While GES circuit-mode services is awaiting completion of the call across the terrestrial network it shall enable the circuit path between the C channel unit and the forward circuit of the terrestrial network while simultaneously forwarding to the link layer a "call progress — test" CM-LIDU every tG10 seconds indefinitely. It shall also do the following:

Note.— At this point, circuit continuity is established through the GES between the C channel and the terrestrial network circuit. Call completion across the terrestrial network is still under way and call progress tones from that network may be audible to the on-aircraft party. If the called party answers the call attempt, this will be indicated by receipt from the terrestrial network of an "answer" event (BITE 22) at the interworking interface.

a) if the C channel from-aircraft carrier terminates for more than tG13 seconds, GES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface. After the FITE 22 event has been forwarded, GES circuit-mode services shall stop forwarding "call progress — test" CM-LIDUs. GES circuit-mode services shall then forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band. GES circuit-mode services shall then perform the GES incoming release guard procedure defined in 4.8.6.1.2.2.6; or

b) if either a "release incoming side" event (BITE 29) or a "call unsuccessful" event (BITE 12, 14, 15, 16, 17 or 20) were received from the interworking interface, GES circuit-mode services shall stop forwarding "call progress — test" CM-LIDUs. GES circuit-mode services shall then forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band. GES circuit-mode services shall then perform the GES incoming release guard procedure defined in 4.8.6.1.2.2.6; or

c) if a "call progress — channel release" CM-LIDU is received, GES circuit-mode services shall stop forwarding "call progress — test" CM-LIDUs and shall forward a "clear forward" event (FITE 22) to the interworking interface. (If additional "call progress — channel release" CM-LIDUs are received, GES circuit-mode services shall ignore them.) If the from-aircraft carrier is not present, terminate all activities for the call; otherwise, if the C channel from-aircraft carrier terminates within tG14 seconds, GES circuit-mode services shall terminate all activities for the call. If the C channel from-aircraft carrier does not terminate within the same period, GES circuit-mode services shall terminate all activities for the call at the end of the period; or

Note.— The status of an unterminated from-aircraft carrier should be posted to a monitoring function.

d) if an "address complete" event (BITE 5) or "sending finished" event (BITE 27) are received at the interworking interface, GES circuit-mode services shall stop forwarding "call progress — test" CM-LIDUs. It shall then forward to the link layer a "call progress — call attempt result" CM-LIDU every tG10 seconds until a positive "telephony acknowledge" CM-LIDU is received. If a positive "telephony acknowledge" CM-LIDU is not received within tG11 seconds of the transmission of the first "call progress — call attempt result" CM-LIDU, GES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface, forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band, and perform the GES incoming release guard procedure defined in 4.8.6.1.2.2.6; otherwise, GES circuit-mode services shall perform the GES incoming C channel maintenance procedure defined in 4.8.6.1.2.2.5; or

e) if an "answer" event (BITE 22) is received at the interworking interface, GES circuit-mode services shall stop forwarding "call progress — test" CM-LIDUs. It shall then forward to the link layer a "call progress — connect" CM-LIDU every tG10 seconds until a positive "telephony acknowledge" CM-LIDU is received. If a positive "telephony acknowledge" CM-LIDU is not received within tG11 seconds after the first "call progress — connect" CM-LIDU was forwarded, GES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface, forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band, and perform the GES incoming release guard procedure defined in 4.8.6.1.2.2.6; otherwise, GES circuit-mode services shall perform the GES incoming C channel maintenance procedure defined in 4.8.6.1.2.2.5.

4.8.6.1.2.2.5 *GES incoming C channel maintenance.* GES circuit-mode services shall then allow the end-to-end circuit-mode connection to continue until any of the following occur:

a) if an "answer" event (BITE 22) is received at the interworking interface, GES circuit-mode services shall forward to the link layer a "call progress — connect" CM-LIDU every tG10 seconds until a positive "telephony acknowledge" CM-LIDU is received. If a positive "telephony acknowledge" CM-LIDU is not received within tG11 seconds after the first "call progress — connect" CM-LIDU was forwarded, GES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface, forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band, and perform the GES incoming release guard procedure defined in 4.8.6.1.2.2.6. Otherwise, GES circuit-mode services shall allow the end-to-end circuit-mode connection to continue; or

b) if a "clear back" event (BITE 25) is received at the interworking interface, GES circuit-mode services shall forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band. GES circuit-mode services shall then perform the GES incoming release guard procedure defined in 4.8.6.1.2.2.6; or

c) if the C channel from-aircraft carrier terminates for more than tG13 seconds, GES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface. GES circuit-mode services shall then forward to the link layer six "call progress — channel release" CM-LIDUs via the C channel sub-band and then perform the GES incoming release guard procedure defined in 4.8.6.1.2.2.6; or

d) if a "call progress — channel release" CM-LIDU is received, GES circuit-mode services shall forward a "clear forward" event (FITE 22) to the interworking interface. (If additional "call progress — channel release" CM-LIDUs are received, GES circuit-mode services shall ignore them.) If the from-aircraft carrier is not present, terminate all activities for the call; otherwise, if the C channel from-aircraft carrier does not terminate within tG14 seconds after the receipt of the "call progress — channel release" CM-LIDU, GES circuit-mode services shall terminate all activities for the call. If the C channel from-aircraft carrier terminates within the same tG14 second period, GES circuit-mode services shall terminate all activities for the call at the end of the period.

Note.— The status of an unterminated from-aircraft carrier should be posted to a monitoring function.

4.8.6.1.2.2.6 *GES incoming release guard.* When releasing a C channel which is in use for an air-origination, GES circuit-mode services shall do the following when required elsewhere in 4.8:

a) if the C channel from-aircraft carrier terminates within tG12 seconds after the last of the six "call progress — channel release" CM-LIDUs was forwarded, GES circuit-mode services shall terminate all activities for the call; or

b) if the C channel from-aircraft carrier does not terminate within tG12 seconds after the last of the six "call progress — channel release" CM-LIDUs was forwarded, GES circuit-mode services shall forward to the link layer twelve "call progress — channel release" CM-LIDUs via the C channel sub-band followed by one "call progress — channel release" CM-LIDU via the P channel. If the from-aircraft carrier is not present, terminate all activities for the call. Otherwise, if the C channel from-aircraft carrier terminates within tG14 seconds after the transmission of the "call progress — channel release" CM-LIDU sent via the P channel, GES circuit-mode services shall terminate all activities for the call. If the C channel from-aircraft carrier does not terminate within the same tG14 second period, GES circuit-mode services shall terminate all activities for the call at the end of the period; or

Note.— The status of an unterminated from-aircraft carrier should be posted to a monitoring function.

c) if a "call progress — channel release" CM-LIDU is received, GES circuit-mode services shall await the termination of the C channel from-aircraft carrier. If the from-aircraft carrier is not present, terminate all activities for the call; otherwise, if the C channel from-aircraft carrier terminates within tG14 seconds after receipt of the "call progress — channel release" CM-LIDU, GES circuit-mode services shall terminate all activities for the call. If the C channel from-aircraft carrier does not terminate within the same tG14 second period, GES circuit-mode services shall terminate all activities for the call at the end of the period.

Note.— The status of an unterminated from-aircraft carrier should be posted to a monitoring function.

4.8.7 ATS-specific terrestrial network standards

Note.— Guidance material on aeronautical speech circuit switching and signalling is contained in ICAO Circular 183 — ATS Speech Circuits — Guidance Material on Switched Network Planning *and in Attachment A to Part I.*

4.8.7.1 *Closed user group.* The AMS(R)S voice service inclusive of interconnecting aircraft and terrestrial networks shall be considered a closed user group to the extent that it is a non-public safety service to be accessible only by ATS and AOC users and used strictly for the conveyance of safety information.

Note.— The definition of a closed user group implies that a private numbering plan is also in effect. A telephony numbering plan for the safety service need not conform to that of the international public switched telephone network (PSTN) as defined in CCITT Recommendation E.163.

4.8.7.2 *Safety terrestrial private networks.* The GES shall interwork in tandem with private ground networks that may be implemented by ATS administrations and aircraft operators. These networks shall provide connectivity between the GES facilities and the relevant ATS or aircraft operator facilities and shall interwork with the GES circuit-mode procedures defined herein.

4.8.7.2.1 The application of aeronautical speech circuit switching and signalling interfaces between the GES and an administration or aircraft operator shall be made on the basis of individual agreements.

4.8.7.2.1.1 **Recommendation.—** *Terrestrial networks should provide:*

a) priority access to the ground party without adversely impacting any existing communications by the ground party;

b) automatic call-back in those instances where a call is blocked by an engaged condition at a ground party;

c) the capability of alternate routing, when necessary and feasible;

d) identification of originator of incoming air-originated calls, when feasible; and

e) call forwarding, when necessary and feasible.

Note.— Call forwarding ensures that calls to operating positions which are temporarily not manned will be rerouted automatically to an appropriate operating position.

4.8.7.2.2 The characteristics of the ringing tone, the busy tone and the congestion tone used by the terrestrial network shall conform to ITU CCITT Recommendation E.180.

Note.— Details of ITU CCITT Recommendation E.180 are contained in CCITT Blue Book, Volume II — Fascicle II-2.

4.8.7.3 *Registration of air-originated attempts to a busy ground party.* All call attempts offered to a terrestrial network or a ground destination shall be afforded the priority and pre-emption services defined in 4.8.3.2.

4.8.7.3.1 **Recommendation.—** *If an air-originated call attempt is blocked due to an engaged condition at the ground party, a record of the call attempt should be maintained by the ground user or terrestrial network for a subsequent ground-originated return call to the original aircraft. A GES should not be required to provide specific functions that allow a blocked call attempt to be held in a GES-managed internal queue for later service.*

4.8.8 Telephony numbering plan

4.8.8.1 *General.* A universal telephony numbering plan for AMS(R)S circuit-mode services shall be established so as to facilitate universal interoperability with terrestrial networks.

4.8.8.2 AIRCRAFT NUMBERING

4.8.8.2.1 *Specific requirements.* A fixed address length of 10 address digits shall be allotted to the aircraft numbering plan. All assigned addresses shall be of the same length.

4.8.8.2.2 *Address analysis.* Numbering of individual aircraft destinations shall consist of the AES ID of the aircraft expressed as eight octal digits to which is appended the two-digit decimal ID of the calling or called terminal on the aircraft numbered from 00 to 99 decimal. The first 10 terminal addresses (00-09) shall be reserved for ATS application.

4.8.8.2.2.1 AES circuit-mode services shall maintain a private, 100 entry terminal ID address space specific to all AMS(R)S safety terminals on an aircraft. Use of this address space, as opposed to the parallel address space for non-safety services, shall be inferred by AES circuit-mode services by the associated priority of the call attempt.

4.8.8.2.2.2 **Recommendation.—** *Subsequent mutual agreement by aircraft manufacturers and ATS administrations should provide for the assignment of aircraft terminal ID "00" as the default destination for all ground-originated safety voice calls to an aircraft. Flight deck audio management systems should associate any incoming call directed to this terminal ID with an appropriate available audio channel on the flight deck (e.g. "SATCOM 1" or "SATCOM 2" on a flight deck audio panel). Terminal IDs "05" to "09" should be reserved for the future application of facsimile devices or other types of digital terminals.*

4.8.8.3 TERRESTRIAL NUMBERING

4.8.8.3.1 *Ground destination address.* When there exists a private network specifically intended to support safety circuit mode services, all terrestrial addresses shall be 10 digits in length. In the other cases, the terrestrial addresses for safety calls are of variable length and shall be in accordance with the numbering plan of the network to which the call is directed.

4.8.8.3.1.1 *Address analysis.* When there exists a private network specifically intended to support safety circuit mode services, numbering of individual ground destinations shall consist of the following digit sequence:

a) a digit "8";

b) a three-digit country code signifying the destination State;

c) a three-digit facility code signifying the destination facility within the destination State. The code values to be assigned to individual facilities within a State shall be determined and published by the administration of the destination State; and

d) a three-digit agent code signifying the destination agent within the destination facility. The code values to be assigned to individual agents within a facility shall be determined and published by the organizational entity controlling the facility.

Note 1.— A GES is not required to convert any ground address received during an air-originated AMS(R)S call. The terrestrial network may convert any such address, if necessary, to that which is required for that particular network.

Note 2.— GES operators may convert a ground address to that which is required by a particular terrestrial network upon mutual agreement with that network operator.

Note 3.— Country codes are based on the International Telecommunication Union (ITU) country code shown in Table 1 of Appendix 43 of the ITU Radio Regulations. However, only one code per country should be used in the AMS(R)S service for safety and regulatory communications.

4.8.8.3.2 *Network ID.* Network ID "10" shall be used in all air-originated safety calls which are to be routed to a private network specifically intended to support safety circuit mode services.

Note.— Additional network IDs may be used for safety communications upon prior arrangement between GES operators and the affected ATS administrations and aircraft operators.

4.9 AIRCRAFT EARTH STATION (AES) MANAGEMENT

4.9.1 General

AES management functions shall include the functions performed in the AES to initiate and carry out a log-on process, to maintain a logged-on status, to initiate and carry out a log-off process, and to manage the data and voice communications with a GES.

4.9.2 AES management interfaces

4.9.2.1 The AES management shall provide for interfaces to the following AES entities:

a) subnetwork layer;

b) link layer;

c) physical layer;

d) circuit-mode services.

4.9.2.1.1 *SUBNETWORK LAYER*

The information exchanged between the AES management and the subnetwork layer shall include the following to the subnetwork layer:

1) log-on status: logged on initial or renewal/logged off;

2) log-on GES ID (if logged on);

3) AES ID.

4.9.2.1.2 *LINK LAYER*

The information exchanged between the AES management and the link layer shall be in the form of the link interface data units (LIDUs) described in 4.5.2. All LIDUs exchanged across this interface shall be as specified in Table 4-44 except that the information sent to the AES management shall also include interface control information commanding the AES management to randomly select an R channel frequency.

Note.— The link layer assembles SUs in accordance with the information in the received LIDUs. LIDU formats are not prescribed. SU formats are given in Appendix 2 to Chapter 4.

4.9.2.1.3 *PHYSICAL LAYER*

The information exchanged between the AES management and the physical layer shall include the following:

a) to the physical layer:

1) frequencies for the transmit and receive channel units;

2) channel unit mode selection (R, T or C channel);

3) channel rates;

4) transmitter power settings;

5) channel unit number;

b) from the physical layer:

1) P channel loss/degradation indication;

2) P channel synchronization indication;

3) estimated bit error rate on each channel unit receiving a C channel.

4.9.2.1.4 *CIRCUIT-MODE SERVICES*

The information exchanged between the AES management and the circuit-mode services shall include the following:

a) to circuit-mode services:

1) log-on status, (i.e. logged on/logged off);

2) log-on GES ID;

3) channel unit number in response to each request for a channel unit assignment;

b) from circuit-mode services:

1) request for assignment of a transmit channel unit and associated Q number, application reference number, frequency, channel rate and initial EIRP;

2) request for assignment of a receive channel unit and associated Q number, application reference number, frequency and channel rate;

3) command to randomly select an R channel frequency.

4.9.3 AES management functions

4.9.3.1 AES management shall carry out the following functions:

a) AES table management;

b) AES log-status management;

c) AES channel management.

4.9.3.2 AES TABLE MANAGEMENT

4.9.3.2.1 AES management shall maintain the following two tables:

a) system table;

b) log-on confirm table.

4.9.3.2.2 *SYSTEM TABLE*

The content of this table for each beam in a satellite service area shall be as provided by the GES (see 4.10.4.2.2).

4.9.3.2.3 *AES SYSTEM TABLE UPDATE*

For updating the contents of the system tables, the AES management shall use the following procedures:

a) *Prior to log-on.* Once the AES management receives a broadcast sequence on a satellite/beam-identifying P_{smc} channel frequency, it shall determine whether the received sequence is a partial sequence or a complete sequence (see 4.10.4.5.2) and then do the following:

1) if it is a partial sequence, the AES management shall compare the revision number specified in the received partial sequence with the revision number of the corresponding current data segment in the system table. If the received revision number is one higher

than the current number, the AES shall update its system table according to the received sequence. If the received revision number differs from the current number by more than one, the AES management shall wait for the following complete sequence and update its system table accordingly.

2) if the received sequence is a complete sequence, the AES shall update its system table accordingly.

b) *After log-on.* When the AES management receives a partial sequence from the log-on GES, it shall update its system table accordingly.

4.9.3.2.4 *LOG-ON CONFIRM TABLE*

This table shall include the following:

a) satellite ID;

b) beam ID;

c) log-on GES ID;

d) initial EIRP for R channels;

e) P_d channel frequency and channel rate;

f) R_d channel frequencies and channel rate;

g) T channel frequencies and channel rate;

h) number of C channels supportable by the AES simultaneously (including a C channel that utilizes a transmitter that is shared by the C, R and T channels for Level 3 AES).

4.9.3.2.5 *LOG-ON CONFIRM TABLE UPDATE*

The content of the log-on confirm table, except for item h), shall be updated whenever the AES management logs on, renews its log-on or completes a data channel reassignment procedure with the GES (4.9.3.3.4.2 f)).

4.9.3.3 AES LOG-STATUS MANAGEMENT

4.9.3.3.1 Before an AES begins providing user communication services, the AES management shall successfully complete the log-on procedure, given in 4.9.3.3.4, with a selected GES. Prior to initiating the log-on procedure, the AES management shall select a suitable satellite, beam and GES combination as specified in 4.9.3.3.2.

4.9.3.3.2 *SATELLITE, BEAM AND GES SELECTIONS*

The satellite, beam and GES selections shall be made such that the AES is capable of receiving an adequate signal level on a P_{smc} channel of the selected GES. The adequacy of the signal level shall be based on receiving a P channel synchronization indication (4.9.2.1.3 b)) from the physical layer. The information used to make these selections shall be as specified in the most current version of the system table. The currency of the system table shall be determined by comparing the revision number (Appendix 3 to Chapter 4, Item 49) of the system table currently held at the AES with the revision number of the system table broadcast received on the satellite/beam-identifying P_{smc} channel. If necessary, the system table shall be updated in accordance with 4.9.3.2.3.

4.9.3.3.3 *LOG-ON PROCEDURE*

4.9.3.3.3.1 Initiation of a log-on procedure with the selected GES shall be either automatic or in response to a received command. The AES management shall initiate the log-on procedure immediately following the selection of a log-on GES. When the AES is able to receive a satellite-identifying P_{smc} channel, and does not have an equipment fault, it shall always be logged on to a selected GES during those periods when AMS(R)S operation is intended.

4.9.3.3.3.2 To log on to the selected GES, the AES management shall transmit a log-on request LIDU to the GES on an R_{smc} channel frequency randomly selected from the GES R_{smc} channel frequencies given in the system table. The AES management shall then do the following:

a) If tA11 seconds (Appendix 4 to Chapter 4) elapses without receiving a response from the GES as specified in b) to e) below, the AES management shall command the selection of an R_{smc} channel frequency and then retransmit the log-on request LIDU to the selected GES. The AES management shall command the selection of an R_{smc} channel frequency and then retransmit the log-on request LIDU every tA11 seconds until a response is received, except that the number of transmissions of the log-on request LIDU shall not exceed 5. If, after the fifth transmission, a response is not received within tA11 seconds, the AES management shall abort the log-on procedure to the current selected GES, select a GES according to 4.9.3.3.2 and then shall log-on to the selected GES in accordance with 4.9.3.3.3.

b) If within tA11 seconds the AES management receives a log-on confirm LIDU, and the channel control LIDUs (P/ R and T channel control LIDUs) indicated in the log-on confirm LIDU, the AES management shall command the selection of an R_d channel frequency and then shall transmit a log-on acknowledgement LIDU indicating the correct receipt of all expected LIDUs to the GES. If, after tA12 seconds from sending a log-on acknowledgement LIDU, the AES management does not receive a log-on acknowledgement LIDU from the GES on the assigned P_d channel, it shall command the selection of an R_d channel frequency and then shall retransmit the log-on acknowledgement LIDU. The AES management shall command the selection of an R_d channel frequency and then shall retransmit the same LIDU every tA12 seconds until a log-on acknowledgement LIDU is received from the GES, except that the total number of transmissions of the log-on acknowledgement LIDU shall not exceed four. If, after tA12 seconds from the fourth transmission, a log-on acknowledgement LIDU is not yet received from the GES, the AES management shall abort the log-on procedure to the current selected GES, select a GES according to 4.9.3.3.2 and then shall log-on to the selected GES in accordance with 4.9.3.3.3; otherwise, when a log-on acknowledgement LIDU is received, the AES shall be considered logged on. The AES management shall then relay this information on the various interfaces, where applicable, and update its log-on confirm table.

c) If some, but not all, of the expected LIDUs are received within tA11 seconds, the AES management shall transmit a log-on acknowledgement LIDU to the GES indicating the missing LIDUs. If, after tA11 seconds from the time the AES log-on acknowledgement LIDU was transmitted, the AES management still has not received all expected LIDUs, it shall command the selection of an R_{smc} channel frequency and then retransmit another log-on acknowledgement LIDU indicating all missing LIDUs to the same GES. The AES management shall command the selection of an R_{smc} channel frequency and then shall repeat the transmission of a log-on acknowledgement LIDU, indicating all missing LIDUs, every tA11 seconds until all expected LIDUs are received, except that the total number of transmitted log-on request LIDUs (in a) above) and log-on acknowledgement LIDUs shall not exceed five. If, after tA11 seconds from the fifth transmission, all expected LIDUs have not been received, the AES management shall abort the log-on procedure to the current selected GES, select a GES according to 4.9.3.3.2 and then shall log-on to the selected GES in accordance with 4.9.3.3.3. If, and when, within the required time the AES management receives all the expected LIDUs, it shall transmit a log-on acknowledgement LIDU indicating no errors to the GES and shall then proceed as given in b).

d) If a log-on reject LIDU is received, the AES management shall respond according to the rejection reason (Appendix 3 to Chapter 4, item 44) indicated in the LIDU.

e) If a log-off request LIDU is received from the GES, the AES management shall consider the AES logged off and immediately inhibit its transmissions on the R and T channels to the GES. The GES shall be considered as "temporarily unavailable" (see Appendix 3 to Chapter 4, Item 44).

f) If a selective release broadcast LIDU is received from the GES, the AES shall immediately inhibit any transmission on the frequency specified in the LIDU.

4.9.3.3.3.2.1 If during the log-on procedure the AES management receives a P channel loss/degradation indication (defined in Appendix 1 to Chapter 4), it shall abort the log-on procedure to the current selected GES, select a GES according to 4.9.3.3.2 and log on to the selected GES in accordance with 4.9.3.3.3.

4.9.3.3.4 *PROCEDURES AFTER LOG-ON*

4.9.3.3.4.1 The AES management shall attempt to log-off before terminating communication with the log-on GES.

Note.— Loss or degradation of the P channel precludes any log-off attempt (4.9.3.3.4.4 refers).

4.9.3.3.4.2 The AES management shall respond to the LIDUs received from its log-on GES as follows:

a) *partial sequence of system table broadcast LIDUs:* the AES management shall update its system table as indicated in 4.9.3.2.3;

b) *log-on prompt LIDU:* the AES management shall initiate the log-on procedure (4.9.3.3.3) with the selected GES being the one specified in the log-on prompt LIDU;

c) *log-on interrogation LIDU:* if the AES management has indicated the capability of responding to a log-on interrogation LIDU (by setting LOV = 0 in the log-on request LIDU, Table 4-44), it shall respond by sending a log-on acknowledgement LIDU to the GES;

d) *selective release broadcast LIDU:* the AES management shall immediately inhibit any transmission on the frequency specified in the LIDU.

Note.— A selective release broadcast LIDU may be sent by a GES to its logged-on AESs at any time.

e) *GES channel status report LIDU:* the AES management shall respond by sending an AES channel report LIDU corresponding to the C channel indicated in the received LIDU. Any transmit channel EIRP adjustment indicated in the received LIDU shall be made in accordance with 4.9.3.4.1.3.2.

f) *log control/data channel reassignment LIDU:* the AES management shall respond with a log control/ready for reassignment LIDU, then shall do the following:

1) if within tA11 seconds (Appendix 4 to Chapter 4) the AES management does not receive all of the expected LIDUs (a log-on confirm LIDU and, either a P/R channel control LIDU or a T channel control LIDU or both), the AES management shall send a log control/reassignment reject LIDU to the GES;

2) if all the expected LIDUs are received, the AES management shall command the selection of an R_d channel frequency and then shall send a log-on acknowledgement LIDU to the GES. If the AES management does not receive a return log-on acknowledgement LIDU from the GES within tA12 (Appendix 4 to Chapter 4) seconds from the time the log-on acknowledgement LIDU was sent to the GES, it shall command the selection of an R_d channel frequency and then shall retransmit the same LIDU. The AES management shall command the selection of an R_d channel frequency and then shall repeat the retransmission of the same LIDU every tA12 seconds until a log-on acknowledgement is received from the GES, except that the number of transmissions of the log-on acknowledgement LIDU shall not exceed four. If, after the fourth transmission, a log-on acknowledgement LIDU is not received from the GES within tA12 seconds, the AES management shall initiate the log-on procedure (4.9.3.3.3) with the current log-on GES if an adequate signal level is received on the log-on GES P_{smc} channel; otherwise, with a different GES selected according to the GES selection procedure (4.9.3.3.2). If a log-on acknowledgement LIDU is received from the GES, the AES management shall update its log-on confirm table.

g) *log-off request LIDU:* the AES management shall consider the AES logged-off and immediately inhibit its transmissions on the R and T channels to the GES. The GES shall be considered as "temporarily unavailable" (see Appendix 3 to Chapter 4, Item 44).

4.9.3.3.4.2.1 **Recommendation.—** *Upon receipt of a universal time broadcast LIDU from the GES, the AES management should make the time information in the LIDU available to the appropriate application processes within the aircraft. The time information in the LIDU should be considered correct at the instant of reception of the first bit of the next P channel superframe (4.4.2).*

4.9.3.3.4.3 The AES management shall respond to received commands as follows:

a) *log-off command:* the AES management shall transmit a log-off request LIDU to the GES, relay the log-off status on the AES management interfaces as specified in 4.9.2, and then do the following:

1) if a log-off acknowledgement LIDU from the GES is not received within tA10 seconds (Appendix 4 to Chapter 4) from the time the log-off request LIDU was transmitted, the AES management shall retransmit another log-off request LIDU. The AES management shall retransmit the same LIDU every tA10 seconds until a log-off acknowledgement LIDU from the GES is received, except that the number of transmissions of the log-off request LIDU shall not exceed five. If, within tA10 seconds from the time of the fifth transmission, a log-off acknowledgement LIDU is not received, the AES management shall consider the AES logged off;

2) when a log-off acknowledgement LIDU is received from the log-on GES, the AES management shall consider the AES logged off;

b) *GES-to-GES handover command:* the AES management shall log on to the specified GES within the same satellite service area as the current log-on GES using the procedure in 4.9.3.3.3. However, for a Level-3 AES, if the AES transmit channel unit is being used for a circuit-mode call, the AES management shall initiate the log-on procedure after the circuit-mode call is terminated;

c) *satellite-to-satellite handover command:* the AES management shall first maintain all previously established circuit-mode calls for three minutes or until all calls are cleared, whichever comes first. After three minutes, the AES management shall clear any remaining circuit-mode calls. After all calls are cleared, the AES management shall select a suitable beam in the service area of the specified satellite. If a suitable beam cannot be found, the AES management shall select a different satellite and a beam within its service area according to 4.9.3.3.2. The AES management shall then select, according to 4.9.3.3.2, a GES that supports the selected beam and shall automatically log on to the selected GES using the procedure in 4.9.3.3.3.

4.9.3.3.4.4 The AES management shall respond to the indications relayed to it via the AES physical layer interface as follows:

P_d channel loss/degradation indication: the AES management shall either attempt to (1) reacquire an adequate signal level on the same P_d channel and resume normal operation, or (2) renew its log-on to the same GES by re-initiating the log-on procedure to the same GES, or (3) re-initiate the satellite, beam and GES selection and the log-on process as specified in 4.9.3.3.2 and 4.9.3.3.3 respectively. All R and T channel transmissions shall be inhibited if there is a loss or degradation of the P_d channel. C channel transmissions for an existing circuit-mode call shall be allowed to continue provided the bit error rate of received C channel transmissions does not exceed its nominal value for any subsequent period of more than 40 seconds.

4.9.3.4 AES CHANNEL MANAGEMENT

4.9.3.4.1 *CHANNEL UNIT CONTROL*

4.9.3.4.1.1 The AES management shall control all of the AES transmit and receive channel units via the interface with the AES physical layer.

4.9.3.4.1.2 *Channel unit frequency and channel rate control.* The AES management shall control the frequencies and channel rate settings of all the AES receive and transmit channel units. The frequencies and the channel rates for the P_{smc} and R_{smc} channels shall be as provided in the system table. The frequencies and channel rates for the P_d, R_d and T channels shall be as instructed by the GES in the log-on confirm LIDU and the P/R channel control and the T channel control LIDUs. When the AES management receives from the circuit-mode services a request for assignment of transmit and receive channel units with certain settings of frequencies and channel rates, it shall accomplish these assignments and settings by communication with the physical layer and shall relay these assignments and settings back to the circuit-mode services. However, the AES management shall ensure that no assigned frequencies are used for transmission that could generate intermodulation products that produce harmful interference to on-aircraft satellite navigation receiver operation and shall pre-empt a lower priority call if necessary.

4.9.3.4.1.2.1 The AES management shall carry out the randomized selection of R channel frequencies in response to commands generated by protocols in the link layer, circuit-mode services and the AES management itself. Every selection shall persist until another such random selection is made.

4.9.3.4.1.3 *Channel unit power control.* The AES management shall control the EIRP settings of each of the AES transmit channels via the AES management-physical layer interface.

4.9.3.4.1.3.1 The AES management shall use the EIRP setting in 4.2.3.5.5 for transmission of the log-on request LIDU on the R_{smc} channel. Thereafter, the AES management shall set the EIRP on the R_d channel to the initial EIRP setting value communicated to it by the GES, either via the log-on confirm LIDU, or via the data EIRP broadcast LIDUs. If the initial EIRP is obtained from the log-on confirm LIDU, the T channel initial EIRP setting shall be computed according to the ratio of R_d channel and T channel channel rates and the assigned R_d channel initial EIRP.

Note.— The log-on GES is responsible for determining the amount of the adjustments of the values of the EIRP settings for the R_d and T channels.

4.9.3.4.1.3.2 For a C channel, the AES management shall relay from the circuit-mode services to the physical layer the initial EIRP setting of the transmit channel unit. Subsequent adjustments to the EIRP setting shall be made according to the EIRP adjustment values received from the GES in the GES channel status report LIDUs.

Note.— All decisions about the power control and the adjustments required for a C channel are made at the GES through which the call is established and relayed to the AES circuit-mode services on the C channel sub-band.

4.9.3.4.1.4 *Level-3 AES channel unit switching.* In the case of a level-3 AES, the single transmit channel unit shall be shared between the R/T channel mode and the C channel mode of transmission.

4.9.3.4.1.4.1 The transmit channel unit shall be switched to the R/T channel mode whenever not doing so would inhibit the transmission of:

a) any packet-mode data SU with precedence higher than the precedence of the circuit-mode call-in-progress; or

b) any link layer signalling SU associated with packet-mode data SUs of a precedence higher than the precedence of the circuit-mode call-in-progress; or

c) any call setup signalling SU associated with a circuit-mode call of a precedence higher than the precedence of the circuit-mode call-in-progress.

4.9.3.4.1.4.2 The transmit channel unit shall be switched to the C channel mode whenever not doing so would inhibit the establishment or the continuation of a circuit-mode call having a precedence higher than the precedences of all packet-mode data SUs in the link layer and the precedences of the packet-mode data SUs associated with all signalling SUs in the link layer.

4.10 GROUND EARTH STATION (GES) MANAGEMENT

4.10.1 General

Note.— This section defines the management functions required at the GES to initiate and execute the log-on process and to manage the data and voice communications between the AES and the GES.

4.10.1.1 The GES shall perform the set of functions described in this section in order to establish and maintain communications channels with its logged-on AESs and shall share the information about the status of each of its logged-on AESs with all the other GESs supporting AMS(R)S services through the same satellite.

4.10.2 GES management architecture

4.10.2.1 GROUND-TO-AIR

Anywhere within a satellite service area, an AES shall have at least one unique P_{smc} channel available at 600 bits/s for identification of the satellite and the beam supporting the P_{smc} channel.

4.10.2.2 GROUND-TO-GROUND

There shall be communication between the GESs in the same satellite service area to exchange information as required for carrying out the GES management functions specified in 4.10.4.

4.10.3 GES management interfaces

4.10.3.1 The GES management shall interface with the subnetwork layer, circuit-mode services, link layer and physical layer in order to exchange control information required for GES table management, log status management and channel management.

4.10.3.2 SUBNETWORK LAYER

The following control information shall be exchanged between the GES management and the subnetwork layer in the GES:

a) to subnetwork layer:

1) log status information:

i) logged-on/logged-off;

ii) AES ID;

iii) GES ID;

2) minimum channel rate of T channel;

3) channel rate of P_d and R_d channels.

4.10.3.3 CIRCUIT-MODE SERVICES

The following control information shall be exchanged between the GES management and the circuit-mode services in the GES:

a) to circuit-mode services:

1) log status information:

i) logged-on/logged-off;

ii) AES ID;

iii) GES ID;

2) EIRP value;

3) frequency assigned (Q number, application reference number);

4) voice channel characteristics;

5) channel unit assigned (Q number, application reference number);

6) channel unit pre-empted (Q number, application reference number);

b) from circuit-mode services:

1) voice channel characteristics;

2) request for frequency (Q number, application reference number);

3) request for channel unit (Q number, application reference number).

4.10.3.4 LINK LAYER

4.10.3.4.1 The control information exchanged between the GES management and the link layer in the GES shall be as in Table 4-45.

4.10.3.4.2 The information shall be exchanged in the form of link interface data units (LIDUs). The LIDU shall contain link interface control information (LICI) only.

Note.— Each LIDU received from the GES management is mapped into a corresponding SU set in the link layer according to 4.5.3.2.3.

4.10.3.5 PHYSICAL LAYER

The following control information shall be exchanged between the GES management and the physical layer in the GES:

a) to physical layer (for each channel):

1) frequency;

2) channel rate setting (if selectable);

3) power setting;

4) mode (T, or R, or C, if selectable);

5) channel unit number;

b) from physical layer (for each channel):

1) estimated C channel bit error rate;

2) channel unit number;

3) mode.

4.10.4 GES management functions

4.10.4.1 The GES management shall carry out the following functions:

a) GES table management;

b) GES log status management;

c) GES channel management;

d) GES system broadcast.

4.10.4.2 GES TABLE MANAGEMENT

4.10.4.2.1 The GES management shall maintain the following tables:

a) AES system table;

b) AES log-on status table.

4.10.4.2.2 *AES SYSTEM TABLE*

4.10.4.2.2.1 The AES system table for a satellite service area shall include initial search data (search frequencies for satellite and beam identification) and regional data (information about each GES in the satellite service area).

4.10.4.2.2.2 Each GES in a satellite service area shall broadcast both the initial search data and regional data. The initial search data shall consist of the information specified in 4.10.4.2.2.3 for each satellite service area of all the satellite systems providing AMS(R)S services in accordance with SARPs for near geosynchronous satellites. The regional data shall consist of the information specified in 4.10.4.2.2.4 for that satellite service area. The initial search data shall be exchanged in a timely manner among all AMS(R)S providers and shall be broadcast as common initial search data.

4.10.4.2.2.3 The initial search data for a satellite service area shall include the following satellite/beam identifying information for each beam that supports a satellite/beam-identifying P_{smc} channel in the satellite service area:

a) primary satellite/beam-identifying P_{smc} channel frequency at 600 bits/s;

b) secondary satellite/beam-identifying P_{smc} channel frequency at 600 bits/s;

c) satellite ID;

d) satellite location, orbit inclination and right ascension epoch;

e) beam ID (for spot-beam-only satellites).

4.10.4.2.2.4 The regional data for a satellite service area shall include the following information:

a) system table revision number;

b) satellite ID;

c) for a satellite with a global beam, for each GES supporting the global beam:

1) GES ID;

2) P_{smc} channel and R_{smc} channel frequencies; and

3) P_{smc} channel and R_{smc} channel rates;

d) for a satellite with spot beams only:

1) beam ID (same as in e) of initial search);

2) GES spot beam support table indicating in which spot beam the GES radiates; and

3) for each GES supporting a spot beam:

i) GES ID;

ii) P_{smc} channel and R_{smc} channel frequencies; and

iii) P_{smc} channel and R_{smc} channel rates.

4.10.4.2.3 *AES LOG-ON STATUS TABLE*

4.10.4.2.3.1 Each GES shall maintain an AES log-on status table, which shall include the information specified in 4.10.4.2.3.2 and 4.10.4.2.3.3.

4.10.4.2.3.2 The GES shall include in its AES log-on status table, for every AES logged-on to it or to any other GES in the same satellite service area, the following information:

a) AES ID;

b) satellite ID;

c) beam ID;

d) log-on GES ID.

4.10.4.2.3.3 For each AES logged-on to the GES, the AES log-on status table at the GES shall contain the following information in addition to the information specified in 4.10.4.2.3.2:

a) P channel frequency assigned to the AES;

b) R channel frequencies assigned to the AES;

c) T channel frequencies assigned to the AES;

d) channel rate capabilities of P, R, T and C channels;

e) AES activity indicator (active or inactive).

4.10.4.2.3.4 *AES log-on status table update*

The GES shall update the AES log-on status table when an AES logs on (initial or renewal) or logs off from this GES or when the GES receives log-on or log-off information corresponding to an AES from another GES.

4.10.4.3 GES LOG STATUS MANAGEMENT

4.10.4.3.1 The GES log status management function shall manage the AES log-on/log-off, verify the activity of each of its log-on AESs, renew the log-on (when required), and reassign data channels to the AESs (when required).

4.10.4.3.2 *LOG-ON*

Note.— The AES initiates a log-on by sending a log-on request LIDU to the GES (4.9.3.3.3) after the AES has selected a satellite, a beam and a GES.

4.10.4.3.2.1 To reject the log-on request of an AES, the GES management shall reply to the log-on request LIDU by sending a log-on reject LIDU to the AES indicating the reason for rejection.

4.10.4.3.2.1 *bis* The "Reason" code "AES not authorized" (see Appendix 3 to Chapter 4, Item 44) shall be sent (in response to a log-on request LIDU) only to an AES which has not been authorized to use the satellite system.

Note.— The "Q number of the application" parameter in the log-on request LIDU will indicate whether the aircraft is in distress or not. The "Q number of application" parameter will be set to 15 for an aircraft in distress.

4.10.4.3.2.2 To accept the log-on request of an AES, the GES management shall reply to the log-on request LIDU by sending a log-on confirm LIDU followed by a P/R channel control LIDU and a T channel control LIDU to the AES, as required to assign new P_d, R_d and T channels to the AES.

4.10.4.3.2.3 After transmitting the log-on confirm LIDU followed by the channel control LIDUs (P/R and T channel control LIDUs) as indicated in the log-on confirm LIDU to the AES or after transmitting the missing LIDUs identified in the log-on acknowledgement LIDU received from the AES, the GES management shall do the following:

a) If no response is received from the AES within tG26 seconds (Appendix 4 to Chapter 4) from the time the log-on confirm LIDU followed by channel control LIDUs were sent or the missing LIDUs indicated in the log-on acknowledgement LIDU received from the AES were retransmitted, the GES management shall send another log-on confirm LIDU followed by the required channel control LIDUs to the AES. The GES management shall send the log-on confirm LIDU followed by channel control LIDUs to the AES every tG26 seconds until a response is received or the number of times the log-on confirm LIDU followed by channel control LIDUs have been sent equals four. If no response is received within tG26 seconds from the time the fourth log-on confirm LIDU followed by the channel control LIDUs were sent, the GES management shall delete the requesting AES from its AES log-on status table and then transmit log-off information to other GESs in the same satellite service area if the AES is identified as logged on to this GES in the AES log-on status table.

b) If a log-on acknowledgement LIDU indicating no error is received from the AES, the GES management shall send a log-on acknowledgement LIDU to the AES on the newly assigned P_d channel. Thereafter, the GES management shall, each time another log-on acknowledgement LIDU is received from the AES within tG27 seconds (Appendix 4 to Chapter 4) from the time the last log-on acknowledgement LIDU was sent to the AES, send another log-on acknowledgement LIDU to the AES. The GES management shall repeat the above procedure until one of the following occurs:

   1) no log-on acknowledgement LIDU is received from the AES within tG27 seconds from the time the last log-on acknowledgement LIDU was sent to the AES; or

   2) an R channel SU that is not a log-on request LIDU or a log-on acknowledgement LIDU is received from the AES, after which, the GES management shall update its AES log-on status table as specified in 4.10.4.2.3, and send log-on information to the other GESs in the same satellite service area.

c) If a log-on acknowledgement LIDU identifying the missing LIDUs is received from the AES, the GES management shall retransmit the missing LIDUs to the AES and shall proceed as in 4.10.4.3.2.3.

4.10.4.3.2.4 If another log-on request LIDU is received from the AES before the GES management has finished responding to the previously received log-on request LIDU, the GES management shall discard the last received log-on request LIDU.

4.10.4.3.3 *LOG-OFF*

Note.— An AES log-off may be initiated by the AES by sending a log-off request LIDU to the GES or by the GES by sending a log-off request LIDU to the AES. The GES initiated log-off is intended to provide the GES with the capability to shut down undesired AES transmissions.

4.10.4.3.3.1 Upon receipt of a log-off request LIDU from an AES, the GES management shall do the following:

a) if the AES is identified as logged on to this GES in the AES log-on status table, delete the AES from its AES log-on status table, transmit log-off information to other GESs in the same satellite service area and then transmit log-off acknowledgement LIDU to the AES; or

b) if the AES is not identified as logged-on to this GES in the AES log-on status table but is in the process of logging on, transmit log-off acknowledgement LIDU to the AES.

4.10.4.3.3.2 After sending a log-off request LIDU to an AES, the GES management shall consider the AES as logged off.

4.10.4.3.4 *LOG-ON VERIFICATION*

Note.— The AES log-on status table in the GES management contains an activity indicator for each AES logged on to the GES. The activity indicator for the AES is set to "active" whenever any data/signalling is received from the AES. The activity indicator is set to "inactive" if no data or signalling is received from the AES within tG6 seconds (Appendix 4 to Chapter 4) from the time the activity indicator was last set to "active".

4.10.4.3.4.1 The GES management shall verify the AES activity status by either of the following two methods:

a) direct verification; or

b) indirect verification.

Note.— The log-on verification of the AES is the responsibility of its log-on GES only.

4.10.4.3.4.2 *Direct verification*

If no data/signalling is received at the log-on GES or at another GES in the same satellite service area as the log-on GES from an AES capable of responding to log-on interrogation LIDU within tG6 seconds (Appendix 4 to Chapter 4) from the time the activity indicator for the AES was last set to inactive, the GES management shall send a log-on interrogation LIDU to the AES. The GES management shall then do the following:

a) If no log-on acknowledgement LIDU is received from the AES within tG8 seconds (Appendix 4 to Chapter 4) from the time the log-on interrogation LIDU was sent, the GES management shall send another log-on interrogation LIDU to the AES. The GES management shall retransmit the log-on interrogation LIDU to the AES every tG8 seconds until a log-on acknowledgement LIDU is received or the total number of times the log-on interrogation LIDU has been sent equals five. When tG8 seconds has elapsed after the transmission of the fifth log-on interrogation LIDU without receiving a log-on acknowledgement LIDU from the AES, the GES management shall delete the AES from its AES log-on status table and shall send log-off information to the other GESs in the same satellite service area.

b) If a log-on acknowledgement LIDU is received from the AES, the GES management shall set the activity indicator for the AES in the AES log-on status table to "active".

4.10.4.3.4.3 *Indirect verification*

The AES shall remain inactive for twelve hours before the GES management considers it logged off.

4.10.4.3.5 *LOG-ON PROMPT*

Upon receipt of an R channel SU (ISU or a C channel access request SU) by the GES link layer from an AES which is not in its AES log-on status table, the GES management shall send a log-on prompt LIDU to the AES.

4.10.4.3.6 *CHANNEL REASSIGNMENT*

4.10.4.3.6.1 The GES management shall have the capability to reassign the data channels to a logged-on AES.

4.10.4.3.6.2 Upon receipt of a data channel reassignment request, the GES management shall forward a log control/data channel reassignment LIDU to the AES. The GES management shall then do the following:

a) If no response is received from the AES within tG31 seconds (Appendix 4 to Chapter 4) from the time the log control/data channel reassignment LIDU was sent to the AES, the GES management shall send another log control/data channel reassignment LIDU to the AES. If no response is received again within the tG31 seconds, the GES management shall abort the data channel reassignment procedure.

b) If data channel reassignment reject LIDU is received from the AES, the GES management shall abort the data channel reassignment procedure.

c) If a log control/ready for assignment LIDU is received from the AES, the GES management shall transmit a log-on confirm LIDU followed by a P/R channel control LIDU and a T channel control LIDU, as required, containing the reassigned channel information to the AES. The GES management shall then do the following:

1) If no response is received from the AES within tG32 seconds (Appendix 4 to Chapter 4) from the time the log-on confirm LIDU followed by the channel control LIDUs were sent, the GES management shall send another log-on confirm LIDU on the previous P_d channel followed by a P/R channel control and T channel control LIDUs as appropriate. If no response is received again within tG32 seconds, the GES management shall abort the data channel reassignment procedure.

2) If a log-on acknowledgement LIDU indicating no error is received from the AES on the newly assigned R_d channel, the GES management shall send a log-on acknowledgement LIDU to the AES on the newly assigned P_d channel. The GES management shall, if another log-on acknowledgement LIDU is received within tG33 seconds (Appendix 4 to Chapter 4) from the time the last log-on acknowledgement LIDU was sent, send another log-on acknowledgement LIDU to the AES on the new P_d channel. The GES management shall repeat the above procedure until no response has been received from the AES within tG33 seconds from the time the last log-on acknowledgement was sent by the GES, after which the GES management shall update the AES log-on status table with the new channel frequencies assigned to the AES.

3) If a data channel reassignment reject LIDU is received from the AES, the GES management shall abort the data channel reassignment procedure.

4.10.4.4 GES CHANNEL MANAGEMENT

4.10.4.4.1 The GES channel management shall control the AES/GES channel configuration, channel power and channel frequency.

4.10.4.4.2 *CHANNEL CONFIGURATION MANAGEMENT*

4.10.4.4.2.1 *GES channel configuration for management communication*

For each GES, the following channels shall be provided for system management communications:

a) at least one transmit P_{smc} channel, and

b) at least four receive R_{smc} channels.

4.10.4.4.2.2 *AES channel configuration assignment and adjustment*

4.10.4.4.2.2.1 During log-on, the GES management shall assign a P_d channel to an AES in a manner which ensures that the performance requirements in 4.7 and 4.8 are met.

4.10.4.4.2.2.2 During log-on, the GES management shall assign a group of R channels and one or more T channels to an AES, in a manner which ensures that the performance requirements in 4.7 and 4.8 are met.

4.10.4.4.2.2.3 For the C channel(s), the GES management shall assign C channel(s) on a per-call basis.

4.10.4.4.2.2.4 After log-on, the GES management shall adjust an AES channel configuration, if required, by initiating channel reassignment as described in 4.10.4.3.6.

4.10.4.4.2.2.5 The GES or its system management shall ensure that no frequencies are assigned to an AES that could generate intermodulation products that produce harmful interference to on-aircraft satellite navigation receiver operations.

4.10.4.4.3 *CHANNEL POWER MANAGEMENT*

4.10.4.4.3.1 *AES power setting*

Note.— Prior to log-on, the AES will use its default power setting to transmit the log-on request LIDU to the GES management.

4.10.4.4.3.1.1 For the R and T channels, during the log-on process the GES management shall assign an initial power setting to the AES as the "initial EIRP" value in the log-on confirm LIDU sent to the AES. The initial EIRP value shall be determined so that the estimated bit error rate at the GES shall not exceed 10^{-5}.

4.10.4.4.3.1.1 *bis.* **Recommendation.—** *For increased power management efficiency, the R and T channel EIRPs should be determined from the data EIRP broadcast LIDUs (Figure A2-61) for both global and spot beam channels. For a global beam channel, the most significant bit of the channel frequency shall be set to "0" (zero). For a spot beam channel, the most significant bit of the channel frequency shall be set to "1" (one).*

Note.— The AES will adjust its channel unit power levels according to the EIRP value received in either the log-on confirm LIDU or the data EIRP broadcast LIDUs.

4.10.4.4.3.1.2 For the C channel, the initial EIRP value shall be assigned by the GES management on a per-call basis and shall be sent to the AES via the circuit-mode services in the C channel assignment LIDU.

4.10.4.4.3.2 *C channel power adjustment*

4.10.4.4.3.2.1 For the to-aircraft C channel, the GES management shall adjust the GES EIRP according to the BER value received from the AES management in the channel status report LIDU. The adjustment EIRP shall be required to maintain a BER of no more than 10^{-3}.

4.10.4.4.3.2.2 For the from-aircraft C channel, the GES management shall determine the AES EIRP adjustment required to maintain a BER of no more than 10^{-3} based on the BER value measured at the GES. The adjustment shall be sent to the AES management in the channel status report LIDU.

4.10.4.4.4 *CHANNEL FREQUENCY MANAGEMENT*

4.10.4.4.4.1 *AES frequency setting*

Note.— Prior to log-on, the AES will use the R_{smc} channel frequency from the system table to send the log-on request LIDU to the GES management.

4.10.4.4.4.1.1 For the P, R and T channels, the GES management shall assign the initial P, R and T channel frequencies to the AES (if the P_d/R_d frequency is different from the P_{smc}/R_{smc} frequencies) by sending P/R channel control LIDU and T channel control LIDU to the AES after the log-on confirm LIDU in response to the received log-on request LIDU.

4.10.4.4.4.1.2 For a C channel, the GES management shall assign the AES C channel transmit/receive frequency by passing the assigned frequencies to the AES in the C channel assignment LIDU transmitted by the circuit-mode services in the GES.

4.10.4.4.4.2 *AES channel frequency reassignment*

4.10.4.4.4.2.1 For the P and R channels, the GES management shall adjust the P/R channel frequencies previously assigned to the AES by initiating channel reassignment procedure as described in 4.10.4.3.6 and sending the newly assigned frequencies in the P/ R channel control LIDUs following the log-on confirm LIDU.

4.10.4.4.4.2.2 For the T channel, the GES management shall adjust the T channel frequencies by initiating channel reassignment procedure and transmitting the T channel control LIDU, following the log-on confirm LIDU, to the AES.

4.10.4.4.5 *CHANNEL INTERFERENCE MANAGEMENT*

The GES management shall maintain one or more reserve frequencies for each GES in each beam it supports to be used as P_{smc} channel and as R_{smc} channel frequencies, in the event of interference to the previously assigned P_{smc} channel and R_{smc} channel frequencies. In the event that changeover is required, the GES management shall update the system table accordingly.

4.10.4.4.6 *PRE-EMPTION MANAGEMENT*

4.10.4.4.6.1 *Voice versus voice pre-emption*

After the circuit-mode services in the GES transmits a C channel assignment LIDU to the AES, the GES management shall immediately make available a channel unit serving the lowest precedence call for the new call, when no channel units are available, and indicate the availability of the channel unit to the circuit-mode services in the GES.

4.10.4.4.6.2 *Data versus voice pre-emption*

The GES shall have the capability to reassign spectrum and power resources from circuit-mode services to packet-mode services in order to meet packet data service requirements.

4.10.4.5 GES SYSTEM BROADCAST

4.10.4.5.1 The GES management shall transmit the system table and time data to the AES in order to maintain the currency of the data and time in the AES.

4.10.4.5.2 *SYSTEM TABLE BROADCAST*

4.10.4.5.2.1 The GES management shall transmit the system table data to the AES by means of one or more of the following broadcast LIDUs:

a) broadcast index;

b) GES P/R channel advice;

c) satellite identification advice;

d) GES beam support advice;

e) data EIRP table broadcast.

4.10.4.5.2.2 The system table data shall be transmitted in the following two forms:

a) partial sequence containing the most recent updates; and

b) complete sequence containing the full initial search and regional data update.

4.10.4.5.2.3 A partial sequence shall comprise one or more broadcast LIDUs described in 4.10.4.5.2.1.

4.10.4.5.2.4 The complete sequence shall include all the broadcast LIDUs in 4.10.4.5.2.1. There shall be a complete sequence for each beam in the satellite service area supporting a satellite/beam-identifying P_{smc} channel.

4.10.4.5.2.5 The partial and complete sequence shall each include one broadcast index LIDU.

Note 1.— The broadcast index LIDU provides an existence flag for each LIDU in the complete sequence.

Note 2.— The GES P_{smc} and R_{smc} channel series of the complete sequence can contain up to 64 LIDUs because of the size of the "initial sequence number" field in the broadcast index LIDU. In case more LIDUs are included in the series, the second series of the GES P_{smc} and R_{smc} channel series is used.

4.10.4.5.2.6 The GES shall transmit the partial sequence on all the P channels it supports. In addition, the GES shall transmit the complete sequence on each satellite/beam-identifying P_{smc} channel it supports. Each GES in a satellite service area shall transmit to each of its logged-on AESs all partial sequences due to any update made by any GES in the satellite service area.

4.10.4.5.2.7 The partial sequence shall be transmitted twice as often as the complete sequence.

4.10.4.5.3 *SELECTIVE RELEASE BROADCAST*

Note.— The selective release broadcast LIDU is used to command all logged-on AESs to cease transmission on specified L-band frequency(ies).

4.10.4.5.3.1 The GES management shall send one or more selective release broadcast LIDUs to the AES upon occurrence of either of the following events:

a) request to release certain channels;

b) for circuit-mode calls, if the in-band channel clearing facilities (such as the channel release signalling facility on the sub-band C channel) are ineffective.

4.10.4.5.4 **Recommendation.—** *The GES management should broadcast the system time to the AES following an AES log-on by transmitting the system time broadcast LIDU on all P channels. The time in the system time broadcast LIDU should be the predicted time of reception at an AES of the first bit of the next superframe of the relevant P channel.*

4.10.5 Satellite system management

At least one satellite/beam-identifying P_{smc} channel shall be active at all times for each beam that supports a satellite/beam-identifying P_{smc} channel.

TABLES FOR CHAPTER 4

Table 4-1. Received phase noise mask

Offset from carrier (Hz)	Phase noise (dBc)
10	–34
100	–65
1 000	–73
3 000	–77
10 000	–79
35 000	–79

1. Phase noise is measured single sideband relative to carrier.
2. The mask shall be defined by drawing straight lines through the above points on a graph which is logarithmic in frequency.

Note.— This mask is illustrated in the guidance material contained in Attachment A to Part I of Annex 10, Volume III.

Table 4-2. P channel acquisition carrier-to-noise levels

Channel rates (bits/s)	C/No (dB-Hz)	Nominal channel spacing (kHz)
600	31.9	5
1 200	35.0	5
2 400	38.0	5
4 800	39.5	5
10 500	42.9	10
10 500	43.3	7.5

Table 4-3. Maximum harmonic, discrete spurious and noise density levels

Frequency (MHz)	EIRP (density)
below 1 525	–135 dBc/4 kHz
1 525 to 1 559	–203 dBc/4 kHz
1 559 to 1 585	–155 dBc/MHz
1 585 to 1 605	–143 dBc/MHz
1 605 to 1 610	–117 dBc/MHz
1 610 to 1 614	–95 dBc/MHz
1 614 to 1 660	–55 dBc/4 kHz[1]
1 660 to 1 670	–55 dBc/20 kHz[1]
1 670 to 1 735	–55 dBc/4 kHz
1 735 to 12 000	–105 dBc/4 kHz
12 000 to 18 000	–70 dBc/4 kHz

1. Within the transmit band, excluding the frequency band within ±35 kHz of the carrier.

Table 4-4. Transmitted phase noise mask

Offset from carrier (Hz)	Phase noise (dBc)
10	–40
100	–67
500	–72
1 100	–80
X	–80

1. Phase noise is measured single sideband relative to carrier.
2. The mask shall be defined by drawing straight lines through the above points on a graph which is logarithmic in frequency.
3. X is equal to 35 kHz or four times the symbol rate, whichever is less.
4. Where discrete spectral components exist, the sum of the discrete phase noise components and continuous spectral component averaged over a bandwidth of ±10 Hz on either side of the discrete component shall not exceed the phase noise mask.

Note.— This mask is illustrated in the guidance material contained in Attachment A to Part I.

Table 4-5. Required spectral limits for AES transmissions

Frequency offset	Attenuation (dB) (relative to maximum envelope level)
±0.75 SR	0
±1.40 SR	20
±2.95 SR	40
35 kHz	40

1. The mask shall be defined by drawing straight lines through the above points.
2. The symbol rate, SR, is equal to the channel rate for A-BPSK and is half the channel rate for A-QPSK.

Table 4-6. Required spectral limits for A-BPSK received by AES

Upper bound		Lower bound	
Normalized frequency	Amplitude response (dB)	Normalized frequency	Amplitude response (dB)
–X	–40	—	—
–0.75	–40	—	—
–0.66	–12	—	—
–0.56	–3.5	—	—
–0.4	0.25	–0.1	–3
0.4	0.25	0.1	–3
0.56	–3.5	—	—
0.66	–12	—	—
0.75	–40	—	—
X	–40	—	—

1. The mask shall be defined by drawing straight lines through the above points where frequencies are normalized to the channel rate, and the amplitude is normalized to 0 dB at a frequency of 0.
2. X is equal to 35 kHz. For larger frequency offsets the spurious requirements of 4.2.3.5.6 apply.

Note.— This mask is illustrated in the guidance material contained in Attachment A to Part I.

Table 4-7. Required spectral limits for A-QPSK received by AES for 100 per cent roll-off

Upper bound		Lower bound	
Normalized frequency	Amplitude response (dB)	Normalized frequency	Amplitude response (dB)
–X	–40	—	—
–0.625	–40	—	—
–0.5	–20	—	—
–0.425	–10	—	—
–0.375	–6	—	—
–0.275	–3	—	—
–0.175	–1	—	—
–0.075	0.25	–0.05	–3
0.075	0.25	0.05	–3
0.175	–1	—	—
0.275	–3	—	—
0.375	–6	—	—
0.425	–10	—	—
0.5	–20	—	—
0.625	–40	—	—
X	–40	—	—

1. The mask shall be defined by drawing straight lines through the above points where frequencies are normalized to the channel rate, and the amplitude is normalized to 0 dB at a frequency of 0.
2. X is 35 kHz. For larger frequency offsets the spurious requirements of 4.2.3.5.6 apply.

Note.— This mask is illustrated in the guidance material contained in Attachment A to Part I.

Table 4-7A. Required spectral limits for A-QPSK received by AES for 60 per cent roll-off

Upper bound		Lower bound	
Normalized frequency	Amplitude response (dB)	Normalized frequency	Amplitude response (dB)
–X	–40	–X	—
–0.839	–40	–0.839	—
–0.43	–35	–0.43	—
–0.41	–22	–0.41	—
–0.375	–13	–0.375	–25
–0.357	—	–0.357	–15
–0.34	–8	–0.34	–11
–0.286	–4.4	–0.286	–6.4
–0.232	–1.6	–0.232	–2.6
–0.16	0	–0.16	–1
–0.125	0.25	–0.125	—
–0.107	—	–0.107	–0.25
0.107	—	0.107	–0.25
0.125	0.25	0.125	—
0.16	0	0.16	–1
0.232	–1.6	0.232	–2.6
0.286	–4.4	0.286	–6.4
0.34	–8	0.34	–11
0.357	—	0.357	–15
0.375	–13	0.375	–25
0.41	–22	0.41	—
0.43	–35	0.43	—
0.839	–40	0.839	—
X	–40	X	—

1. The mask shall be defined by drawing straight lines through the above points where frequencies are normalized to the channel rate, and the amplitude is normalized to 0 dB at a frequency of 0.
2. X is 35 kHz. For larger frequency offsets, the spurious requirements of 4.2.3.5.6 apply.

Note.— This mask is illustrated in the guidance material contained in Attachment A to Part I.

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Table 4-8. Demodulator performance

Channel type	Required BER	E_s/N_0[1] (dB)
P: 0.6, 1.2 and 2.4 kbits/s	10^{-5}	7.3
R,T: 0.6, 1.2 and 2.4 kbits/s	10^{-5}	7.5
P: 4.8 and 10.5 kbits/s	10^{-5}	5.4
R,T: 4.8 and 10.5 kbits/s	10^{-5}	5.7
C: 5.25 kbits/s	10^{-3}	10.8
C: 6.0 kbits/s	10^{-3}	3.9
C: 8.4 kbits/s, 7.5 kHz[2,3]	10^{-3}	7.0
C: 10.5 kbits/s, 10 kHz[2]	10^{-3}	10.8
C: 10.5 kbits/s, 7.5 kHz[2]	10^{-3}	12.7
C: 21.0 kbits/s	10^{-3}	5.4

1. E_s/N_0 is the ratio of the average energy transmitted per channel bit period to the noise power spectral density.
2. Channel spacing.
3. Demodulator performance shall be tested with the local frequency offset of adjacent channels of 1.5 kHz towards the carrier frequency.

Table 4-9. Channel rates

Channel rates (kbits/s)	Applicable channels AES receive	AES transmit
0.6	P	R,T
1.2	P	R,T
2.4	P	R,T
4.8	P	R,T
5.25	C	C
6.0	C	C
8.4	C	C
10.5	P,C	R,T,C
21.0	C	C

Table 4-10. P channel information field components

	Channel rate (kbits/s) 0.6	1.2	2.4	4.8	10.5
Number of bits	1152	1152	1152	2304	4992
Number of interleaver blocks	3	2	1	1	1
Number of SUs/interleaver block	2	3	6	12	26

Table 4-11. P channel interleaver structure

	Channel rate (kbits/s)				
	0.6	1.2	2.4	4.8	10.5
Interleaver columns	6	9	18	36	78

Table 4-12. R and T channel preamble structure

	Channel rate (kbits/s)			
	0.6	1.2	2.4	10.5
Unmodulated carrier (equivalent bit periods)	150	126	78	248
Modulated bits	74	74	74	256
Total	224	200	152	504

Table 4-13. T channel interleaver structure

	Channel rate (kbits/s)			
	0.6	1.2	2.4	10.5
Interleaver columns:				
first block	5	5	5	8-95[1]
subsequent blocks	3	3	3	NA

1. The number of interleaver columns is variable from 8 to 95 in steps of 3 and is chosen to match the amount of data.

Table 4-14. C channel preamble structure

	Channel rate (kbits/s)				
	5.25	6.0	8.4	10.5	21.0
Unmodulated carrier (equivalent bit periods)	80	96	not required	160	336
Modulated bits	128	144	0	256	504
Total	208	240	0	416	840

Table 4-15. SNPDU type identifier encoding

Code	SNPDU TYPE
Bits 654321	(refer to Figures 4-13 through 4-24 SNPDU format)
000000	CONNECTION REQUEST, NO CALLING NSAP ADD., NO CALLED NSAP ADD., NO FACILITY FIELD, NO RESTRICTION ON RESPONSE
000001	CONNECTION REQUEST, NO CALLING NSAP ADD., NO CALLED NSAP ADD., WITH FACILITY FIELD, NO RESTRICTION ON RESPONSE
000010	CONNECTION REQUEST, NO CALLING NSAP ADD., WITH CALLED NSAP ADD., NO FACILITY FIELD, NO RESTRICTION ON RESPONSE
000011	CONNECTION REQUEST, NO CALLING NSAP ADD., WITH CALLED NSAP ADD., WITH FACILITY FIELD, NO RESTRICTION ON RESPONSE
000100	CONNECTION REQUEST, WITH CALLING NSAP ADD., NO CALLED NSAP ADD., NO FACILITY FIELD, NO RESTRICTION ON RESPONSE
000101	CONNECTION REQUEST, WITH CALLING NSAP ADD., NO CALLED NSAP ADD., WITH FACILITY FIELD, NO RESTRICTION ON RESPONSE
000110	CONNECTION REQUEST, WITH CALLING NSAP ADD., WITH CALLED NSAP ADD., NO FACILITY FIELD, NO RESTRICTION ON RESPONSE
000111	CONNECTION REQUEST, WITH CALLING NSAP ADD., WITH CALLED NSAP ADD., WITH FACILITY FIELD, NO RESTRICTION ON RESPONSE
001000	CONNECTION CONFIRM, NO CALLED NSAP ADD., NO FACILITY FIELD
001001	CONNECTION CONFIRM, NO CALLED NSAP ADD., WITH FACILITY FIELD
001010	CONNECTION CONFIRM, WITH CALLED NSAP ADD., NO FACILITY FIELD
001011	CONNECTION CONFIRM, WITH CALLED NSAP ADD., WITH FACILITY FIELD
0011XX	SPARES
010000	CONNECTION RELEASED, NO CALLED NSAP ADD., NO FACILITY FIELD
010010	CONNECTION RELEASED, WITH CALLED NSAP ADD., NO FACILITY FIELD
0100X1	SPARES
0101XX	SPARES
011000	CONNECTION RELEASE COMPLETE
011010	SPARE
0111X0	SPARES
011XX1	SPARES
100000	CONNECTION REQUEST, NO CALLING NSAP ADD., NO CALLED NSAP ADD., NO FACILITY FIELD, WITH RESTRICTION ON RESPONSE
100001	CONNECTION REQUEST, NO CALLING NSAP ADD., NO CALLED NSAP ADD., WITH FACILITY FIELD, WITH RESTRICTION ON RESPONSE
100010	CONNECTION REQUEST, NO CALLING NSAP ADD., WITH CALLED NSAP ADD., NO FACILITY FIELD, WITH RESTRICTION ON RESPONSE
100011	CONNECTION REQUEST, NO CALLING NSAP ADD., WITH CALLED NSAP ADD., WITH FACILITY FIELD, WITH RESTRICTION ON RESPONSE
100100	CONNECTION REQUEST, WITH CALLING NSAP ADD., NO CALLED NSAP ADD., NO FACILITY FIELD, WITH RESTRICTION ON RESPONSE
100101	CONNECTION REQUEST, WITH CALLING NSAP ADD., NO CALLED NSAP ADD., WITH FACILITY FIELD, WITH RESTRICTION ON RESPONSE
100110	CONNECTION REQUEST, WITH CALLING NSAP ADD., WITH CALLED NSAP ADD., NO FACILITY FIELD, WITH RESTRICTION ON RESPONSE
100111	CONNECTION REQUEST, WITH CALLING NSAP ADD., WITH CALLED NSAP ADD., WITH FACILITY FIELD, WITH RESTRICTION ON RESPONSE
101XXX	SPARES
110000	DATA
110001	SPARE
110010	INTERRUPT
110011	RESET
110100	RESERVED
110101	SPARE
11011X	SPARES
111000	RESERVED
111001	FLOW CONTROL
111010	INTERRUPT CONFIRM
111011	RESET CONFIRM
11110X	SPARES
111110	SPARE
111111	RESERVED

Table 4-16. SSNDPX generated cause field coding

Generating condition	Release/reset cause field coding Bits 8765	Bits 4321
SSNDPX originated release (local link error)	1001	0011
SSNDPX originated release (invalid facility request)	1000	0011
SSNDPX originated release (network congestion)	1000	0101
SSNDPX originated reset (local link error)	1000	0101
SSNDPX originated reset (network congestion)	1000	0111

Table 4-17. Diagnostic code field codings (for those originated by the SSND sub-layer)

Generating condition	Diagnostic field coding (decimal)	Applicable SNPDUs
SSNDP operation:		
Disconnection (temporary, e.g. handover)	1110 0001 (225)	Released
Disconnection (permanent, e.g. log off)	1110 0010 (226)	Released
Unable to establish call (temporary)	1110 0011 (227)	Released
Unable to establish call (permanent)	1110 0100 (228)	Released
Connection rejection — requested quality of service not available (transient condition)	1110 0101 (229)	Released
Connection rejection — requested quality of service not available (permanent condition)	1110 0110 (230)	Released
Protocol error (SNPDU type invalid while in):		
Ready state	0001 0100 (20)	Released
IWF call request state	0001 0101 (21)	Released
Incoming call state	0001 0110 (22)	Released
Data transfer state	0001 0111 (23)	Released
Remote clear request state	0001 1010 (26)	Released
Flow control state	0001 1011 (27)	Reset
Remote reset request state	0001 1101 (29)	Reset
Protocol error (SNPDU not allowed):		
Unidentifiable SNPDU	0010 0001 (33)	Released, reset
Invalid LCN (see 4.7.3.3)	0010 0010 (34)	Released
SNPDU too short	0010 0110 (38)	Released, reset
SNPDU too long	0010 0111 (39)	Released, reset
SNPDU type not compatible with facility	0010 1010 (42)	Released
Unauthorized interrupt confirm SNPDU	0010 1011 (43)	Reset
Unauthorized interrupt SNPDU	0010 1100 (44)	Reset
Invalid called DTE address	0100 0011 (67)	Released

(continued)

Generating condition	Diagnostic field coding (decimal)	Applicable SNPDUs
Invalid calling DTE address	0100 0100 (68)	Released
Invalid facility length	0100 0101 (69)	Released
D-bit procedure not supported	1010 0110 (166)	Reset
Transmission error:		
No additional information	0000 0000 (0)	Released, reset
Invalid SNPDU number	0000 0001 (1)	Reset
Retransmission count surpassed	1001 0000 (144)	Released, reset
Timer expired:		
tN1 (for connection confirm SNPDU)	0011 0001 (49)	Released
tN3 (for reset confirm SNPDU)	0011 0011 (51)	Released
tN4 (for interrupt confirm SNPDU)	0011 1001 (57)	Reset
tN7 (for flow control (suspend) supervision)	0011 1011 (59)	Reset

Table 4-18. SSNDPX time supervision

Timer design	Start event	Normally terminated by	Action when timer expires
tN1	Transmission of connection request SNPDU	Reception of connection confirm or connection released SNPDU	The SSNDPX shall initiate a release of the connection
tN3	Transmission of reset SNPDU	Reception of reset confirm or reset SNPDU	The SSNDPX shall initiate a release of the connection
tN4	Transmission of interrupt SNPDU	Reception of interrupt confirm SNPDU	SSNDPX shall initiate a reset of connection
tN6	Transmission of connection released SNPDU	Reception of connection release complete or connection released SNPDU	Return logical channel to ready state
tN7	Transmission of flow control (suspend) SNPDU	Transmission of flow control (resume) SNPDU	SSNDPX shall initiate a reset of connection

NOTES:

1. The timers tN2, tN5 and tN8 are reserved.
2. Timers are started when the SSNDPX receives success status in the transmission status indication LIDU from the link layer, unless the response SNPDU from the remote SSNDPX has been received prior to the status indication.

Table 4-19. SSNDPX supervision of transmission errors — receiving a "Fail" LIDU

SNPDU type reported through fail	SSNDPX action
CONNECTION REQUEST	Send clear indication packet to IWF and return the logical channel to the ready state
CONNECTION CONFIRM, CONNECTION RELEASE COMPLETE, INTERRUPT CONFIRM	No action
RESET CONFIRM	Retry once. If retry fails then return the logical channel to the data transfer state
CONNECTION RELEASED	Retry once. If retry fails then return the logical channel to the ready state
DATA, INTERRUPT	SSNDPX initiates a reset of the connection (reset cause = "network congestion")
FLOW CONTROL	SSNDPX initiates a release of the connection (release cause = "network congestion")
RESET	Retry once. If retry fails then initiate a release of the connection (release cause = "network congestion")

Note.— For SNPDUs which are confirmed by the remote SSND sub-layer entity, processing of the corresponding fail LIDU only applies if it is received prior to the reception of the expected response from the other end.

Table 4-20. SSNDPX timers

Timer	Value (seconds)
tN1	180
tN3	120
tN4	120
tN6	120
tN7	60

Table 4-21. SSNDPX actions — any state

SNPDU received from remote SSNDPX	Any state
Any SNPDU with an invalid SNPDU type	Discard
Any SNPDU less than 2 octets in length	Discard

Note.— The SNPDU type is invalid if it is identified as "spare" or "reserved" in Table 4-15.

Table 4-22. SSNDPX actions — connection establishment states

SNPDU received from remote SSNDPX	Call setup states (Notes 1, 3) Ready state	 IWF call request	 Incoming call
CONNECTION REQUEST	Action: Normal (forward to IWF)	Not applicable	Action: Error send CONNECTION RELEASED D = 0001 0110 (extend clear to IWF)
CONNECTION CONFIRM	Action: Error * send CONNECTION RELEASED D = 0001 0100	Action: Normal (forward to IWF) or Action: Error (Note 2), send CONNECTION RELEASED (extend clear to IWF) D = 0010 1010	Action: Error send CONNECTION RELEASED D = 0001 0110 (extend clear to IWF)
CONNECTION RELEASED	Action: Normal (do not forward)	Action: Normal (forward to IWF)	Action: Normal (forward to IWF)
CONNECTION RELEASE COMPLETE	Action: Error * send CONNECTION RELEASED D = 0001 0100	Action: Error send CONNECTION RELEASED D = 0001 0101 (extend clear to IWF)	Action: Error send CONNECTION RELEASED D = 0001 0110 (extend clear to IWF)
DATA, INTERRUPT, INTERRUPT CONFIRM, RESET, RESET CONFIRM, FLOW CONTROL	Action: Error * send CONNECTION RELEASED D = 0001 0100	Action: Error send CONNECTION RELEASED D = 0001 0101 (extend clear to IWF)	Action: Error send CONNECTION RELEASED D = 0001 0110 (extend clear to IWF)

*SSNDPX internal connection release request (i.e. IWF not informed)

NOTES:

1. In cases where the SNPDU is not acceptable to the state of the logical channel (i.e., Action = Error), the clearing cause field is equal to 147, i.e. SSND local link error.
2. The error may occur if fast select with restriction on response has been requested.
3. If the SNPDU is acceptable to the state of the logical channel (i.e. action = normal) but contains a format error or is otherwise unacceptable then the SSND initiates a connection release procedure (diagnostic codes that may apply include 34, 38, 39, 67, 68, 69, 225-230).

Table 4-23. SSNDPX actions — data transfer and connection release states

SNPDU received from remote SSNDPX	Data transfer and call clearing states		
	Data transfer	Local clear request*	Remote clear request
CONNECTION REQUEST	Action: Error send CONNECTION RELEASED D = 0001 0111 (see Note 1) (extend clear to IWF)	Action: Discard	Action: Error send CONNECTION RELEASED D = 0001 1010
CONNECTION CONFIRM	Action: Error send CONNECTION RELEASED D = 0001 0111 (see Note 1) (extend clear to IWF)	Action: Discard	Action: Error send CONNECTION RELEASED D = 0001 1010
CONNECTION RELEASE COMPLETE	Action: Error send CONNECTION RELEASED D = 0001 0111 (extend clear to IWF) (see Note 1)	Action: Normal	Action: Error send CONNECTION RELEASED D = 0001 1010
CONNECTION RELEASED	Action: Normal (forward to IWF)	Action: Normal (do not forward to IWF)	Action: Discard
DATA, INTERRUPT, INTERRUPT CONFIRM, RESET, RESET CONFIRM, FLOW CONTROL	See Table 4-24	Action: Discard	Action: Error send CONNECTION RELEASED D = 0001 1010

* Internal clear (at connection establishment) or clear requested by the IWF

NOTES:

1. The clearing cause field is equal to 147, i.e. SSND local link error.
2. If the SNPDU is acceptable to the state of the logical channel (i.e. Action = Normal) but contains a format error, then the SSND initiates a connection release procedure (diagnostic codes that may apply include 38, 39).

Table 4-24. SSNDPX actions — data transfer states

SNPDU received from remote SSNDPX	Data transfer states			
	Flow control		Local reset request	Remote reset request
RESET	Action: Normal		Action: Normal (do not forward)	Action: Discard
RESET CONFIRM	Action: Error send RESET SNPDU D = 0001 1011 (extend reset to IWF)		Action: Normal (do not forward)	Action: Error send RESET SNPDU D = 0001 1101
INTERRUPT	*No remote interrupt pending:* Action: Normal	*Remote interrupt ongoing:* Action: Error send RESET SNPDU D = 0010 1100 (extend reset to IWF)	Action: Discard	Action: Error, send RESET SNPDU D = 0001 1101
INTERRUPT CONFIRM	*No local interrupt pending:* Action: Error send RESET SNPDU D = 0010 1011 (extend reset to IWF)	*Local interrupt ongoing:* Action: Normal	Action: Discard	Action: Error, send RESET SNPDU D = 0001 1101
DATA with valid SNPDU No.	Action: Normal (if flow control ready) or Action: Discard (if flow control not ready)		Action: Discard	Action: Error send RESET SNPDU D = 0001 1101
DATA with invalid SNPDU No. (unrecoverable)	Action: Error send RESET SNPDU D = 0000 0001 (extend reset to IWF) or Action: Discard (if flow control not ready)		Action: Discard	Action: Error send RESET SNPDU D = 0001 1101
FLOW CONTROL (suspend) with valid SNPDU No. or flow control (resume)	Action: Normal		Action: Discard	Action: Error send RESET SNPDU D = 0001 1101
FLOW CONTROL (suspend) with invalid SNPDU No.	Action: Error send RESET SNPDU D = 0000 0001 (extend reset to IWF)		Action: Discard	Action: Error send RESET SNPDU D = 0001 1101

NOTES:

1. In cases where the SNPDU is not acceptable to the state of the logical channel (i.e. Action = Error), the resetting cause field is equal to 133, i.e. SSND local link error.
2. If the SNDPU is acceptable to the state of the logical channel (i.e. Action = Normal) but contains a format error, then the SSND initiates a connection reset procedure (diagnostic codes that may apply include 1, 38, 39).

Table 4-25. Summary of link interface data units and parameters

Direction	LIDU name	Parameters
From the subnetwork layer to the link layer	Data	GES ID (in AES) or AES ID (in GES) RLS Q number LSDU
From the link layer to the subnetwork layer	Data	GES ID (in AES) or AES ID (in GES) RLS Q number LSDU
	Transmission status indication	RLS Success/Fail First two octets of LSDU

Table 4-26. Subnetwork connection priority mapping

Categories of messages	Priority/Q number mapping		
	SNC priority in CALL REQUEST/CALL ACCEPTED packet	Q number	SNC priority in INCOMING CALL/CALL CONNECTED packet
Unspecified	255	0	None
Reserved	254-15	Invalid/reject call	Not applicable
Distress communications, urgent communications, network/systems management	14	14	14
Reserved	13	Invalid/reject call	Not applicable
Reserved	12	Invalid/reject call	Not applicable
Communications relating to direction finding, flight safety messages	11	11	11
Reserved	10	Invalid/reject call	Not applicable
Reserved	9	Invalid/reject call	Not applicable
Meteorological communications	8	8	8
Flight regularity communications	7	7	7
Aeronautical information services messages	6	6	6
Aeronautical administrative messages, network/systems administration	5	5	5
Reserved	4	Invalid/reject call	Not applicable
Urgent priority administrative and UN Charter communications	3	3	3
High priority administrative and State/Government communications	2	2	2
Normal priority/administrative	1	1	1
Low priority administrative	0	0	None

Note 1.— SNC priority value 255 (unspecified) in call request/call accepted packet should be mapped to Q number = 0, and none in incoming call/call connected packet.

Note 2.— Network/system management and administration are not categories of end-user messages, but are used by the ATN or other network management/administration.

Table 4-27. DCE actions at restart, call setup, and call clearing states

DCE state	State definition	Action when entering state
r1	PACKET LAYER READY	All VCs are returned to the p1 state (see p1 state READY explanation) and all PVCs are returned to d1, (flow control ready) state.
r2	DTE RESTART REQUEST	The DCE returns each VC to the p1 state (see p1 state explanation) and issues a restart confirmation packet to the DTE.
r3	DCE RESTART INDICATION	The DCE returns each VC to the p1 state (see p1 state explanation) and issues a restart indication packet to the DTE.
p1	READY	Release all resources assigned to VC channel.
p2	DTE CALL REQUEST	Determine if sufficient resources exist to support request; if so, allocate resources and forward ISO 8208 call request packet to IWF; if not, enter DCE clear indication to DTE state (p7). Determination of resources and allocation is as defined in ISO 8208.
p3	DCE INCOMING CALL	Determine if sufficient resources exist to support request; if so, allocate resources and forward ISO 8208 incoming call packet to DTE; if not, send a clear request packet to the IWF. Determination of resources and allocation is as defined in ISO 8208.
p4	DATA TRANSFER	No action.
p5	CALL COLLISION	Send a clear request packet to the IWF, corresponding to the incoming call packet (the DTE in its call collision state ignores the incoming call), and proceed with the DTE call request packet.
p6	DTE CLEAR REQUEST	Release all resources assigned to VC channel. Send an ISO 8208 clear confirmation packet to the DTE, a clear request packet to the IWF, and enter p1 state.
p7	DCE CLEAR INDICATION TO DTE	Forward ISO 8208 clear indication packet to DTE.

Note.— State nomenclature in this table may differ from that used in ISO 8208.

Table 4-28. DCE actions at reset, interrupt, and flow control states

DCE state	State definition	Action when entering state
d1	FLOW CONTROL READY	No action.
d2	RESET REQUEST BY DTE	Remove data packets transmitted to DTE from window; discard any data packets that represent partially transmitted M-bit sequences and discard interrupt and interrupt confirmation packets awaiting transfer to the DTE; reset all window counters to zero. Send reset confirmation packet to DTE. Return channel to d1 state.
d3	RESET INDICATION BY DCE TO DTE	Remove data packets transmitted to DTE from window; discard any data packets that represent partially transmitted M-bit sequences and discard interrupt and interrupt confirmation packets awaiting transfer to the DTE; reset all window counters to zero. Send reset indication packet to DTE.
i1	DTE INTERRUPT READY	No action.
i2	DTE INTERRUPT SENT	Forward interrupt packet received from DTE to IWF.
j1	DCE INTERRUPT READY	No action.
j2	DCE INTERRUPT SENT	Forward interrupt packet received from IWF to DTE.
f1	DCE RECEIVE READY	No action.
f2	DCE RECEIVE NOT READY	No action.
g1	DTE RECEIVE READY	No action.
g2	DTE RECEIVE NOT READY	No action.

Note.— State nomenclature in this table may differ from that used in ISO 8208.

Table 4-29. DCE state table — any state

Received from DTE	DCE special cases Any state
Any packet less than 2 octets in length	A = DIAG D = 38
Any packet with an invalid general format identifier	A = DIAG D = 40
Any packet with unassigned logical channel identifier	A = DIAG D = 36
Any packet with a valid general format identifier and an assigned logical channel identifier (includes a logical channel identifier of 0)	See Table 4-30

Table 4-30. DTE effect on DCE restart states

Packet received from DTE	DCE restart states (see Notes 6 and 7) Packet layer READY (see Note 1) r1	DTE RESTART REQUEST (see Note 4) r2	DCE RESTART INDICATION (see Note 5) r3
Packets having a packet type identifier shorter than 1 octet with assigned logical channel identifier <> 0	see Table 4-31	A = ERROR S = r3 D = 38 (see Note 3)	A = DISCARD
Packet supported by DCE other than restart with a logical channel identifier of 0	A = DIAG D = 36	A = DIAG D = 36	A = DIAG D = 36
Packet with a packet type identifier which is undefined or not supported by DCE and with assigned logical channel identifer <> 0	see Table 4-31	A = ERROR S = r3 D = 33 (see Note 3)	A = DISCARD
Restart request, or restart confirmation packet with a logical channel identifier <> 0	see Table 4-31	A = ERROR S = r3 D = 41 (see Note 3)	A = DISCARD
Restart request	A = NORMAL (see Note 1) S = r2	A = DISCARD	A = NORMAL (4.2) S = p1 or d1 (see Note 2)
Restart confirmation	A = ERROR S = r3 D = 17 (see Note 8)	A = ERROR S = r3 D = 18 (see Note 3)	A = NORMAL (4.4) S = p1 or d1 (see Note 2)
Restart request or restart confirmation packet with format error	A = DIAG D = 38, 39, 81, or 82	A = DISCARD	A = ERROR D = 38, 39, 81, or 82
Call setup, call clearing, data, interrupt, flow control, or reset packet	see Table 4-31	A = ERROR S = r3 D = 18	A = DISCARD
Packets having a packet type identifier shorter than 1 byte and a logical channel identifier equal to 0	A = DIAG D = 38	A = ERROR S = r3 D = 38	A = DISCARD
Packet with a packet type identifier which is undefined or not supported by DCE and a logical channel identifier equal to 0	A = DIAG D = 33	A = ERROR S = r3 D = 33 (see Note 4)	A = DISCARD

NOTES:

1. Receipt of a restart request packet causes the DCE to issue a clear request packet to the IWF for each VC associated with the DCE entity.
2. The VC channels are returned to state p1, the PVC channels are returned to state d1.
3. No action is taken by the DCE.
4. The restart request packet is not forwarded to the IWF.
5. The DCE upon entering the r3 state checks for the completion of r2 processing and issues an ISO 8208 restart indication packet to the DTE, when the r3 state is entered via the r2 state. If the r3 state is not entered via the r2 state, the DCE performs all of the actions normally performed when entering r2 and issues an ISO 8208 restart indication packet to the DTE, and send a clear request packet to the IWF for each VC associated with the DCE entity.
6. Table entries are defined as follows: A = action to be taken, S = state to be entered, D = diagnostic code to be used in packets generated as a result of this action, and discard indicates that the received packet is to be cleared from the buffers.
7. The number in the parentheses below an "A = normal" table entry is the paragraph number in ISO 8208, second edition. The DCE shall take the same action as the one taken by the DTE, acting as a DCE, to perform nominal processing on the received packet. If no paragraph number is referenced, the normal processing is defined in the table entry.
8. The error procedure consists of entering the r3 state and sending a restart indication packet to the DTE.

Table 4-31. DTE effect on DCE call setup and clearing states

Packet received from DTE	DCE call setup and clearing states (see Notes 5 and 6) READY p1	DTE CALL REQUEST p2	DCE INCOMING CALL p3	DATA TRANSFER p4	CALL COLLISION p5; see Notes 1 and 4	DTE CLEAR REQUEST p6	DCE CLEAR INDICATION TO DTE p7
Packet having a packet type identifier shorter than 1 octet	A = ERROR S = p7 D = 38	A = ERROR S = p7 D = 38 see Note 2	A = ERROR S = p7 D = 38 see Note 2	see Table 4-32	A = ERROR S = p7 D = 38 see Note 2	A = ERROR S = P7 D = 38 see Note 2	A = DISCARD
Packet having a packet type identifier which is undefined or not supported by DCE	A = ERROR S = p7 D = 33	A = ERROR S = p7 D = 33 see Note 2	A = ERROR S = p7 D = 33 see Note 2	see Table 4-32	A = ERROR S = p7 D = 33 see Note 2	A = ERROR S = p7 D = 33 see Note 2	A = DISCARD
RESTART REQUEST, or RESTART CONFIRMATION packet with logical channel identifier not = 0	A = ERROR S = p7 D = 41	A = ERROR S = p7 D = 41 see Note 2	A = ERROR S = p7 D = 41 see Note 2	see Table 4-32	A = ERROR S = p7 D = 41 see Note 2	A = ERROR S = p7 D = 41 see Note 2	A = DISCARD
CALL REQUEST	A = NORMAL (5.2.2) S = p2 (forward)	A = ERROR S = p7 D = 21 see Note 2	A = NORMAL (5.2.5) S = p5	A = ERROR S = p7 D = 23 see Note 2	A = ERROR S = p7 D = 24 see Note 2	A = ERROR S = p7 D = 25 see Note 2	A = DISCARD
CALL ACCEPTED	A = ERROR S = p7 D = 20	A = ERROR S = p7 D = 21 see Note 2	A = NORMAL (5.2.4) S = p4(Frd)/ A = ERROR S = p7 D = 42; see Notes 2 and 3	A = ERROR S = p7 D = 23 see Note 2	A = ERROR S = p7 D = 24; see Notes 2 and 4	A = ERROR S = p7 D = 25 see Note 2	A = DISCARD
CLEAR REQUEST	A = NORMAL (4.5.5.2) S = p6	A = NORMAL (4.5.5.2) S = p6 (forward)	A = NORMAL (4.5.5.2) S = p6 (forward)	A = NORMAL (4.5.5.2) S = p6 (forward)	A = NORMAL (4.5.5.2) S = p6 (forward)	A = DISCARD	A = NORMAL (4.5.5.4) S = p1 (do not forward)
CLEAR CONFIRMATION	A = ERROR S = p7 D = 20	A = ERROR S = p7 D = 21 see Note 2	A = ERROR S = p7 D = 22 see Note 2	A = ERROR S = p7 D = 23 see Note 2	A = ERROR S = p7 D = 24 see Note 2	A = ERROR S = p7 D =25 see Note 2	A = NORMAL (5.5.4) S = p1 (do not forward)
Data, interrupt, flow control or reset packets	A = ERROR S = p7 D = 20	A = ERROR S = p7 D = 21 see Note 2	A = ERROR S = p7 D = 22 see Note 2	see Table 4-32	A = ERROR S = p7 D = 24 see Note 2	A = ERROR S = p7 D = 25 see Note 2	A = DISCARD

NOTES:

1. On entering the p5 state, the DCE sends a clear request packet to the IWF, corresponding to the incoming call (the DTE in its call collision state ignores the incoming call), and proceed with the DTE call request.
2. The error procedure consists of performing the actions specified when entering the p7 state (including sending a clear indication packet to the DTE) and additionally sending a clear request packet to the IWF.
3. The use of fast select facility with restriction on response prohibits the DTE from sending a call accepted packet.
4. The DTE in the event of a call collision must discard the call request packet received from the DCE.
5. Table entries are defined as follows: A = action to be taken, S = the state to be entered, D = diagnostic code to be used in packets generated as a result of this action, and discard indicates that the received packet is to be cleaned from the buffers.
6. The number in parentheses below an "A = normal" table entry is the paragraph number in ISO 8208, second edition. The DCE shall take the same actions as the one taken by the DTE, acting as a DCE, to perform normal processing on the received packet. If no paragraph number is referenced, the normal processing is defined in the table entry.
7. If the packet is acceptable to the state of the logical channel (i.e. action = normal) but contains a format error or is otherwise unacceptable, then the DCE shall initiate a connection release procedure (diagnostic codes that may apply include 34, 38, 39, 65, 66, 67, 68, 69, 73, 77, 82). If such an error is detected in state p1 or state p7, the DCE does not send a clear request packet to the IWF.

Table 4-32. DTE effect on DCE reset states

	DCE reset states (see Notes 2 and 3)		
Packet received from DTE	FLOW CONTROL READY d1	RESET REQUEST by DTE d2	RESET INDICATION BY DCE to DTE d3
Packet with a packet type identifier shorter than 1 octet	A = ERROR S = d3 D = 38 (see Note 1)	A = ERROR S = d3 D = 38 (see Note 1)	A = DISCARD
Packet with a packet type identifier which is undefined or not supported by DCE	A = ERROR S = d3 D = 33 (see Note 1)	A = ERROR S = d3 D = 33 (see Note 1)	A = DISCARD
RESTART REQUEST, or RESTART CONFIRMATION packet with logical channel identifier <> 0	A = ERROR S = d3 D = 41 (see Note 1)	A = ERROR S = d3 D = 41 (see Note 1)	A = DISCARD
RESET REQUEST	A = NORMAL (8.2) S = d2 (forward)	A = DISCARD	A = NORMAL (8.3) S = d1 (do not forward)
RESET CONFIRMATION	A = ERROR S = d3 D = 27 (see Note 1)	A = ERROR S = d3 D = 28 (see Note 1)	A = NORMAL (8.4) S = d1 (do not forward)
INTERRUPT packet	see Table 4-33	A = ERROR S = d3 D = 28 (see Note 1)	A = DISCARD
INTERRUPT CONFIRMATION packet	see Table 4-33	A = ERROR S = d3 D = 28 (see Note 1)	A = DISCARD
DATA or flow control packet	see Table 4-34	A = ERROR S = d3 D = 28 (see Note 1)	A = DISCARD

NOTES:

1. The error procedure consists of performing the specified actions when entering the d3 state (which includes forwarding a reset indication packet to the DTE) and sending a reset request packet to the IWF.
2. Table entries are defined as follows: A = action to be taken, S = the state to be entered, D = the diagnostic code to be used in packets generated as a result of this action, and discard indicates that the received packet is to be cleared from the AES buffers.
3. The number in parentheses below an "A = normal" table entry is the paragraph number in ISO 8208, second edition. The DCE shall take the same actions as those taken by the DTE to perform normal processing on the received packet. If no paragraph is referenced, the normal processing is defined in the table entry.
4. If the packet is acceptable to the state of the logical channel (i.e. action = normal) but contains a format error, then the DCE shall initiate a connection reset procedure (diagnostic codes that may apply include 38, 39, 81, 82).

Table 4-33. DTE effect on DCE interrupt transfer states

Packet received from DTE	DTE/DCE INTERRUPT TRANSFER STATES (see Notes 2 and 3) DTE INTERRUPT READY i1	 DTE INTERRUPT SENT i2
INTERRUPT (see Note 1)	A = NORMAL (6.8.2) S = i2 (forward)	A = ERROR S = d3 D = 44 (see Note 4)

Packet received from DTE	DTE/DCE INTERRUPT TRANSFER STATES (see Notes 2 and 3) DCE INTERRUPT READY j1	 DCE INTERRUPT SENT j2
INTERRUPT CONFIRMATION (see Note 1)	A = ERROR S = d3 D = 43 (see Note 4)	A = NORMAL (6.8.3) S = j1 (forward)

NOTES:

1. If the packet is acceptable to the state of the logical channel (i.e. action = normal) but contains a format error, then the error procedure applies (see Note 4).
2. Table entries are defined as follows: A = action to be taken, S = the state to be entered, and D = the diagnostic code to be used in packets generated as a result of this action.
3. The number in parentheses below an "A = normal" table entry is the paragraph number in ISO 8208, second edition. The DCE shall take the same action as those taken by the DTE to perform normal processing on the received packet. If no paragraph is referenced, the normal processing is defined in the table entry.
4. The error procedure consists of performing the specified actions when entering the d3 state (which includes forwarding a reset indication packet to the DTE) and sending a reset request packet to the IWF.

Table 4-34. DTE effect on DCE flow control transfer states

Packet received from DTE	DCE flow control transfer states (see Note 2) DCE RECEIVE READY f1	DCE RECEIVE NOT READY f2
DATA packet with invalid PR	A = ERROR S = d3 D = 2 (see Note 4)	A = ERROR S = d3 D = 2 (see Note 4)
DATA packet with valid PR but invalid PS or user data field with improper format	A = ERROR S = d3 D = (see Note 5) (see Note 4)	A = DISCARD (process PR data)
DATA packet with valid PR with M-bit set to 1 when the user data field is partially full, or the D-bit set to 1 (when not supported)	A = ERROR S = d3 D = 165 or 166 (see Note 4)	A = DISCARD (process PR data)
DATA packet with valid PR, PS and user data field with proper format	A = NORMAL (forward)	A = DISCARD (process PR data) (see Note 7)
Packet received from DTE	**DCE flow control transfer states (see Notes 2 and 3) DTE RECEIVE READY g1**	**DTE RECEIVE NOT READY g2**
RR, or RNR packet with an invalid PR	A = ERROR S = d3 D = 2 (see Note 4)	A = ERROR S = d3 D = 2 (see Note 4)
RR packet with a valid PR (see Note 6)	A = NORMAL (4.7.1.5)	A = NORMAL (4.7.1.5) S = g1
RNR packet with a valid PR (see Note 6)	A = NORMAL (4.7.1.6) S = g2	A = NORMAL (4.7.1.6)

NOTES:

1. The RR and RNR procedures are a local DTE/DCE matter and the corresponding packets are not forwarded to the IWF.
2. Table entries are defined as follows: A = action to be taken, S = the state to be entered, D = the diagnostic code to be used in packets generated as a result of this action, and discard indicates that the received packet is to be cleared from the buffers.
3. The number in parentheses below an "A = normal" table entry is the paragraph number in ISO 8208, second edition. The DCE shall take the same action as those taken by the DTE to perform normal processing on the received packet. If no paragraph is referenced, the normal processing is defined in the table entry.
4. The error procedure consists of performing the specified actions when entering the d3 state (which includes forwarding a reset indication packet to the DTE) and sending a reset request packet to the IWF.
5. The diagnostic codes are as follows: D = 1 for invalid PS; D = 39 for a user data field greater than 128 octets; D = 82 for a user data field not octet aligned.
6. For RR, RNR, or REJECT packets, the presence of one or more octets beyond the third octet is considered an error. Although a valid P(R) may be accepted to update the status of outstanding data packets, the DCE shall invoke the error procedure as defined in Note 4 (with D = 39).
7. If possible, the DCE should process these packets normally. On the other hand, the DCE may define an internal mechanism to indicate that valid data packets have been discarded during a receive-not-ready condition. In this case, when the receive-not-ready condition clears, the DCE should reset the logical channel, forwarding both a reset indication packet to the DTE (D=0, no additional information) and a reset request packet to the IWF.

Table 4-35. DCE timer

Timer design	Default time-limit value	Start event	Normally terminated by	Action when timer expires
tN10	60 s	DCE issues a RESTART INDICATION packet	Reception of RESTART CONFIRMATION or RESTART REQUEST packet	DCE enters the r1 state and may issue a DIAGNOSTIC packet (D = 52)
tN11	180 s	DCE issues an INCOMING CALL packet	Reception of CALL ACCEPTED or CLEAR REQUEST or CALL REQUEST packet	DCE enters the p7 state signalling a CLEAR INDICATION packet (D = 49) (see Note)
tN12	60 s	DCE issues a RESET INDICATION packet	Receipt of RESET CONFIRMATION or RESET REQUEST packet	DCE enters the p7 state signalling a CLEAR INDICATION packet (D = 51) (see Note)
tN13	60 s	DCE issues a CLEAR INDICATION packet	Reception of a CLEAR CONFIRMATION or CLEAR REQUEST packet	DCE enters the p1 state and may issue a DIAGNOSTIC packet (D = 50)

Note.— The clear is extended to the IWF, i.e. the DCE shall issue a clear request packet to the IWF.

Table 4-36. SSNDPX/IWF interface

Packets received from SSNDPX	Action
INCOMING CALL	See 4.7.5.1.2
CALL CONNECTED	See 4.7.5.1.3
CLEAR INDICATION	See 4.7.5.1.4
DATA	See 4.7.5.1.5
INTERRUPT	See 4.7.5.1.5
INTERRUPT CONFIRMATION	See 4.7.5.1.5
RESET INDICATION	See 4.7.5.1.5

Packets sent to SSNDPX
CALL REQUEST
CALL ACCEPTED
CLEAR REQUEST
DATA
INTERRUPT
INTERRUPT CONFIRMATION
RESET REQUEST

Table 4-37. ISO 8208 DCE/IWF interface

Packets received from ISO 8208 DCE	Action
CALL REQUEST	See 4.7.5.2.2
CALL ACCEPTED	See 4.7.5.2.3
CLEAR REQUEST	See 4.7.5.2.4
DATA	See 4.7.5.2.5
INTERRUPT	See 4.7.5.2.5
INTERRUPT CONFIRMATION	See 4.7.5.2.5
RESET REQUEST	See 4.7.5.2.5

Packets sent to ISO 8208 DCE
INCOMING CALL
CALL CONNECTED
CLEAR INDICATION
DATA
INTERRUPT
INTERRUPT CONFIRMATION
RESET INDICATION
RESTART INDICATION

Table 4-38. Circuit-mode — link interface data units

LIDU
1. Access request — telephone
2. Call announcement
3. C channel assignment
4. Call information — service address
5. Call progress — call attempt result
6. Call progress — channel release
7. Call progress — data mode
8. Call progress — test
9. Call progress — connect
10. Telephony acknowledge

LICI parameters
Message type (all)
AES ID (all)
GES ID (all)
Q number (all)
Application reference number (all)
Source (1,2)
Service direction (1,2)
Service ID (1,2)
Network ID (1)
Circuit data rate (1,2)
Voice channel characteristics (1,2)
Called terminal (2)
Calling terminal (1,4)
Initial EIRP (3)
Receive channel frequency (3)
Transmit channel frequency (3)
Report type (5,6,7,8,9)
S (5,6)
Location (5,6)
Cause class (5,6)
Cause value (5,6)
Digit 0,1 (1)
Digit 2-9 (1,4)
Ack/nack (10)
Routing (5,6,10)
Message type of missing CM-LIDU (10)

Table 4-39. AES outgoing procedure — interworking telephony events

Event type	Event name	Parameter mapping requirements (Figure*)	To/from interworking interface with aircraft network
FITE 18	Calling party category indicator — AMS(R)S call origination	A5-1 a), b)	From
FITE 22	Clear forward	A5-2	From
BITE 5	Address complete	A5-3	To
BITE 12	Call unsuccessful — network congestion	A5-4	To
BITE 14	Call unsuccessful — address incomplete	A5-5	To
BITE 15	Call unsuccessful — unallocated number	A5-6	To
BITE 16	Call unsuccessful — called party busy	A5-7	To
BITE 17	Call unsuccessful — line out of service	A5-8	To
BITE 20	Call unsuccessful — send error indication	A5-9	To
BITE 22	Answer	A5-10	To
BITE 25	Clear back	A5-11	To

* Figures are located in Appendix 5 to Chapter 4.

Table 4-40. AES incoming procedure — interworking telephony events

Event type	Event name	Parameter mapping requirements (Figure*)	To/from interworking interface with aircraft network
FITE 18	Calling party category indicator — AMS(R)S call origination	A5-12	To
FITE 22	Clear forward	A5-13	To
BITE 12	Call unsuccessful — network congestion	A5-14	From
BITE 16	Call unsuccessful — called party busy	A5-15	From
BITE 17	Call unsuccessful — line out of service	A5-16	From
BITE 22	Answer	A5-17	From
BITE 25	Clear back	A5-18	From

* Figures are located in Appendix 5 to Chapter 4.

Table 4-41. GES outgoing procedure — interworking telephony events

Event type	Event name	Parameter mapping requirements (Figure*)	To/from interworking interface with terrestrial network
FITE 18	Calling party category indicator — AMS(R)S call origination	A5-19	From
FITE 22	Clear forward	A5-20	From
BITE 5	Address complete	A5-21	To
BITE 12	Call unsuccessful — network congestion	A5-22	To
BITE 16	Call unsuccessful — called party busy	A5-23	To
BITE 17	Call unsuccessful — line out of service	A5-24	To
BITE 20	Call unsuccessful — send error indication	A5-25	To
BITE 22	Answer	A5-26	To
BITE 25	Clear back	A5-27	To

* Figures are located in Appendix 5 to Chapter 4.

Table 4-42. GES incoming procedure — interworking telephony events

Event type	Event name	Parameter mapping requirements (Figure*)	To/from interworking interface with terrestrial network
FITE 18	Calling party category indicator — AMS(R)S call origination	A5-28	To
FITE 22	Clear forward	A5-29	To
BITE 5	Address complete	A5-30	From
BITE 12	Call unsuccessful — network congestion	A5-31	From
BITE 14	Call unsuccessful — address incomplete	A5-32	From
BITE 15	Call unsuccessful — unallocated number	A5-33	From
BITE 16	Call unsuccessful — subscriber busy	A5-34	From
BITE 17	Call unsuccessful — line out of service	A5-35	From
BITE 20	Call unsuccessful — send error indication	A5-36	From
BITE 22	Answer	A5-37	From
BITE 25	Clear back	A5-38	From
BITE 27	Sending finished — Set up speech condition	A5-39	From
BITE 29	Release incoming side	A5-40	From

* Figures are located in Appendix 5 to Chapter 4.

Table 4-43. Circuit-mode priority

Priority	Service	Link layer Q No.	C channel Q No.	Description
1	AMS(R)S	15	15	Distress and urgency
2	AMS(R)S	12	12	Flight safety
3	AMS(R)S	10	10	Regularity and meteorological
4	AMSS	9	4	Public correspondence

Table 4-44. AES management — link layer interface data units

LIDU name	LIDU parameters[1]
From link layer 1. Log-on confirm 2. Log-on acknowledgement 3. Log-off acknowledgement 4. Log-on reject 5. Log-on interrogation 6. Log-on prompt 7. P/R channel control 8. T channel control 9. AES system table broadcast a) index b) GES P/R channel advice c) satellite ID channel advice d) beam ID channel advice e) GES beam support advice f) data EIRP table broadcast 10. System time broadcast 11. Selective release broadcast 12. Log control data channel reassignment 13. Channel status report 13a. Log-off request *To link layer* 14. Log-on request 15. Log-off request 16. Log-on acknowledgement 17. Log control ready for reassignment 18. Log control reassignment reject 19. Channel status report	Q number of application (14) Message type (all) AES ID (all) GES ID (all) Q number (all) Satellite ID (1, 9c, 9d, 14) Initial EIRP (1) TDMA message (1) Received bit error rate (19) EIRP adjust (13) P/R message (1) Voice channel characteristics (1, 14) Channel rate(s) (7, 8, 9d) Reason (4) P, R channel frequencies (7, 9b, d) T channel frequencies (8) Number of frequencies (7, 8) Beam IDs (1, 9d, 14) Revision number (9a, b, c, d, e) Application reference no. (13, 19) Satellite inclination (9c) Satellite right ascension (9c) Satellite longitude (9c) Satellite/beam identification frequencies (9c) Century, year, month, day, hour, second (10) Data bit rate capability (14) ACK/NAK messages 1-3 (2, 3, 16) Class of AES (1, 14) Number of C channels (14) Initial/renewal (14) Primary/secondary (14) Existence (9a) NOT (number of transmitters) (14) Report type (13, 19) LOV (log-on verification) (14) Channel frequency (11) AAS (9e) Antenna gain (14) Data EIRP (Global or Spot) (9f) Data EIRP table sequence number (9f) DETC/DETP (9a) ISU/SSU (9f) SIN/DOU (9f)

1. Definitions of LIDU parameters shall be as given in Appendix 3 to Chapter 4. The number(s) associated with each LIDU parameter shall indicate the LIDU(s) containing the parameter.

Table 4-45. GES management — link interface data units (LIDUs)

LIDU name	LIDU parameters[1]
To link layer 1. Log-on confirm 2. Log-on acknowledgement 3. Log-off acknowledgement 4. Log-on reject 5. Log-on interrogation 6. Log-on prompt 7. P/R channel control 8. T channel control 9. AES system table broadcast a) index b) GES P/R channel advice c) satellite ID channel advice d) beam ID channel advice e) GES beam support advice f) data EIRP table broadcast 10. System time broadcast 11. Selective release broadcast 12. Log control-data channel reassignment 12a. Channel status report 12b. Log-off request *From link layer* 13. Log-on request 14. Log-off request 15. Log-on acknowledgement 16. Log control-ready for reassignment 17. Log control-reassignment reject 18. Channel status report	Message type (all) AES ID (all) GES ID (all) Q Number of application (13) Satellite ID (1, 9c, 9d, 13) Initial EIRP (1) BER (18) TDMA message (1) P/R message (1) Voice channel characteristics (1, 13) Bit rate (7, 8, 9d) Reason (4) P, R channel freqencies (7, 9b) T channel frequency (8) Number of frequencies (7, 8) Beam IDs (1, 9c, 9d, 13) Revision number (9a, b, c, d, e) Satellite inclination (9c) EIRP adjustment (12a) Satellite right ascension (9c) Satellite longitude (9c) Satellite/beam-ID. frequency (9c) Century, year, month, day, hour, minute, second (10) ACK/NAK MSG1, MSG2, MSG3 (2, 3, 15) Number of C channels (13) Initial/renew (13) Primary/secondary (13) NOT (13) Beam-ID P channel frequency (9c) Beam support table (9e) Report type (12a, 18) Application reference number (12a, 18) Class of AES (13) LOV (13) Transmit channel frequency (11) Existence (9a) AAS (9e) Antenna gain (13) Data EIRP (Global or Spot) (9) Data EIRP table sequence number (9f) DETC/DETP (9a) ISU/SSU (9f) SIN/DOU (9f)

1. The order of the LIDU PARAMETER list does not correspond to the order of the LIDU NAME list. The number in parentheses after each LIDU parameter indicates the LIDU name to which the parameter applies.

FIGURES FOR CHAPTER 4

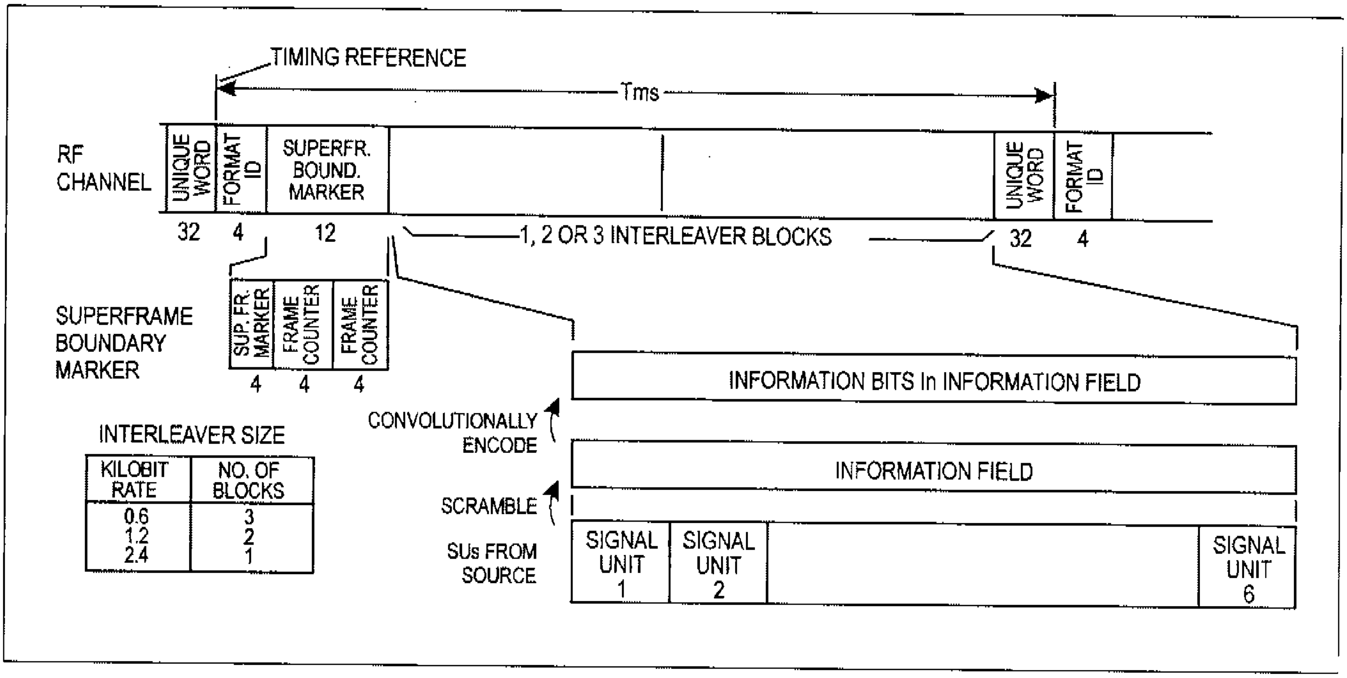

Figure 4-1. P channel format (0.6, 1.2 and 2.4 kbits/s)

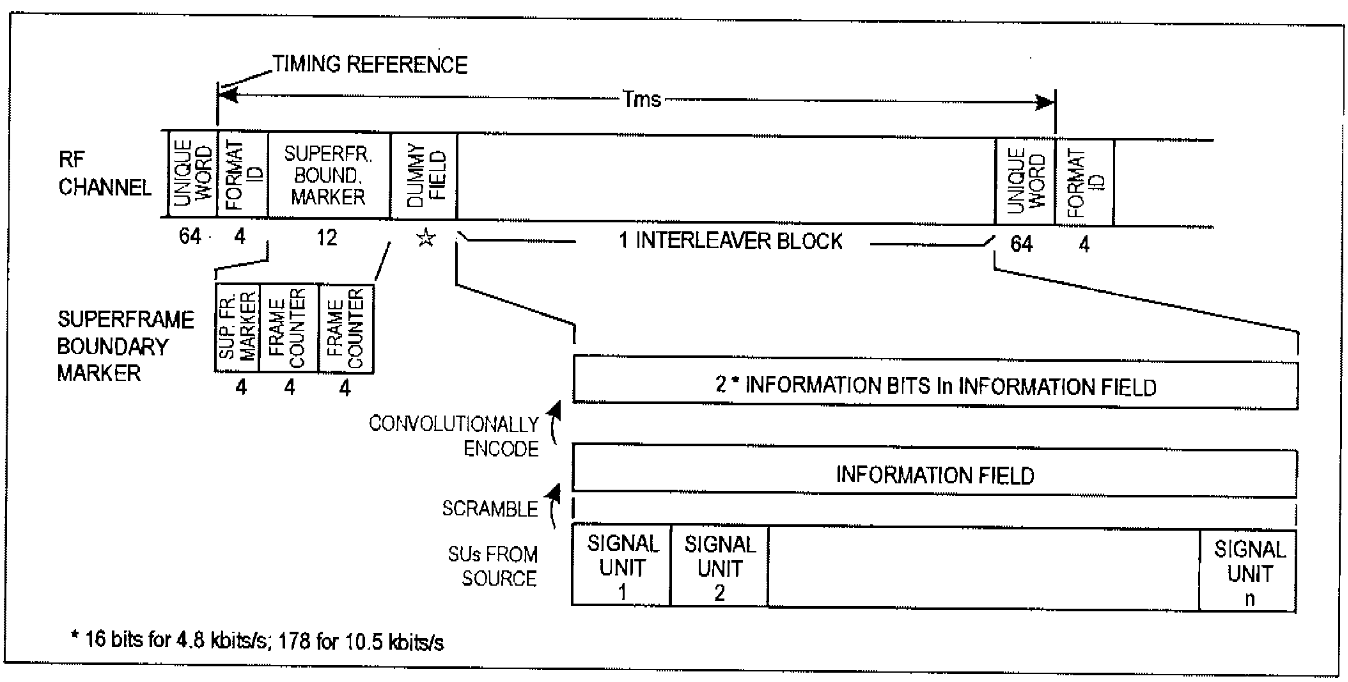

Figure 4-2. P channel format (4.8 and 10.5 kbits/s)

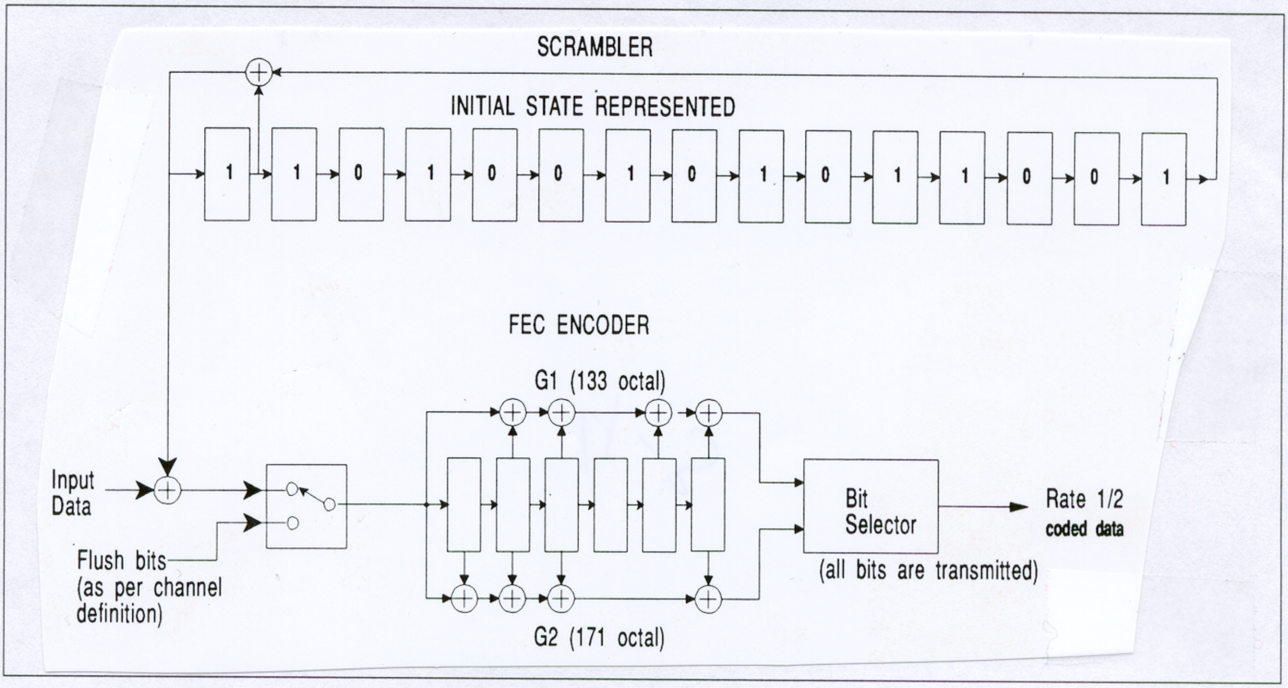

Figure 4-3. Scrambler and convolutional encoder functions

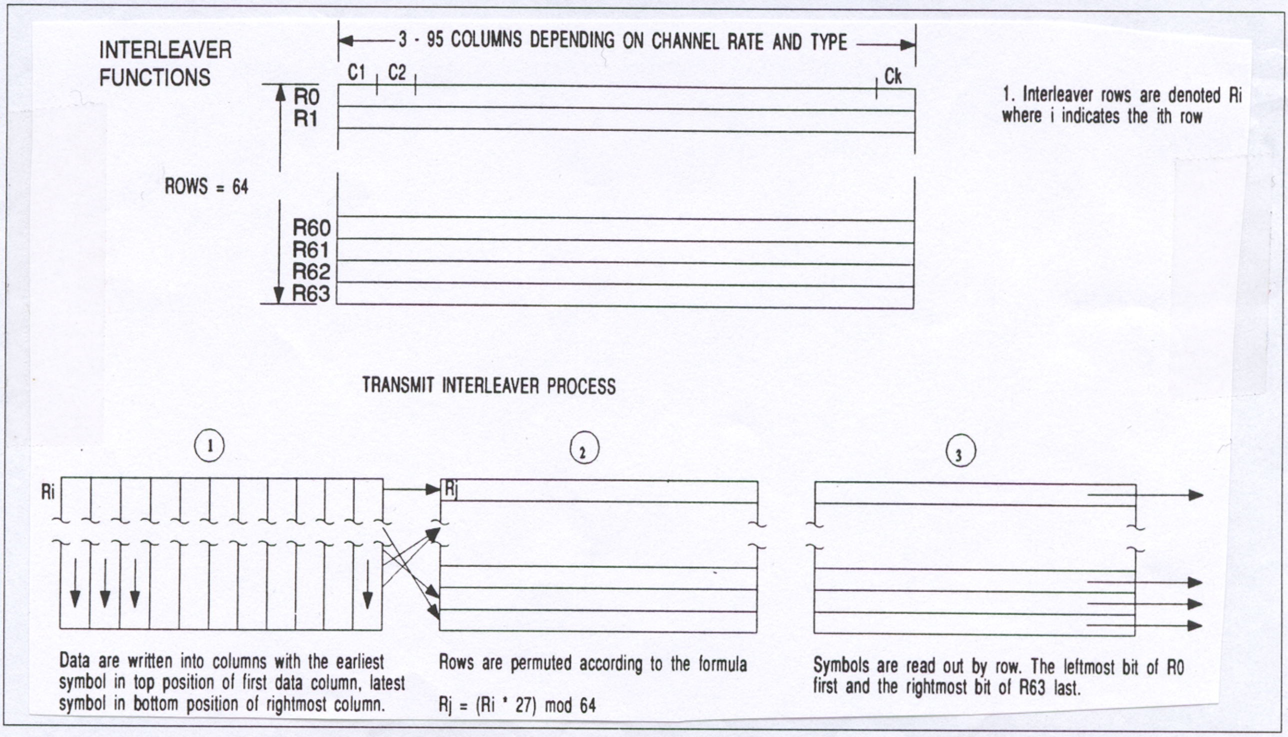

Figure 4-4. Interleaver functions

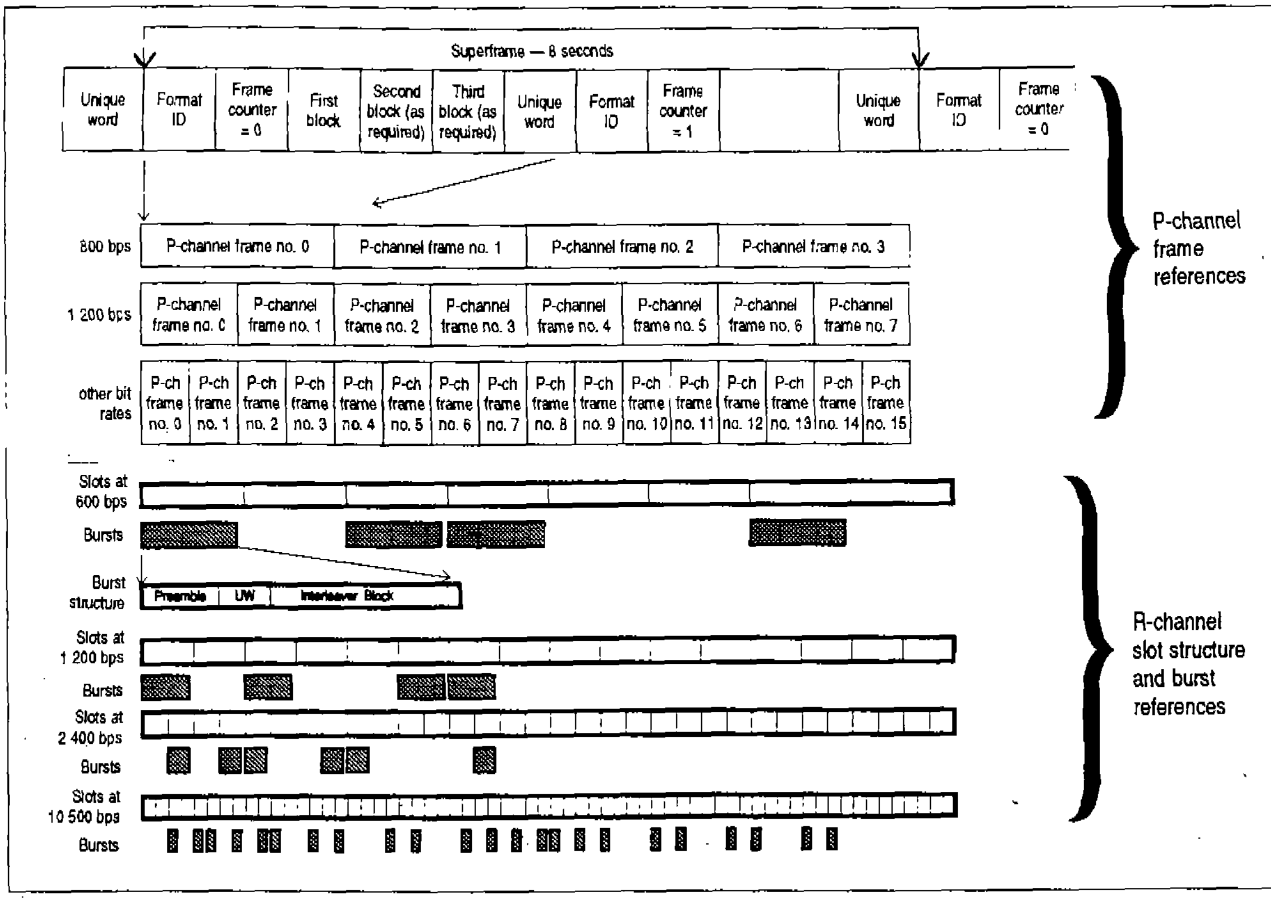

Figure 4-5. Timing references between P and R channels

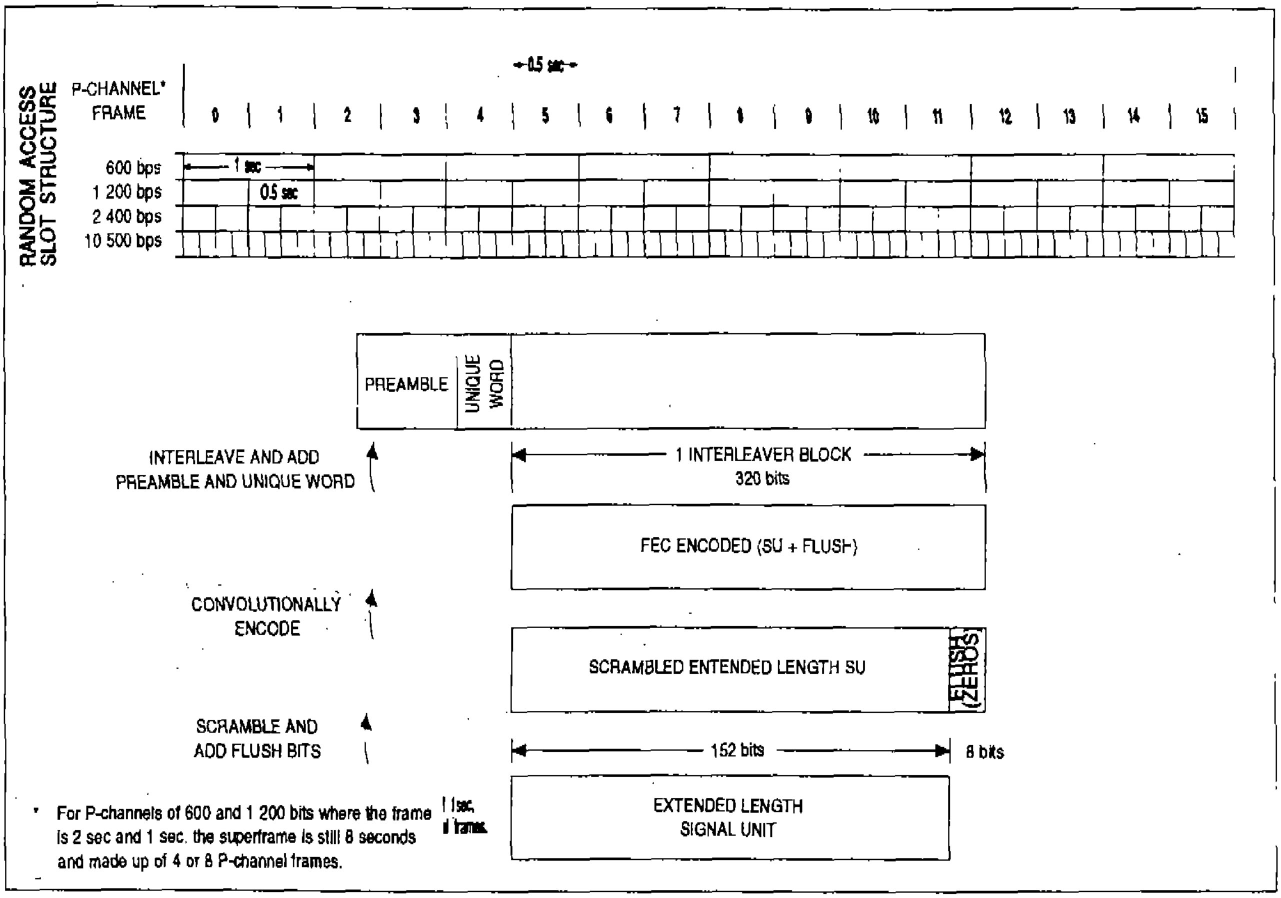

Figure 4-6. R channel burst format

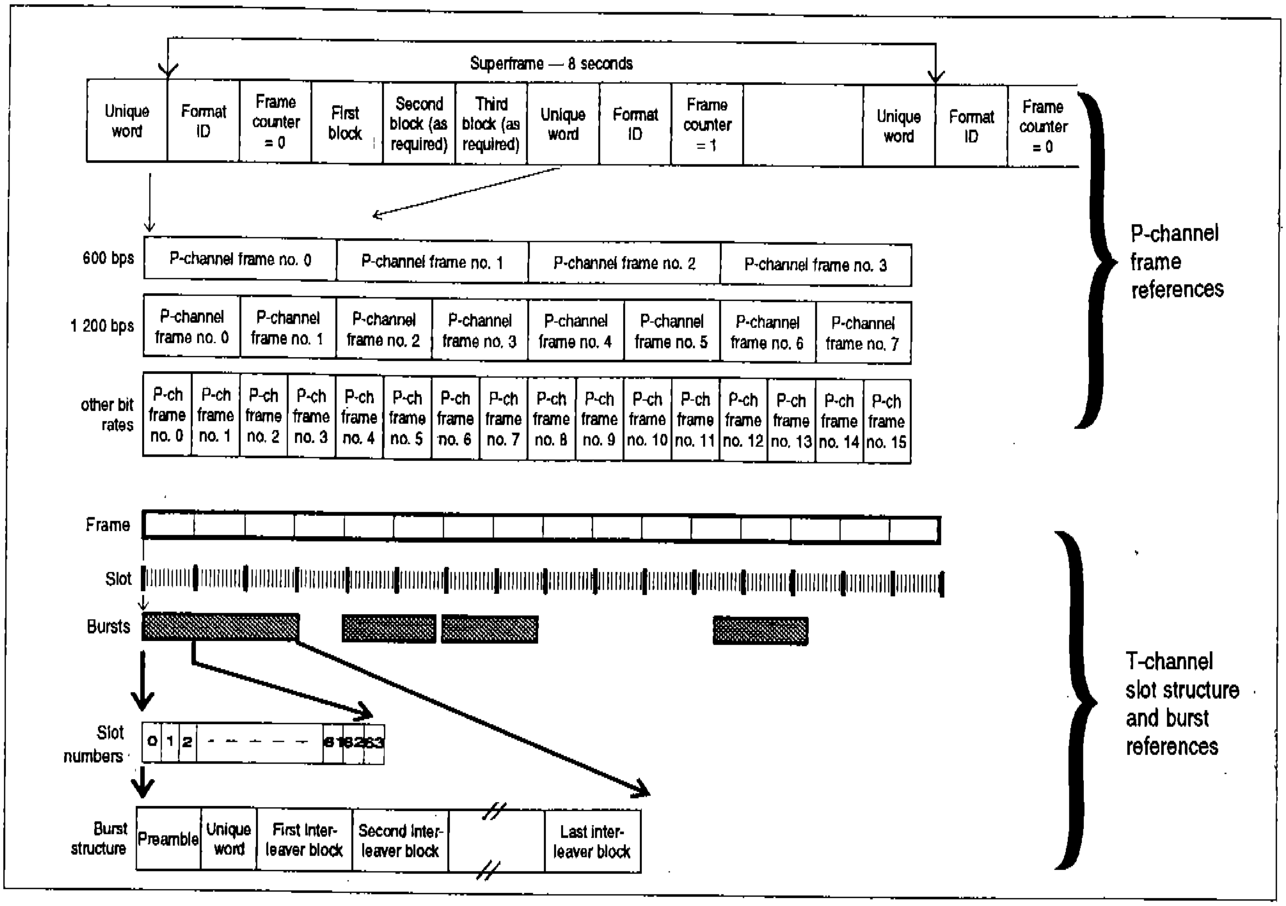

Figure 4-7. Timing references between P and T channels

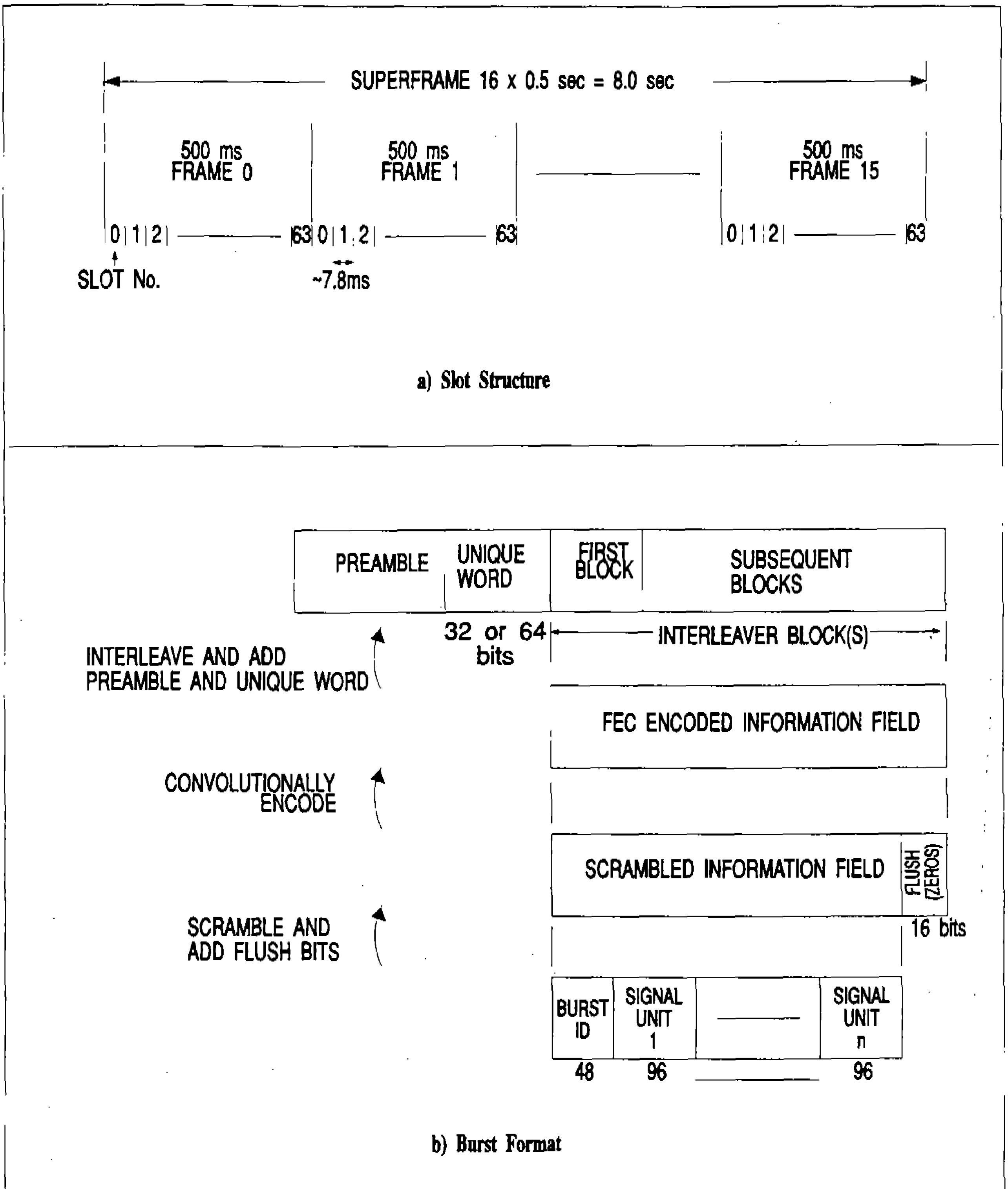

Figure 4-8. T channel format

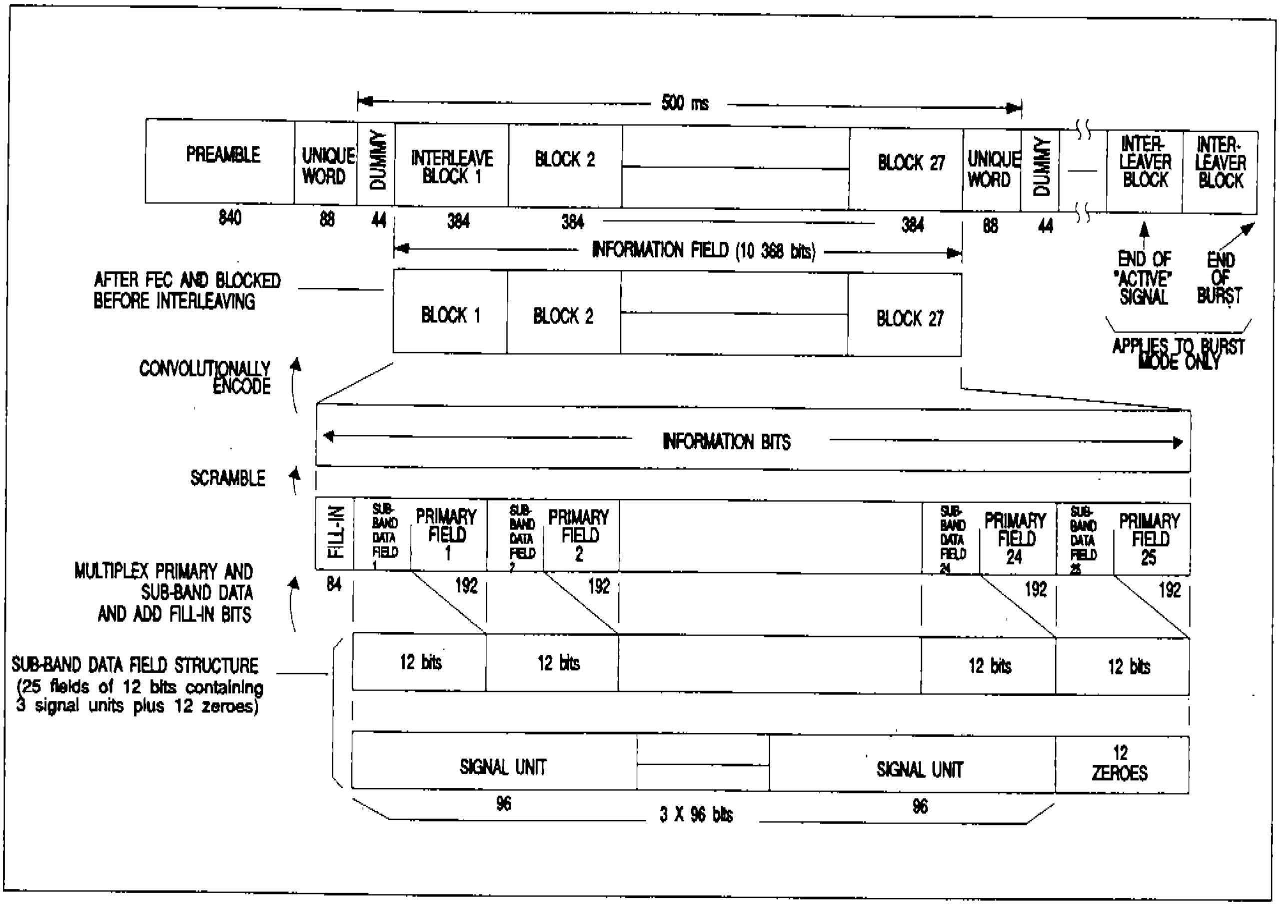

Figure 4-9. C channel format at 21.0 kbits/s channel rate

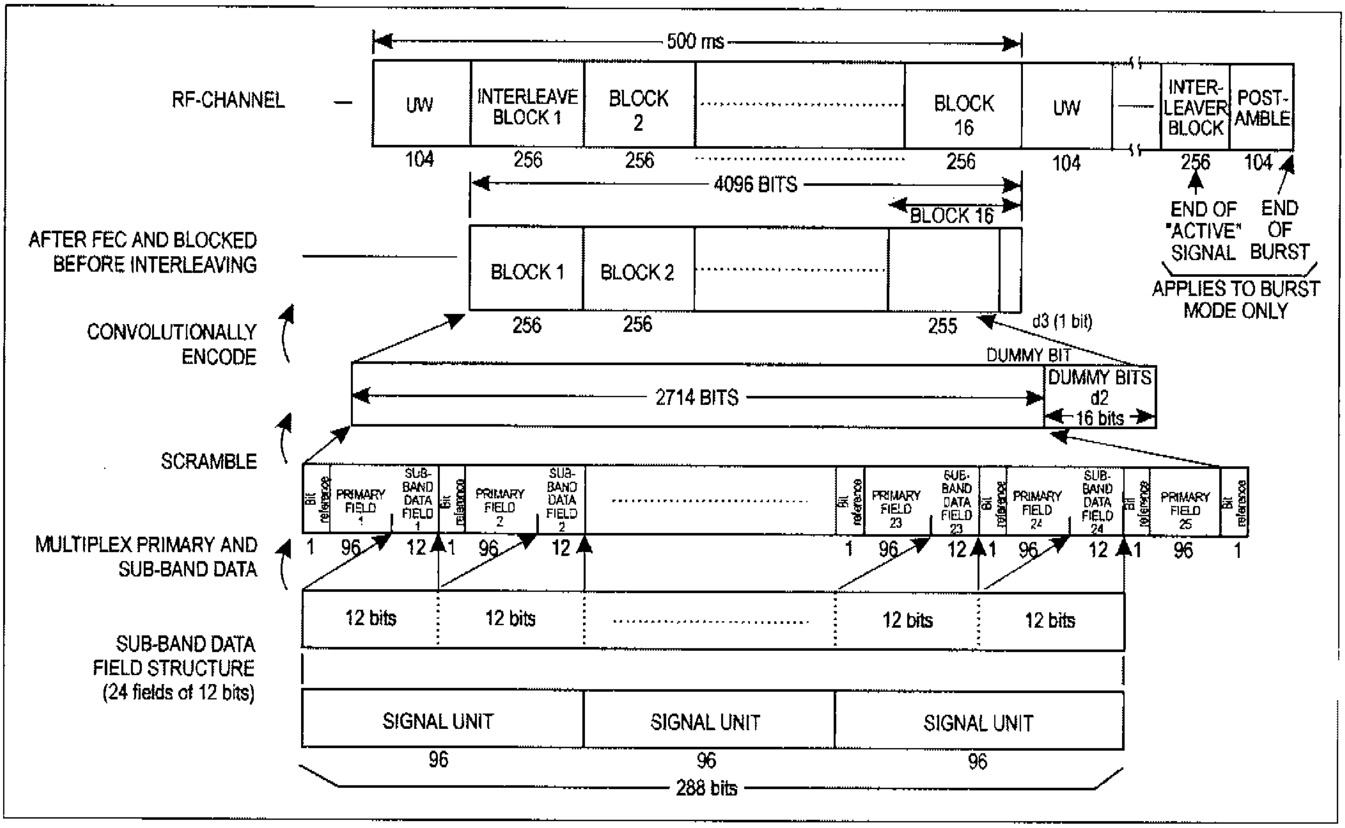

Figure 4-9 *bis*. C channel format at 8.4 kbits/s channel rate

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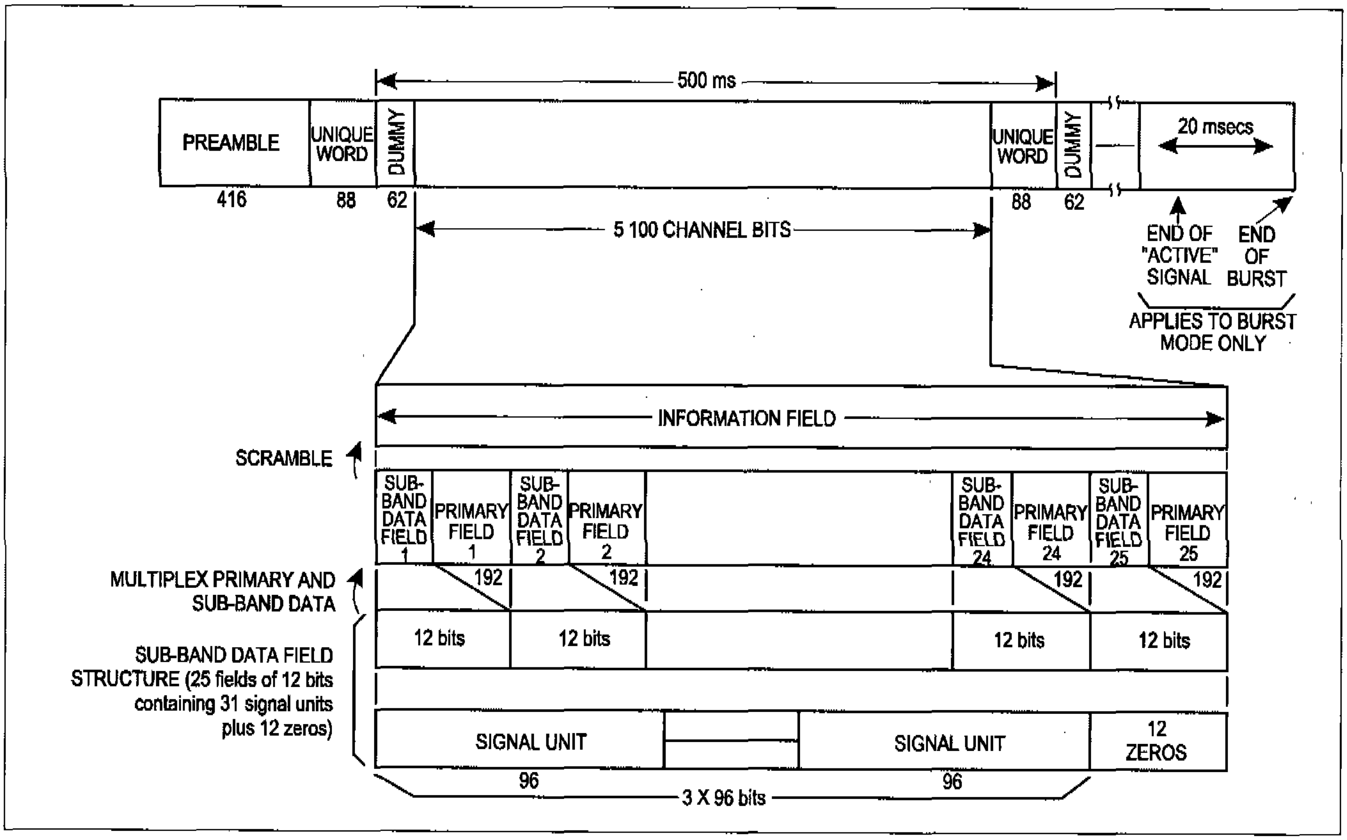

Figure 4-10. C channel format at 10.5 kbits/s channel rate

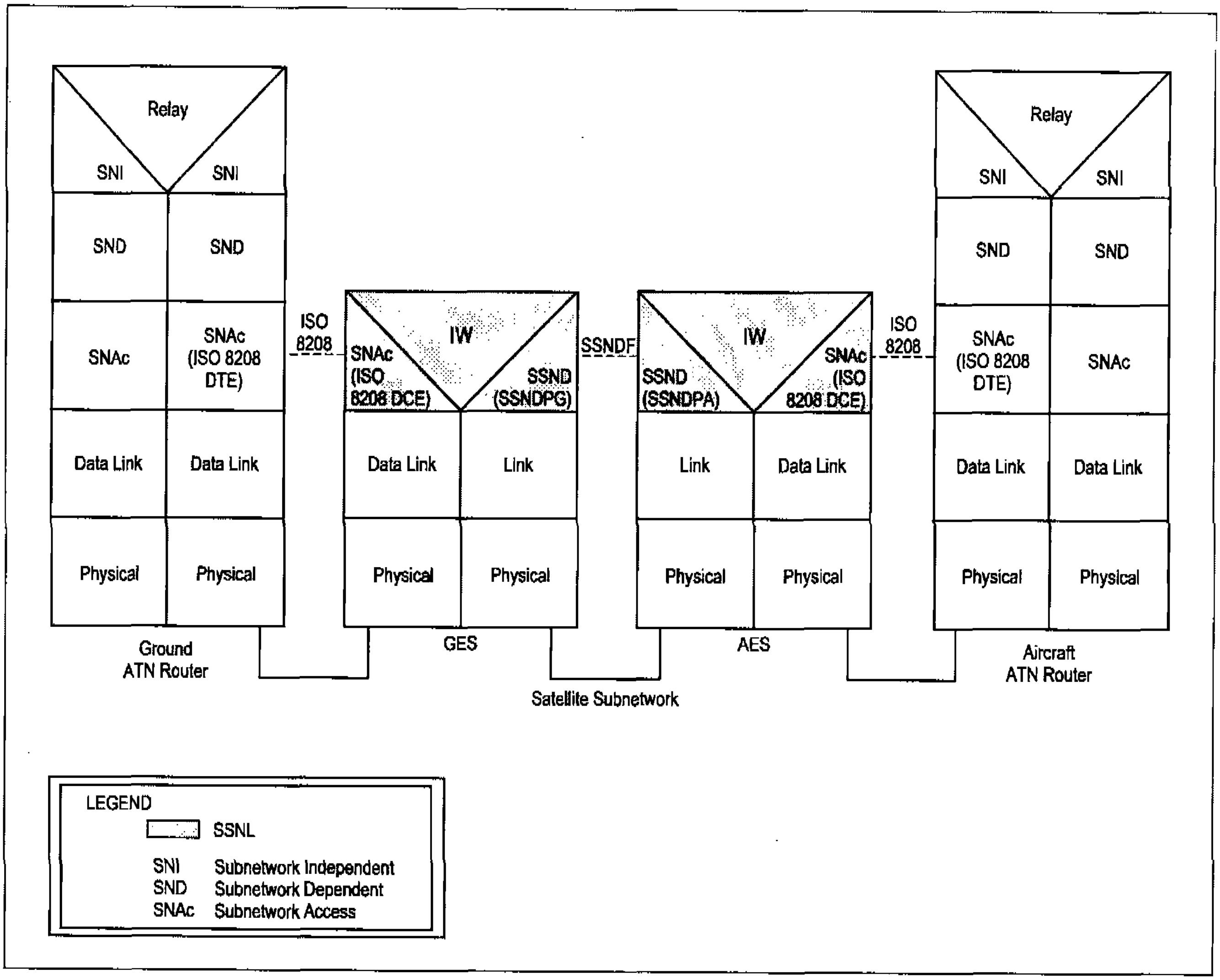

Figure 4-11. The SSNL functions and the ATN satellite subnetwork

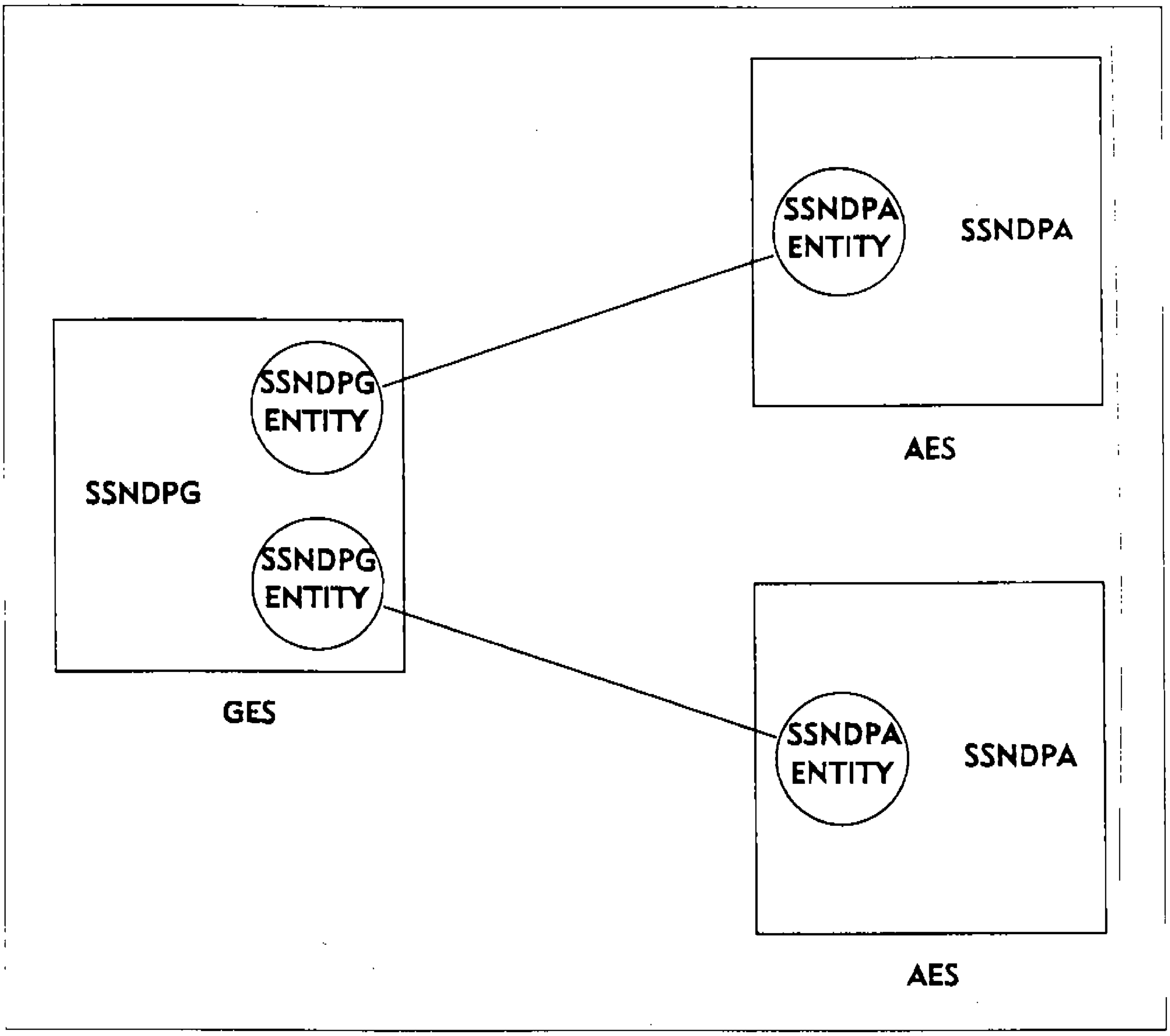

Figure 4-12. SSNDPX entities

Bits

Octets	8	7	6	5	4	3	2	1
1	M	D	SNPDU type identifier					
2	Logical channel number							
	Additional fields depending on SNPDU type							

Figure 4-13. General format of a SNPDU

Bits

Octets	8	7	6	5	4	3	2	1
1	0	X	X	0	0	X	X	X
2	Logical channel number							
3	DTE address length							
	Called DTE **							
	Calling DTE **							
	Called NSAP *							
	Calling NSAP *							
	Facility field length *							
	Facilities *							
	Call user data *							

* if present
** if length not equal to 0

Figure 4-14. Connection request SNPDU format

Bits

Octets	8	7	6	5	4	3	2	1
1	0	X	0	0	1	0	X	X
2	Logical channel number							
	Called NSAP address *							
	Facility field length *							
	Facilities *							
	Call user data *							

* if present

Figure 4-15. Connection confirm SNPDU format

Bits

Octets	8	7	6	5	4	3	2	1
1	0	0	0	1	0	0	X	0
2	Logical channel number							
	Called NSAP address *							
	Clearing cause							
	Diagnostic code							
	Clear user data *							

* if present

Figure 4-16. Connection released SNPDU format

Bits

Octets	8	7	6	5	4	3	2	1
1	0	0	0	1	1	0	0	0
2	Logical channel number							

Figure 4-17. Connection release complete SNPDU format

Bits

Octets	8	7	6	5	4	3	2	1
1	M	D	1	1	0	0	0	0
2	Logical channel number							
3	SNPDU number							
	User data							

Figure 4-18. Data SNPDU format

Bits

Octets	8	7	6	5	4	3	2	1
1	0	0	1	1	0	0	1	0
2	Logical channel number							
	Interrupt user data							

Figure 4-19. Interrupt data SNPDU format

Bits

Octets	8	7	6	5	4	3	2	1
1	0	0	1	1	1	0	1	0
2	Logical channel number							

Figure 4-20. Interrupt confirm SNPDU format

Bits

Octets	8	7	6	5	4	3	2	1
1	0	0	1	1	0	0	1	1
2	Logical channel number							
3	Resetting cause							
4	Diagnostic code							

Figure 4-21. Reset SNPDU format

Bits

Octets	8	7	6	5	4	3	2	1
1	0	0	1	1	1	0	1	1
2	Logical channel number							

Figure 4-22. Reset confirm SNPDU format

Bits

Octets	8	7	6	5	4	3	2	1
1	0	0	1	1	1	0	0	1
2	Logical channel number							
3	Flow control reason							
4	SNPDU number							

Figure 4-23. Flow control (suspend) SNPDU format

Bits

Octets	8	7	6	5	4	3	2	1
1	0	0	1	1	1	0	0	1
2	Logical channel number							
3	Flow control reason							

Figure 4-24. Flow control (resume) SNPDU format

Bits

	8	7	6	5	4	3	2	1
Code:	0	0	0	0	0	0	1	0

	8 7 6 5	4 3 2 1
Parameter field:	from the called DTE *	from the calling DTE *

* The four bits indicating each throughput class are binary coded and correspond to throughput classes as indicated on the right

Bits: 8765 or Bits: 4321	Throughput class (bits/s) as defined in ISO-8208
0000	Reserved
0001	Reserved
0010	Reserved
0011	75
0100	150
0101	300
0110	600
0111	1200
1000	2400
1001	4800
1010	9600
1011	19200
1100	48000
1101	64000
1110	Reserved
1111	Reserved

Figure 4-25. Throughput class negotiation (TCN) facility field

Bits

	8	7	6	5	4	3	2	1
Code:	0	1	0	0	1	0	0	1

	8 7 6 5 4 3 2 1
Parameter field: Octet 1	Transit delay expressed in millisecond (higher order bits)
Octet 2	Transit delay expressed in millisecond (lower order bits)

Figure 4.26. Transit delay selection and indication facility format

	Bits							
	8	7	6	5	4	3	2	1
Code:	0	0	0	0	0	0	0	1
	8	7	6	5	4	3	2	1
Parameter field:	0	0	0	0	0	0	0	0

Figure 4-27. Fast select (use not permitted) facility format

	Bits							
	8	7	6	5	4	3	2	1
Code:	0	0	0	0	1	0	1	1
	8	7	6	5	4	3	2	1
Parameter field:	0	0	0	0	0	0	0	0

Figure 4-28. Expedited data negotiation ("no use of expedited data") facility format

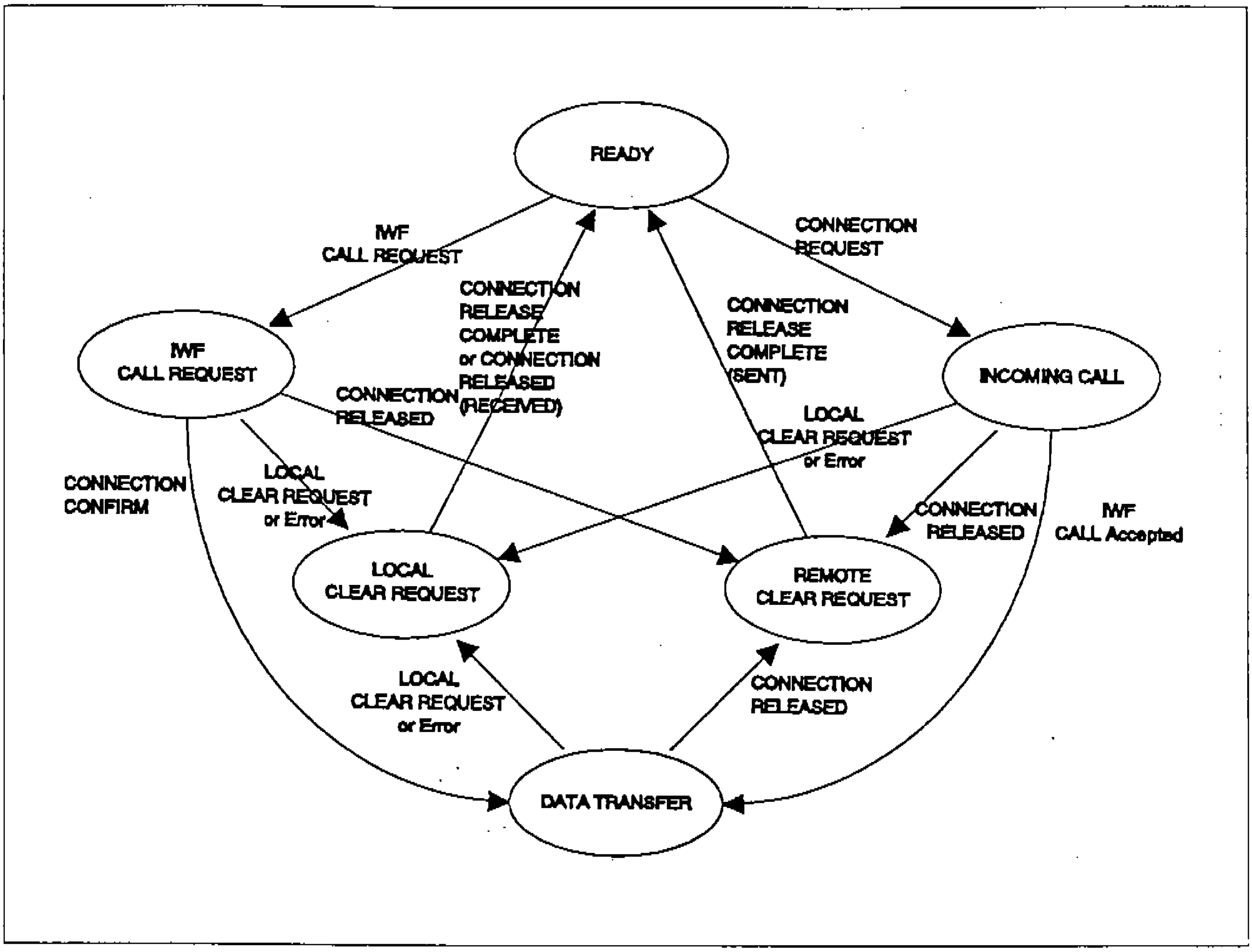

Figure 4-29. Connection establishment and release state diagram

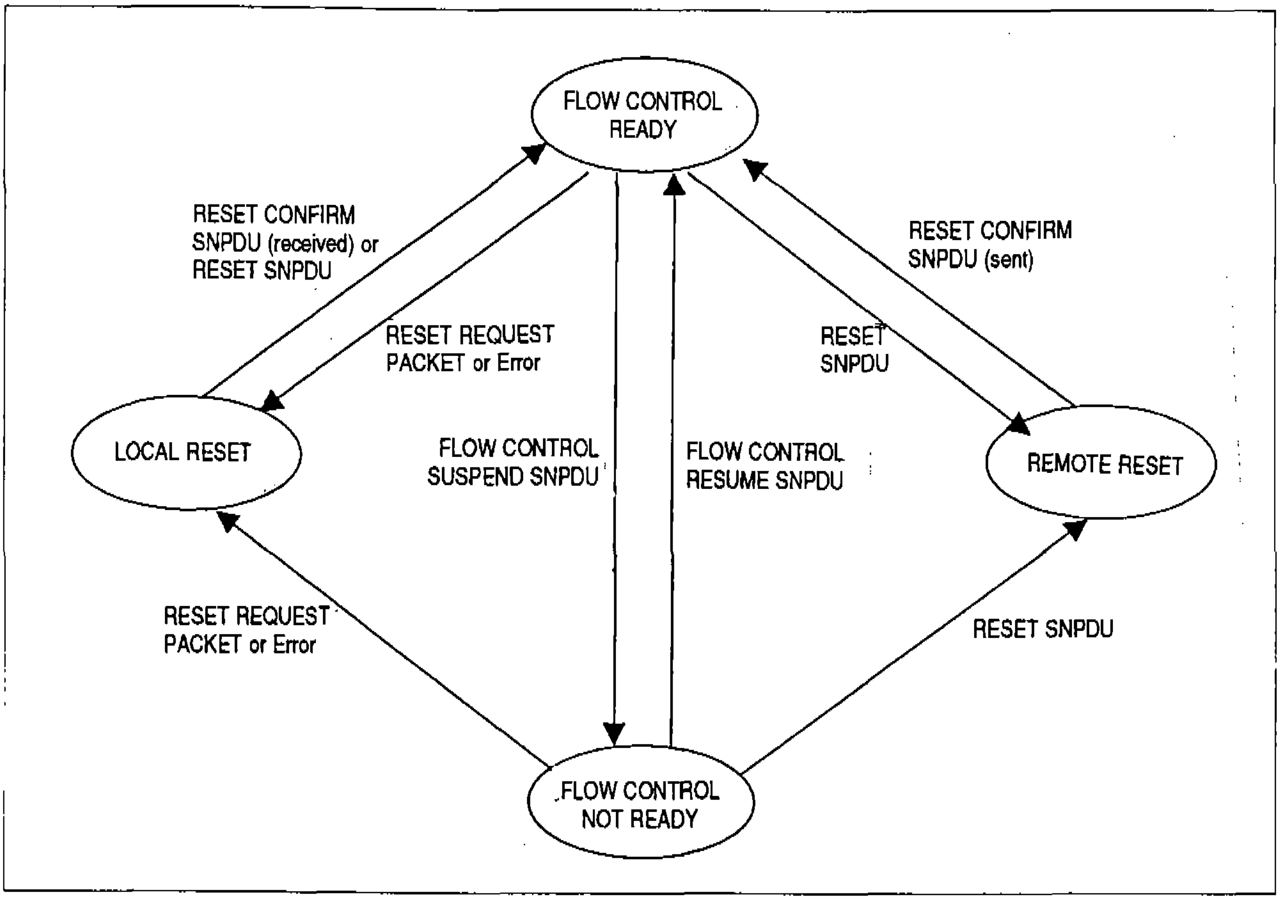

Figure 4-30. Reset and flow control state diagrams within the data transfer state

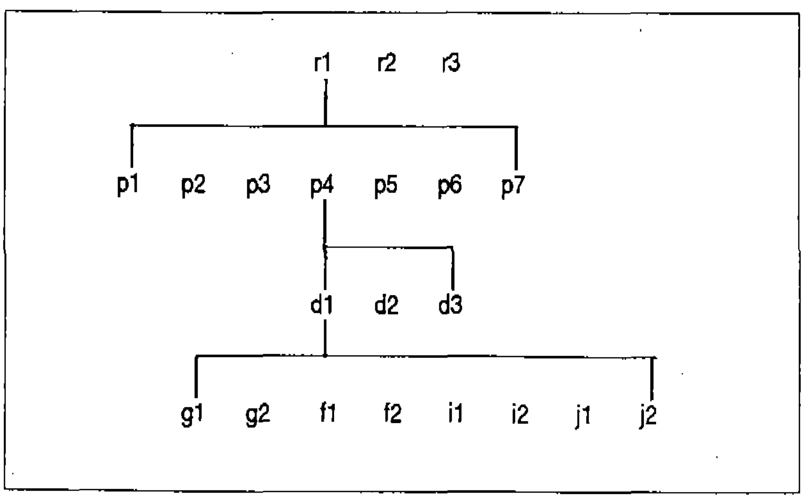

Figure 4-31. ISO-8208 DCE sub-state hierarchy

Appendix 1 to Chapter 4

RESPONSE MASKS OF A-BPSK AND A-QPSK FILTERS

Table A1-1. Required filter amplitude versus frequency response limits for A-BPSK

Upper bound		Lower bound	
Normalized frequency	Amplitude response (dB)	Normalized frequency	Amplitude response (dB)
0	0.25	0	–0.25
0.8	0.25	0.6	–0.25
1.133	–3.5	0.9	–2.5
1.333	–12	1.05	–5.5
1.533	–40	1.22	–12
—	—	1.333	–28
—	—	1.333	–45

The mask shall be defined by drawing straight lines through the above points where frequencies are normalized to the channel rate divided by 2, and the amplitude is normalized to 0 dB at a frequency of 0. This mask is illustrated in the guidance material.

Table A1-2. Required filter phase versus frequency response limits for A-BPSK and A-QPSK for 100 per cent roll-off

Upper bound		Lower bound	
Normalized frequency	Phase response (deg)	Normalized frequency	Phase response (deg)
0	1.8	0	–1.8
1.0	1.8	1.0	–1.8
1.0	2.8	1.0	–2.8
1.25	≥2.8	1.25	≤–2.8

The mask shall be defined by drawing straight lines through the above points where frequencies are normalized to the channel rate divided by 2, and the amplitude is normalized to 0 dB at a frequency of 0. This mask is illustrated in the guidance material.

Table A1-2 *bis*. Required filter phase versus frequency response limits for A-QPSK for 60 per cent roll off

Upper bound		Lower bound	
Normalized frequency	Phase response (deg)	Normalized frequency	Phase response (deg)
0	1.8	0	−1.8
0.25	1.8	0.25	−1.8
0.25	2.8	0.25	−2.8
0.31	≥2.8	0.31	≤−2.8

The mask shall be defined by drawing straight lines through the above points where frequencies are normalized to the channel rate divided by 2, and the amplitude is normalized to 0 dB at a frequency of 0. This mask is illustrated in the guidance material.

Table A1-3. Required filter amplitude versus frequency response limits for A-QPSK for 100 per cent roll-off

Upper bound		Lower bound	
Normalized frequency	Amplitude response (dB)	Normalized frequency	Amplitude response (dB)
0	0.25	0	−0.25
0.3	0.25	0.2	−0.25
0.7	−1	0.5	−1
1.1	−3	0.9	−3
1.5	−6	1.2	−6
1.7	−10	1.5	−10
2.0	−20	1.7	−16
2.5	−40	1.733	−27
3.0	−40	1.733	−40

The mask shall be defined by drawing straight lines through the above points where frequencies are normalized to the channel rate divided by 4, and the amplitude is normalized to 0 dB at a frequency of 0. This mask is illustrated in the guidance material.

Table A1-3 *bis*. Required filter amplitude versus frequency response limits for A-QPSK for 60 per cent roll-off

Upper bound		Lower bound	
Normalized frequency	Amplitude response (dB)	Normalized frequency	Amplitude response (dB)
0	0.25	0	–0.25
0.5	0.25	0.43	–0.25
0.64	0	0.64	–1
0.93	–1.6	0.93	–2.6
1.14	–4.4	1.14	–6.4
1.36	–8	1.36	–11
1.5	–13	1.43	–15
1.64	–22	1.5	–25
1.71	–35		
3.36	–40		
16.67	–40		

The mask shall be defined by drawing straight lines through the above points where frequencies are normalized to the channel rate divided by 4, and the amplitude is normalized to 0 dB at a frequency of 0. This mask is illustrated in the guidance material.

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Appendix 2 to Chapter 4

SIGNAL UNIT FORMATS

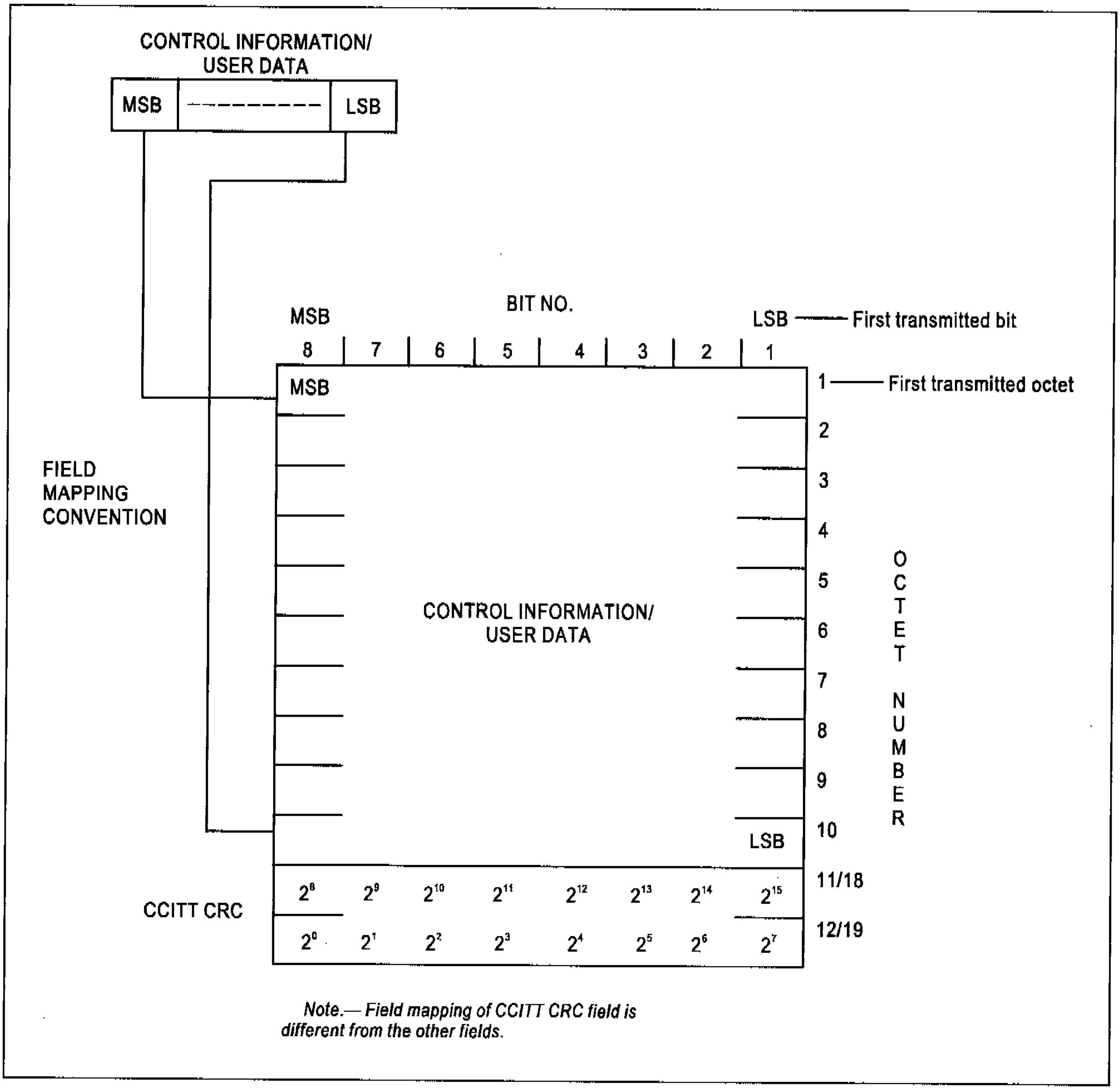

Figure A2-1. Signal unit field mapping and bit transmission order

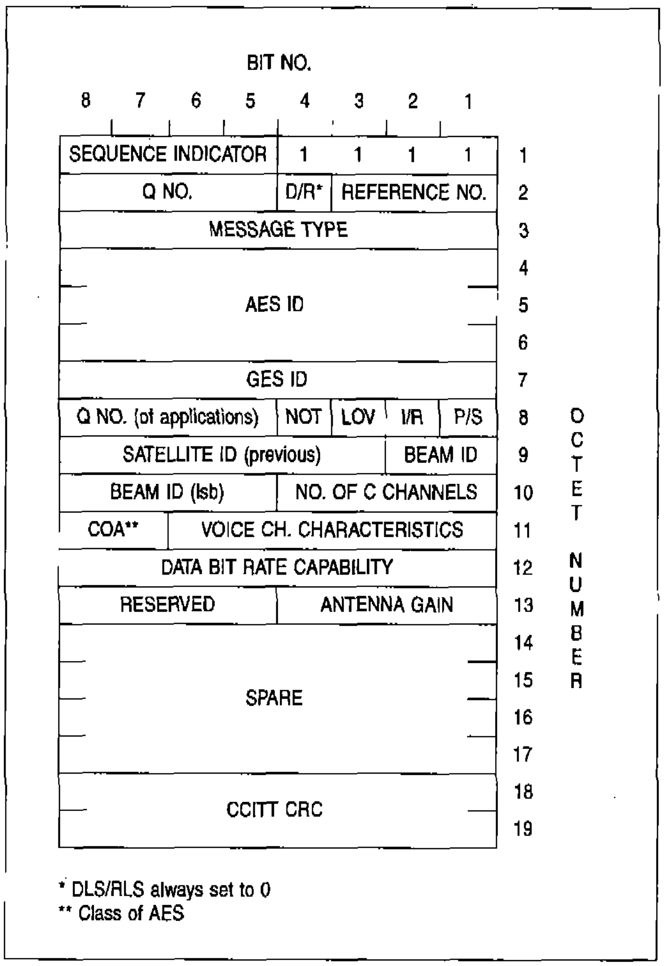

Figure A2-2. Log-on request — R channel

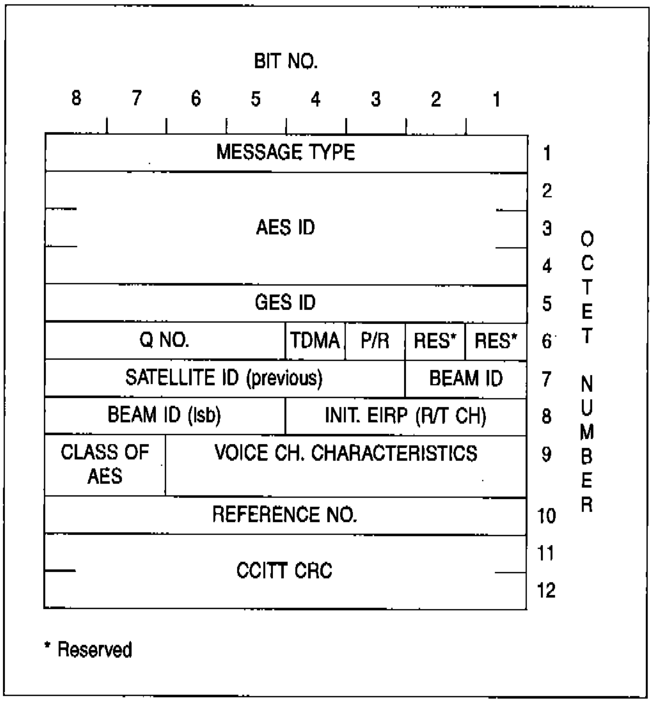

Figure A2-3. Log-on confirm — P channel

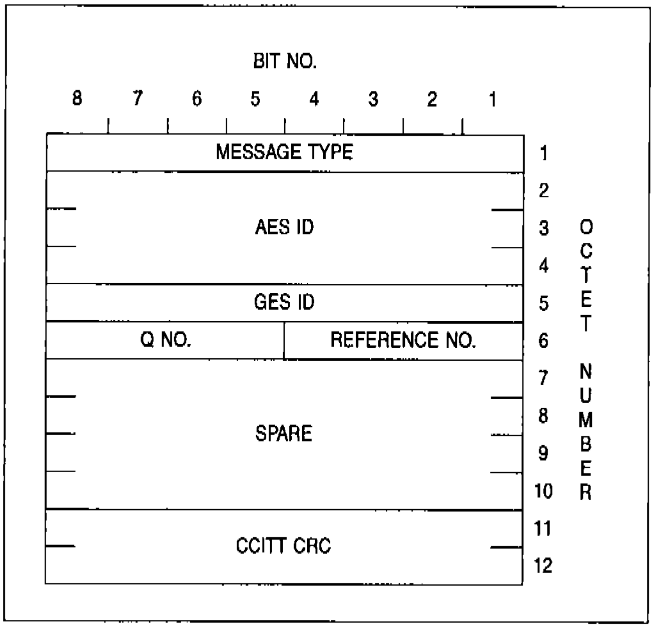

Figure A2-4. Log control — P channel
Log-on interrogation/log-on prompt/
log-off acknowledgement/data channel reassignment

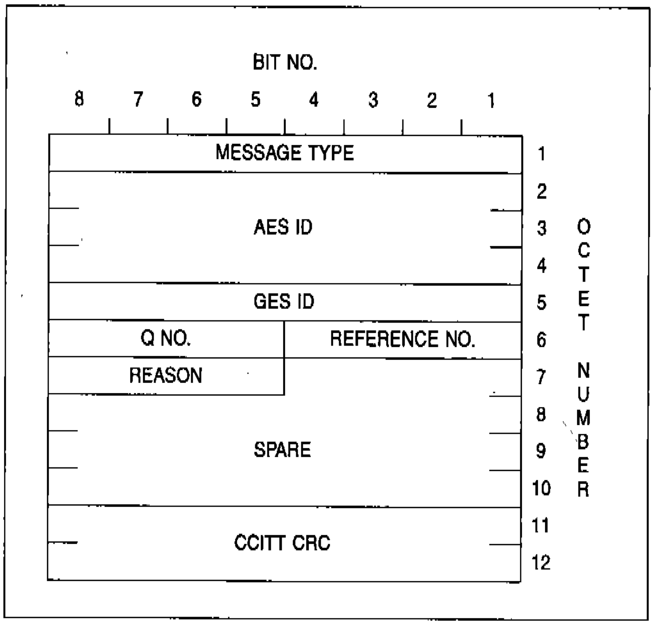

Figure A2-5. Log control — P channel
Log-on reject

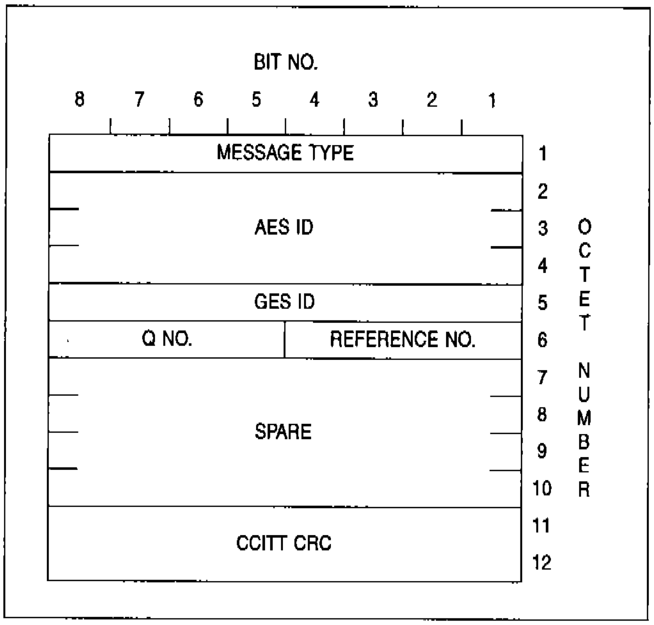

Figure A2-6. Log control — P channel
Log-off request

BIT NO. 8 7 6 5 4 3 2 1

Bits 8–1			Octet number
MESSAGE TYPE			1
AES ID			2–4
GES ID			5
Q NO.	RESERVED		6
SOURCE	SERVICE DIRECTION	SERVICE ID	7
Q NO. (of message)	REF. NO. (of message)		8
SPARE	MESSAGE LENGTH		9
SPARE			10
CCITT CRC			11–12

Figure A2-7. Access request data — T channel
Request for reservation (REQ)

BIT NO. 8 7 6 5 4 3 2 1

Bits 8–1			Octet number
MESSAGE TYPE			1
AES ID			2–4
GES ID			5
Q NO.	APPLICATION REF. NO.		6
SOURCE	SERVICE DIRECTION	SERVICE ID	7
CIRCUIT DATA RATE	RESERVED		8
SPARE	VOICE CH. CHARACTERISTICS		9
CALLED TERMINAL ID (units digit)	CALLED TERMINAL ID (tens digit)		10
CCITT CRC			11–12

Figure A2-8. Call announcement telephone — P channel

BIT NO. 8 7 6 5 4 3 2 1

Bits 8–1		Octet number
MESSAGE TYPE		1
AES ID		2–4
GES ID		5
Q NO.	APPLICATION REF. NO.	6
RESERVED	SEQUENCE NO.	7
CALLING TERMINAL ID (units digit)	CALLING TERMINAL ID (tens digit)	8
DIGIT 3	DIGIT 2	9
DIGIT 5	DIGIT 4	10
CCITT CRC		11–12

Figure A2-9. Call information telephone — from-aircraft sub-band C channel
Service address (ISU)

BIT NO. 8 7 6 5 4 3 2 1

Bits 8–1			Octet number
1	1	SEQUENCE NO.	1
Q NO.	APPLICATION REF. NO.		2
DIGIT 7	DIGIT 6		3
DIGIT 9	DIGIT 8		4
RESERVED	RESERVED		5
RESERVED	RESERVED		6
RESERVED	RESERVED		7
RESERVED	RESERVED		8
SPARE	SPARE		9
SPARE	SPARE		10
CCITT CRC			11–12

Figure A2-10. Call information telephone — from-aircraft sub-band C channel
Service address (SSU)

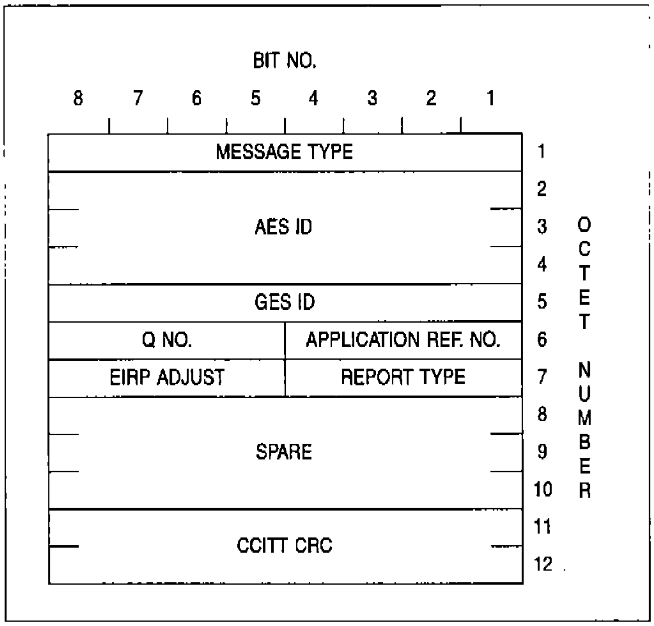

Figure A2-11. Call progress — to-aircraft sub-band C channel
Channel status report

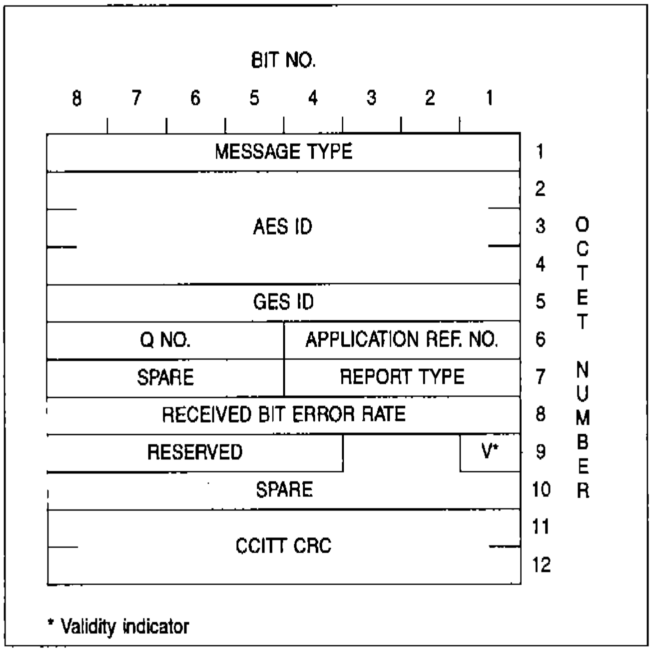

Figure A2-12. Call progress — from-aircraft sub-band C channel
Channel status report

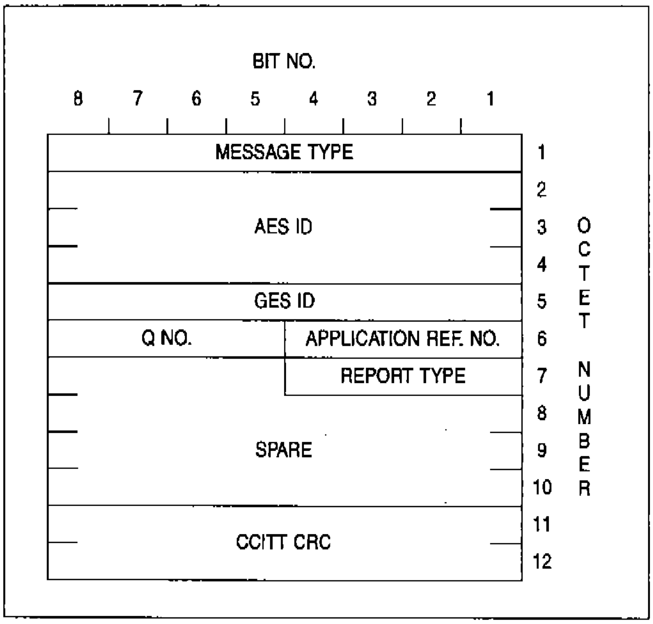

Figure A2-13. Call progress — To-/from-aircraft sub-band C channel
Connect

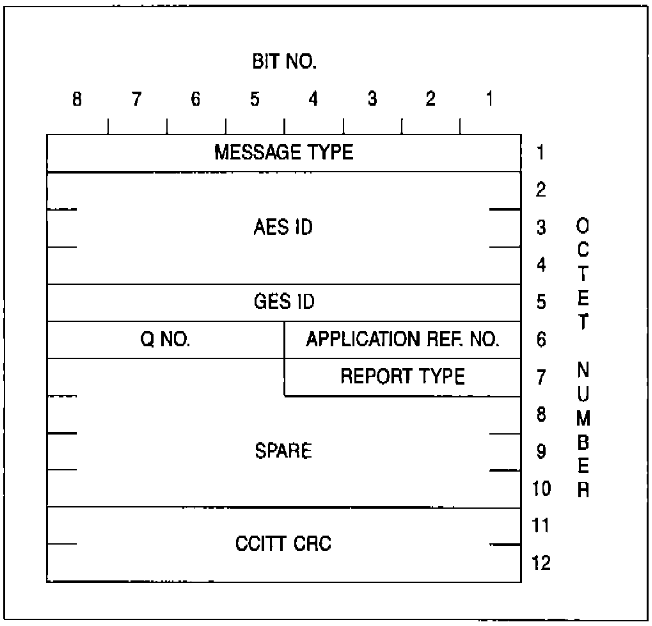

Figure A2-14. Call progress — To-/from-aircraft sub-band C channel
Test

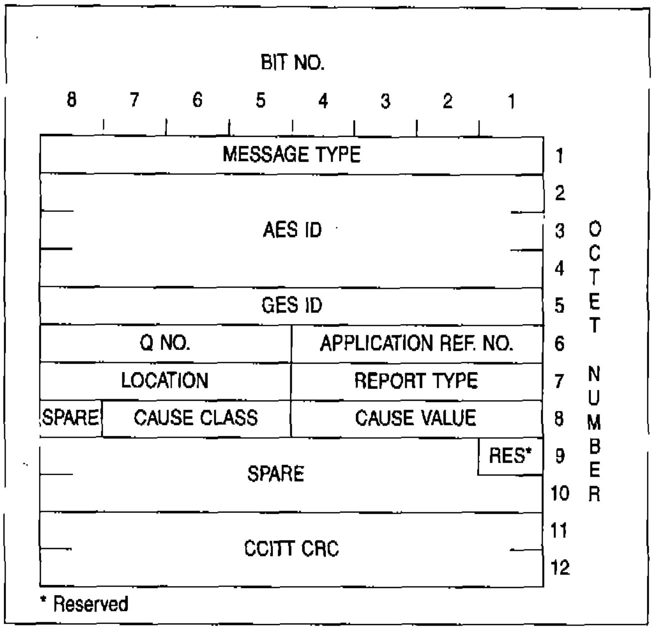

Figure A2-15. Call progress — P or to-/from-aircraft sub-band C channel
Call attempt result

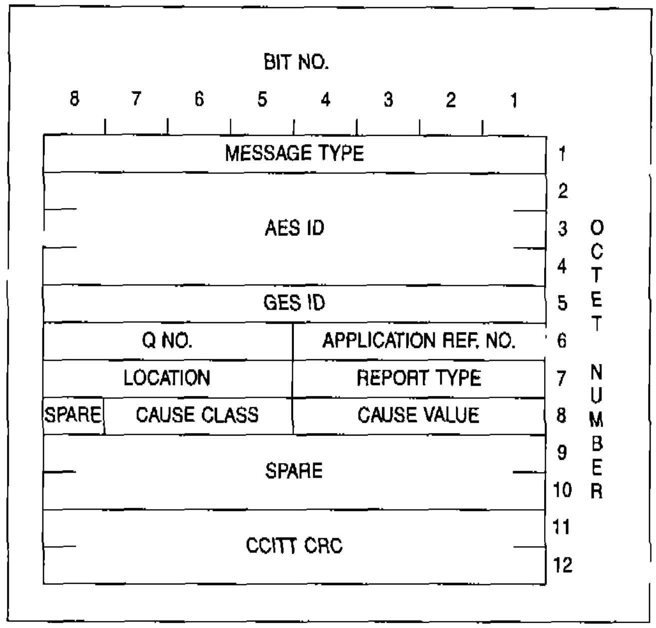

Figure A2-16. Call progress — P or to-/from-aircraft sub-band C channel
Channel release

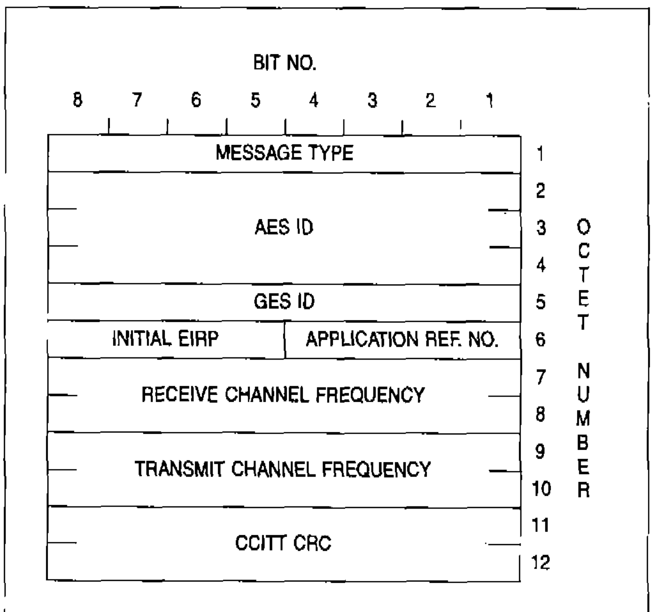

Figure A2-17. C channel assignment — P channel

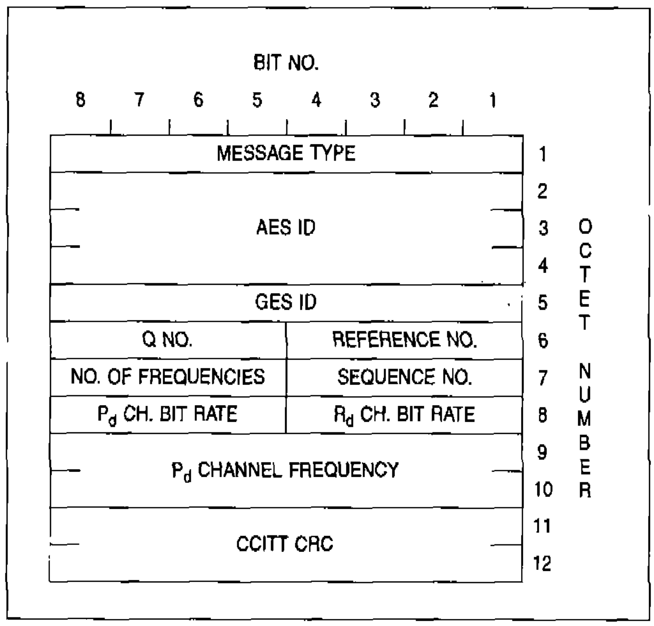

Figure A2-18. P/R channel control — P channel
(ISU)

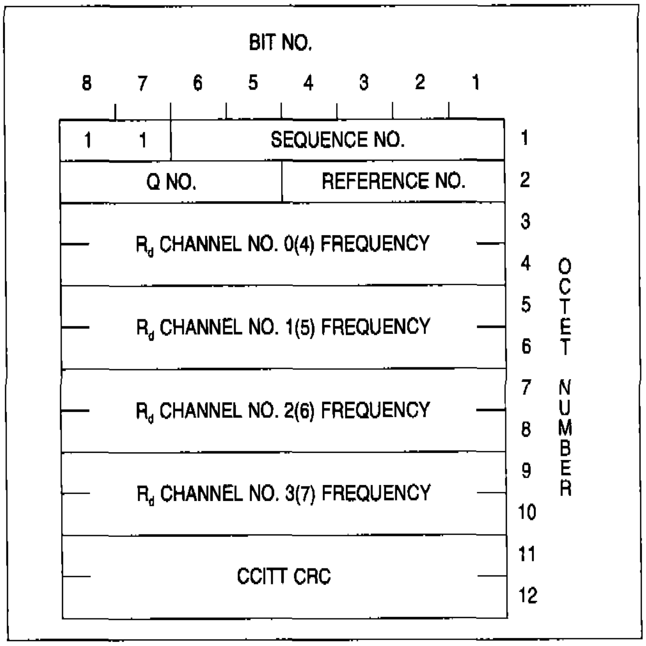

Figure A2-19. P/R channel control — P channel
(SSU)

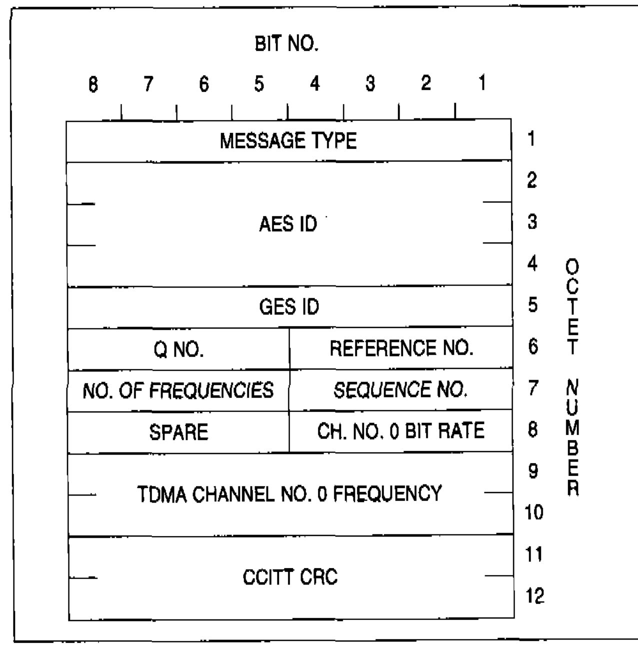

Figure A2-20. T channel control — P channel
(ISU)

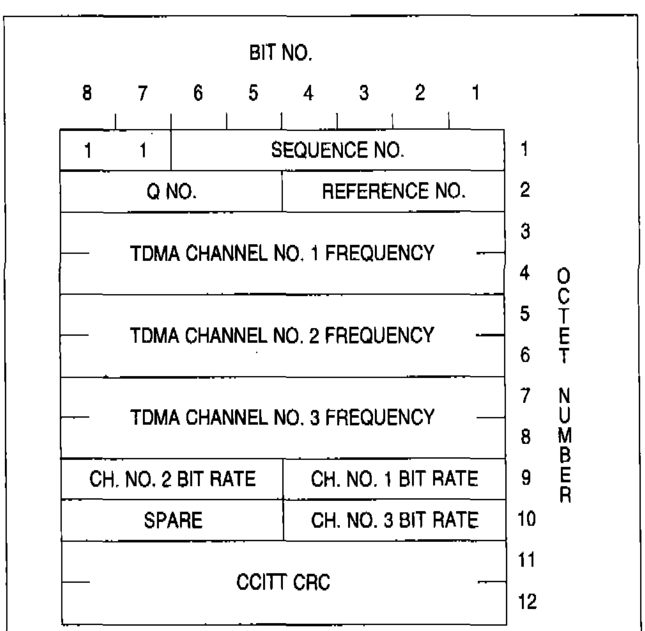

Figure A2-21. T channel control — P channel
(SSU)

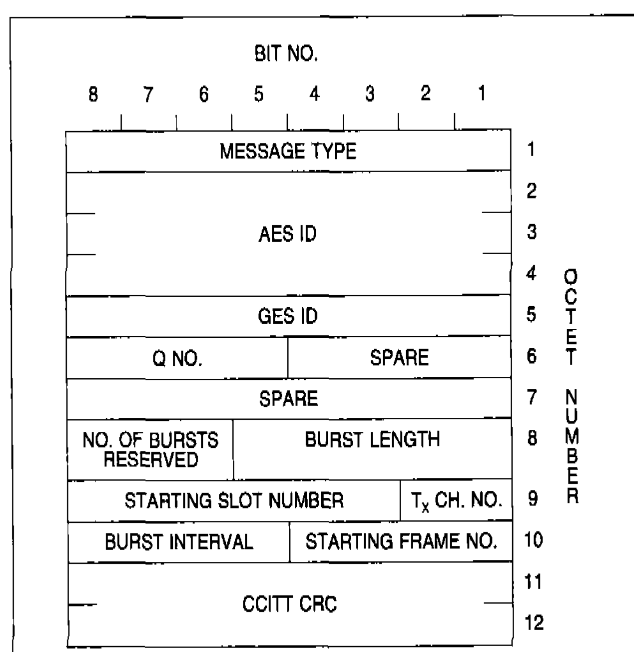

Figure A2-22. Unsolicited reservation — P channel

BIT NO. 8 7 6 5 4 3 2 1

Field (bits 8–1)			Octet number
MESSAGE TYPE			1
AES ID			2, 3, 4
GES ID			5
Q NO.	SPARE	RFC*	6
Q NO. (of message)	REF. NO. (of message)		7
NO. OF BURSTS RESERVED	BURST LENGTH		8
STARTING SLOT NUMBER	T_x CH. NO.		9
BURST INTERVAL	STARTING FRAME NO.		10
CCITT CRC			11, 12

* Reservation forthcoming flag

Figure A2-23. T channel assignment — P channel
RES SU

BIT NO. 8 7 6 5 4 3 2 1

Field (bits 8–1)			Octet number
MESSAGE TYPE			1
AES ID			2, 3, 4
GES ID			5
Q NO.	SPARE	RFC*	6
Q NO. (of message)	REF. NO (of message)		7
(MSB) DELAY TO RES. (LSB)	SPARE		8, 9, 10
CCITT CRC			11, 12

* Reservation forthcoming flag

Figure A2-24. Reservation forthcoming — P channel
RFC LSU

BIT NO. 8 7 6 5 4 3 2 1

Field (bits 8–1)					Octet number
MESSAGE TYPE					1
AES ID					2, 3, 4
GES ID					5
Q NO.				REFERENCE NO.	6
SPARE	AN3*	AN2*	AN1*	SPARE	7
ACKNOWLEDGE MESSAGE TYPE OF MSG1					8
ACKNOWLEDGE MESSAGE TYPE OF MSG2					9
ACKNOWLEDGE MESSAGE TYPE OF MSG3					10
CCITT CRC					11, 12

* ACK/NAK for Messages 1, 2 or 3

Figure A2-25. Log-on acknowledgement — P channel

BIT NO. 8 7 6 5 4 3 2 1

Field (bits 8–1)			Octet number
MESSAGE TYPE			1
AES ID			2, 3, 4
GES ID			5
Q NO.		APPLICATION REF. NO.	6
SPARE	ACK/NAK	REPORT TYPE	7
MESSAGE TYPE OF MISSING SU(s)			8
SPARE			9, 10
CCITT CRC			11, 12

Figure A2-26. Telephony acknowledgement — P/sub-band C channel

BIT NO. 8 7 6 5 4 3 2 1

Octet number		
1	MESSAGE TYPE	
2–4	AES ID	
5	GES ID	
6	Q NO. (of message)	REF. NO. (of message)
7	SPARE	MESSAGE LENGTH
8–10	SPARE	
11–12	CCITT CRC	

Figure A2-27. Request for acknowledgement — P channel

BIT NO. 8 7 6 5 4 3 2 1

Octet number			
1	MESSAGE TYPE		
2–4	AES ID		
5	GES ID		
6	Q NO. (of message)		REF. NO. (of message)
7	CH. TYPE	NO. OF SSU NK*	ACKNOWLEDGE CONTROL
8	SPARE		SSU SEQUENCE IND.+
9	SPARE		SSU SEQUENCE IND**
10	SPARE		RESERVED
11–12	CCITT CRC		

* Number of SSUs in acknowledgement indicating error
** Spare in RACK identifying one missing SU and in RACK indicating no error
+ Spare in RACK indicating no error

Figure A2-28. Acknowledgement — P channel
R channel acknowledgement (RACK)

BIT NO. 8 7 6 5 4 3 2 1

Octet number			
1	MESSAGE TYPE		
2–4	AES ID		
5	GES ID		
6	Q NO. (of message)		REF. NO. (of message)
7	CH. TYPE	NO. OF SSU NK*	ACKNOWLEDGE CONTROL
8	(MSB) DELAY TO RES. (LSB)	SSU SEQUENCE NO.**	
9		SSU SEQUENCE NO.**	
10		SSU SEQUENCE NO.**	
11–12	CCITT CRC		

* Number of SSUs in acknowledgement indicating error
** Spare in TACK requesting complete retransmissions and in TACK indicating no error
+ Spare in TACK indicating no error

Figure A2-29. Acknowledgement — P channel
T channel acknowledgement (TACK)

BIT NO. 8 7 6 5 4 3 2 1

Octet number			
1	MESSAGE TYPE		
2	REVISION NO.		
3	INITIAL SEQ. NO. OF A2-31 (PARTIAL)	DETC**	EXS*
4	INITIAL SEQ. NO. OF A2-32 & 33 (PARTIAL)	DETP++	EXS*
5	INITIAL SEQ. NO. OF A2-34 (PARTIAL)	SPARE	EXS*
6	INITIAL SEQ. NO. OF A2-31 (COMP)	SPARE	EXS*
7	INITIAL SEQ. NO. OF A2-32 & 33 (COMP)	SPARE	EXS*
8	INITIAL SEQ. NO. OF A2-34 (COMP)	SPARE	EXS*
9	INITIAL SEQ. NO. OF 2nd 2-31 (COMP)	SPARE	EXS*
10	SPARE		SBS+
11–12	CCITT CRC		

* Existence
+ Spot beam series
** Data EIRP Table — Complete
++ Data EIRP Table — Partial

Figure A2-30. AES system table broadcast — P channel
Global beam series index

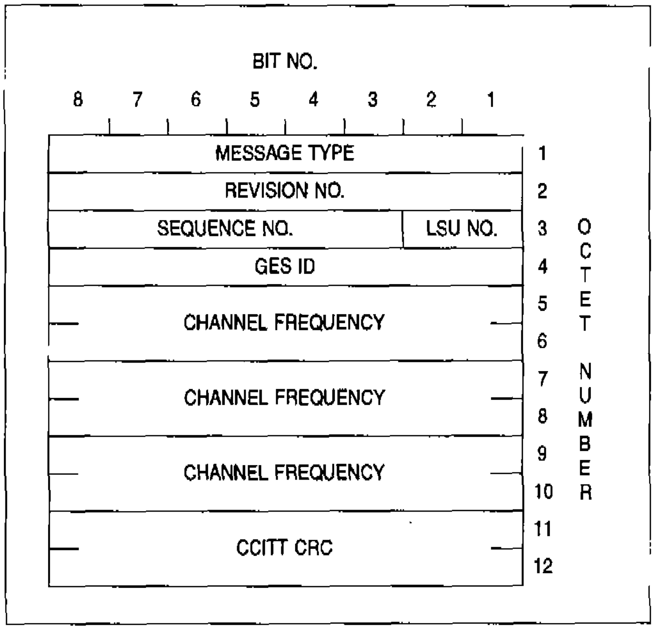

Figure A2-31. AES system table broadcast — P channel
GES P/R channel advice

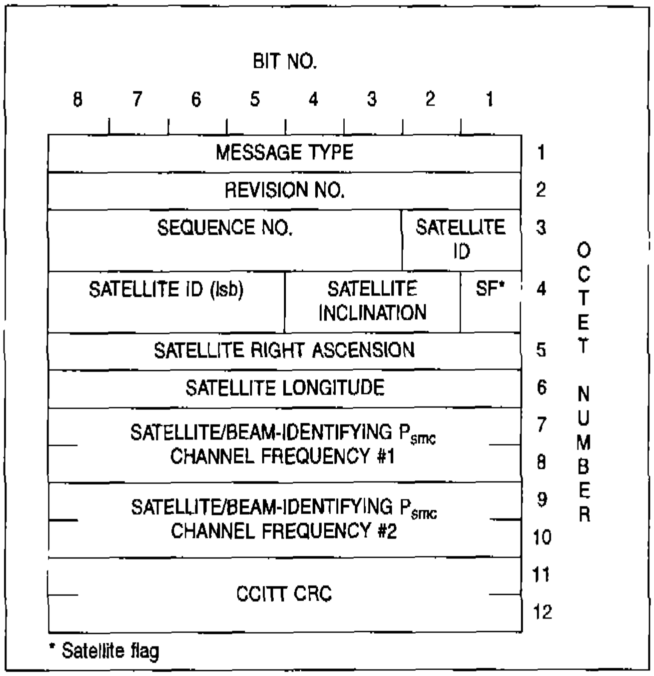

Figure A2-32. AES system table broadcast — P channel
Satellite/beam ID channel advice

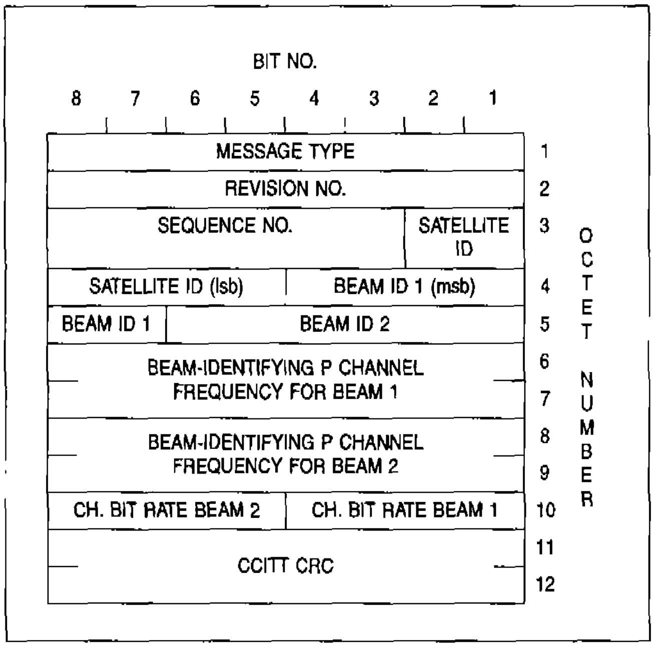

Figure A2-33. AES system table broadcast — P channel
Beam ID channel advice

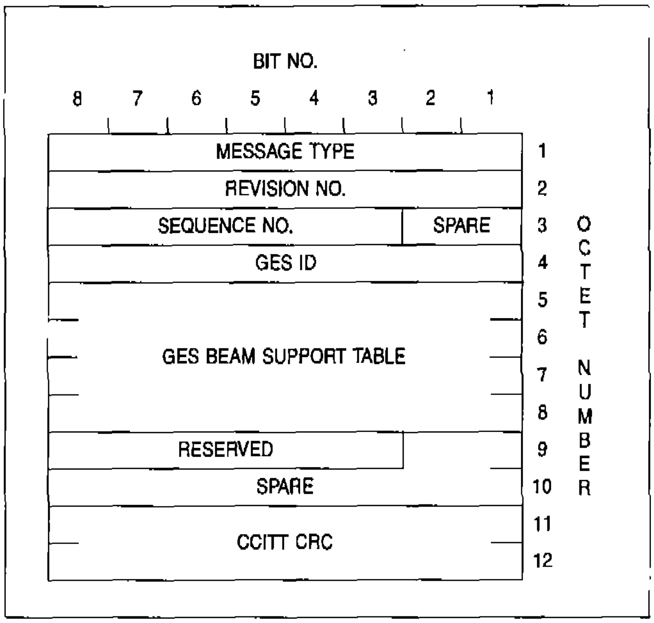

Figure A2-34. AES system table broadcast — P channel
GES beam support advice

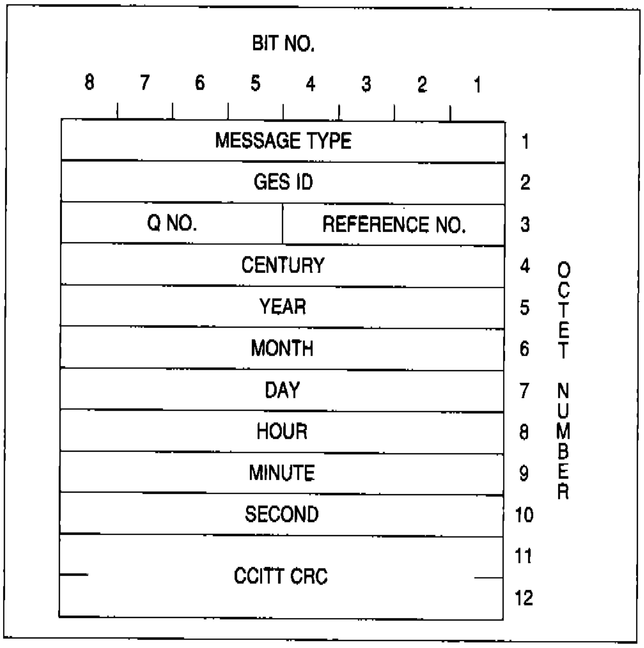

Figure A2-35. System broadcast — P channel
Universal Time

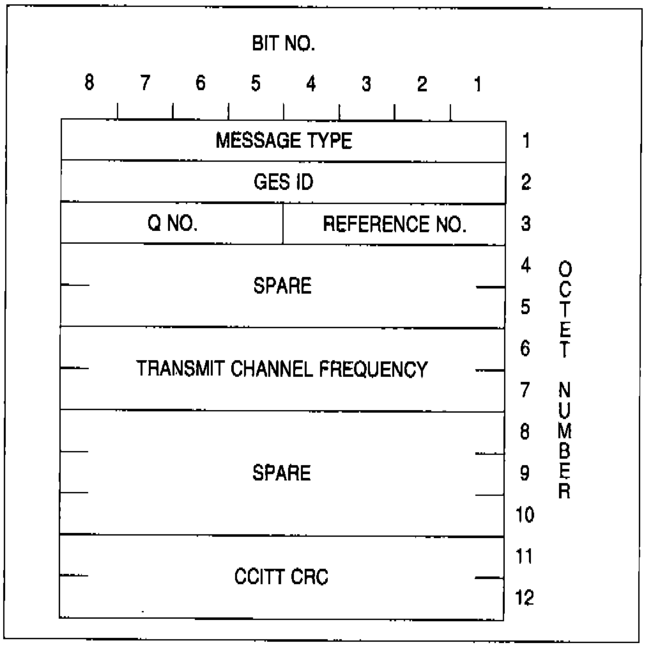

Figure A2-36. System broadcast — P channel
Selective release

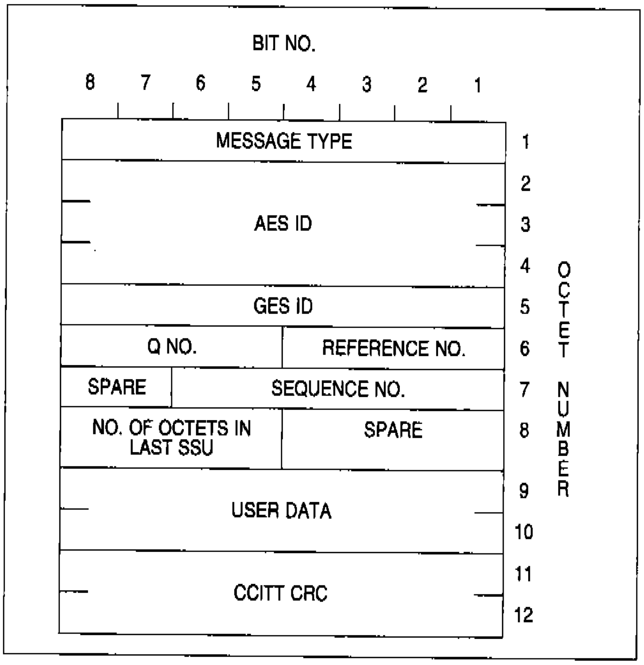

Figure A2-37. User data — P/T channel
ISU

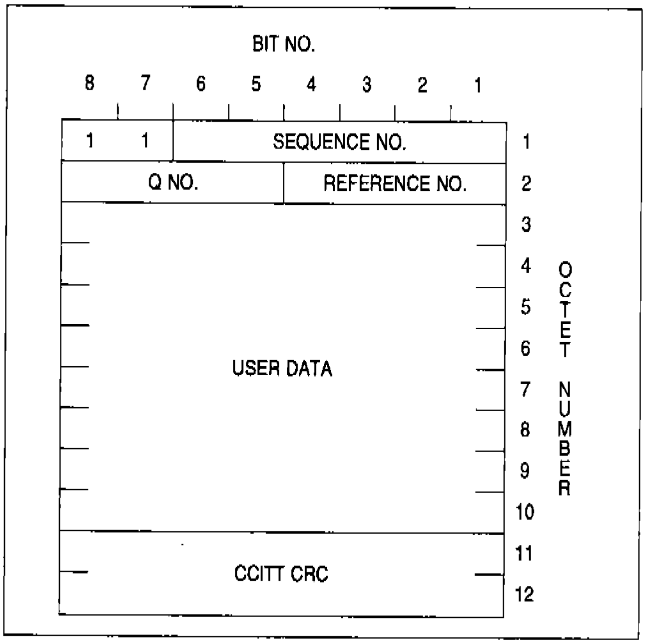

Figure A2-38. User data — P/T channel
SSU

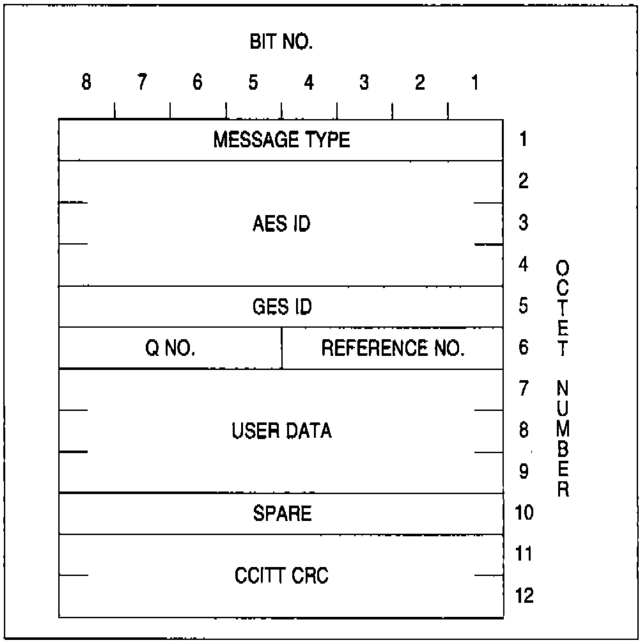

Figure A2-39. User data — P channel
3 octet LSU

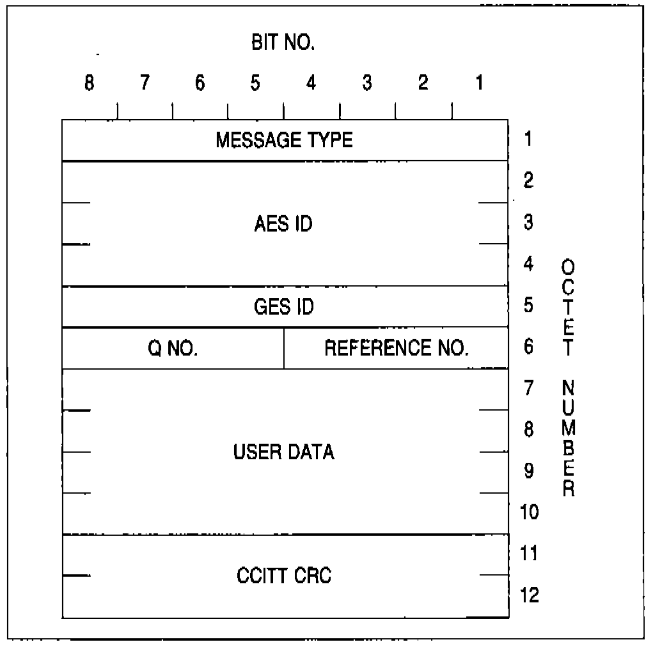

Figure A2-40. User data — P channel
4 octet LSU

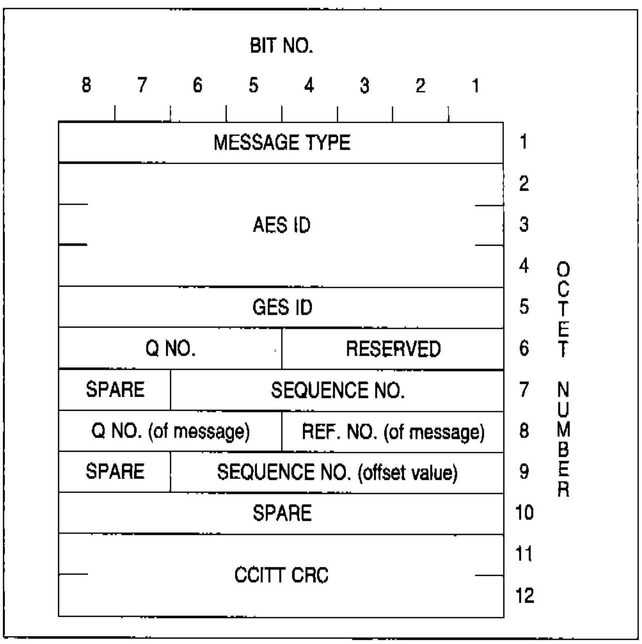

Figure A2-41. Retransmission header — P/T channel
RTX SU

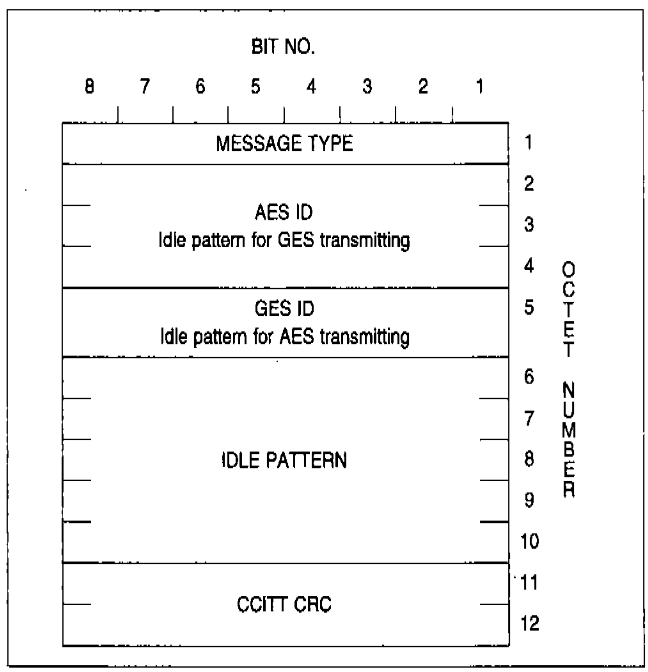

Figure A2-42. Fill-in — P, T and to-/from-aircraft sub-band C channel
FISU

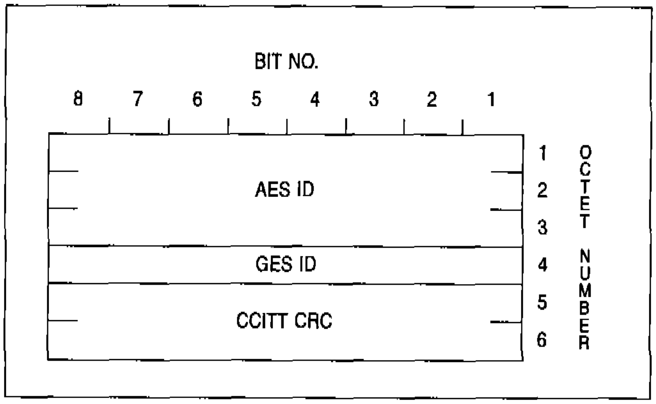

Figure A2-43. Burst identifier — T channel

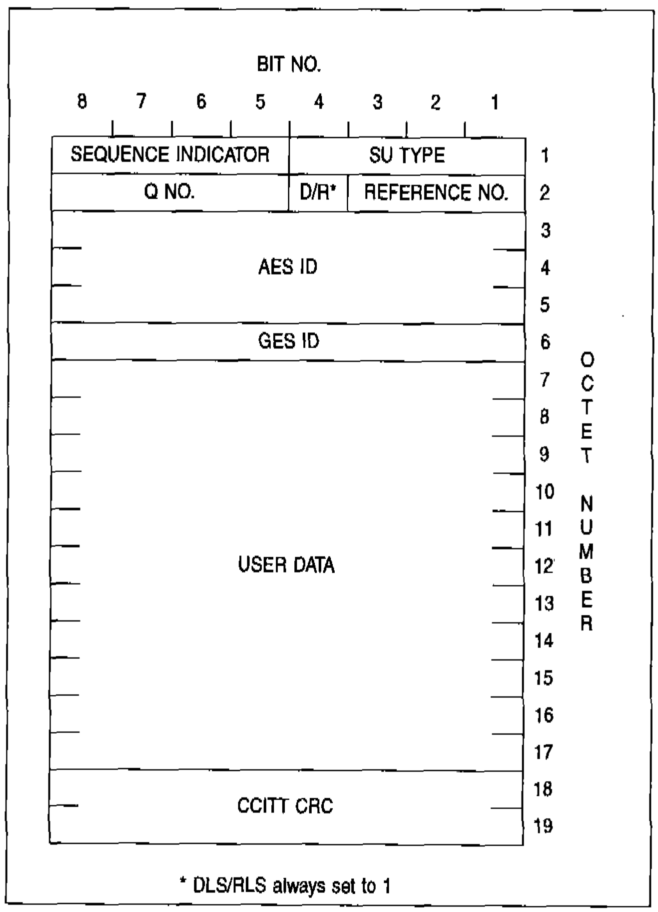

Figure A2-44. User data — R channel
ISU/SSU

BIT NO.

8 7	6 5	4	3 2 1	OCTET NUMBER
SEQUENCE INDICATOR		1	1 1 1	1
Q NO.		D/R*	RESERVED	2
MESSAGE TYPE				3
AES ID				4
				5
				6
GES ID				7
RESERVED		APPLICATION REF. NO.		8
SOURCE	SERVICE DIRECTION	SERVICE ID		9
RESERVED		NETWORK ID		10
RESERVED	VOICE CH. CHARACTERISTICS			11
DIGIT 1		DIGIT 0		12
SPARE				13
				14
				15
				16
				17
CCITT CRC				18
				19

* DLS/RLS always set to 0

Figure A2-45. General access request telephone — R channel

BIT NO.

8 7	6 5	4	3 2 1	OCTET NUMBER
SEQUENCE INDICATOR		1	1 1 1	1
Q NO.		D/R*	RESERVED	2
MESSAGE TYPE				3
AES ID				4
				5
				6
GES ID				7
RESERVED		APPLICATION REF. NO.		8
SOURCE	SERVICE DIRECTION	SERVICE ID		9
RESERVED		NETWORK ID		10
RESERVED	VOICE CH. CHARACTERISTICS			11
DIGIT 1		DIGIT 0		12
DIGIT 3		DIGIT 2		13
DIGIT 5		DIGIT 4		14
DIGIT 7		DIGIT 6		15
DIGIT 9		DIGIT 8		16
CALLING TERMINAL ID (units digit)		CALLING TERMINAL ID (tens digit)		17
CCITT CRC				18
				19

* DLS/RLS always set to 0

Figure A2-46. Abbreviated access request telephone — R channel

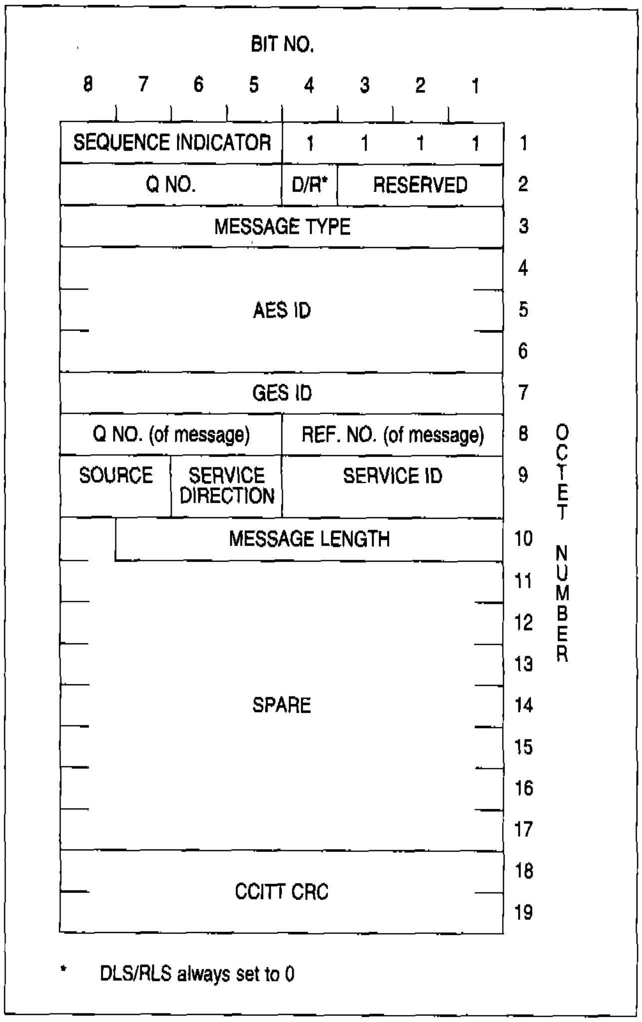

Figure A2-47. Access request data — R channel
Request for reservation (REQ)

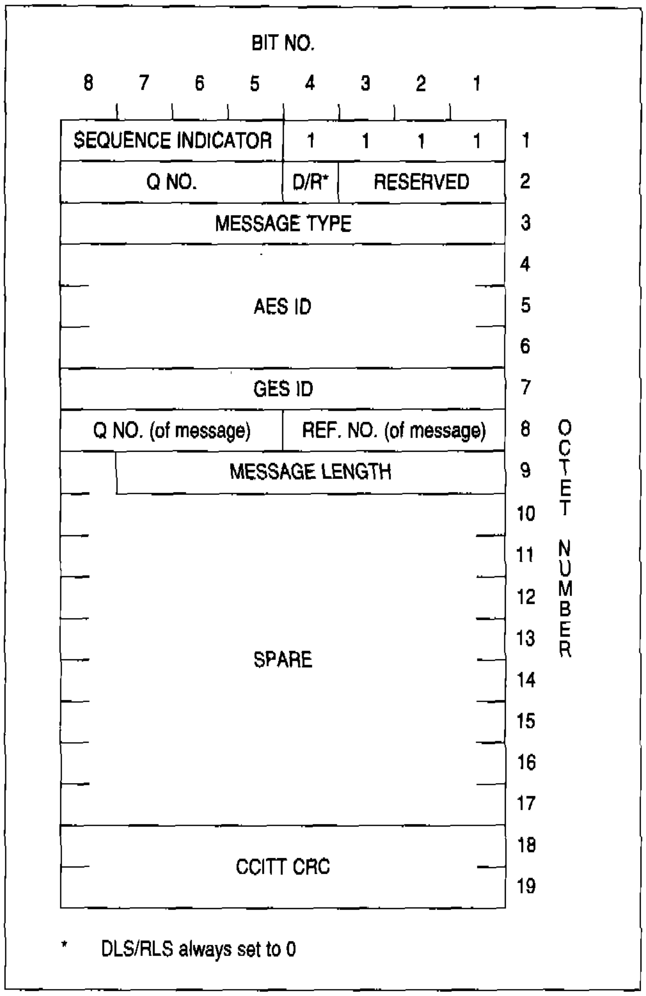

Figure A2-48. Request for acknowledgement — R channel
RQA SU

BIT NO. (8 7 6 5 4 3 2 1)

Bits 8–5		Bits 4–1		Octet number
SEQUENCE INDICATOR		1 1 1 1		1
Q NO.		D/R*	RESERVED	2
MESSAGE TYPE				3
AES ID				4–6
GES ID				7
Q NO. (of message)		REF. NO. (of message)		8
CH. TYPE	NO. OF SSU NK**	ACKNOWLEDGE CONTROL		9
SPARE	SSU SEQUENCE NO.+			10
SPARE	SSU SEQUENCE NO.+			11
SPARE	SSU SEQUENCE NO.+			12
SPARE				13–17
CCITT CRC				18–19

* DLS/RLS always set to 0

** Number of SSUs in acknowledgement indicating error

\+ spare in PACK requesting complete retransmission and in PACK indicating no error

Figure A2-49. Acknowledgement — R channel
P channel acknowledgement (PACK)

BIT NO. (8 7 6 5 4 3 2 1)

Bits 8–5	Bits 4–1		Octet number
SEQUENCE INDICATOR	1 1 1 1		1
Q NO.	D/R*	REFERENCE NO.	2
MESSAGE TYPE			3
AES ID			4–6
GES ID			7
RESERVED	SPARE		8
SPARE			9–17
CCITT CRC			18–19

* DLS/RLS always set to 0

Figure A2-50. Log control — R channel
Log-off request/ready for reassignment/ reassignment reject

BIT NO.

8	7	6	5	4	3	2	1	OCTET NUMBER
SEQUENCE INDICATOR				1	1	1	1	1
Q NO.				D/R*	RESERVED			2
MESSAGE TYPE								3
AES ID								4
								5
								6
GES ID								7
RESERVED				APPLICATION REF. NO.				8
LOCATION				REPORT TYPE				9
SPARE	CAUSE CLASS			CAUSE VALUE				10
SPARE								11
								12
								13
								14
								15
								16
								17
CCITT CRC								18
								19

* DLS/RLS always set to 0

Figure A2-51. Call progress — R channel
Channel release

BIT NO.

8	7	6	5	4	3	2	1	OCTET NUMBER
SEQUENCE INDICATOR				1	1	1	1	1
Q NO.				D/R*	RESERVED			2
MESSAGE TYPE								3
AES ID								4
								5
								6
GES ID								7
RESERVED				APPLICATION REF. NO.				8
LOCATION				REPORT TYPE				9
SPARE	CAUSE CLASS			CAUSE VALUE				10
SPARE								11
								12
								13
								14
								15
								16
								17
CCITT CRC								18
								19

* DLS/RLS always set to 0

Figure A2-52. Call progress — R channel
Call attempt result

BIT NO.

8	7	6	5	4	3	2	1	OCTET NUMBER
SEQUENCE INDICATOR				1	1	1	1	1
Q NO.				DR**	REFERENCE NO.			2
MESSAGE TYPE								3
AES ID								4–6
GES ID								7
RESERVED				SPARE				8
SPARE	AN3*	AN2*	AN1*	SPARE				9
ACKNOWLEDGE MESSAGE TYPE MSG1								10
ACKNOWLEDGE MESSAGE TYPE MSG2								11
ACKNOWLEDGE MESSAGE TYPE MSG3								12
SPARE								13–17
CCITT CRC								18–19

* ACK/NAK for messages 1, 2 or 3
** DLS/RLS always set to 0

Figure A2-53. Log-on acknowledgement — R channel

BIT NO.

8	7	6	5	4	3	2	1	OCTET NUMBER
SEQUENCE INDICATOR				1	1	1	1	1
Q NO.				DR**	RESERVED			2
MESSAGE TYPE								3
AES ID								4–6
GES ID								7
RESERVED				APPLICATION REF. NO.				8
SPARE			ACK/ NAK	SPARE				9
MESSAGE TYPE OF MISSING SU								10
SPARE								11–17
CCITT CRC								18–19

* DLS/RLS always set to 0

Figure A2-54. Telephony acknowledge — R channel

BIT NO. 8 7 6 5 4 3 2 1

Bits 8–3	Bit 2	Bit 1	OCTET NUMBER
MESSAGE TYPE			1
REVISION NO.			2
INITIAL SEQ. NO. OF A2-56 (PARTIAL)	SPARE	EXS*	3
INITIAL SEQ. NO. OF A2-58 (PARTIAL)	SPARE	EXS*	4
INITIAL SEQ. NO. OF A2-60 (PARTIAL)	SPARE	EXS*	5
INITIAL SEQ. NO. OF A2-56 (COMP)	SPARE	EXS*	6
INITIAL SEQ. NO. OF A2-58 (COMP)	SPARE	EXS*	7
INITIAL SEQ. NO. OF A2-60 (COMP)	SPARE	EXS*	8
INITIAL SEQ. NO. OF 2nd A2-56 (COMP)	SPARE	EXS*	9
SPARE		GBS+	10
CCITT CRC			11–12

* Existence + Global beam series

Figure A2-55. AES system table broadcast — P channel
Spot beam series index

BIT NO. 8 7 6 5 4 3 2 1

Bits 8–1		OCTET NUMBER
MESSAGE TYPE		1
REVISION NO.		2
SEQUENCE NO.	LSU NO.	3
GES ID		4
CHANNEL FREQUENCY		5–6
CHANNEL FREQUENCY		7–8
CHANNEL FREQUENCY		9–10
CCITT CRC		11–12

Figure A2-56. AES system table broadcast — P channel
Spot beam series GES P/R channel advice SU

BIT NO. 8 7 6 5 4 3 2 1

Bits 8–1		OCTET NUMBER
MESSAGE TYPE		1
REVISION NO.		2
SEQUENCE NO.	SPARE	3
GES ID		4
BEAM ID		5
SPARE		5–10
CCITT CRC		11–12

Figure A2-57. AES system table broadcast — P channel
Spot beam series GES P/R channel advice last SSU

BIT NO. 8 7 6 5 4 3 2 1

Bits 8–1			OCTET NUMBER
MESSAGE TYPE			1
REVISION NO.			2
SEQUENCE NO.	SAT. ID		3
SAT. ID (lsb)	SAT. INCLINATION	SF*	4
SATELLITE RIGHT ASCENSION			5
SATELLITE LONGITUDE			6
SATELLITE/BEAM-IDENTIFYING P_{smc} CHANNEL FREQUENCY NO. 1			7–8
SATELLITE/BEAM-IDENTIFYING P_{smc} CHANNEL FREQUENCY NO. 2			9–10
CCITT CRC			11–12

* Satellite flag

Figure A2-58. AES system table broadcast — P channel
Spot beam series satellite/beam ID channel advice ISU

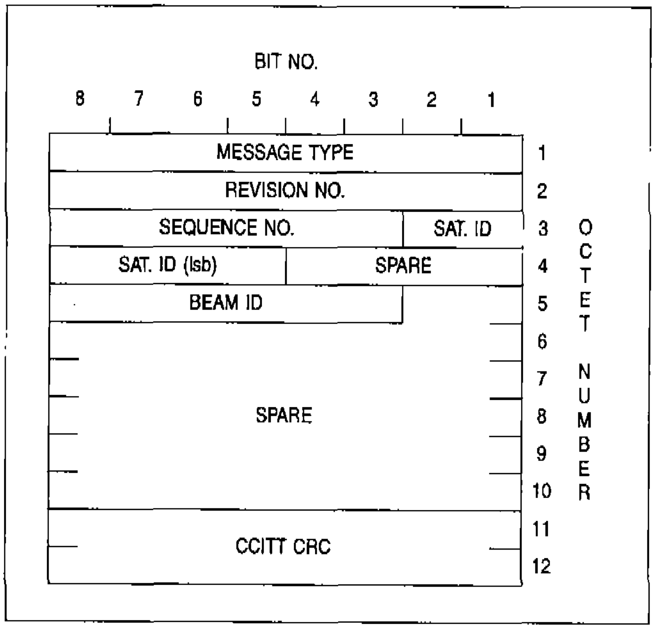

Figure A2-59. AES system table broadcast — P channel
Spot beam series satellite/beam ID channel advice SSU

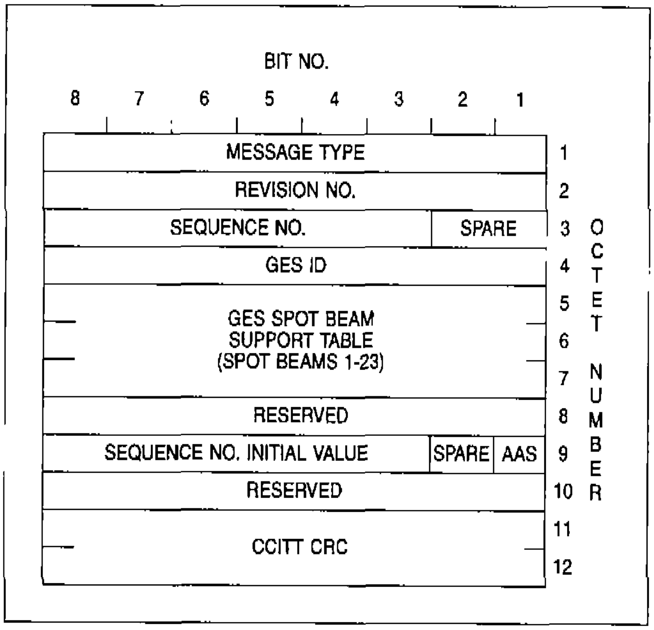

Figure A2-60. AES system table broadcast — P channel
Spot beam series GES beam support advice
(beams 1 – 23)

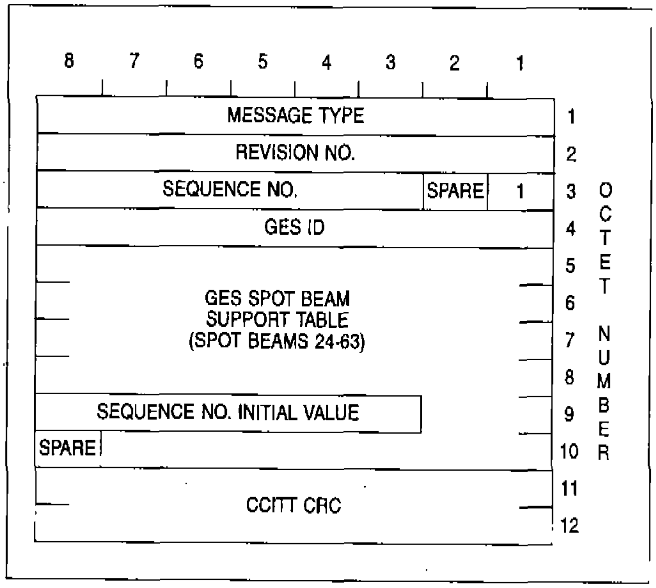

Figure A2-61. AES system table broadcast — P channel
Spot beam series GES beam support advice
(beams 24 – 63)

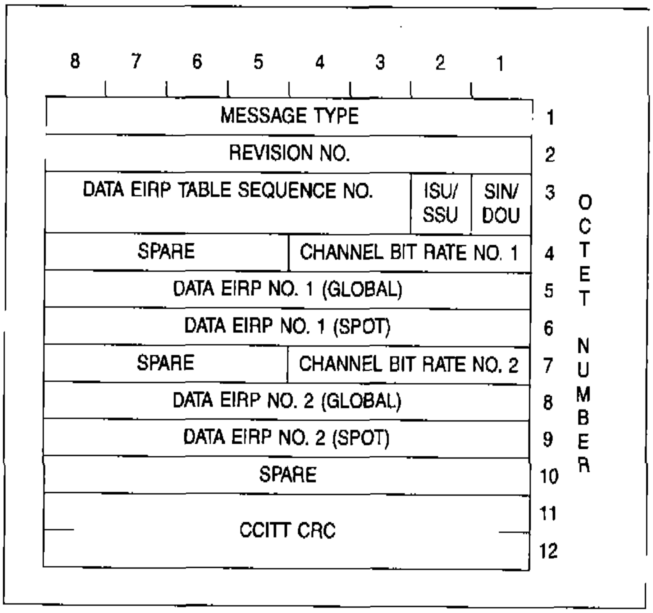

Figure A2-62. Data EIRP table broadcast

Appendix 3 to Chapter 4

SIGNAL UNIT FIELD CODING AND DESIGNATION

1. ACK/NAK
1a. AAS
2. Acknowledge control
3. AES ID
3a. Antenna gain
4. Application reference number
5. Beam ID
6. Burst interval
7. Burst length
8. Called/calling terminal
9. Cause class
10. Cause value
11. Channel bit rate
12. Channel frequency
13. Channel type
14. Circuit data rate
15. Circuit data requirement
16. Class of AES
17. CCITT CRC
18. Data bit rate capability
18a. Data EIRP (global or spot)
18b. Data EIRP table sequence number
19. Delay to RES
19a. DETC/DETP (data EIRP table complete/data EIRP table partial)
20. Digit
21. DLS/RLS
22. EIRP adjustment
23. Existence
24. GES ID
25. GES beam support table
26. Idle pattern
27. Initial EIRP
27a. ISU/SSU (initial signal unit/subsequent signal unit)
28. I/R (initial/renewal)
29. Length
29a. Global beam series (GBS)
30. Location
31. LSU number
31a. LOV
32. Message length
33. Message type
34. Network ID
35. NOT (number of transmitters)
36. Number of bursts reserved
37. Number of C channels
38. Number of frequencies
39. Number of octets in the last SSU
40. Number of SSUs (in Ack)
41. P/R MSG
42. P/S (primary/secondary)
43. Q number (precedence)
44. Reason
45. Received bit error rate
46. Reference number
47. Report type
48. Reserved
49. Revision number
50. RFC flag
51. S (coding standard)
52. Satellite flag
53. Satellite ID
54. Satellite inclination
55. Satellite longitude
56. Satellite right ascension
58. Sequence indicator
59. Sequence number
60. Sequence number (off-set value)
61. Service direction
62. Service identity
62a. SIN/DOU (single/double)
63. Source
64. Spare
64a. Spot beam series (SPS)
65. Starting frame number
66. Starting slot number
67. SU type
68. TDMA MSG
69. T_X channel number
70. Universal time
71. Voice channel characteristics

SIGNAL UNIT FIELD CODING AND DESIGNATIONS

Note.— Codes are listed as their decimal values unless indicated as hexadecimal by the letters HEX. Codes marked RESERVED are reserved for use in particular AMSS system implementations.

1. ACK/NAK (1 bit)

Code	Function
0	NAK, retransmit indicated message
1	ACK, do not retransmit indicated message

1a. AAS (1 bit)

This field shall indicate that the GES supports the "Abbreviated Call Establishment" procedure.

Code	Function
0	The GES does not support the "Abbreviated Call Establishment" procedure.
1	The GES does support the "Abbreviated Call Establishment" procedure.

2. Acknowledge control (4 bits)

Code	Function
0	This ACK includes all retransmission requests
1-13	Number of retransmission request ACK messages remaining (applicable for PACK and TACK SUs only)
14	No errors in entire message
15	Retransmit entire message (applicable for PACK and TACK SUs only)

3. AES ID (3 octets)

This field shall be the 24-bit aircraft address of the AES (see Chapter 9).

3a. Antenna gain (4 bits)

This field shall indicate the antenna gain for an AES of Class 3-4 (see 16). This field shall be "spare" for class 1 AES.

Code	Function
0	High gain
1	Intermediate gain
2-15	Spare

4. Application reference number (4 bits)

This field shall contain the direct binary number of the reference number assigned by the circuit-mode services to the circuit-mode call.

The application reference number shall uniquely identify a call between an AES/GES pair. Application reference numbers shall be assigned cyclically by the AES on air-to-ground calls from the range 0-7 and by the GES on ground-to-air calls to a given AES from the range 8-15.

5. Beam ID (6 bits)

Code	Function
0	Global beam
1-63	Spot beams

6. Burst interval (4 bits)

In a multi-burst reservation, this field shall indicate that there is one burst reservation per 2^{BI} frames, where BI=burst interval.

7. Burst length (5 bits)

This field shall indicate the length of the burst in terms of the number of signal units.

8. Called/calling terminal (8 bits)

Binary coded decimal (BCD) encoding, with the most significant digits appearing in least significant half octet, and vice versa.

9. Cause class (3 bits)

The assignment and interpretation of this field shall be dictated by the value assigned to the S (coding standard) field (Item 51). Cause class shall be used in association with cause value (Item 10) to identify the actual cause meaning.

CCITT Q.931 standard coding:

Code	Function
0	Normal event
1	Normal event
2	Resource unavailable
3	Service or option not available
4	Service or option not implemented
5	Invalid message (e.g. parameter out of range)
6	Protocol error (e.g. unknown message)
7	Interworking

Satellite network specific coding:

Code	Function
0	PSTN/ISDN call progress events
1	Call pre-emption
2	Resource unavailable
3	Invalid parameter
4	Out of service
5	Network failure
6	Service/option not supported
7	Normal event

10. Cause value (4 bits)

The assignment and interpretation of this field shall be dictated by the value of the S (coding standard) field (Item 51). Cause value shall be used in association with cause class (Item 9) to identify the actual cause meaning. The values given below are those required for interworking with the PSTN signalling systems R2, CCITT No. 5 and CCITT No. 7 TUP.

CCITT Q.931 standard coding:

Cause class	Cause value	Function
0	1	Unallocated number
0	3	No route to destination
1	0	Normal clearing
1	1	User busy
1	2	No user responding
1	3	Called user busy (user alerted)
1	5	Call rejected
1	11	Destination out of service
1	12	Invalid (incomplete) number format
1	15	Normal, unspecified
2	2	No circuit/channel available
2	6	Network out of order
2	10	Switching equipment congestion
4	2	Channel type not implemented

Satellite network specific coding:

Cause class	Cause value	Function
0	1	Address complete
1	1	Call pre-empted
2	1	No channel available
2	2	No channel unit available
2	3	Analog data equipment not available
2	4	Digital data equipment not available
3	1	Reserved
3	2	Invalid/incomplete address
4	1	Destination out of service
4	2	AES not authorized
4	3	Incoming calls barred
5	1	Continuity failure or no response
6	1	Reserved
6	2	Required analog data rate not supported
6	3	Required digital data rate not supported
6	4	Voice channel type not supported
6	5	Service type not supported
7	1	User busy
7	2	Unallocated number
7	3	AES absent
7	4	Spot beam handover
7	15	Undefined cause

11. Channel bit rate (receive or transmit) (4 bits)

Code	Function
0	600 bits/s
1	1 200 bits/s
2	2 400 bits/s
3	4 800 bits/s
4	6 000 bits/s
5	5 250 bits/s
6	10 500 bits/s
7	8 400 bits/s
8	Unassigned
9	21 000 bits/s
10-15	Unassigned

12. Channel frequency (2 octets)

Most significant bit: 1=spot beam, 0=global beam
Least significant 15 bits: 0000 to 7FFF (HEX)
Frequency expressed as binary number N, where:

frequency (MHz) = Base (MHz) + N * 0.0025 MHz;
base = 1 510.0000 MHz for receive channels;
base = 1 611.5000 MHz for transmit channels.

The all ZEROs code shall be used to denote the null value.

13. Channel type (2 bits)

This field shall identify the channel which was used for the message being acknowledged.

Code	Function
0	R channel
1	P channel
2	T channel
3	Unassigned

14. Circuit data rate (4 bits)

This field shall be used by the AES to indicate the requested circuit-mode data rate (modem type, if applicable). It shall also be used by the GES to inform the AES of the actual data rate achieved, which may be different from the requested data rate if a multi-rate modem is used or if modem synchronization is not achieved.

The coding shall be dependent on the type of circuit-mode data service, as indicated by the service identity field (Item 62).

Analog-interconnect data service:

Code	Function
0	Data mode not required/achieved
1	1 200 bits/s: CCITT V.22
2	1 200 bits/s: CCITT V.22 *bis*
3	2 400 bits/s: CCITT V.22 *bis*
4	4 800 bits/s: CCITT V.32
5	9 600 bits/s: CCITT V.32
6	1 200 bits/s: CCITT V.23
7-14	Unassigned
15	Facsimile (Group 3) service: CCITT T.30

Digital interconnect data service:

Code	Function
0	Data mode not required/achieved
1	1 200 bits/s
2	2 400 bits/s
3	4 800 bits/s
4	9 600 bits/s
5-15	Unassigned

15. Circuit data requirement (2 bits)

This field shall be used by the AES to indicate whether all ground-to-air circuit-mode calls should be allocated circuit-mode data service-capable channel equipment by the GES, and if so, which type of interconnect capability shall be required.

Code	Function
00	Circuit-mode data service not required
01	Analog interconnect service required
10	Digital interconnect service required
11	Unassigned

16. Class of AES (2 bits)

The AESs shall be classified according to their equipment configuration and capabilities, as follows:

Class 1: Low gain antenna only, packet-mode services only;
Class 2: Reserved;
Class 3: High gain or intermediate gain antenna, circuit-mode and packet-mode (simultaneous and non-simultaneous) services;
Class 4: High gain or intermediate gain antenna, packet-mode services only.

Code	Function
0	Class 1
1	Reserved
2	Class 3
3	Class 4

17. CCITT CRC (16 bits)

Each signal unit shall contain 16 check bits (the last two octets) for error detection. These check bits shall be calculated from the first 10 octets of standard length SU, from the first 17 octets of an extended length signal unit or from the first 4 octets of the burst identifier SU (Appendix 2 to Chapter 4, Figure A2-47), using the following generator polynomial:

$$x^{16} + x^{12} + x^5 + 1$$

(see CCITT Red Book, Recommendation X.25, Section 2.2.7)

At the receiving end, the check bits for each received signal unit shall be calculated and if there is a mismatch with the received check bits, the signal unit shall be discarded.

18. Data bit rate capability (1 octet)

Each bit in this field shall indicate the availability ("1") or unavailability ("0") of the corresponding channel/bit rate combination at the AES as follows:

Bit	Combination	
1	P-Ch	1 200 bits/s
2	P-Ch	2 400 bits/s
3	P-Ch	4 800 bits/s
4	P-Ch	10 500 bits/s
5	R-/T-Ch	2 400 bits/s
6	R-/T-Ch	10 500 bits/s
7	R-/T-Ch	4 800 bits/s
8	Unassigned	

Note.— 0.6 and 1.2 kbit/s P, R and T channels are mandatory for all AESs.

18a. Data EIRP (global or spot) (8 bits)

Data EIRP level for global beam or spot beam operation expressed as a binary number N, where:

Data EIRP = N*0.1 dBW

The EIRP range shall be from 0.1 to 25.5 dB. The EIRP values are valid for all types of antenna. The all zeros code shall be used to denote a NULL value.

18b. Data EIRP table sequence number (6 bits)

Sequence number of Data EIRP table SUs. The field shall be set in the ISU to equal the total number of SSUs in the sequence corresponding to that ISU (i.e. in the complete sequence if the ISU is for the complete sequence, in the partial sequence otherwise). The value shall be decremented by one in each following SSU, until the last SSU of the sequence has a value of zero.

19. Delay to RES (6 bits)

This field shall indicate the delay before the reservation will be sent to the AES by the GES. The delay shall be given as a direct binary number of superframes.

19a. DETC/DETP (1 bit)

This field shall indicate whether the complete (DETC) or partial (DETP) data EIRP tables are transmitted.

Code	Function
0	The data EIRP table is not transmitted
1	The data EIRP table is transmitted

20. Digit

This field shall be a binary coded decimal digit. The end-of-digits code shall be combination F (HEX).

21. DLS/RLS (1 bit)

Code	Function
0	Direct link service (DLS)
1	Reliable link service (RLS)

22. EIRP adjustment (4 bits)

This field shall be used to indicate the EIRP adjustment value relative to the current transmit level as follows:

Code	Function
0	No adjustment
1	+1 dB
2	+2 dB
3	+3 dB
4-12	Unassigned
13	–3 dB
14	–2 dB
15	–1 dB

23. Existence (1 bit)

Code	Function
0	This series of broadcasts is not being transmitted
1	This series of broadcasts is being transmitted

24. GES ID (1 octet)

This field shall be the 8-bit identifier given to the GES.

25. GES beam support table

This field shall start from octet 5, bit 1 and shall end at octet 7, bit 8 of the AES System Table Broadcast P-channel, spot beam series GES beam support advice signal unit (Figure A2-60). Each bit shall correspond to a satellite beam, starting from global beam in the first bit then spot beam 1, 2, 3, etc. up to spot beam 23, respectively.

This field shall start from octet 5, bit 1 and shall end at octet 10, bit 7 of the AES System Table Broadcast P-channel, spot beam series GES beam support advice signal unit (Figure A2-61). Each bit shall correspond to a satellite beam, starting from global beam in the first bit then spot beam 24, 25, 26, etc. up to spot beam 63, respectively.

Each bit shall be encoded as:

Code	Function
0	The GES does not support the beam
1	The GES does support that beam

26. Idle pattern

All zeros.

27. Initial EIRP (4 bits)

The EIRP value shall be equal to:

(–1.5 + N) dBW for a Class 1 AES (as defined in section 16);

(–0.5 + N) dBW for Class 3/4 AES with intermediate gain antenna;

(10.5 + N) dBW for Class 3/4 AES with high gain antenna;

where N is the value of this field (range 0 to 15).

27a. ISU/SSU (1 bit)

This bit shall be 0 for the initial signal unit of a series of SUs in a set. This bit shall be 1 for each subsequent signal unit in the series.

28. I/R (initial/renewal) (1 bit)

This field shall indicate whether the log-on request is initial or for log-on renewal.

Code	Function
0	Initial log-on
1	Log-on renewal

29. Length (8 bits)

This field shall be the direct binary representation of the number of octets to follow.

29a. Global beam series (GBS) (1 bit)

This field shall indicate, in the spot beam series broadcast index SU, whether or not a global beam series is present. This field shall be set to one if the global beam series is present; otherwise, the field shall be set to zero.

30. Location (of cause) (4 bits)

This information element shall indicate the location relevant to the cause value and cause class information elements. Its interpretation shall be dictated by the value assigned to the S (coding standard) information element, which specifies whether the CCITT Q.931 standard coding or the satellite network specific coding rules apply.

CCITT Q.931 standard coding:

Code	Function
0	User
1	Private network serving the local user
2	Public network serving the local user
3	Transit network
4	Public network serving the remote user
5	Private network serving the remote user
7	International network
10	Network beyond interworking point

All other values are reserved.

Satellite network specific coding:

Code	Function
1	AES — user network side
2	AES — satellite network side
3	GES — satellite network side
4	GES — fixed network side
5	Reserved
6	Interworking with the terrestrial network

All other values are unassigned.

31. LSU number (2 bits)

Code	Function
0	Indicating the initial LSU and the LSU contains P_{smc}, $R_{smc}0$, $R_{smc}1$ frequencies in this order
1	LSU contains P_{smc}, $R_{smc}0$, $R_{smc}1$ frequencies in this order (as for code 0, but this can appear anywhere in the sequence)
2	LSU contains $R_{smc}2$, $R_{smc}3$, $R_{smc}4$ frequencies in this order
3	LSU contains $R_{smc}5$, $R_{smc}6$, $R_{smc}7$ frequencies in this order

31a. LOV (1 bit)

This field shall indicate the capability of the AES to respond to the log-on interrogation from the GES.

Code	Function
0	AES capable of responding
1	AES not capable of responding

32. Message length (7 bits)

This field shall indicate, in direct binary number, the number of SUs in an SU set (2 user octets in the initial signal unit, and 8 octets per subsequent signal unit). When used for requesting T channel capacity, this number shall be increased by one each time a request (initial or repeated) is transmitted via the T channel. The maximum length of an initial SU set shall be limited to 64 (SUs).

33. Message type (1 octet)

This field shall identify the type of the message. The complete set of message types shall be as listed in the table "Message type list" which is included at the end of this appendix.

34. Network ID (4 bits)

Code	Function
0	Unassigned
1	E164/E163
2	X.121
3	F.69
4	Private network — no address following
5	Private network — address following
6-14	To be coded for applicable public and private networks (SITA, ARINC, etc.)
15	Distress call

35. NOT (1 bit)

This field shall indicate the transmitter capability of the AES.

Code	Function
0	Indicating the AES has one transmitter
1	Indicating the AES has multiple transmitters

36. Number of bursts reserved (3 bits)

This field shall identify the number of bursts reserved as a binary number.

Code	Function
0	Unassigned
1-7	1-7 bursts reserved

37. Number of C channels (5 bits)

This field shall indicate, as a direct binary number, the number of voice channels which the AES is equipped for. This field shall be 1 for Level 3 AES.

38. Number of frequencies (4 bits)

This field shall indicate, as a direct binary number (e.g. 1 = 1 frequency), the number of frequencies assigned.

39. Number of octets in the last SSU (4 bits)

This field shall indicate, as a direct binary number (e.g. 1 = 1 octet), the number of octets of user data in the user data field of the last SSU of the SU set.

40. Number of SSUs (in ACK/NAK) (2 bits)

Code	Function
0	No SSU, only used when ACKCTL field equals 14 or 15
1	One SSU
2	Two SSUs
3	Three SSUs

41. P/R MSG (1 bit)

This field shall indicate whether the log-on confirm SU has an associated P/R channel control SU.

Code	Function
0	No associated P/R channel control SU
1	Associated P/R channel control SU exists

42. P/S (primary/secondary) (1 bit)

This field shall indicate whether the log-on is primary or secondary.

Code	Function
0	Primary log-on
1	Secondary log-on

43. Q number (precedence) (4 bits)

The following table shall indicate the scheme for the assignment of Q numbers to the various categories of messages for transmission on the P, R, T and sub-band C channels. The actual Q numbers assigned to the individual signal unit message types shall be as specified in the message type list at the end of this appendix.

Code	Function
15	Distress/urgency C channel request/assignment signalling; distress/urgency T channel request signalling; all T channel assignment signalling (including reservation forthcoming signalling); link layer protocol signalling for distress data traffic (Q = 14)
14	Distress/urgency packet-mode data
13	Link layer protocol signalling for flight safety, other safety and non-safety data traffic (Q = 0-3, 5-8, 11); AES/GES management SUs; flight safety and other "safety" T channel request signalling (Q = 11, 5-8); C channel signalling other than request/assignment
12	Flight safety C channel request/assignment signalling
11	Flight safety packet-mode data
10	Other "safety" C channel request/assignment signalling
9	"Non-safety" C channel request/assignment signalling; "non-safety" T channel request signalling (Q = 0-3)
5-8	Other "safety" packet-mode data (See Table 4-12)
4	Reserved for "non-safety" C channel precedence
0-3	"Non-safety" packet-mode data (See Table 4-12)
NA	System table broadcast SUs and fill-in SU

44. Reason (4 bits)

Code	Function	Rejection category
0	Log-on table full	Temporary unavailable
1	Requested voice channel characteristic not available	Permanent unavailable
2	Requested beam not served	Invalid parameters
3	Fixed network failure	Temporary unavailable
4	Unassigned	
5	Invalid satellite ID	Invalid parameters
6	Invalid GES ID	Invalid parameters
7	P/R/T channels not available	Temporary unavailable
8	Packet-mode data services not available	Permanent unavailable
9	Reserved	
10	Requested VCC and data services not available	Permanent unavailable
11-13	Unassigned	
14	Other unspecified reason	Temporary unavailable
15	AES not authorized	Permanent unavailable

45. Received bit error rate (8 bits)

This field shall indicate the error rate before FEC decoding. The code value = V, where V = average number of errors per 2 560 channel bits.

46. Reference number (3 bits for R channel or 4 or 8 bits for P and T channels)

The value for this field shall be assigned by the AES for air-to-ground data transfer and by the GES for ground-to-air data transfer. The scope of the reference number shall be within its Q number (precedence level). The reference number, in association with the Q number, shall be used for message segmentation/assembly and ARQ error control at the link level.

Each user data message shall be given a reference number at the time of initial transmission and this is used in subsequent acknowledge, retransmission, and request for acknowledge messages to guard against confusion/duplication of messages. The allocation of the reference numbers shall be performed independently for messages sent via the R, T and P channels.

47. Report type (4 bits)

This field shall identify the specific type of call progress signal unit.

Code	Function
0	Unassigned
1	Channel status report
2	Connect
3	Test
4	Call attempt result
5	Channel release
6-8	Reserved
9-15	Unassigned

48. Reserved (variable number of bits)

Fields marked RESERVED are reserved for use in particular AMSS system implementations.

49. Revision number (8 bits)

This field shall indicate the revision number of the AES system table. It shall be incremented by one for each successive revision.

50. RFC flag (1 bit)

This field shall be used to identify whether or not a reservation (RES) SU or a reservation forthcoming (RFC) SU has been preceded by either an RFC LSU or TACK LSU indicating errors.

Code	Function
0	Not preceded by either RFC LSU or TACK SU set indicating errors
1	Has been preceded by either an RFC LSU or TACK SU set indicating errors

51. S (coding standard) (1 bit)

The field shall identify the rules (coding standard) according to which the location, cause class and cause value information elements are coded.

Code	Function
0	CCITT Q.931 standard coding
1	Satellite network specific coding

52. Satellite flag (1 bit)

Code	Function
0	Indicating the SU contains information for the satellite via which it is broadcast
1	Indicating the SU contains information for the satellite in another region

53. Satellite ID (6 bits)

This field shall be the 6-bit identifier given to the satellite.

54. Satellite inclination (3 bits)

Code	Function
0	0 to 5/8 degree
1	more than 5/8 up to 10/8 degrees
2	more than 10/8 up to 15/8 degrees
3	more than 15/8 up to 20/8 degrees
4	more than 20/8 up to 25/8 degrees
5	more than 25/8 up to 30/8 degrees
6	more than 30/8 up to 35/8 degrees
7	more than 35/8 up to 40/8 degrees

55. Satellite longitude (8 bits)

This field shall be a binary code representation of the longitudinal location of the satellite, as east longitude relative to the Greenwich meridian in units of 1.5 degrees.

56. Satellite right ascension (8 bits)

This field shall indicate the closest time point expressed in minutes from 00:00 UTC with 10 minutes increment to the time when the satellite crosses the equatorial plane from south to north on the New Year's day. The time of satellite ascension on day "n" of the year shall be "4 x n" minutes earlier than on the New Year's day.

58. Sequence indicator (4 bits)

This field shall be used only in extended length (i.e. 19 octet) SUs on the R channel. It shall indicate the position of the SU within the sequence of SUs that comprise an SU set. It also specifies the total number of SUs in the SU set.

Code	SU position	Number of SUs in the SU set
0	Unassigned	Unassigned
1	1	1
2	1 (first)	2
3	2 (last)	2
4	1 (first)	3
5	2 (intermediate)	3
6	3 (last)	3
7-15	Unassigned	Unassigned

59. Sequence number (4 bits or 6 bits)

This field shall be used in standard length (i.e. 12 octet) signal units on all channels. The field shall be set in an ISU of an SU set to the total number of subsequent signal units (SSUs) in the SU set and shall be decremented by one in each following SSU, until the last SSU of the SU set has a value of 0. The field in a broadcast index SU of the AES system table broadcast shall be set to the largest sequence number (one less than the number of LSUs included) in each series of broadcast LSUs. The sequence number in the first LSU in a series shall be set to the same number as in the index SU and shall be decremented by one in each following LSU, until the last LSU of the series has a value of 0. The field in an RTX SU heading of a retransmission SU set shall be set equal to the total number of SSUs in the retransmission SU set. In each retransmitted SSU, this field shall be offset by subtracting the value in the sequence number (offset value) field of the RTX SU from the original SSU sequence number.

60. Sequence number (offset value) (6 bits)

This field shall be used in standard length (i.e. 12 octet) signal units on all channels. It shall indicate the last (lowest) SSU sequence number in error.

61. Service direction (2 bits)

Code	Function
0	Unassigned
1	Air-to-ground
2	Ground-to-air
3	Bi-directional

62. Service identity (4 bits)

Code	Function
0	Unassigned
1	Telephone
2	Circuit-mode data, analog-interconnect
3	Circuit-mode data, digital-interconnect
4-9	Unassigned
10	Direct link service message
11	Reliable link service message
12-15	Unassigned

62a. SIN/DOU (1 bit)

This bit shall be set to 0 if one channel bit rate and EIRP is defined in the signal unit. This bit shall be set to 1 if two channel bit rates and EIRPs are defined in the signal unit.

63. Source (2 bits)

This field shall identify the location at which the signal unit was generated.

Code	Function
0	Unassigned
1	AES
2	GES
3	Reserved

64. Spare (variable number of bits)

Fields marked SPARE shall be filled entirely with zeros.

64a. Spot beam series (SBS) (1 bit)

This field shall indicate, in the global beam series broadcast index SU, whether or not a spot beam series is present. This field shall be set to one if the spot beam series is present; otherwise, the field shall be set to zero.

65. Starting frame number (4 bits)

This field shall indicate, as a direct number, the starting frame number of the allocated reservation.

66. Starting slot number (6 bits)

This field shall indicate, as a direct binary number, the starting slot number of the allocated reservation within the starting frame number.

67. SU type (4 bits)

This field shall indicate whether the extended length SU is carrying signalling application information or user data. In the latter case, its value shall represent the number of octets of user data in the user data field of the extended length (i.e. 19 octet) SU.

Code	Function
0	Unassigned
1-11	1 to 11 octets of user data SU
12-14	Unassigned
15	Signalling information SU

68. TDMA MSG (1 bit)

This field shall indicate whether the log-on confirm SU has an associated T channel control message.

Code	Function
0	No associated T channel control message
1	Associated T channel control message exists

69. TX channel number (2 bits)

Code	Function
0	Channel No. 0
1	Channel No. 1
2	Channel No. 2
3	Channel No. 3

70. Universal time (7 octets)

The time information shall be synchronized to the UTC time standard.

Format:	Each of the following is a single octet field coded in the binary coded decimal (BCD) format. The code FF_H can be used in any field to represent a NULL entry.
Century:	Century AD (Anno Domini), CC (2 digit): 00 to 99
Year:	Year within the century, YY (2 digit): 00 to 99
Month:	Month within the year, MM (2 digit): 01 to 12
Day:	Day within the month, DD (2 digit): 01 to 31
Hour:	Hour within the day, hh (2 digit): 00 to 24
Minute:	Minute within the hour, mm (2 digit): 00 to 59
Second:	Second in the minute, ss (2 digit): 00 to 59

71. Voice channel characteristics (6 bits)

Code	Voice rate to AES	Voice rate from AES	Channel bit rate	FEC rate
0	Unassigned			
1	Reserved			
2	9 600 LPC[1]	9 600 LPC[1]	21 000	1/2
3	4 800 AMBE[2]	4 800 AMBE[2]	8 400	2/3
4	9 600 LPC[1]	9 600 LPC[1]	21 000	1/2
	and			
	4 800 AMBE[2]	4 800 AMBE[2]	8 400	2/3
5	Reserved			
6	Unassigned			
7	Reserved			
8-63	Unassigned			

1. LPC corresponds to the multi-pulse excited linear predictive coding algorithm as defined in Section 4.8.

2. AMBE corresponds to the advanced multi-band excitation algorithm as identified in Section 4.8.

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MESSAGE TYPE LIST (see paragraph 33)

Code (HEX)	Function	Message format figure (refer to Appendix 2 to Chapter 4)	Q number (precedence)
BROADCAST			
00	Reserved		
01	Fill-in signal unit	A2-42	NA
02	AES system table broadcast (GES P_{smc} and R_{smc} channels PARTIAL)	A2-31	NA
03	AES system table broadcast (beam identification PARTIAL)	A2-33	NA
04	AES system table broadcast (GES beam support PARTIAL)	A2-34/A2-61	NA
05	AES system table broadcast (GES P_{smc} and R_{smc} channels COMPLETE)	A2-31	NA
06	AES system table broadcast (beam identification COMPLETE)	A2-33	NA
07	AES system table broadcast (GES beam support COMPLETE)	A2-34/A2-61	NA
08	System broadcast — selective release	A2-36	13
09	System broadcast — universal time	A2-35	13
0A	AES system table broadcast (index)	A2-30	NA
0B	AES system table broadcast (satellite identification PARTIAL)	A2-32	NA
0C	AES system table broadcast (satellite identification COMPLETE)	A2-32	NA
0D	AES system table broadcast (2nd series of GES P_{smc} and R_{smc} channels COMPLETE)	A2-31	NA
0E	Reserved		
SYSTEM LOG-ON/LOG-OFF			
10	Log-on request	A2-2	13
11	Log-on confirm	A2-3	13
12	Log control (R channel)-log-off request	A2-50	13
12	Log control (P channel)-log-off request	A2-6	13
13	Log control (P channel)-log-on reject	A2-5	13
13	Log control (R channel)-reassignment reject	A2-50	13
14	Log control (P channel)-log-on interrogation	A2-4	13
15	Log-on/log-off acknowledge (P channel)	A2-25	13
15	Log-on/log-off acknowledge (R channel)	A2-53	13
16	Log control (P channel)-log-on prompt	A2-4	13
17	Log control (P channel)-data channel reassignment	A2-4	13
17	Log control (R channel)-ready for reassignment	A2-50	13
18	Reserved		
19	Reserved		

Code (HEX)	Function	Message format figure (refer to Appendix 2 to Chapter 4)	Q number (precedence)
CALL INITIATION			
20	General access request telephone (non-safety)	A2-45	9
20	General access request telephone (other safety)	A2-45	10
20	General access request telephone (flight safety)	A2-45	12
20	General access request telephone (distress)	A2-45	15
20	Call announcement (non-safety)	A2-8	9
20	Call announcement (other safety)	A2-8	10
20	Call announcement (flight safety)	A2-8	12
20	Call announcement (distress)	A2-8	15
21	Call information service address (ISU)	A2-9	13
22	Access request data (R/T channel) (non-safety)	A2-47/A2-7	9
22	Access request data (R/T channel) (flight safety and other safety)	A2-47/A2-7	13
22	Access request data (R/T channel) (distress)	A2-47/A2-7	15
23	Abbreviated access request telephone (other safety)	A2-46	10
23	Abbreviated access request telephone (flight safety)	A2-46	12
23	Abbreviated access request telephone (distress)	A2-46	15
24	Reserved		
25	Reserved		
26	Reserved		
27	Reserved		
28	Data EIRP table broadcast — complete sequence	A2-62	NA
29	Data EIRP table broadcast — partial sequence	A2-62	NA
CALL PROGRESS			
30	Call progress (P/C channel)	A2-11/A2-12/A2-13/ A2-14/A2-15/A2-16	13
30	Call progress (R channel)	A2-51/A2-52	13
31	C channel assignment (distress)	A2-17	15
32	C channel assignment (flight safety)	A2-17	12
33	C channel assignment (other safety)	A2-17	10
34	C channel assignment (non-safety)	A2-17	9
35	Reserved		
36	Reserved		
37	Reserved		
38	Reserved		
39	Reserved		

Code (HEX)	Function	Message format figure (refer to Appendix 2 to Chapter 4)	Q number (precedence)
CHANNEL INFORMATION			
40	P/R channel control (ISU)	A2-18	13
41	T channel control (ISU)	A2-20	13
TDMA RESERVATION			
50	Unsolicited reservation	A2-22	15
51	T channel assignment	A2-23	15
52	Reserved		
53	Reservation forthcoming (RFC)	A2-24	15
ACKNOWLEDGEMENT			
60	Telephony acknowledge (P/C channel)	A2-26	13
60	Telephony acknowledge (R channel)	A2-54	13
61	Request for acknowledgement (RQA) (P channel) — distress data	A2-27	15
61	Request for acknowledgement (RQA) (P channel) — all other data	A2-27	13
61	Request for acknowledgement (RQA) (P channel) — distress data	A2-48	15
61	Request for acknowledgement (RQA) (P channel) — all other data	A2-48	13
62	Acknowledge (RACK, TACK) (P channel) — distress data	A2-29/A2-28	15
62	Acknowledge (RACK, TACK) (P channel) — all other data	A2-29/A2-28	13
62	Acknowledge (PACK) (R channel) — distress data	A2-49	15
62	Acknowledge (PACK) (R channel) — all other data	A2-49	13
63	Reserved		
64	Reserved		
65	Reserved		
USER DATA			
70	Reserved		
71	User data (ISU) — RLS (P/T channel)	A2-37	V(0-3,5-8,11,14)
72	Retransmission header (RTX) (P/T channel)	A2-41	V(0-3,5-8,11,14)
73	Reserved		
74	User data (3 octet LSDU) — RLS (P channel)	A2-39	V(0-3,5-8,11,14)
75	Reserved		
76	User data (4 octet LSDU) — RLS (P channel)	A2-40	V(0-3,5-8,11,14)
N/A	User data (ISU/SSU) (R channel)	A2-44	V(0-3,5-8,11,14)

Code (HEX)	Function	Message format figure (refer to Appendix 2 to Chapter 4)	Q number (precedence)
80	Broadcast reserved		
81	AES system table broadcast-spot beam series GES P/R channel (partial)	A2-56/A2-57	NA
82	AES system table broadcast-spot beam series GES beam support (partial)	A2-60	NA
83	AES system table broadcast-spot beam series GES P/R channel (complete)	A2-56/A2-57	NA
84	AES system table broadcast-spot beam series GES beam support (complete)	A2-60	NA
85	AES system table broadcast-spot beam series index	A2-55	NA
86	AES system table broadcast-spot beam series satellite/beam ID (partial)	A2-58/A2-59	NA
87	AES system table broadcast-spot beam series satellite/beam ID (complete)	A2-58/A2-59	NA
88	AES system table broadcast-spot beam series 2nd series of GES P/R channel (complete)	A2-56/A2-57	NA
89	Reserved		
SUBSEQUENT SIGNAL UNITS: bits 8-7 = 1 1			
	Call information service address (SSU)	A2-10	13
	P/R channel control (SSU)	A2-19	13
	T channel control (SSU)	A2-21	13
	User data (SSU) — (P/T channel)	A2-38	V(0-3,5-8,11,14)

All other codes are unassigned.

In the Q number column, message types with a variable Q number are indicated by V followed in brackets by the value or range of values normally used.

Appendix 4 to Chapter 4

TIME-OUT VALUES

Time	Value (seconds)
tG1	9.3
tG2	5
tG3	18
tG3A	Reserved
tG3B	Reserved
tG4	2.5
tG5	Reserved
tG6	At the discretion of the GES operator
tG7	Unassigned
tG8	10
tG9	20 to 30
tG10	Tch (Note 3)
tG11	12
tG12	10
tG13	10
tG14	7
tG15	Unassigned
tG16	10
tG17	10
tG18	7
tG19	10
tG20	120 to 240
tG21	120 to 240
tG22	60 to 120
tG23	10
tG24	10
tG25	2
tG26	25
tG27	12
tG28-tG29	Unassigned
tG30	2
tG31	5 + 5* (P-Ch frame duration)
tG32	10
tG33	10
tG34	4
tG35	Tch (Note 3)
tG36	2
tA1	20 + (No. of SUs)*Ts (Note 2)
tA2	Unassigned
tA3	7.9 + RND (0,Z_k – 1)*Ts (Notes 2, 4)
tA4	Unassigned
tA4A	8
tA4B	7.9 + RND (0,Z_k – 1)*Ts (Notes 2, 4)
tA5	4
tA6	8
tA7	7.9 + RND (0,Z_k – 1)*Ts (Notes 2, 4)
tA8(i) (Note 1)	(Delay to res)*8 + 2
tA9	Unassigned
tA10	5 + RND (0,Z_k – 1)*Ts (Notes 2, 4)
tA11	12 + RND (0,Z_k – 1)*Ts (Notes 2, 4)
tA12	10
tA13	10
tA14	10
tA15-tA17	Unassigned
tA18	20 to 30
tA19	10
tA20	15 + RND (0,Z_k – 1)*Ts (Notes 2, 4)
tA21	Unassigned
tA22	Tch (Note 3)
tA23-tA24	Unassigned
tA25	5
tA26	Tch (Note 3)
tA27	10
tA28	10
tA29	K *Tch, K = 2 (Note 3)
tA30	10
tA31	20
tA32	10
tA33	Tch (Note 3)
tA34	20
tA35	10
tA36	Tch (Note 3)
tA37	5
tA38	(No. of SUs)*Tch (Note 3)
tA39	5
tA40	(No. of SUs)*Tch (Note 3)
tA41	15
tA42	120 to 240
tA43-tA49	Unassigned
tA50	4 + 2* (P-Ch frame duration)

NOTES

1. Multiple timers as required, indicated by suffix (i).
2. Z_k = Zo * 2^k, Zo = 4 normally; Ts = R channel slot duration and k is the number of retries; k = 0 for initial transmission.
3. Tch = time required to transmit 1 SU on sub-band C channel, e.g. 0.167 seconds for 21 000 bits/s channel.
4. RND(x,y) = function that randomly selects an integer value from the interval [x,y]; all integers in the interval are equally probable.

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INTERWORKING TELEPHONY EVENT MAPPING

FITE 18	Event Name: AMS(R)S Call Origination (Calling Party Category Indicator, Subscriber, Call with Priority)	
MAPS INTO:	AMS(R)S CM-LIDU: Access Request — Telephone and Call Information — Service Address	Procedure Usage: AES Outgoing

Parameter Mapping:

FITE PARAMETER	LICI PARAMETER CODING	
CPCI (Calling Party Category Indicator)	Q Number	
Distress/Urgency		→ 15
Flight Safety		→ 12
Regularity		→ 10
Called Party Number Ground Address (10-digit fixed length)	Address Digit 0-9 (10-digit fixed length)	→ (Variable)
Calling Party Subaddress Aircraft Audio System Channel	Calling Terminal	→ (Variable)
	Network ID	10 (AMS(R)S Terrestrial Voice Network)
	Service ID	1
	Circuit Data Rate	0
	Voice Channel Characteristics	2 or 3
	Source	1
	Service Direction	3
	Application Reference Number	(Variable)
	Message Type	20/23 (hex)
	Routing	R channel

Comments:

This parameter mapping is applicable to the "Access Request — Telephone" CM-LIDU only.

Message type 23 (hex) corresponds to the "Abbreviated Access Request — Telephone" SU.
Message type 20 (hex) corresponds to the "General Access Request — Telephone" SU; and in this case, only the first two digits of the ground address are transmitted with this CM-LIDU.
Network ID = 10 is applicable if there is a private AMS(R)S terrestrial voice network.

Figure A5-1 a)

FITE 18 CONTINUED	Event Name: **AMS(R)S Call Origination (Calling Party Category Indicator, Subscriber, Call with Priority)**	
MAPS INTO:	AMS(R)S CM-LIDU: **Access Request — Telephone and Call Information — Service Address**	Procedure Usage: **AES Outgoing**

Parameter Mapping:

FITE PARAMETER	LICI PARAMETER CODING	
Called Party Number Ground Address ········▶	Address Digit 2-9	(Variable)
Calling Party Sub-address Aircraft Audio System Channel ········▶	Calling Terminal	(Variable)
	Message Type	21 (hex)
	Routing	C channel sub-band

Comments:

This parameter mapping is applicable to the "Call Information — Service Address" CM-LIDU only.

Figure A5-1 b)

FITE 22	Event Name: Clear Forward	
MAPS INTO:	AMS(R)S CM-LIDU: Call Progress - Channel Release	Procedure Usage: AES Outgoing

Parameter Mapping:

FITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) [Values as per table below]
Cause Location (See below) →	Location (of Cause) [Values as per table below]
Cause Class (See below) →	Cause Class [Values as per table below]
Cause Value (See below) →	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
	Routing R-Channel or C-Channel subband

Comments: ① The preemption event is generated internal to the AES Outgoing procedure in response to the arrival of the higher priority AMS(R)S call. It does not arrive via the interworking interface.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
① Preemption by higher priority AMS(R)S call at the AES	1	1	1	1
Normal forward clearing by the calling subscriber	0	0	1	0

Figure A5-2

BITE 5	Event Name: Address Complete	
MAPS FROM:	AMS(R)S CM-LIDU: Call Progress - Call Attempt Result	Procedure Usage: AES Outgoing

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 4
Comments:	

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Address complete signal received from the terrestrial network	1	6	0	1

Figure A5-3

BITE 12	Event Name: Call Unsuccessful - Network Congestion	
MAPS FROM:	AMS(R)S CM-LIDU: Call Progress - Channel Release or Call Progress - Call Attempt Result	Procedure Usage: AES Outgoing

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5 (Channel release) 4 (Call attempt result)

Comments:

① This event is generated internal to the AES Outgoing procedure. It does not arrive via the Link Layer.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
C-Channel frequency unavailable at GES	1	3	2	1
C-Channel unit unavailable at GES	1	3	2	2
GES equipment congestion	0	2	2	10
Terrestrial network congestion	0	4	2	10
① C-Channel unit unavailable at AES	1	2	2	2

Figure A5-4

BITE 14	Event Name: Call Unsuccessful - Address Incomplete	
MAPS FROM:	AMS(R)S CM-LIDU: Call Progress - Channel Release	Procedure Usage: AES Outgoing

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
Comments:	

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Incomplete called number format detected by terrestrial network	0	4	1	12
Incomplete called number format detected by GES	1	4	3	2

Figure A5-5

BITE 15	Event Name: **Call Unsuccessful - Unallocated Number**	
MAPS FROM:	AMS(R)S CM-LIDU: **Call Progress - Channel Release**	Procedure Usage: **AES Outgoing**

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
Comments:	

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Unallocated called number detected by terrestrial network	0	4	0	1

Figure A5-6

BITE 16	Event Name: Call Unsuccessful - Called Party Busy	
MAPS FROM:	AMS(R)S CM-LIDU: Call Progress - Channel Release	Procedure Usage: AES Outgoing

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5

Comments:

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Called user busy	0	5	1	1
Called user busy (Called user alerted)	0	5	1	3

Figure A5-7

BITE 17	Event Name: **Call Unsuccessful - Line out of Service**	
MAPS FROM:	AMS(R)S CM-LIDU: **Call Progress - Channel Release**	Procedure Usage: **AES Outgoing**

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5

Comments:

(1) The "No response from GES" event trigger is generated internally by the AES Outgoing procedure and is not mapped from a received CM-LIDU.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT

Event Trigger	Coding Std.	Location	Cause Class	Cause Value
C-Channel continuity test failure at the GES or carrier interruption	1	3	5	1
Destination out of service	0	5	1	11
(1) No response from GES	1	2	5	1

Figure A5-8

BITE 20	Event Name: Call Unsuccessful - Send Error Indication	
MAPS FROM:	AMS(R)S CM-LIDU: Call Progress - Channel Release	Procedure Usage: AES Outgoing

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
Comments:	

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Reqd voice characteristics not supported by GES	1	3	6	4
Undefined cause	1	3	7	15
Calling AES not authorized for service	1	3	4	2
Expiry of answer timer at GES	0	4	1	2

Figure A5-9

BITE 22	Event Name: Answer	
MAPS FROM:	AMS(R)S CM-LIDU: Call Progress - Connect	Procedure Usage: AES Outgoing

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
	Message Type 30 (hex)
	Report Type 2
Comments:	

Figure A5-10

BITE 25	Event Name: Clear Back	
MAPS FROM:	AMS(R)S CM-LIDU: Call Progress - Channel Release	Procedure Usage: AES Outgoing

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5

Comments:

(1) The preemption event is generated internal to the AES Outgoing procedure in response to the arrival of a higher priority AMS(R)S call.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Normal backward clearing	0	0	1	0
(1) Preemption by higher priority AMS(R)S call at the AES	1	2	1	1

Figure A5-11

FITE 18	Event Name: **AMS(R)S Call Origination (Calling-Party-Category Indicator, Subscriber, Call with Priority)**	
MAPS FROM:	AMS(R)S CM-LIDU: **Call Announcement and C-Channel Assignment**	Procedure Usage: **AES Incoming**

Parameter Mapping:

FITE PARAMETER	LICI PARAMETER CODING
CPCI (Calling Party Category Indicator)	Q Number
Distress/Urgency ←	15
Flight Safety ←	12
Regularity ←	10
Called Party Subaddress Aircraft Audio System Channel ←	Called Terminal (Variable)
Network-Specific Facilities Voice Call ←	Service ID 1
User Data Rate Data Mode Not Required ←	Circuit Data Rate 0
	Voice Channel Characteristics 2
	Source 2
	Service Direction 3
	Message Type 20 (hex)

Comments: This parameter mapping is applicable to the "Call Announcement" CM-LIDU only.

Parameter Mapping:

FITE PARAMETER	LICI PARAMETER CODING
	Initial EIRP (Variable)
	Receive Channel Frequency (variable)
	Transmit Channel Frequency (variable)
	Message Type 31 (hex)

Comments: This parameter mapping is applicable to the "C-Channel Assignment" CM-LIDU only.

Figure A5-12

FITE 22	Event Name: Clear Forward	
MAPS FROM:	AMS(R)S CM-LIDU: Call Progress - Channel Release	Procedure Usage: AES Incoming

Parameter Mapping:

FITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5

Comments:

(1) The preemption event is generated internal to the AES Incoming procedure in response to the arrival of a higher priority AMS(R)S call. It does not arrive via the CM-LIDU.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Normal forward clearing	0	0	1	0
(1) Preemption by higher priority AMS(R)S call at the AES	1	1	1	1
Undefined cause	1	4	7	15
C-channel continuity test failure at the GES/AES not responding or interruption in received AES carrier.	1	3	5	1
Expiry of answer timer (internally generated by the AES)	0	1	1	2
Connection acknowledgement not received by AES (internally generated by the AES)	1	2	5	1
Call preempted at the GES	1	3	1	1

Figure A5-13

BITE 12	Event Name: **Call Unsuccessful - Network Congestion**	
MAPS INTO:	AMS(R)S CM-LIDU: **Call Progress - Call Attempt Result**	Procedure Usage: **AES Incoming**

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard	S (Coding Standard) [Value as per table below]
Cause Location	Location (of Cause) [Value as per table below]
Cause Class	Cause Class [Value as per table below]
Cause Value	Cause Value [Value as per table below]
	Message Type 30 (hex)
	Report Type 4
	Routing R-Channel

Comments:

These events are generated internal to the AES incoming procedure and do not arrive via the interworking interface.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
C-channel unit unavailable at the AES	1	2	2	2
Preempted by higher priority AMS(R)S call at the AES	1	1	1	1

Figure A5-14

BITE 16	Event Name: Call Unsuccessful - Called Party Busy	
MAPS INTO:	AMS(R)S CM-LIDU: Call Progress - Call Attempt Result	Procedure Usage: AES Incoming

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) → [Values as per table below]
Cause Location (See below) →	Location (of Cause) → [Values as per table below]
Cause Class (See below) →	Cause Class → [Values as per table below]
Cause Value (See below) →	Cause Value → [Values as per table below]
	Message Type 30 (hex)
	Report Type 4
	Routing R-Channel
Comments:	

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Called Terminal Busy	1	1	7	1

Figure A5-15

BITE 17	Event Name: Call Unsuccessful - Line out of Service	
MAPS INTO:	AMS(R)S CM-LIDU: Call Progress - Call Attempt Result	Procedure Usage: AES Incoming

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) [Values as per table below]
Cause Location (See below) →	Location (of Cause) [Values as per table below]
Cause Class (See below) →	Cause Class [Values as per table below]
Cause Value (See below) →	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 4
	Routing R-channel

Comments:
(1) These events are generated internally by the AES Incoming procedure.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
(1) Continuity test failure at the AES	1	2	5	1
Called terminal out of service	1	1	4	1
(1) Call announcement or C-channel assignment CM-LIDU not received from GES	1	2	3	2

Figure A5-16

BITE 22	Event Name: Answer	
MAPS INTO:	AMS(R)S CM-LIDU: Call Progress - Connect	Procedure Usage: AES Incoming

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
	Message Type 30 (hex)
	Report Type 2
	Routing C-channel subband
Comments:	

Figure A5-17

BITE 25	Event Name: Clear Back	
MAPS INTO:	AMS(R)S CM-LIDU: Call Progress - Channel Release	Procedure Usage: AES Incoming

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) [Values as per table below]
Cause Location (See below) →	Location (of Cause) [Values as per table below]
Cause Class (See below) →	Cause Class [Values as per table below]
Cause Value (See below) →	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
	Routing C-Channel subband

Comments:
(1) These events are generated internal to the AES Incoming procedure.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
(1) Preemption by AMS(R)S call at the AES	1	1	1	1
Normal backward clearing	0	0	1	0
(1) Answer timer expiry at the AES	0	1	1	2
(1) Connection-acknowledgement timer expiry at the AES	1	2	5	1
Undefined cause	1	2	7	15

Figure A5-18

FITE 18	Event Name: AMS(R)S Call Origination (Calling-Party Category Indicator,Subscriber, Call with Priority)	
MAPS INTO:	AMS(R)S CM-LIDU: Call Announcement and C-Channel Assignment	Procedure Usage: GES Outgoing

Parameter Mapping:

FITE PARAMETER	LICI PARAMETER CODING	
CPCI (Calling Party Category Indicator)	Q Number	
Distress/Urgency →		15
Flight Safety →		12
Regularity →		10
First 8 digits of 10-digit address (Variable) →	AES ID	(Variable)
Last 2 digits of 10-digit address (Variable) →	Called Terminal	(Variable)
	Service ID	1
	Circuit Data Rate	0
	Voice Channel Characteristics	2
	Source	2
	Service Direction	3
	Message Type	20 (hex)
	Routing	P-Channel

Comments: This parameter mapping is applicable to the "Call Announcement" CM-LIDU only.

	Initial EIRP	(Variable)
	Receive Channel Frequency	(variable)
	Transmit Channel Frequency	(variable)
	Message Type	31 (hex)
	Routing	P-Channel

Comments: This parameter mapping is applicable to the "C-Channel Assignment" CM-LIDU only.

Figure A5-19

FITE 22	Event Name: **Clear Forward**	
MAPS INTO:	AMS(R)S CM-LIDU: **Call Progress - Channel Release**	Procedure Usage: **GES Outgoing**

Parameter Mapping:

FITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below)	S (Coding Standard) ➤ [Values as per table below]
Cause Location (See below)	Location (of Cause) ➤ [Values as per table below]
Cause Class (See below)	Cause Class ➤ [Values as per table below]
Cause Value (See below)	Cause Value ➤ [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
	Routing: P-Channel or C-Channel subband

Comments:

(1) These events are generated internal to the GES outgoing procedure.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	**Coding Std.**	**Location**	**Cause Class**	**Cause Value**
Normal forward clearing by the calling subscriber	0	0	1	0
(1) C-channel continuity test failure at the GES/AES not responding	1	3	5	1
(1) Interruption in received AES carrier	1	3	5	1
(1) Call preempted by higher priority AMS(R)S call	1	3	1	1
Undefined cause	1	4	7	15

Figure A5-20

BITE 5	Event Name: **Address Complete**	
MAPS FROM:	AMS(R)S CM-LIDU: **Telephony Acknowledge** (When received by the GES at the completion of the C-Channel continuity check)	Procedure Usage: **GES Outgoing**

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
	Message Type 60 (hex)
	Ack/Nack Ack

Comments:

No parameters are mapped for this event. However, the Telephony Acknowledge CM-LIDU received during the C-Channel continuity check must have its Ack/Nack parameter set to ACK.

Figure A5-21

BITE 12	Event Name: **Call Unsuccessful - Network Congestion**	
MAPS FROM:	AMS(R)S CM-LIDU: **Call Progress - Call Attempt Result**	Procedure Usage: **GES Outgoing**

Parameter Mapping:

FITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) [Values as per table below]
Cause Location (See below) →	Location (of Cause) [Values as per table below]
Cause Class (See below) →	Cause Class [Values as per table below]
Cause Value (See below) →	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 4

Comments:

(1) These events are generated internal to the GES outgoing procedure.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	**Coding Std.**	**Location**	**Cause Class**	**Cause Value**
(1) C-Channel frequency unavailable at GES	1	3	2	1
(1) C-Channel unit unavailable at GES	1	3	2	2
(1) GES equipment congestion	0	4	2	10
Call preempted by higher priority AMS(R)S call at the AES	1	1	1	1

Figure A5-22

BITE 16	Event Name: Call Unsuccessful - Called Party Busy	
MAPS FROM:	AMS(R)S CM-LIDU: Call Progress - Call Attempt Result	Procedure Usage: GES Outgoing

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 4

Comments:

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Called party busy	1	1	7	1
C-channel unit unavailable at AES	1	2	2	2

Figure A5-23

BITE 17	Event Name: **Call Unsuccessful - Line out of Service**	
MAPS FROM:	AMS(R)S CM-LIDU: **Call Progress - Call Attempt Result**	Procedure Usage: **GES Outgoing**

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 4

Comments:

① This event trigger is generated internally by the GES Outgoing procedure upon the failure of the C-Channel continuity test within the GES. It does not arrive via the CM-LIDU.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT

Event Trigger	Coding Std.	Location	Cause Class	Cause Value
C-channel continuity test failure at the AES	1	2	5	1
① C-channel continuity test failure at the GES/AES not responding	1	3	5	1
Called terminal out of service	1	1	4	1
Call announcement or C-channel assignment CM-LIDU not received from GES	1	2	3	2

Figure A5-24

BITE 20	Event Name: Call Unsuccessful - Send Error Indication	
MAPS FROM:	AMS(R)S CM-LIDU: (None. See below.)	Procedure Usage: GES Outgoing

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Comments: This event is generated internal to the GES Outgoing procedure when a call is attempted to an AES which is not logged-on.	

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
AES not logged on	1	3	7	3

Figure A5-25

BITE 22	Event Name: Answer	
MAPS FROM:	AMS(R)S CM-LIDU: Call Progress - Connect	Procedure Usage: GES Outgoing

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
	Message Type 30 (hex)
	Report Type 2
Comments:	

Figure A5-26

BITE 25	Event Name: Clear Back	
MAPS FROM:	AMS(R)S CM-LIDU: Call Progress - Channel Release	Procedure Usage: GES Outgoing

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5

Comments:

(1) These events are generated internal to the AES incoming procedure.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	**Coding Std.**	**Location**	**Cause Class**	**Cause Value**
Normal backward clearing	0	0	1	0
Preempted by higher priority AMS(R)S call at the AES	1	1	1	1
Answer timer expiry at the AES	0	1	1	2
Connection-acknowledgement timer expiry at the AES	1	2	5	1
(1) Interruption in received AES carrier	1	3	5	1
(1) Call preempted for higher priority AMS(R)S call	1	3	1	1
Undefined cause	1	2	7	15

Figure A5-27

FITE 18	Event Name: AMS(R)S Call Origination (Calling-Party Category Indicator,Subscriber, Call with Priority)	
MAPS FROM:	AMS(R)S CM-LIDU: Abbreviated Access Request - Telephone	Procedure Usage: GES Incoming

Parameter Mapping:

FITE PARAMETER	LICI PARAMETER CODING	
CPCI (Calling Party Category Indicator)	Q Number	
Distress/Urgency ←		15
Flight Safety ←		12
Regularity ←		10
Called Party Number	Address Digit 0-9 (10 digit fixed length)	
Ground Address (10 digit fixed length) ←		(Variable)
Calling Party Number	AES ID	
Aircraft Address (first 8 of 10 digits) ←		(Variable)
Aircraft Address (last 2 of 10 digits) ←	Calling Terminal	(Variable)
Closed User Group Info	Network ID	
AMS(R)S Terrestrial Voice Network ←		10
Network-Specific Facilities	Service ID	
Voice Call ←		1
User Data Rate	Circuit Data Rate	
Data Mode Not Required ←		0
	Voice Channel Characteristics	2
	Source	1
	Service Direction	3
	Application Reference Number	(Variable)
	Message Type	23 (hex)

Comments:

Figure A5-28

FITE 22	Event Name: Clear Forward	
MAPS FROM:	AMS(R)S CM-LIDU: Call Progress - Channel Release	Procedure Usage: GES Incoming

Parameter Mapping:

FITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) ←	S (Coding Standard) [Values as per table below]
Cause Location (See below) ←	Location (of Cause) [Values as per table below]
Cause Class (See below) ←	Cause Class [Values as per table below]
Cause Value (See below) ←	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5

Comments:

(1) This event is generated internal to the GES incoming procedure.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Preemption by higher priority AMS(R)S call at the AES	1	1	1	1
Normal forward clearing by the calling party	0	0	1	0
(1) Interruption in received AES carrier or continuity failure	1	3	5	1

Figure A5-29

BITE 5	Event Name: **Address Complete**	
MAPS INTO:	AMS(R)S CM-LIDU: **Call Progress - Call Attempt Result**	Procedure Usage: **GES Incoming**

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) → [Values as per table below]
Cause Location (See below) →	Location (of Cause) → [Values as per table below]
Cause Class (See below) →	Cause Class → [Values as per table below]
Cause Value (See below) →	Cause Value → [Values as per table below]
	Message Type 30 (hex)
	Report Type 4
	Routing C-Channel subband
Comments:	

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Address complete signal received from the terrestrial network	1	6	0	1

Figure A5-30

BITE 12	Event Name: **Call Unsuccessful - Network Congestion**	
MAPS INTO:	AMS(R)S CM-LIDU: **Call Progress - Channel Release** or **Call Progress - Call Attempt Result**	Procedure Usage: **GES Incoming**

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) → [Values as per table below]
Cause Location (See below) →	Location (of Cause) → [Values as per table below]
Cause Class (See below) →	Cause Class → [Values as per table below]
Cause Value (See below) →	Cause Value → [Values as per table below]
	Message Type 30 (hex)
	Report Type 5 (channel release) 4 (call attempt result)
	Routing P-channel or C-channel subband

Comments:

① This event trigger is generated internal to the GES Incoming procedure and does not arrive via the interworking interface with the terrestrial network.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	**Coding Std.**	**Location**	**Cause Class**	**Cause Value**
① C-Channel frequency unavailable at GES	1	3	2	1
① C-Channel unit unavailable at GES	1	3	2	2
① GES equipment congestion	0	2	2	10
Terrestrial network congestion or no route to destination	0	4	2	10

Figure A5-31

BITE 14	Event Name: Call Unsuccessful - Address Incomplete	
MAPS INTO:	AMS(R)S CM-LIDU: Call Progress - Channel Release	Procedure Usage: GES Incoming

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) [Values as per table below]
Cause Location (See below) →	Location (of Cause) [Values as per table below]
Cause Class (See below) →	Cause Class [Values as per table below]
Cause Value (See below) →	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
	Routing P-channel or C-channel subband
Comments:	

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Incomplete called number format detected by the terrestrial network	0	4	1	12
Invalid called number format detected by the terrestrial network	1	4	3	2

Figure A5-32

BITE 15	Event Name: Call Unsuccessful - Unallocated Number	
MAPS INTO:	AMS(R)S CM-LIDU: Call Progress - Channel Release	Procedure Usage: GES Incoming

Parameter Mapping:

FITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) → [Values as per table below]
Cause Location (See below) →	Location (of Cause) → [Values as per table below]
Cause Class (See below) →	Cause Class → [Values as per table below]
Cause Value (See below) →	Cause Value → [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
	Routing P-channel or C-channel subband
Comments:	

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Unallocated called number detected by terrestrial network	0	4	0	1

Figure A5-33

BITE 16	Event Name: **Call Unsuccessful - Called Party Busy**	
MAPS INTO:	AMS(R)S CM-LIDU: **Call Progress - Channel Release**	Procedure Usage: **GES Incoming**

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) [Values as per table below]
Cause Location (See below) →	Location (of Cause) [Values as per table below]
Cause Class (See below) →	Cause Class [Values as per table below]
Cause Value (See below) →	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
	Routing P-channel or C-channel subband

Comments:

(1) The "called party busy (called party alerted)" event trigger is supported only by a GES which is equipped to receive that event from the terrestrial network.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Called party busy	0	5	1	1
(1) Called party busy (Called party alerted)	0	5	1	3

Figure A5-34

BITE 17	Event Name: **Call Unsuccessful - Line out of Service**	
MAPS INTO:	AMS(R)S CM-LIDU: **Call Progress - Channel Release**	Procedure Usage: **GES Incoming**

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) [Values as per table below]
Cause Location (See below) →	Location (of Cause) [Values as per table below]
Cause Class (See below) →	Cause Class [Values as per table below]
Cause Value (See below) →	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
	Routing P-channel or C-channel subband
Comments: (1) This event is generated internal to the GES Incoming procedure. It does not arrive via the Interworking Interface.	

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
(1) C-Channel continuity test failure at the GES or carrier interruption	1	3	5	1
Destination out of service	0	5	1	11

Figure A5-35

BITE 20	Event Name: **Call Unsuccessful - Send Error Indication**

MAPS INTO:	AMS(R)S CM-LIDU: **Call Progress -- Channel Release**	Procedure Usage: **GES Incoming**

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) [Values as per table below]
Cause Location (See below) →	Location (of Cause) [Values as per table below]
Cause Class (See below) →	Cause Class [Values as per table below]
Cause Value (See below) →	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
	Routing P-channel or C-channel subband

Comments:

All event triggers for this BITE are generated internal to the GES Incoming procedure. They do not arrive via the interworking interface.

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT

Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Reqd voice characteristics not supported by GES	1	3	6	4
Undefined cause	1	3	7	15
Calling AES not authorized for service	1	3	4	2
Expiry of answer timer at GES	0	4	1	2

Figure A5-36

BITE 22	Event Name: Answer	
MAPS INTO:	AMS(R)S CM-LIDU: Call Progress - Connect	Procedure Usage: GES Incoming

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
	Message Type 30 (hex)
	Report Type 2
	Routing C-channel subband
Comments:	

Figure A5-37

BITE 25	Event Name: Clear Back	
MAPS INTO:	AMS(R)S CM-LIDU: Call Progress - Channel Release	Procedure Usage: GES Incoming

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) [Values as per table below]
Cause Location (See below) →	Location (of Cause) [Values as per table below]
Cause Class (See below) →	Cause Class [Values as per table below]
Cause Value (See below) →	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
	Routing P-Channel or C-channel subband

Comments:

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Normal backward clearing	0	0	1	0

Figure A5-38

BITE 27	Event Name: **Sending Finished - Set Up Speech Condition**	
MAPS INTO:	AMS(R)S CM-LIDU: **Call Progress - Call Attempt Result**	Procedure Usage: **GES Incoming**

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) → [Values as per table below]
Cause Location (See below) →	Location (of Cause) → [Values as per table below]
Cause Class (See below) →	Cause Class → [Values as per table below]
Cause Value (See below) →	Cause Value → [Values as per table below]
	Message Type 30 (hex)
	Report Type 4
	Routing C-channel subband

Comments:

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Address complete signal received from the terrestrial network	1	6	0	1

Figure A5-39

BITE 29	**Event Name:** Release Incoming Side	
MAPS INTO:	**AMS(R)S CM-LIDU:** Call Progress - Channel Release	**Procedure Usage:** GES Incoming

Parameter Mapping:

BITE PARAMETER	LICI PARAMETER CODING
Coding Standard (See below) →	S (Coding Standard) [Values as per table below]
Cause Location (See below) →	Location (of Cause) [Values as per table below]
Cause Class (See below) →	Cause Class [Values as per table below]
Cause Value (See below) →	Cause Value [Values as per table below]
	Message Type 30 (hex)
	Report Type 5
	Routing P-Channel or C-channel subband

Comments:

SPECIFIC CM-LIDU PARAMETER CODING INDICATIVE OF THIS EVENT				
Event Trigger	Coding Std.	Location	Cause Class	Cause Value
Release Incoming Side event received from terrestrial network *(Normal backward clearing)*	0	0	1	0

Figure A5-40

Appendix 6 to Chapter 4

AMS(R)S CONFIGURATION PARAMETERS

Table A6-1. Circuit-mode configuration parameters

Parameter	Description	Value
nA21	Length of CM-LIDU series for distress/urgency air-originations	4
nA22	Length of CM-LIDU series for flight safety air-originations	3
nA23	Length of CM-LIDU series for regularity/meteorological air-originations	2

Appendix 7 to Chapter 4

VOICE ENCODING ALGORITHM DEFINITION

1. INTRODUCTION

Interoperability of equipments utilizing the 9.6 kbits/s LPC codec operating in the AMS(R)S service can only be ensured if all provisions of this algorithm definition are fully complied with.

Note 1.— Refer to Figure A7-1 for a schematic representation of the algorithm.*

Note 2.— The flow and processing of information within the algorithm is defined with the use of the Pascal language. Individual implementations of this algorithm need not use this language.

Note 3.— All scalar variable names are depicted with a simple name. All vector variable names are depicted with a simple name followed by paired brackets ([]).

2. REQUIREMENTS FOR NUMERIC CALCULATIONS

Except where explicitly noted, and except for obvious integer variables such as vector indices and loop counters, all variables shall be maintained as floating-point values with a minimum mantissa precision of 24 bits inclusive of a sign bit. The range of the associated exponent shall be such that the magnitude of a positive or negative non-zero variable can vary over a minimum range of $5.87747*10^{-39}$ to $3.40282*10^{38}$.

Note.— Compliance with this minimum numeric range is essential if interoperability between different vocoder implementations is to be ensured.

3. AUDIO INPUT CHARACTERISTICS

3.1 Audio input spectral characteristics

Prior to sampling and quantization, speech audio which is presented to the encoding algorithm shall exhibit the following minimum spectral characteristics. These characteristics may be met by any combination of specific anti-aliasing filters and/or the natural spectral roll-off characteristics of transducers and audio channels:

Note.— All specifications are referenced to 1 020 Hz.

a) over a passband of 300 to 3 400 Hz; a gain variation of no more than ±2 dB;

b) over a transition band of 4 000 Hz to 4 600 Hz, a gain of –45 dB or lower; and

c) at 4 600 Hz and above, a gain of –75 dB or lower.

Note 1.— In addition to the listed spectral characteristics, additional filtering appropriate to the particular equipment installation should be provided in the low-end response characteristics of the vocoder so as to mitigate the effects of power supply noise pickup (e.g. 400 Hz for AES installations and 50/60 Hz for GES installations).

Note 2.— The input to the encoding algorithm is defined in 3.2 to be quantized audio samples with at least 12 bits of resolution. Consequently, all required spectral characteristics at the point of sampling are defined with this in mind. The use of u-law or A-law companded audio in conjunction with both reduced resolution (e.g. 8 bits) and appropriately relaxed transition-band and stop-band gain characteristics is permitted provided that the quantized samples are decompanded (linearized) prior to their presentation to the algorithm.

---

* All figures are located at the end of this chapter.

3.2 Sampling, quantization and scaling

Audio which exhibits the spectral characteristics defined in 3.1 shall be sampled at a continuous 8 kHz rate, and the resultant series of samples shall be quantized to an equivalent time-ordered series of linear (i.e. non-companded) binary values. Each quantization operation shall be performed with a precision of at least 12 bits and a linearity of at least 10 bits. The maximum dynamic range of this series shall be scaled up or down in magnitude as appropriate so that it is tightly bounded by the floating-point range of 4 095.0 to –4 096.0 without exceeding it. The resultant time-ordered series of scaled values shall be presented to the segmentation and windowing logic defined in 4.1.

Note.— The above bounding range of scaled values is indicative of a fixed-point signed value of 13 bits in length. Scaling of the time-ordered series of binary values to the indicated numeric range is required in order to take maximum advantage of the internal numeric range of the algorithm.

4. ENCODING PROCESS DEFINITION

4.1 Segmentation and windowing

The time-ordered stream of input samples shall be subdivided into time-ordered segments termed *segspch[]*, each comprising 256 time-ordered input samples (32 ms). Each *segspch[]* shall be so constructed that the first and last 96 samples (12 ms) contained within it overlap with the immediately previous and subsequent *segspch[]*. Each *segspch[]* shall be windowed with a Hamming window vector *hamwindow[]* defined by:

```
FOR n:=0 TO 255 DO hamwindow[n]:=
0.54–0.46*COS(2*3.1415927*n/255);
```

and a windowing operation defined by:

```
FOR n:=0 TO 255 DO windspch[n]:=
segspch[n]*hamwindow[n];.
```

An additional time-ordered vector *spch[]* corresponding to the central 160 samples of each *segspch[]* vector shall be generated by the operation defined by:

```
FOR n:=0 TO 159 DO spch[]:=segspch[n+48];.
```

4.2 Autocorrelation

For each *windspch[]*, an eleven element autocorrelation vector *corr[]* shall be generated by the operation defined by:

```
FOR i:=0 TO 10 DO
BEGIN
dot:=0;
   FOR n:=0 TO 255-i DO dot:=dot+windspch[n]
   *windspch[n+i];
corr[i]:=dot
END;
```

4.3 Durbin's recursion

For each *corr[]*, a partial correlation coefficient vector *parcor[]* shall be generated by the operation defined by:

```
IF corr[0]=0 THEN FOR i:=1 TO 10 DO parcor[i]:=0;
ELSE
BEGIN
parcor[1]:=corr[1]/corr[0];
taps[1]:=parcor[1];
error:=(1-sqr(parcor[1]))*corr[0];
FOR i:=2 TO 10 DO
   BEGIN
   FOR j:=1 TO pred(i) DO alpha[j]:=taps[j];
   parcor[i]:=corr[i];
   FOR j:=1 TO pred(i) DO parcor[i]:=parcor[i]-
      alpha[j]*corr[i-j];
   parcor[i]:=parcor[i]/error;
   taps[i]:=parcor[i];
   FOR j:=1 TO pred(i) DO taps[j]:=alpha[j]-
      parcor[i]*alpha[i-j];
   error:=(1-sqr(parcor[i]))*error
   END
END;
```

4.4 Quantization of the partial correlation coefficients

For each *parcor[]*, the ten partial correlation coefficients contained within shall be quantized and stored in vector *qparcor[]* which is generated by the operation defined by:

```
{Quantizer initialization procedure}

{No. of quantizer levels for each coefficient}

plevel[1]:=64;
plevel[2]:=64;
plevel[3]:=32;
plevel[4]:=32;
plevel[5]:=16;
plevel[6]:=16;
plevel[7]:=8;
plevel[8]:=8;
plevel[9]:=4;
plevel[10]:=4;
```

```
FOR i:=1 TO 10 DO
FOR j:=0 TO pred(plevel[i]) DO
    parql[i,j]:=pardl[i,pred(j)]+pardl[i,j]/2;

{Partial correlation coefficient quantizer}

FOR i:=1 TO 10 DO
BEGIN
j:=0;
        WHILE (parcor[i]>pardl[i,j] and
        (j<pred(plevel[i])) DO j:=succ(j);
    qparcor[i]:=parql[i,j]
END;
```

Note.— Vector pardl[] *contains the fixed decision levels for each partial correlation coefficient and its contents are defined in Table A7-1.**

4.5 Line codes for the partial correlation coefficients

A line code corresponding to each quantized partial correlation coefficient contained in *qparcor[]* shall be inserted into the transmission frame. Each line code shall be generated by the table look-up operation defined by:

a) for *qparcor[1]* use Table A7-2;

b) for *qparcor[2]* use Table A7-3;

c) for *qparcor[3]* use Table A7-4;

d) for *qparcor[4]* use Table A7-5;

e) for *qparcor[5]* use Table A7-6;

f) for *qparcor[6]* use Table A7-7;

g) for *qparcor[7]* use Table A7-8;

h) for *qparcor[8]* use Table A7-9;

i) for *qparcor[9]* use Table A7-10; and

j) for *qparcor[10]* use Table A7-11.

4.6 LPC filter tap step up

For each *qparcor[]*, the vector *qtaps[]* shall be generated by the operation defined by:

```
qtaps:=qparcor; {all 10 elements of vector qtaps set equal
to corresponding elements in qparcor}

FOR i:=2 TO 10 DO
BEGIN
    FOR j:=1 TO pred(i) DO alpha[j]:=qtaps[j];
        FOR j:=1 TO pred(i) DO qtaps[j]:=alpha[j]-
            qtaps[i]*alpha[i-j]
END;
```

4.7 Long-term correlation analysis

4.7.1 LPC inverse filtering

For each *spch[]*, the vector *residue[]* shall be generated by the operation defined by:

```
FOR n:=0 TO 159 DO
BEGIN
sum:=spch[n];
FOR i:=1 TO 10 DO sum:=sum-qtaps[i]*spch[n-i];
residue[n]:=sum
END;
```

Note.— The values near the start of each spch[], *for which the index of* spch[] *is less than zero, refers to speech samples at the end of the previous* spch[]. *For the first* spch[] *processed by the encoder, these values shall be considered to be zero.*

4.7.2 Long-term correlation

For each *residue[]*, the scalars *gain* and *delay* shall be generated by the operation defined by:

```
max:=0
FOR lag:=33 TO 96 DO
    BEGIN
    sum:=0;
    FOR n:=0 TO 159 DO sum:-
        sum+residue[n]*residue[n-lag];
        IF sum>max THEN
        BEGIN
        max:=sum;
        delay:=lag
        END
    END;
sum:=0;
FOR n:=0 TO 159 DO sum:=sum+sqr(residue[n-delay]);
IF sum=0 THEN gain:=0 ELSE gain:=max/sum;
END;
```

* All tables are located at the end of this chapter.

Note 1.— The scalar delay is a 16-bit signed integer.

Note 2.— Negative values of the indices n-lag and n-delay point to entries in the residue[] *that were calculated for the previous* spch[]. *For the first* spch[] *processed, the referenced entries in* residue[] *shall be considered to be zero.*

4.7.3 QUANTIZATION AND LINE ENCODING OF THE SCALAR GAIN

For each *gain*, its contents shall be quantized and stored in scalar *qgain* by the operation defined by:

```
IF gain>0.75 THEN qgain:=0.9 ELSE
    IF gain>0.45 THEN qgain:=0.60 ELSE
        IF gain>0.2 THEN qgain:=0.325 ELSE qgain:=0.1
```

A 2-bit line code corresponding to *qgain* shall be inserted into the transmission frame. The line code shall be generated by the table look-up operation defined by Table A7-12.

4.7.4 LINE ENCODING OF THE SCALAR DELAY

A line code corresponding to *delay* shall be generated by the table look-up operation defined by Table A7-13.

4.8 Excitation analysis

Note 1.— The transmission frame generated by this encoding algorithm contains five excitation frames. Each group of five excitation frames is associated with the same speech frame (spch[]) *from which the partial correlation coefficients of the current transmission frame were calculated.*

Note 2.— Any operation that generates an output variable that is a component of an excitation frame must be performed at the generation rate of the excitation frames (i.e. five executions for each spch[]).

4.8.1 ERROR SIGNAL DERIVATION

For each *delay*, *qgain*, *qtaps[]*, *synthspch[]*, and *s2[]*, the vector *error[]* shall be generated by the operation defined by:

```
local_synthspch:=synthspch; {create a local copy
    of the short term predictor filter memory}
local_s2:=s2; {create a local copy of the
    long term predictor filter memory}
FOR n:=b TO b+31 DO
    BEGIN
    sum:=0;
        FOR i:=1 TO 10 DO sum:=sum+qtaps[i]*
        local_synthspch[n-i];
local_synthspch[n]:=qgain*local_s2[n-delay]+sum;
error[n]:=spch[n]-local_synthspch[n]
END;
```

Note.— This operation is performed for each of the five excitation frames contained within a transmission frame.

4.8.2 IMPULSE RESPONSE CALCULATION

For each *qtaps[]*, the vectors *iresp[]* and *ipwr[]* shall be generated by the operation defined by the following:

```
iresp[0]:=1;
ipwr[31]:=1;
FOR n:=1 TO 31 DO
    BEGIN
    sum:=0;
    FOR j:=1 TO 10 DO IF n>=j THEN
        sum:=sum+qtaps[j]*iresp[n-j];
    iresp[n]:=sum;
    ipwr[32-succ(n)]:=ipwr[32-n]+sqr(sum)
    END;
```

Note.— Since the minimum possible value for the delay parameter is 32, the long-term predictor has no influence on the first 32 samples of the impulse response.

4.8.3 CROSS-CORRELATION CALCULATION

For each *error[]* and *iresp[]*, the vector *xcorr[]* shall be generated by the operation defined by:

```
FOR n:=0 TO 31 DO
    BEGIN
    dot:=0;
        FOR j:=n TO 31 DO dot:=dot+error[b+j]*
            iresp[j-n];
    xcorr[n]:=dot
    END;
```

Note 1.— The scalar b is the sample number corresponding to the start of the current excitation frame within the current speech frame. For the first, second, third, fourth and fifth excitation frames of each speech frame, the value of b equals 0, 32, 64, 96, and 128 respectively.

Note 2.— This operation is performed for each of the five excitation frames contained within a transmission frame.

4.8.4 PULSE SELECTION

For each *xcorr[]*, *ipwr[]*, and *iresp[]*, the vectors *posns[]* and *qamp[]* shall be generated by the operation defined by:

```
    FOR pulse:=1 TO 3 DO
    BEGIN
    max:=0;
    FOR n:=0 TO 31 DO
        IF (sqr(xcorr[n])>=max*ipwr[n]) and not
            (n in posn_set) THEN BEGIN
        max:=sqr(xcorr[n])/ipwr[n];
        pos:=n
    END;
    posn_set:=posn_set+[pos];
    posns[pulse]:=pos;
    amp:= xcorr[pos]/ipwr[pos];
    qamp[pulse]:=quantamp(amp,pulse);

{Account for the effect of the quantized pulse
    just calculated on the error to be minimized}
    WHILE pulse<npulse DO
    BEGIN
        FOR n:=0 TO pred(pos) DO
        BEGIN
        dot:=0;
            FOR j:=0 TO 31-pos DO dot:=dot+iresp[j]*
                iresp[j+(pos-n)];
        xcorr[n]:=xcorr[n-qamp*dot
        END;

        FOR n:= pos TO 31 DO
        BEGIN
        dot:=0;
            FOR j:=0 TO 31-n DO dot:=dot+iresp[j]*
                iresp[j+(n-pos)];
        xcorr[n]:=xcorr[n]-qamp*dot
        END
    END
END;
```

Note 1.— The second and third pulses selected in each excitation frame are not allowed to occupy a position already occupied by a previously selected pulse in that excitation frame.

Note 2.— The function quantamp(amp,pulse) *is defined in 4.8.4.1.*

Note 3.— This operation is performed for each of the five excitation frames contained within a transmission frame.

4.8.4.1 *PULSE AMPLITUDE QUANTIZATION*

Where invoked elsewhere, the function *quantamp(amp,pulse)* shall be used to generate values in the vector *qamp[]* by the operation defined by:

```
    {Pulse amplitude quantizer initialization}

    gfact_leak:=1; maxadapt:=false;
    adjust[1]:=1; adjust[2]:=1.0/0.625; adjust[3]:=1.0/0.375;

{3 bit quantizer initialization}

adapt[3,0]:=0.875; adapt[3,1]:=0.875;
    adapt[3,2]:=1.0; adapt[3,3]:=1.5;
quant[3,0]:=0.5006; quant[3,1]:=1.050;
    quant[3,2]:=1.748;
inv_quant[3,0]:=0.2451; inv_quant[3,1]:=0.7560;
    inv_quant[3,2]:=1.344;
inv_quant[3,3]:=2.152;

{4 bit quantizer initialization}

adapt[4,0]:=0.75; adapt[4,1]:=0.875;
    adapt[4,2]:=0.875; adapt[4,3]:=0.875;
adapt[4,4]:=1.0;
adapt[4,5]:=1.25; adapt[4,6]:=1.5; adapt[4,7]:=2.0;
quant[4,0]:=0.2582; quant[4,1]:=0.5224;
    quant[4,2]:=0.7996;
quant[4,3]:=1.099; quant[4,4]:=1.437;
    quant[4,5]:=1.844; quant[4,6]:=2.401;
inv_quant[4,0]:=0.1284; inv_quant[4,1]:=0.3881;
    inv_quant[4,2]:=0.6568;
inv_quant[4,3]:=0.9424; inv_quant[4,4]:=1.256;
    inv_quant[4,5]:=1.618; inv_quant[4,6]:=2.069;
inv_quant[4,7]:=2.733;

FUNCTION quantamp(lev:real, pulse:integer):real;

VAR    i,qbits        : integer
sgn    : -1..1;
BEGIN
lev:=lev*adjust[pulse]
IF pulse<3 THEN BEGIN qbits:=4; qlevels:=7 END
    ELSE BEGIN qbits:=3; qlevels:=3 END;
IF lev>0 THEN sgn:=1 ELSE sgn:=-1;
i:=0;
WHILE (abs(lev)>quant[qbits,i]*gfact_leak) and
    (i<qlevels) DO i:=succ(i);
quantamp:=inv_quant[qbits,i]*gfact_leak*
    sgn/adjust[pulse];
gfact_leak:=EXP(0.98*LN(gfact_leak));

IF i=qlevels THEN
    BEGIN
    IF maxadapt THEN gfact_leak:=gfact_leak*
        adapt[qbits,qlevels]; maxadapt:=true
    END ELSE maxadapt:=false;
gfact_leak:=gfact_leak*adapt[qbits,i];
IF gfact_leak>512.0 THEN gfact_leak:=512.0 ELSE
    IF gfact_leak<0.5 THEN gfact_leak:=0.5
END { of quantamp. };
```

Note 1.— This operation is performed for each of the five excitation frames contained within a transmission frame.

Note 2.— The final, post-leakage pulse amplitudes developed within the function quantamp() *are each quantized to a* *fixed value based on internal quantization thresholds; and then converted to corresponding line codes. The quantization and line code generation aspects of the function are, in effect, a table lookup operation which can be visualized by referring to Tables A7-14 and A7-15.*

4.8.5 PULSE POSITION LINE CODE GENERATION

A line code corresponding to the contents of *posns[]* for each excitation frame shall be generated by the table look-up operation defined by Table A7-16.

Note.— Each pulse position shall be encoded with reference to the beginning of the excitation frame within which it falls. There are 32 possible positions per excitation frame. Positions within each excitation frame are numbered from 0 to 31, with 0 corresponding to the first sample position within each frame and 31 corresponding to the last sample position.

4.9 Local decoder

Note.— The local decoder logic is used to generate a locally derived version of the encoded speech for feedback to the excitation analysis logic defined in 4.8. The local decoder logic is also used in the definition of the decoding process in Section 5.

4.9.1 EXCITATION GENERATOR

For each *posns[]* and *qamp[]*, the vector *s1[]* shall be generated by the operation defined by:

```
FOR n:=b TO b+31 DO s1[n]:=0;
FOR pulse:=1 TO 3 DO s1[posns[pulse]+b]:=
    qamp[pulse];
```

Note 1.— The scalar b is the sample number in the current spch[] *frame corresponding to the start of the current excitation frame and* posns[] *is the vector of pulse positions belonging to the current excitation frame. For the first, second, third, fourth and fifth excitation frames of each speech frame, the value of b equals 0, 32, 64, 96, and 128 respectively.*

Note 2.— The vector s1[] *contains pulses of amplitude* qamp[] *located at positions* posns[], *and having the corresponding quantized amplitudes,* qamp[].

Note 3.— This operation is performed for each of the five excitation frames contained within a transmission frame.

4.9.2 LONG-TERM PREDICTOR

For each *qgain* and *delay*, and for each of the five *s1[]* associated with a transmission frame, the vector *s2[]* shall be generated by the operation defined by:

```
FOR n:=b TO b+31 DO s2[n]:=qgain*s2[n-delay]+s1[n];
```

Note 1.— Values of the index, n-delay, *are always less than b (the beginning of the current excitation frame) and the index thus points to values in the long term predictor filter memory. For the first* spch[] *frame processed, the contents of* s2[] *shall be set to zero.*

Note 2.— This operation is performed for each of the five excitation frames contained within a transmission frame.

4.9.3 SHORT-TERM PREDICTOR

For each *qtaps[]*, and for each of the five *s2[]* associated with a transmission frame, the vector *synthspch[]* shall be generated by the operation defined by:

```
FOR n:=b TO b+31 DO
BEGIN
sum:=0;
    FOR i:=1 TO 10 DO sum:=sum+qtaps[i]*
        synthspch[n-i];synthspch[n]:
        =s2[n]+sum
END;
```

Note 1.— The index, n-i, *points to values in the short-term predictor memory. For the first* spch[] *frame processed, the contents of* synthspch[] *shall be set to zero.*

Note 2.— This operation is performed for each of the five excitation frames contained within a transmission frame.

4.10 Transmission frame generation

A transmission frame comprising the structure defined in 4.10.1 shall be generated by the voice encoder process every 20 milliseconds.

4.10.1 TRANSMISSION FRAME STRUCTURE

The 192-bit transmission frame structure shall be as defined in Table A7-17.

4.10.2 TRANSMISSION ORDERING AND ALIGNMENT

Commencing with Partial Correlation Coefficient No. 1, the transmission frame shall be rendered as a sequence of 192 bits by aligning each succeeding line code in Table A7-17 in bit serial order. Alignment shall be such that the least significant bit of each line code is followed immediately by the most significant bit of the following line code. Each 192-bit transmission frame shall be aligned with and contained within a 192-bit C channel primary data field as defined in Section 4.

4.10.3 ERROR PROTECTION

The 26 bits designated by underscoring in Table A7-18 shall be protected by the error correction/detection logic defined in 4.10.3.1 and 4.10.3.2.

4.10.3.1 *SINGLE BIT ERROR CORRECTION AND DOUBLE BIT ERROR DETECTION*

The protected bits defined in 4.10.3 shall be used to generate a 5-bit Hamming code word by the operation defined by:

```
TYPE  hamrng = 1..26;
hamword = array [hamrng] of boolean;

FUNCTION hamming (word:hamword):integer;
VAR n,count,ham :integer;
i   :hamrng;
BEGIN
n:=4; count:=3; ham:=0;
FOR i:=1 TO 26 DO
    BEGIN
    IF word[i] THEN ham:=EXOR(ham,count);
    count:=succ(count);
    IF  count=n  THEN  BEGIN  n:=n*2;
        count:=succ(count)END
    END

hamming:=ham
END{of hamming.};
```

A sixth bit representing an odd-parity bit of the code word shall be generated and appended to the code word as the most significant bit. The resultant 6-bit value shall be inserted in the transmission frame and submitted to the burst error detection logic defined in 4.10.3.2.

4.10.3.2 *BURST ERROR DETECTION*

The 26 protected bits defined in Table A7-18 and the 6-bit value resulting from the Hamming code word defined in 4.10.3.1 shall be arranged in the order defined by the matrix in Table A7-19 at the locations denoted by 'p' and 'e' respectively.

Each bit 'b' shall be set to make even parity for its respective column. The 8 'b' bits shall then be exclusive-ORed with the binary mask '10101010' and the resulting 8 bits inserted in the transmission frame.

5. DECODING PROCESS DEFINITION

Each transmission frame shall be decoded as per 5.1. The line codes shall be used to generate quantized speech samples as per 5.2.

5.1 Transmission frame decoding

5.1.1 PARTIAL CORRELATION COEFFICIENT DECODING

5.1.1.1 *BURST ERROR DETECTION/ CORRECTION*

The 26 protected bits (Table A7-18), the 6-bit Hamming code word, and the 8 burst error detection bits shall be extracted from the transmission frame and arranged in a burst error detection calculation matrix as per Table A7-19. The burst error detection bits shall then be exclusive-ORed in place with the binary mask '10101010'. Each column of the resulting matrix shall then be examined for a potential lack of even parity. The matrix and the associated column parity error information shall then be submitted to the error detection and correction process defined in Figure A7-2. If that process indicates that the corrected error level of the received coefficient line codes is adequate, the coefficients shall be decoded from the line codes as per 5.1.1.2. However, if the corrected error level is inadequate, the line codes shall be discarded and the output of the decoder shall be muted by the logic defined in 5.1.3.2 and 5.1.3.2.1.

Note.— The purpose of the 8 burst error detection bits is to guard against a pathological case where an extremely long burst error series might render '0' bits in all 40 positions of the calculation matrix. In that case, the exclusive-OR operation on the 'b' bits of the matrix would cause odd parity to be made in four of the columns, thereby forcing the error detection and correction process to discard the transmission frame.

5.1.1.2 *COEFFICIENT DECODING*

If the corrected error level of the line codes corresponding to the 10 coefficients is shown to be adequate (5.1.1.1), the 10 coefficients shall be decoded as per Tables A7-2 through A7-11 and the resulting values inserted into the vector *qparcor[]*. Vector *qparcor[]* shall then be used to generate vector *qtaps[]* by the operation defined in 4.6.

5.1.2 LONG-TERM PREDICTOR PARAMETER DECODING

The long-term predictor parameters *qgain* and *delay* shall be decoded from the received line codes by the table look-up operation defined by Tables A7-12 and A7-13 respectively.

5.1.3 EXCITATION PARAMETER DECODING

5.1.3.1 *PULSE POSITION DECODING*

For each excitation frame, the vector *posns[]* shall be generated from the contents of the three pulse position values. The contents shall be decoded from the received line codes by the table look-up operation defined by Table A7-16.

5.1.3.2 *PULSE AMPLITUDE DECODING*

For each excitation frame, the vector *qamp[]* shall be generated from the contents of the three pulse amplitude values contained in the excitation frame. The contents shall be decoded from the received line codes by the table look-up operation defined by Tables A7-14 and A7-15.

5.1.3.2.1 If muting of the decoder output is indicated (5.1.1), the line codes corresponding to *qamp[1]* and *qamp[2]* shall be forced to '0100' prior to decoding. Similarly, the line code corresponding to *qamp[3]* shall be forced to '010' prior to decoding.

Note.— The contents of qamp[1], qamp[2] *and* qamp[3] *represent the amplitudes of the first through third pulses of the excitation frame respectively.*

5.1.3.3 Beginning with excitation frame no. 1 and continuing in sequence for each of the remaining excitation frames, the contents of the vector *qamp[]* corresponding to each of the five excitation frames shall be modified by the operation defined by:

Note.— This operation compensates for the amplitude normalization and gain adjustment processes performed during encoder pulse quantization (4.8.4.1).

```
{Initialization}

gfact_leak:=1; maxadapt:=false;
adjust[1]:=1; adjust[2]:=1.0/0.625; adjust[3]:=1.0/0.375;

{3 bit initialization}

adapt[3,0]:=0.875; adapt[3,1]:=0.875;
    adapt[3,2]:=1.0; adapt[3,3]:=1.5;
inv_quant[3,0]:=0.2451; inv_quant[3,1]:=0.7560;
    inv_quant[3,2]:=1.344; inv_quant[3,3]:=2.152;

{4 bit initialization}

adapt[4,0]:=0.75; adapt[4,1]:=0.875; adapt[4,2]:=0.875;
    adapt[4,3]:=0.875; adapt[4,4]:=1.0;
adapt[4,5]:=1.25; adapt[4,6]:=1.5; adapt[4,7]:=2.0;
inv_quant[4,0]:=0.1284; inv_quant[4,1]:=0.3881;
    inv_quant[4,2]:=0.6568;
inv_quant[4,3]:=0.9424; inv_quant[4,4]:=1.256;
    inv_quant[4,5]:=1.618; inv_quant[4,6]:=2.069;
inv_quant[4,7]:=2.733;

VAR   i,qbits: integer
sgn      : -1..1;

FOR pulse:= 1 TO 3 DO
BEGIN
IF pulse<3 THEN BEGIN qbits:=4; qlevels:=7 END
    ELSE BEGIN qbits:=3; qlevels:=3 END;
i:=0;
WHILE (abs(qamp[pulse])>inv_quant[qbits,i]) and
    (i<qlevels) DO i:=succ(i);
qamp[pulse]:=qamp[pulse]*gfact_leak/adjust[pulse];
gfact_leak:=EXP(0.98*LN(gfact_leak));

IF i=qlevels THEN
    BEGIN
    IF maxadapt THEN gfact_leak:=gfact_leak*
        adapt[qbits,qlevels]; maxadapt:=true
    END ELSE maxadapt:=false;
gfact_leak:=gfact_leak*adapt[qbits,i];
IF gfact_leak>512.0 THEN gfact_leak:=512.0 ELSE
    IF gfact_leak<0.5 THEN gfact_leak:=0.5
END;
```

5.1.3.3.1 If muting of the decoder output is indicated (5.1.1), the contents of *qamp[]* shall be set to zero **after** the completion of the above operation.

5.2 Generation of the decoded speech output

For each decoded transmission frame, time-ordered speech samples shall be generated by the following operations in sequence:

a) for each of the five vectors *posns[]* and *qamp[]* associated with the current transmission frame, a vector *s1[]* shall be generated by the operation defined in 4.9.1;

b) for each of the five vectors *s1[]* associated with the current transmission frame, and for the scalars *qgain* and *delay* associated with the current transmission frame, a vector *s2[]* shall be generated by the operation defined in 4.9.2; and then

c) for each of the five vectors *s2[]* associated with the current transmission frame, and for the vector *qtaps[]* associated with the current transmission frame, a vector *synthspch[]* shall be generated by the operation defined in 4.9.3.

Note.— The rate at which the vector synthspch[] *is generated by the decoder (5 vectors/frame at 50 frames/second) and the rate of speech samples from each* synthspch[] *(32 samples/vector) will yield an over-all speech sample rate of 8.0 kHz.*

5.3 Speech output transcoding

Each speech sample derived from the vector *synthspch[]* will exhibit the internal floating point numeric range as defined in Section 2. The numeric range of the speech sample stream should be appropriately scaled prior to any subsequent digital transcoding or analog speech reconstruction.

Table A7-1. ***pardl[]*** **(decision levels for the partial correlation coefficient quantizer)**

pardl[1,-1], pardl[1,0], pardl[1,1], pardl[1,2]	-0.7512804,	-0.7269750,	-0.7017226,	-0.6755562
pardl[1,3], pardl[1,4], pardl[1,5], pardl[1,6]	-0.6485097,	-0.6206185,	-0.5919189,	-0.5624482
. . . .	-0.5322449,	-0.5013483,	-0.4697985,	-0.4376369
. . . .	-0.4049051,	-0.3716459,	-0.3379026,	-0.3037192
. . . .	-0.2691401,	-0.2342104,	-0.1989756,	-0.1634817
. . . .	-0.1277748,	-0.0919014,	-0.0559084,	-0.0198425
. . . .	0.0162492,	0.0523198,	0.0883222,	0.1241096
. . . .	0.1599351,	0.1954524,	0.2307150,	0.2656771
. . . .	0.3002931,	0.3345180,	0.3683071,	0.4016164
. . . .	0.4344026,	0.4666229,	0.4982354,	0.5291989
. . . .	0.5594731,	0.5890184,	0.6177965,	0.6457698
. . . .	0.6729020,	0.6991577,	0.7245026,	0.7489037
. . . .	0.7723293,	0.7947488,	0.8161331,	0.8364543
. . . .	0.8556859,	0.8738029,	0.8907816,	0.9066001
. . . .	0.9212375,	0.9346749,	0.9468949,	0.9578813
pardl[1,59], pardl[1,60], pardl[1,61], pardl[1,62]	0.9676200,	0.9760983,	0.9833051,	0.9892311
pardl[1,63], pardl[2,-1], pardl[2,0], pardl[2,1]	0.9938684,	-0.9687151,	-0.9600082,	-0.9502578
pardl[2,2], pardl[2,3], pardl[2,4], pardl[2,5]	-0.9394747,	-0.9276705,	-0.9148581,	-0.9010514
. . . .	-0.8862653,	-0.8705161,	-0.8538207,	-0.8361974
. . . .	-0.8176653,	-0.7982445,	-0.7779561,	-0.7568223
. . . .	-0.7348658,	-0.7121107,	-0.6885817,	-0.6643043
. . . .	-0.6393048,	-0.6136106,	-0.5872494,	-0.5602500
. . . .	-0.5326418,	-0.5044546,	-0.4757191,	-0.4464666
. . . .	-0.4167289,	-0.3865382,	-0.3559275,	-0.3249299
. . . .	-0.2935792,	-0.2619094,	-0.2299549,	-0.1977505
. . . .	-0.1653312,	-0.1327322,	-0.0999890,	-0.0671371
. . . .	-0.0342122,	-0.0012501,	0.0317133,	0.0646423
. . . .	0.0975010,	0.1302537,	0.1628649,	0.1952991
. . . .	0.2275210,	0.2594956,	0.2911882,	0.3225643
. . . .	0.3535898,	0.3842311,	0.4144548,	0.4442280
. . . .	0.4735184,	0.5022941,	0.5305240,	0.5581772
. . . .	0.5852238,	0.6116344,	0.6373802,	0.6624333
pardl[2,62], pardl[2,63], pardl[3,-1], pardl[3,0]	0.6867664,	0.7103531,	-0.6209860,	-0.5817980
pardl[3,1], pardl[3,2], (pardl[3,3], pardl[3,4]	-0.5412097,	-0.4993190,	-0.4562265,	-0.4120361
. . . .	-0.3668540,	-0.3207891,	-0.2739522,	-0.2264559
. . . .	-0.1784146,	-0.1299440,	-0.0811606,	-0.0321819
. . . .	0.0168742,	0.0658897,	0.1147467,	0.1633275
. . . .	0.2115152,	0.2591939,	0.3062488,	0.3525667
. . . .	0.3980361,	0.4425475,	0.4859939,	0.5282706
. . . .	0.5692760,	0.6089114,	0.6470813,	0.6836939
pardl[3,29], pardl[3,30], pardl[3,31], pardl[4,-1]	0.7186612,	0.7518988,	0.7833269,	-0.8819578
pardl[4,0], pardl[4,1], pardl[4,2], pardl[4,3]	-0.8576206,	-0.8311930,	-0.8027395,	-0.7723294
. . . .	-0.7400368,	-0.7059404,	-0.6701235,	-0.6326731
. . . .	-0.5936806,	-0.5532411,	-0.5114532,	-0.4684186
. . . .	-0.4242423,	-0.3790320,	-0.3328978,	-0.2859522
. . . .	-0.2383097,	-0.1900863,	-0.1413995,	-0.0923682
. . . .	-0.0431116,	0.0062499,	0.0555963,	0.1048072
. . . .	0.1537625,	0.2023432,	0.2504306,	0.2979076
pardl[4,28], pardl[4,29], pardl[4,30], pardl[4,31]	0.3446585,	0.3905694,	0.4355282,	0.4794255
pardl[5,-1], pardl[5,0], pardl[5,1], pardl[5,2]	-0.5728675,	-0.5044545,	-0.4327131,	-0.3581167
. . . .	-0.2811575,	-0.2023432,	-0.1221939,	-0.0412383
. . . .	0.0399893,	0.1209531,	0.2011188,	0.2799576
. . . .	0.3569492,	0.4315858,	0.5033747,	0.5718424
pardl[5,15], pardl[6,-1], pardl[6,0], pardl[6,1]	0.6365371,	-0.7032794,	-0.6508853,	-0.5951883
. . . .	-0.5364712,	-0.4750316,	-0.4111817,	-0.3452452
. . . .	-0.2775567,	-0.2084599,	-0.1383052,	-0.0674487
. . . .	0.0037500,	0.0749297,	0.1457292,	0.2157892
pardl[6,14], pardl[6,15], pardl[7,-1], pardl[7,0]	0.2847542,	0.3522742,	-0.4617792,	-0.3299494
pardl[7,1], pardl[7,2], pardl[7,3], pardl[7,4]	-0.1913133,	-0.0487307,	0.0948572,	0.2364883
pardl[7,5], pardl[7,6], pardl[7,7], pardl[8,-1]	0.3732410,	0.5022942,	0.6209860,	-0.6287930
pardl[8,0], pardl[8,1], pardl[8,2], pardl[8,3]	-0.5098411,	-0.3801884,	-0.2425563,	-0.0998334
pardl[8,4], pardl[8,5], pardl[8,6], pardl[8,7]	0.0449848,	0.1888589,	0.3287691,	0.4617791
pardl[9,-1], pardl[9,0], pardl[9,1], pardl[9,2]	-0.4259395,	-0.1271548,	0.1839465,	0.4772301
pardl[9,3], pardl[10,-1], pardl[10,0], pardl[10,1]	0.7242872,	-0.4968801,	-0.2763557,	-0.0399893
pardl[10,2], pardl[10,3]	0.1986693,	0.4259395		

Table A7-2. Line codes for partial correlation coefficient No. 1

QUANTIZER LEVEL	LINE CODE	QUANTIZER LEVEL	LINE CODE
−0.7391278	000000	0.3174056	100000
−0.7143489	000001	0.3514125	100001
−0.6886395	000010	0.3849618	100010
−0.6620330	000011	0.4180095	100011
−0.6345642	000100	0.4505128	100100
−0.6062688	000101	0.4824292	100101
−0.5771836	000110	0.5137172	100110
−0.5473465	000111	0.5443360	100111
−0.5167966	001000	0.5742458	101000
−0.4855734	001001	0.6034074	101001
−0.4537177	001010	0.6317832	101010
−0.4212710	001011	0.6593359	101011
−0.3882755	001100	0.6860299	101100
−0.3547743	001101	0.7118301	101101
−0.3208109	001110	0.7367031	101110
−0.2864296	001111	0.7606165	101111
−0.2516752	010000	0.7835391	110000
−0.2165930	010001	0.8054410	110001
−0.1812287	010010	0.8262937	110010
−0.1456282	010011	0.8460701	110011
−0.1098381	010100	0.8647444	110100
−0.0739049	010101	0.8822923	110101
−0.0378754	010110	0.8986909	110110
−0.0017966	010111	0.9139188	110111
0.0342845	011000	0.9279562	111000
0.0703210	011001	0.9407849	111001
0.1062659	011010	0.9523881	111010
0.1420724	011011	0.9627507	111011
0.1776938	011100	0.9718592	111100
0.2130837	011101	0.9797017	111101
0.2481961	011110	0.9862680	111110
0.2829851	011111	0.9915497	111111

Table A7-3. Line codes for partial correlation coefficient No. 2

QUANTIZER LEVEL	LINE CODE
−0.9643617	000000
−0.9551330	000001
−0.9448663	000010
−0.9335726	000011
−0.9212644	000100
−0.9079548	000101
−0.8936584	000110
−0.8783907	000111
−0.8621684	001000
−0.8450091	001001
−0.8269314	001010
−0.8079550	001011
−0.7881004	001100
−0.7673892	001101
−0.7458441	001110
−0.7234883	001111
−0.7003462	010000
−0.6764430	010001
−0.6518046	010010
−0.6264577	010011
−0.6004300	010100
−0.5737497	010101
−0.5464459	010110
−0.5185482	010111
−0.4900868	011000
−0.4610929	011001
−0.4315977	011010
−0.4016336	011011
−0.3712329	011100
−0.3404287	011101
−0.3092546	011110
−0.2777443	011111

QUANTIZER LEVEL	LINE CODE
−0.2459321	100000
−0.2138527	100001
−0.1815409	100010
−0.1490317	100011
−0.1163606	100100
−0.0835630	100101
−0.0506746	100110
−0.0177312	100111
0.0152316	101000
0.0481778	101001
0.0810716	101010
0.1138773	101011
0.1465593	101100
0.1790820	101101
0.2114100	101110
0.2435083	101111
0.2753419	110000
0.3068762	110001
0.3380771	110010
0.3689105	110011
0.3993429	110100
0.4293413	110101
0.4588732	110110
0.4879062	110111
0.5164090	111000
0.5443506	111001
0.5717005	111010
0.5984291	111011
0.6245073	111100
0.6499068	111101
0.6745999	111110
0.6985598	111111

Table A7-4. Line codes for partial correlation coefficient No. 3

QUANTIZER LEVEL	LINE CODE	QUANTIZER LEVEL	LINE CODE
−0.6013920	00000	0.1390371	10000
−0.5615038	00001	0.1874214	10001
−0.5202643	00010	0.2353546	10010
−0.4777727	00011	0.2827214	10011
−0.4341313	00100	0.3294078	10100
−0.3894451	00101	0.3753014	10101
−0.3438216	00110	0.4202918	10110
−0.2973706	00111	0.4642707	10111
−0.2502041	01000	0.5071322	11000
−0.2024353	01001	0.5487733	11001
−0.1541793	01010	0.5890937	11010
−0.1055523	01011	0.6279963	11011
−0.0566713	01100	0.6653876	11100
−0.0076539	01101	0.7011775	11101
0.0413820	01110	0.7352800	11110
0.0903182	01111	0.7676129	11111

Table A7-5. Line codes for partial correlation coefficient No. 4

QUANTIZER LEVEL	LINE CODE	QUANTIZER LEVEL	LINE CODE
−0.8697892	00000	−0.2621310	10000
−0.8444068	00001	−0.2141980	10001
−0.8169663	00010	−0.1657429	10010
−0.7875345	00011	−0.1168839	10011
−0.7561831	00100	−0.0677399	10100
−0.7229886	00101	−0.0184309	10101
−0.6880320	00110	0.0309231	10110
−0.6513983	00111	0.0802017	10111
−0.6131769	01000	0.1292848	11000
−0.5734609	01001	0.1780529	11001
−0.5323472	01010	0.2263869	11010
−0.4899359	01011	0.2741691	11011
−0.4463305	01100	0.3212830	11100
−0.4016372	01101	0.3676139	11101
−0.3559649	01110	0.4130488	11110
−0.3094251	01111	0.4574769	11111

Table A7-6. Line codes for partial correlation coefficient No. 5

QUANTIZER LEVEL	LINE CODE	QUANTIZER LEVEL	LINE CODE
–0.5386610	0000	0.0804712	1000
–0.4685838	0001	0.1610360	1001
–0.3954149	0010	0.2405382	1010
–0.3196371	0011	0.3184534	1011
–0.2417503	0100	0.3942675	1100
–0.1622685	0101	0.4674802	1101
–0.0817161	0110	0.5376085	1110
–0.0006245	0111	0.6041898	1111

Table A7–7. Line codes for partial correlation coefficient No. 6

QUANTIZER LEVEL	LINE CODE	QUANTIZER LEVEL	LINE CODE
–0.6770824	0000	–0.1733826	1000
–0.6230369	0001	–0.1028770	1001
–0.5658298	0010	–0.0318494	1010
–0.5057514	0011	0.0393399	1011
–0.4431067	0100	0.1103295	1100
–0.3782134	0101	0.1807592	1101
–0.3114009	0110	0.2502717	1110
–0.2430083	0111	0.3185142	1111

Table A7–8. Line codes for partial correlation coefficient No. 7

QUANTIZER LEVEL	LINE CODE	QUANTIZER LEVEL	LINE CODE
–0.3958643	000	0.1656727	100
–0.2606314	001	0.3048646	101
–0.1200220	010	0.4377676	110
0.0230632	011	0.5616401	111

Table A7–9. Line codes for partial correlation coefficient No. 8

QUANTIZER LEVEL	LINE CODE
−0.5693170	000
−0.4450148	001
−0.3113724	010
−0.1711949	011

QUANTIZER LEVEL	LINE CODE
−0.0274243	100
0.1169218	101
0.2588140	110
0.3952741	111

Table A7–10. Line codes for partial correlation coefficient No. 9

QUANTIZER LEVEL	LINE CODE
−0.2765472	00
0.0283959	01

QUANTIZER LEVEL	LINE CODE
0.3305883	10
0.6007586	11

Table A7–11. Line codes for partial correlation coefficient No. 10

QUANTIZER LEVEL	LINE CODE
−0.3866179	00
−0.1581725	01

QUANTIZER LEVEL	LINE CODE
0.0793400	10
0.3123044	11

Table A7-12. Line encoding for quantized long-term predictor *qgain*

qgain	LINE CODE
0.100	00
0.325	01
0.600	10
0.900	11

Table A7-13. Line encoding for the long term predictor *delay*

delay	LINE CODE
32	000000
33	000001
34	000010
35	000011
...	...
63	011111
64	100000
65	100001
66	100010
...	...
92	111100
93	111101
94	111110
95	111111

Table A7-14. Line codes for the first and second pulse amplitudes of each excitation frame

DECISION THRESHOLD	CONTENTS OF *QAMP[1]* AND *[2]*	LINE CODE
−2.4010	−2.7330	1111
−1.8440	−2.0690	1110
−1.4370	−1.6180	1101
−1.0990	−1.2560	1100
−0.7996	−0.9424	1011
−0.5224	−0.6568	1010
−0.2582	−0.3881	1001
−0.0000	−0.1284	1000
0.0000	0.1284	0000
0.2582	0.3881	0001
0.5224	0.6568	0010
0.7996	0.9424	0011
1.0990	1.2560	0100
1.4370	1.6180	0101
1.8440	2.0690	0110
2.4010	2.7330	0111

Table A7-15. Line codes for the third pulse amplitude of each excitation frame

DECISION THRESHOLD	CONTENTS OF *QAMP[3]*	LINE CODE
−1.7480	−2.1520	111
−1.0500	−1.3440	110
−0.5006	−0.7560	101
−0.0000	−0.2451	100
0.0000	0.2451	000
0.5006	0.7560	001
1.0500	1.3440	010
1.7480	2.1520	011

Table A7-16. Line codes for the three pulse positions within each excitation frame

PULSE POSITION	LINE CODE
0	00000
1	00001
2	00010
3	00011
4	00100
...	...
15	01111
16	10000
...	...
29	11101
30	11110
31	11111

Table A7-17. Transmission frame structure

FRAME COMPONENT (line code)	REFERENCE	LENGTH (bits)
Partial correlation coefficient No. 1	Table A7-2	6
Partial correlation coefficient No. 2	Table A7-3	6
Partial correlation coefficient No. 3	Table A7-4	5
Partial correlation coefficient No. 4	Table A7-5	5
Partial correlation coefficient No. 5	Table A7-6	4
Partial correlation coefficient No. 6	Table A7-7	4
Partial correlation coefficient No. 7	Table A7-8	3
Partial correlation coefficient No. 8	Table A7-9	3
Partial correlation coefficient No. 9	Table A7-10	2
Partial correlation coefficient No. 10	Table A7-11	2
Hamming code word (5 bits plus odd parity)	4.10.3.1	6
Burst error detection	4.10.3.2	8
Long term correlation gain	Table A7-12	2
Long term correlation delay	Table A7-13	6
Excitation frame No. 1 (pulse no. 1 position)	Table A7-16	5
Excitation frame No. 1 (pulse no. 1 amplitude)	Table A7-14	4
Excitation frame No. 1 (pulse no. 2 position)	Table A7-16	5
Excitation frame No. 1 (pulse no. 2 amplitude)	Table A7-14	4
Excitation frame No. 1 (pulse no. 3 position)	Table A7-16	5
Excitation frame No. 1 (pulse no. 3 amplitude)	Table A7-15	3
Excitation Frame No. 2 (identical to No. 1)	-	26
Excitation frame No. 3 (identical to No. 1)	-	26
Excitation frame No. 4 (identical to No. 1)	-	26
Excitation frame No. 5 (identical to No. 1)	-	26

Table A7-18. Protected partial correlation coefficient line code bits

	Parcor coefficient									
	1	2	3	4	5	6	7	8	9	10
Protected bits ( )	5 4 3 2 1 0	5 4 3 2 1 0	4 3 2 1 0	4 3 2 1 0	3 2 1 0	3 2 1 0	2 1 0	2 1 0	1 0	1 0

Table A7-19. Burst error detection calculation matrix

pppppppp
pppppppp
pppppppp
ppeeeeee
bbbbbbbb

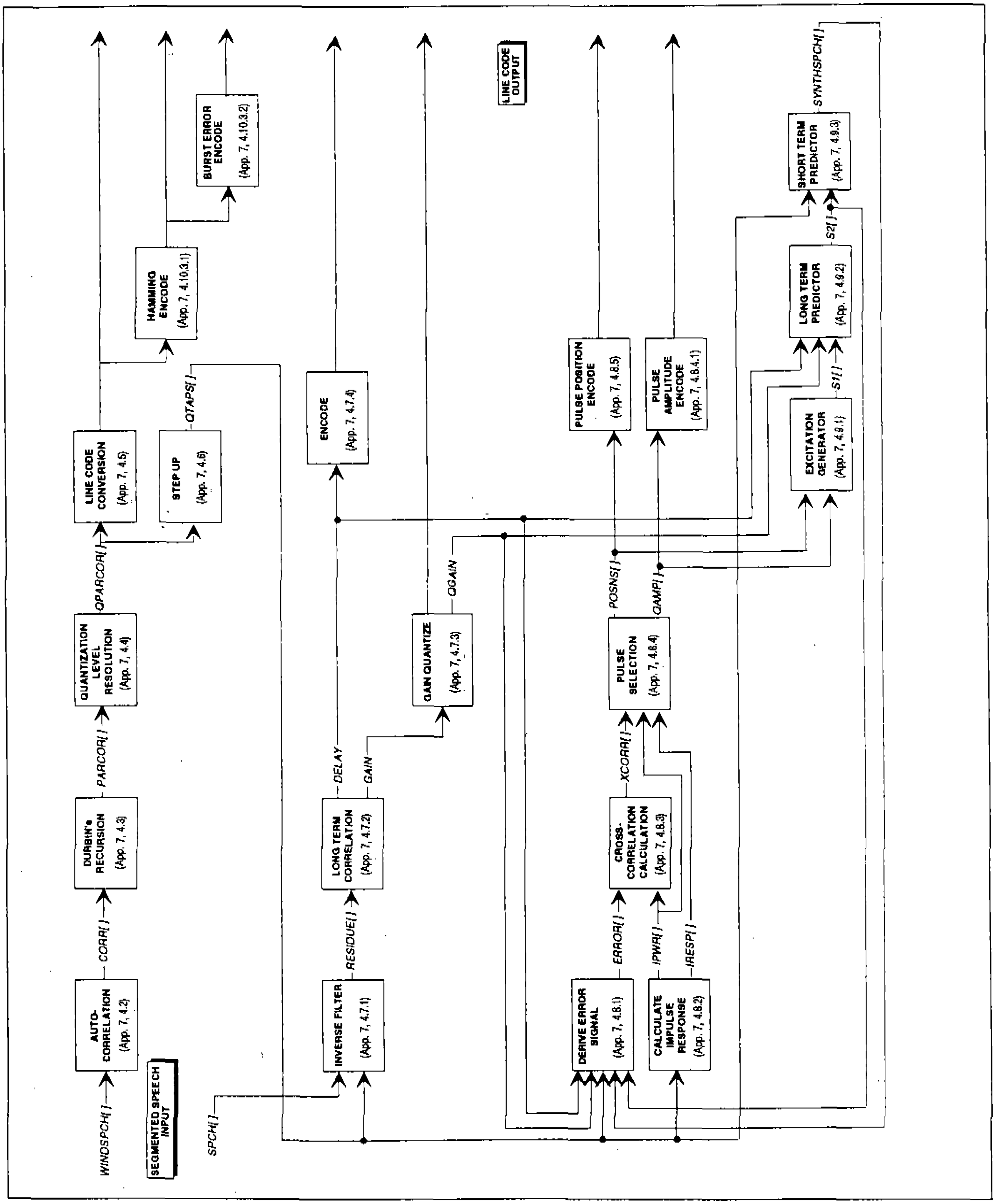

Figure A7-1. AMSS voice encoding algorithm

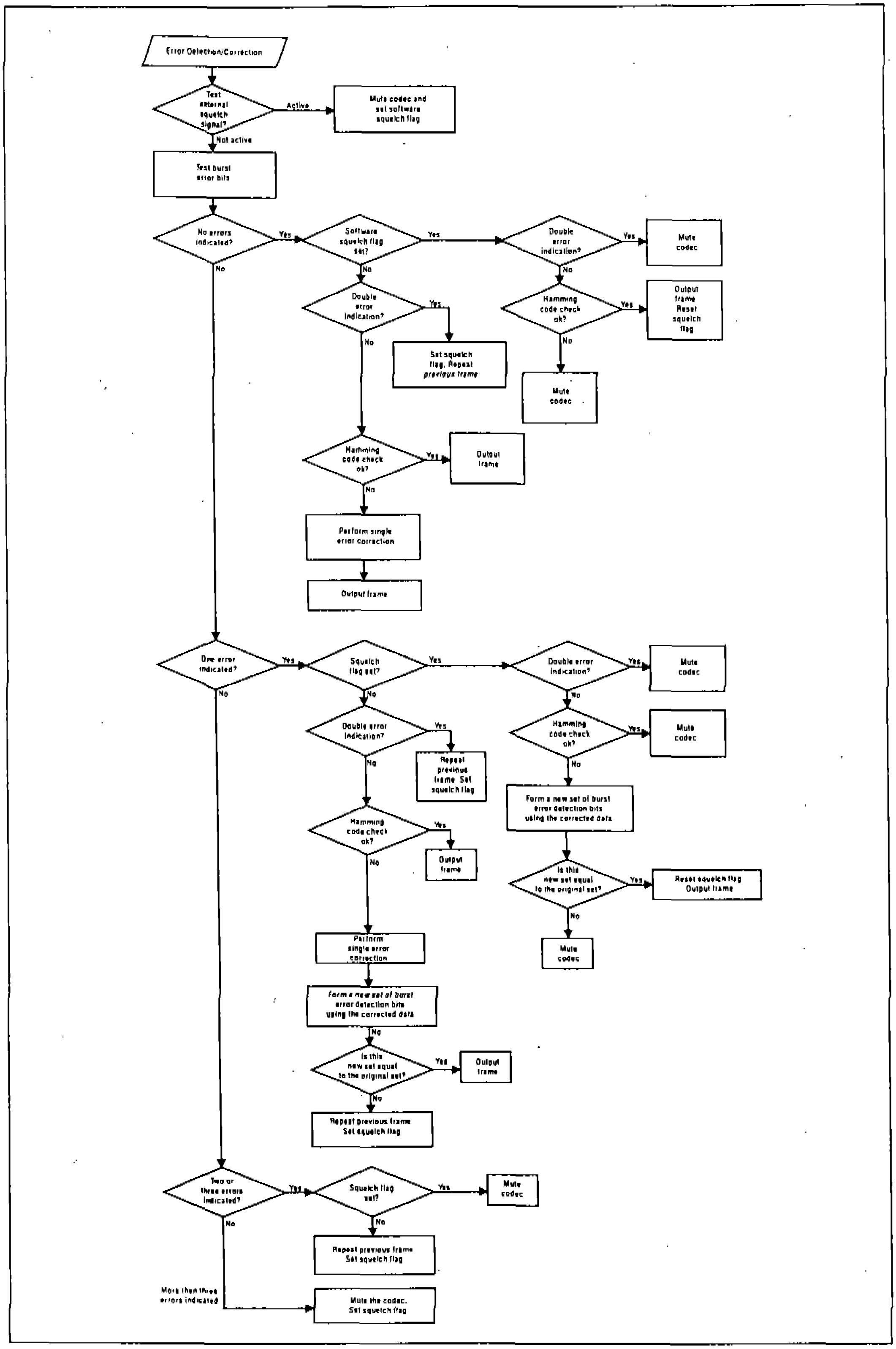

Figure A7-2. Error detection/correction process

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CHAPTER 5. SSR MODE S AIR-GROUND DATA LINK

Note.— The SSR Mode S air-ground data link is also referred to as the Mode S subnetwork in the context of the aeronautical telecommunication network (ATN).

5.1 DEFINITIONS RELATING TO THE MODE S SUBNETWORK

Air-initiated protocol. A procedure initiated by a Mode S aircraft installation for delivering a standard length or extended length downlink message to the ground.

Aircraft. The term aircraft may be used to refer to Mode S emitters (e.g. aircraft/vehicles), where appropriate.

Aircraft data circuit-terminating equipment (ADCE). An aircraft specific data circuit-terminating equipment that is associated with an airborne data link processor (ADLP). It operates a protocol unique to Mode S data link for data transfer between air and ground.

Aircraft data link processor (ADLP). An aircraft-resident processor that is specific to a particular air-ground data link (e.g. Mode S) and which provides channel management, and segments and/or reassembles messages for transfer. It is connected to one side of aircraft elements common to all data link systems and on the other side to the air-ground link itself.

Aircraft address. A unique combination of 24 bits available for assignment to an aircraft for the purpose of air-ground communications, navigation and surveillance.

Aircraft/vehicle. May be used to describe either a machine or device capable of atmospheric flight, or a vehicle on the airport surface movement area (i.e. runways and taxiways).

BDS Comm-B Data Selector. The 8-bit BDS code determines the register whose contents are to be transferred in the MB field of a Comm-B reply. It is expressed in two groups of 4 bits each, BDS1 (most significant 4 bits) and BDS2 (least significant 4 bits).

Broadcast. The protocol within the Mode S system that permits uplink messages to be sent to all aircraft in coverage area, and downlink messages to be made available to all interrogators that have the aircraft wishing to send the message under surveillance.

Capability report. Information identifying whether the transponder has a data link capability as reported in the capability (CA) field of an all-call reply or squitter transmission (see "data link capability report").

Close-out. A command from a Mode S interrogator that terminates a Mode S link layer communication transaction.

Cluster of interrogators. Two or more interrogators with the same interrogator identifier (II) code, operating cooperatively to ensure that there is no interference to the required surveillance and data link performance of each of the interrogators, in areas of common coverage.

Comm-A. A 112-bit interrogation containing the 56-bit MA message field. This field is used by the uplink standard length message (SLM) and broadcast protocols.

Comm-B. A 112-bit reply containing the 56-bit MB message field. This field is used by the downlink SLM, ground-initiated and broadcast protocols.

Comm-C. A 112-bit interrogation containing the 80-bit MC message field. This field is used by the uplink extended length message (ELM) protocol.

Comm-D. A 112-bit reply containing the 80-bit MD message field. This field is used by the downlink ELM protocol.

Connection. A logical association between peer-level entities in a communication system.

Data link capability report. Information in a Comm-B reply identifying the complete Mode S communications capabilities of the aircraft installation.

Downlink. A term referring to the transmission of data from an aircraft to the ground. Mode S air-to-ground signals are transmitted on the 1 090 MHz reply frequency channel.

Extended length message (ELM). A series of Comm-C interrogations (uplink ELM) transmitted without the requirement for intervening replies, or a series of Comm-D replies (downlink ELM) transmitted without intervening interrogations.

Uplink ELM (UELM). A term referring to extended length uplink communication by means of 112-bit Mode S Comm-C interrogations, each containing the 80-bit Comm-C message field (MC).

Downlink ELM (DELM). A term referring to extended length downlink communication by means of 112-bit Mode S Comm-D replies, each containing the 80-bit Comm-D message field (MD).

Frame. The basic unit of transfer at the link level. In the context of Mode S subnetwork, a frame can include from one to four Comm-A or Comm-B segments, from two to sixteen Comm-C segments, or from one to sixteen Comm-D segments.

General formatter/manager (GFM). The aircraft function responsible for formatting messages to be inserted in the transponder registers. It is also responsible for detecting and handling error conditions such as the loss of input data.

Ground data circuit-terminating equipment (GDCE). A ground specific data circuit-terminating equipment associated with a ground data link processor (GDLP). It operates a protocol unique to Mode S data link for data transfer between air and ground.

Ground data link processor (GDLP). A ground-resident processor that is specific to a particular air-ground data link (e.g. Mode S), and which provides channel management, and segments and/or reassembles messages for transfer. It is connected on one side (by means of its DCE) to ground elements common to all data link systems, and on the other side to the air-ground link itself.

Ground-initiated Comm-B (GICB). The ground-initiated Comm-B protocol allows the interrogator to extract Comm-B replies containing data from a defined source in the MB field.

Ground-initiated protocol. A procedure initiated by a Mode S interrogator for delivering standard length or extended length messages to a Mode S aircraft installation.

Mode S air-initiated Comm-B (AICB) protocol. A procedure initiated by a Mode S transponder for transmitting a single Comm-B segment from the aircraft installation.

Mode S broadcast protocols. Procedures allowing standard length uplink or downlink messages to be received by more than one transponder or ground interrogator respectively.

Mode S ground-initiated Comm-B (GICB) protocol. A procedure initiated by a Mode S interrogator for eliciting a single Comm-B segment from a Mode S aircraft installation, incorporating the contents of one of 255 Comm-B registers within the Mode S transponder.

Mode S multisite-directed protocol. A procedure to ensure that extraction and close-out of a downlink standard length or extended length message is affected only by the particular Mode S interrogator selected by the aircraft.

Mode S packet. A packet conforming to the Mode S subnetwork standard, designed to minimize the bandwidth required from the air-ground link. ISO 8208 packets may be transformed into Mode S packets and vice-versa.

Mode S specific protocol (MSP). A protocol that provides restricted datagram service within the Mode S subnetwork.

Mode S specific services. A set of communication services provided by the Mode S system which are not available from other air-ground subnetworks, and therefore not interoperable.

Mode S specific services entity (SSE). An entity resident within an XDLP to provide access to the Mode S specific services.

Packet. The basic unit of data transfer among communication devices within the network layer, (e.g. an ISO 8208 packet or a Mode S packet).

Required navigation performance (RNP). A statement of the navigation performance accuracy necessary for operation within a defined airspace.

Segment. A portion of a message that can be accommodated within a single MA/MB field in the case of a standard length message, or MC/MD field in the case of an extended length message. This term is also applied to the Mode S transmissions containing these fields.

Standard length message (SLM). An exchange of digital data using selectively addressed Comm-A interrogations and/or Comm-B replies (see "Comm-A" and "Comm-B").

Subnetwork. An actual implementation of a data network that employs a homogeneous protocol and addressing plan, and is under the control of a single authority.

Subnetwork management entity (SNME). An entity resident within a GDLP that performs subnetwork management and communicates with peer entities in intermediate or end-systems.

Timeout. The cancellation of a transaction after one of the participating entities has failed to provide a required response within a pre-defined period of time.

Uplink. A term referring to the transmission of data from the ground to an aircraft. Mode S ground-to-air signals are transmitted on the 1 030 MHz interrogation frequency channel.

XDCE. A general term referring to both the ADCE and the GDCE.

XDLP. A general term referring to both the ADLP and the GDLP.

5.2 MODE S SUBNETWORK CHARACTERISTICS

5.2.1 General provisions

Note 1.— Reference ISO document. When the term "ISO 8208" is referred to in this standard, it means the ISO Standard "Information technology — Data communications — X.25 Packet Layer Protocol for Data Terminal Equipment, Reference Number ISO/IEC 8208: 1990(E)".

Note 2.— The overall architecture of the Mode S subnetwork is presented in the diagram on the following page.

Note 3.— The processing splits into three different paths. The first consists of the processing of switched virtual circuits (SVCs), the second consists of the processing of Mode S specific services, and the third consists of the processing of subnetwork management information. SVCs utilize the reformatting process and the ADCE or GDCE function. Mode S specific services utilize the Mode S specific services entity (SSE) function.

5.2.1.1 *Message categories.* The Mode S subnetwork shall only carry aeronautical communications classified under categories of flight safety and flight regularity as specified in Annex 10, Volume II, Chapter 5, 5.1.8.4 and 5.1.8.6.

5.2.1.2 *Signals in space.* The signal-in-space characteristics of the Mode S subnetwork shall conform to the provisions contained in Annex 10, Volume IV, Chapter 3, 3.1.2.

5.2.1.3 *Code and byte independency.* The Mode S subnetwork shall be capable of code and byte independent transmission of digital data.

5.2.1.4 *Data transfer.* Data shall be conveyed over the Mode S data link in segments using either standard length message (SLM) protocols or extended length message (ELM) protocols as defined in 3.1.2.6.11 and 3.1.2.7 of Annex 10, Volume IV.

Note 1.— An SLM segment is the contents of one 56-bit MA or MB field. An ELM segment is the contents of one 80-bit MC or MD field.

Note 2.— An SLM frame is the contents of up to four linked MA or MB fields. An ELM frame is the contents of 2 to 16 MC or 1 to 16 MD fields.

5.2.1.5 *Bit numbering.* In the description of the data exchange fields, the bits shall be numbered in the order of their transmission, beginning with bit 1. Bit numbers shall continue through the second and higher segments of multi-segment frames. Unless otherwise stated, numerical values encoded by groups (fields) of bits shall be encoded using positive binary notation and the first bit transmitted shall be the most significant bit (MSB) (3.1.2.3.1.3 of Annex 10, Volume IV).

5.2.1.6 *Unassigned bits.* When the length of the data is not sufficient to occupy all bit positions within a message field or subfield, the unassigned bit positions shall be set to 0.

5.2.2 Frames

5.2.2.1 UPLINK FRAMES

5.2.2.1.1 *SLM frame.* An uplink SLM frame shall be composed of up to four selectively addressed Comm-A segments.

Note.— Each Comm-A segment (MA field) received by the ADLP is accompanied by the first 32 bits of the interrogation that delivered the segment (3.1.2.10.5.2.1.1 of Annex 10, Volume IV). Within these 32 bits is the 16-bit special designator (SD) field (3.1.2.6.1.4 of Annex 10, Volume IV).

5.2.2.1.1.1 *SD field.* When the designator identification (DI) field (bits 14-16) has a code value of 1 or 7, the special designator (SD) field (bits 17-32) of each Comm-A interrogation shall be used to obtain the interrogator identifier subfield (IIS, bits 17-20) and the linked Comm-A subfield (*LAS*, bits 30-32). The action to be taken shall depend on the value of *LAS*. The contents of *LAS* and IIS shall be retained and shall be associated with the Comm-A message segment for use in assembling the frame as indicated below. All fields other than the *LAS* field shall be as defined in 3.1.2 of Annex 10, Volume IV.

Note.— The SD field structure is shown in Figure 5-1.*

5.2.2.1.1.2 *LAS coding.* The 3-bit *LAS* subfield shall be coded as follows:

LAS	*MEANING*
0	single segment
1	linked, 1st segment
2	linked, 2nd but not final segment
3	linked, 3rd but not final segment
4	linked, 4th and final segment
5	linked, 2nd and final segment
6	linked, 3rd and final segment
7	unassigned

5.2.2.1.1.3 *Single segment SLM frame.* If *LAS* = 0, the data in the MA field shall be considered a complete frame and shall be made available for further processing.

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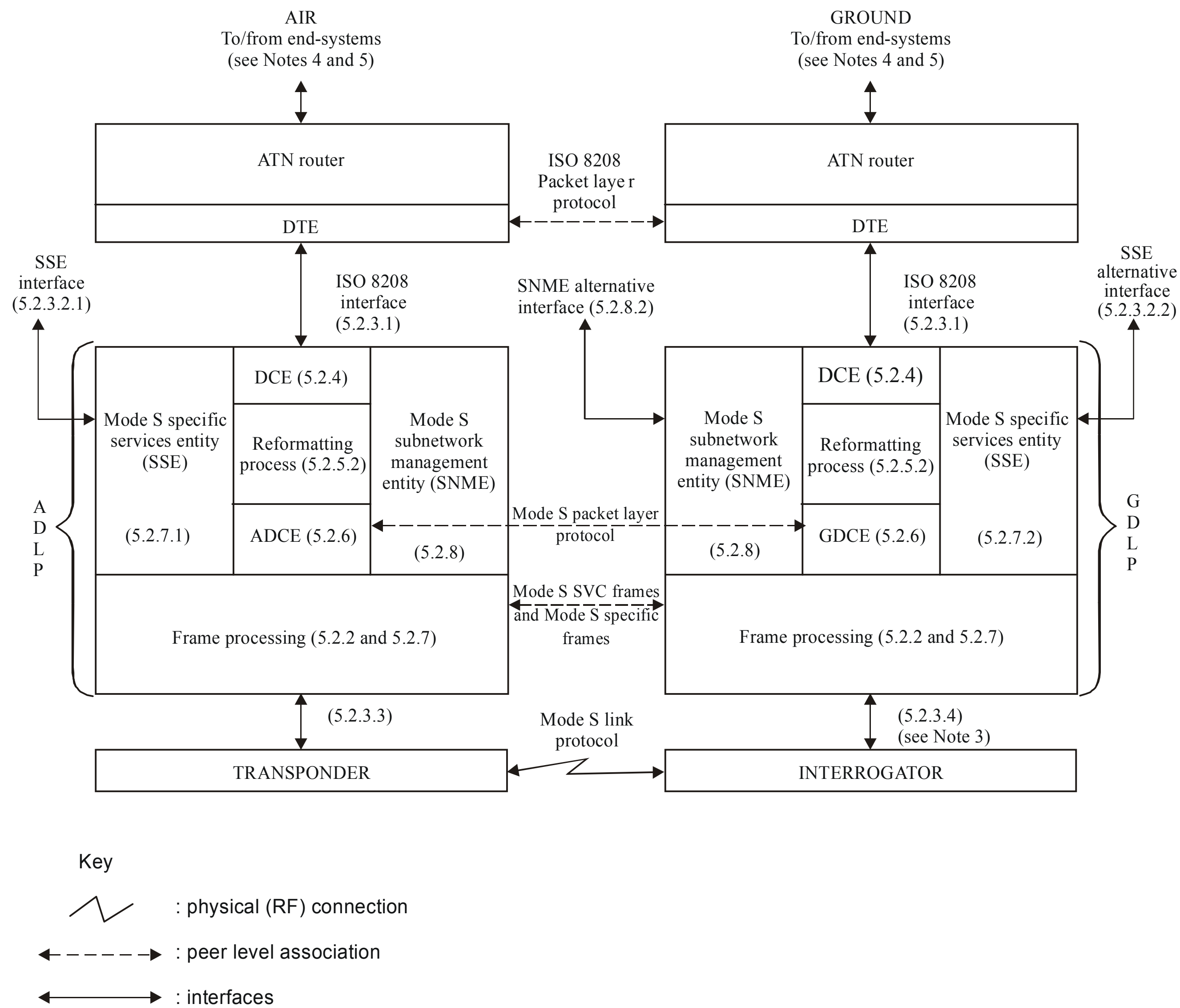
* All tables and figures are located at the end of this chapter.

Functional elements of the Mode S subnetwork



Notes:

1. Relevant Mode S subnetwork SARPs paragraph numbers are given in parenthesis.
2. The ADLP/transponder interface is also specified in Annex 10, Volume IV, 3.1.
3. A GDLP may be interfaced to more than one Mode S interrogator.
4. DTEs may be directly associated with end-systems.
5. ATN router access to end-systems may be made via other intermediate systems.

5.2.2.1.1.4 *Multiple segment SLM frame.* The ADLP shall accept and assemble linked 56-bit Comm-A segments associated with all sixteen possible interrogator identifier (II) codes. Correct linking of Comm-A segments shall be achieved by requiring that all Comm-A segments have the same value of IIS. If *LAS* = 1 through 6, the frame shall consist of two to four Comm-A segments as specified in the following paragraphs.

5.2.2.1.1.4.1 *Initial segment.* If *LAS* = 1, the MA field shall be assembled as the initial segment of an SLM frame. The initial segment shall be stored until all segments of the frame have been received or the frame is cancelled.

5.2.2.1.1.4.2 *Intermediate segment.* If *LAS* = 2 or 3, the MA field shall be assembled in numerical order as an intermediate segment of the SLM frame. It shall be associated with previous segments containing the same value of IIS.

5.2.2.1.1.4.3 *Final segment.* If *LAS* = 4, 5 or 6, the MA field shall be assembled as the final segment of the SLM frame. It shall be associated with previous segments containing the same value of IIS.

5.2.2.1.1.4.4 *Frame completion.* The frame shall be considered complete and shall be made available for further processing as soon as all segments of the frame have been received.

5.2.2.1.1.4.5 *Frame cancellation.* An incomplete SLM frame shall be cancelled if one or more of the following conditions apply:

a) a new initial segment (*LAS* = 1) is received with the same value of IIS. In this case, the new initial segment shall be retained as the initial segment of a new SLM frame;

b) the sequence of received *LAS* codes (after the elimination of duplicates) is not contained in the following list:

   1) *LAS* = 0
   2) *LAS* = 1,5
   3) *LAS* = 1,2,6
   4) *LAS* = 1,6,2
   5) *LAS* = 1,2,3,4
   6) *LAS* = 1,3,2,4
   7) *LAS* = 1,2,4,3
   8) *LAS* = 1,3,4,2
   9) *LAS* = 1,4,2,3
   10) *LAS* = 1,4,3,2

c) *Tc* seconds have elapsed since the last Comm-A segment with the same value of IIS was received (Table 5-1).

5.2.2.1.1.4.6 *Segment cancellation.* A received segment for an SLM frame shall be discarded if it is an intermediate or final segment and no initial segment has been received with the same value of IIS.

5.2.2.1.1.4.7 *Segment duplication.* If a received segment duplicates a currently received segment number with the same value of IIS, the new segment shall replace the currently received segment.

Note.— The action of the Mode S subnetwork protocols may result in the duplicate delivery of Comm-A segments.

5.2.2.1.2 *ELM frame.* An uplink ELM frame shall consist of from 20 to 160 bytes and shall be transferred from the interrogator to the transponder using the protocol defined in 3.1.2.7 of Annex 10, Volume IV. The first 4 bits of each uplink ELM segment (MC field) shall contain the interrogator identifier (II) code of the Mode S interrogator transmitting the ELM. The ADLP shall check the II code of each segment of a completed uplink ELM. If all of the segments contain the same II code, the II code in each segment shall be deleted and the remaining message bits retained as user data for further processing. If all of the segments do not contain the same II code, the entire uplink ELM shall be discarded.

Note.— An uplink ELM frame consists of two to sixteen associated Comm-C segments, each of which contains the 4-bit II code. Therefore, the capacity for packet transfer is 19 to 152 bytes per uplink ELM frame.

5.2.2.2 DOWNLINK FRAMES

5.2.2.2.1 *SLM frame.* A downlink SLM frame shall be composed of up to 4 Comm-B segments. The MB field of the first Comm-B segment of the frame shall contain a 2-bit linked Comm-B subfield (LBS, bits 1 and 2 of the MB field). This subfield shall be used to control linking of up to four Comm-B segments.

Note.— The LBS uses the first 2-bit positions in the first segment of a multi or single segment downlink SLM frame. Hence, 54 bits are available for Mode S packet data in the first segment of a downlink SLM frame. The remaining segments of the downlink SLM frame, if any, have 56 bits available.

5.2.2.2.1.1 *LBS coding.* Linking shall be indicated by the coding of the LBS subfield of the MB field of the initial Comm-B segment of the SLM frame.

The coding of LBS shall be as follows:

LBS	*MEANING*
0	single segment
1	initial segment of a two-segment SLM frame
2	initial segment of a three-segment SLM frame
3	initial segment of a four-segment SLM frame

5.2.2.2.1.2 *Linking protocol*

5.2.2.2.1.2.1 In the Comm-B protocol, the initial segment shall be transmitted using the air-initiated or multisite-directed protocols. The LBS field of the initial segment shall indicate to the ground the number of additional segments to be transferred (if any). Before the transmission of the initial segment to the transponder, the remaining segments of the SLM frame (if any) shall be transferred to the transponder for transmission to the interrogator using the ground-initiated Comm-B protocol. These segments shall be accompanied by control codes that cause the segments to be inserted in ground-initiated Comm-B registers 2, 3 or 4, associated respectively with the second, third, or fourth segment of the frame.

5.2.2.2.1.2.2 Close-out of the air-initiated segment that initiated the protocol shall not be performed until all segments have been successfully transferred.

Note.— The linking procedure including the use of the ground-initiated Comm-B protocol is performed by the ADLP.

5.2.2.2.1.3 *Directing SLM frames.* If the SLM frame is to be multisite-directed, the ADLP shall determine the II code of the Mode S interrogator or cluster of interrogators (5.2.8.1.3) that shall receive the SLM frame.

5.2.2.2.2 *ELM FRAME*

Note.— A downlink ELM consists of one to sixteen associated Comm-D segments.

5.2.2.2.2.1 *Procedure*. Downlink ELM frames shall be used to deliver messages greater than or equal to 28 bytes and shall be formed using the protocol defined in 3.1.2.7 of Annex 10, Volume IV.

5.2.2.2.2.2 *Directing ELM frames.* If the ELM frame is to be multisite-directed, the ADLP shall determine the II code of the Mode S interrogator or cluster of interrogators (5.2.8.1.3) that shall receive the ELM frame.

5.2.2.3 *XDLP frame processing.* Frame processing shall be performed on all Mode S packets (except for the MSP packet) as specified in 5.2.2.3 to 5.2.2.5. Frame processing for Mode S specific services shall be performed as specified in 5.2.7.

5.2.2.3.1 *Packet length*. All packets (including a group of packets multiplexed into a single frame) shall be transferred in a frame consisting of the smallest number of segments needed to accommodate the packet. The user data field shall be an integral multiple of bytes in length. A 4-bit parameter (LV) shall be provided in the Mode S DATA, CALL REQUEST, CALL ACCEPT, CLEAR REQUEST and INTERRUPT packet headers so that during unpacking no additional bytes are added to the user data field. The LV field shall define the number of full bytes used in the last segment of a frame. During LV calculations, the 4-bit II code in the last segment of an uplink ELM message shall be (1) ignored for uplink ELM frames with an odd number of Comm-C segments and (2) counted for uplink ELM frames with an even number of Comm-C segments. The value contained in the LV field shall be ignored if the packet is multiplexed.

Note.— A specific length field is used to define the length of each element of a multiplexed packet. Therefore the LV field value is not used. LV field error handling is described in Tables 5-16 and 5-19.

5.2.2.3.2 *Multiplexing.* When multiplexing multiple Mode S packets into single SLM on ELM frame, the following procedures shall be used. Multiplexing of the packets within the ADLP shall not be applied to packets associated with SVCs of different priorities.

Note.— Multiplexing is not performed on MSP packets.

5.2.2.3.2.1 *Multiplexing optimization*

Recommendation.— *When multiple packets are awaiting transfer to the same XDLP, they should be multiplexed into a single frame in order to optimize throughput, provided that packets associated with SVCs of different priorities are not multiplexed together.*

5.2.2.3.2.2 *Structure.* The structure of the multiplexed packets shall be as follows:

HEADER:6 or 8	LENGTH:8	1ST PACKET:v	LENGTH:8	2ND PACKET:v

Note.— A number in the field signifies the field length in bits; "v" signifies that the field is of variable length.

5.2.2.3.2.2.1 *Multiplexing header.* The header for the multiplexed packets shall be as follows:

DP:1	MP:1	SP:2	ST:2	FILL2:0 or 2

Where,

Data packet type (DP) = 0

MSP packet type (MP) = 1

Supervisory packet (SP) = 3

Supervisory type (ST) = 2

Note.— See Figure 5-23 for a definition for the field structure used in the multiplexing header.

5.2.2.3.2.2.2 *Length.* This field shall contain the length of the following packet in bytes. Any error detected in a multiplexed DATA packet, such as inconsistency between length as indicated in the LENGTH field and the length of the frame hosting that packet, shall result in the discarding of the packet unless the error can be determined to be limited to the LENGTH field, in which case a REJECT packet with the expected PS value can be sent.

Recommendation.— *For multiplex packets it is recommended that, if the entire packet cannot be de-multiplexed, then the first constituent packet be treated as a format error, and the remainder be discarded.*

5.2.2.3.2.3 *Termination.* The end of a frame containing a sequence of multiplexed packets shall be determined by one of the following events:

a) a length field of all zeros; or

b) less than eight bits left in the frame.

5.2.2.3.3 *MODE S CHANNEL SEQUENCE PRESERVATION*

5.2.2.3.3.1 *Application.* In the event that multiple Mode S frames from the same SVC are awaiting transfer to the same XDLP, the following procedure shall be used.

5.2.2.3.3.2 *Procedure*

Note 1.— SLM and ELM transactions can occur independently.

Note 2.— Uplink and downlink transactions can occur independently.

5.2.2.3.3.2.1 *SLM frames.* SLM frames awaiting transfer shall be transmitted in the order received.

5.2.2.3.3.2.2 *ELM frames.* ELM frames awaiting transfer shall be transmitted in the order received.

5.2.2.4 GDLP FRAME PROCESSING

5.2.2.4.1 *GENERAL PROVISIONS*

5.2.2.4.1.1 The GDLP shall determine the data link capability of the ADLP/transponder installation from the data link capability report (5.2.9) before performing any data link activity with that ADLP.

5.2.2.4.1.2 GDLP frame processing shall provide to the interrogator all data for the uplink transmission that are not provided directly by the interrogator.

5.2.2.4.2 *Delivery status.* GDLP frame processing shall accept an indication from the interrogator function that a specified uplink frame that was previously transferred to the interrogator has been successfully delivered over the ground-to-air link.

5.2.2.4.3 *Aircraft address.* GDLP frame processing shall receive from the interrogator along with the data in each downlink SLM or ELM frame, the 24-bit address of the aircraft that transmitted the frame. GDLP frame processing shall be capable of transferring to the interrogator the 24-bit address of the aircraft that is to receive an uplink SLM or ELM frame.

5.2.2.4.4 *Mode S protocol type identification.* GDLP frame processing shall indicate to the interrogator the protocol to be used to transfer the frame: standard length message protocol, extended length message protocol or broadcast protocol.

5.2.2.4.5 *Frame determination.* A Mode S packet (including multiplexed packets but excluding MSP packets) intended for uplink and less than or equal to 28 bytes shall be sent as an SLM frame. A Mode S packet greater than 28 bytes shall be sent as an uplink ELM frame for transponders with ELM capability, using M-bit processing as necessary (5.2.5.1.4.1). If the transponder does not have ELM capability, packets greater than 28 bytes shall be sent using the M-bit or S-bit (5.2.5.1.4.2) assembly procedures as necessary and multiple SLM frames.

Note.— The Mode S DATA, CALL REQUEST, CALL ACCEPT, CLEAR REQUEST and INTERRUPT packets are the only Mode S packets that use M-bit or S-bit sequencing.

5.2.2.5 ADLP FRAME PROCESSING

5.2.2.5.1 *General provisions.* With the possible exception of the last 24 bits (address/parity), ADLP frame processing shall accept from the transponder the entire content of both 56-bit and 112-bit received uplink transmissions, excluding all-call and ACAS interrogations. ADLP frame processing shall provide to the transponder all data for the downlink transmission that is not provided directly by the transponder (5.2.3.3).

5.2.2.5.2 *Delivery status.* ADLP frame processing shall accept an indication from the transponder that a specified downlink frame that was previously transferred to the transponder has been closed out.

5.2.2.5.3 *Interrogator identifier.* ADLP frame processing shall accept from the transponder, along with the data in each uplink SLM and ELM, the interrogator identifier (II) code of the interrogator that transmitted the frame. ADLP frame processing shall transfer to the transponder the II code of the interrogator or cluster of interrogators that shall receive a multisite-directed frame.

5.2.2.5.4 *Mode S protocol type identification.* ADLP frame processing shall indicate to the transponder the protocol to be used to transfer the frame: ground-initiated, air-initiated, broadcast, multisite-directed, standard length or extended length.

5.2.2.5.5 *Frame cancellation.* ADLP frame processing shall be capable of cancelling downlink frames previously transferred to the transponder for transmission but for which a close-out has not been indicated. If more than one frame is stored within the transponder, the cancellation procedure shall be capable of cancelling the stored frames selectively.

5.2.2.5.6 *Frame determination.* A Mode S packet (including multiplexed packets but excluding MSP packets) intended for downlink and less than or equal to 222 bits shall be sent as an SLM frame. A Mode S packet greater than 222 bits shall be sent as a downlink ELM frame for transponders with ELM capability using M-bit processing as necessary (5.2.5.1.4.1). When M-bit processing is used, all ELM frames containing M = 1 shall contain the maximum number of ELM segments that the transponder is capable of transmitting in response to one requesting interrogation (UF = 24) (5.2.9.1). If the transponder does not have ELM capability, packets greater than 222 bits shall be sent using the M-bit or S-bit (5.2.5.1.4.2) assembly procedures and multiple SLM frames.

Note.— The maximum length of a downlink SLM frame is 222 bits. This is equal to 28 bytes (7 bytes for 4 Comm-B segments) minus the 2-bit linked Comm-B subfield (5.2.2.2.1.1).

5.2.2.6 PRIORITY MANAGEMENT

5.2.2.6.1 *ADLP priority management.* Frames shall be transferred from the ADLP to the transponder in the following order of priority (highest first):

a) Mode S specific services;

b) search requests (5.2.8.1);

c) frames containing only high priority SVC packets; and

d) frames containing only low priority SVC packets.

5.2.2.6.2 *GDLP PRIORITY MANAGEMENT*

Recommendation.— *Uplink frames should be transferred in the following order of priority (highest first):*

a) Mode S specific services;

b) frames containing at least one Mode S ROUTE packet (5.2.8.1);

c) frames containing at least one high priority SVC packet; and

d) frames containing only low priority SVC packets.

5.2.3 Data exchange interfaces

5.2.3.1 THE DTE ISO 8208 INTERFACE

5.2.3.1.1 *General provisions.* The interface between the XDLP and the DTE(s) shall conform to ISO 8208 packet layer protocol (PLP). The XDLP shall support the procedures of the DTE as specified in ISO 8208. As such, the XDLP shall contain a DCE (5.2.4).

5.2.3.1.2 *Physical and link layer requirements for the DTE/DCE interface.* The requirements are:

a) the interface shall be code and byte independent and shall not impose restrictions on the sequence, order, or pattern of the bits transferred within a packet; and

b) the interface shall support the transfer of variable length network layer packets.

5.2.3.1.3 *DTE ADDRESS*

5.2.3.1.3.1 *Ground DTE address.* The ground DTE address shall have a total length of 3 binary coded decimal (BCD) digits, as follows:

$X_0X_1X_2$

X_0 shall be the most significant digit. Ground DTE addresses shall be decimal numbers in the range of 0 through 255 coded in BCD. Assignment of the DTE address shall be a local issue. All DTEs connected to GDLPs having overlapping coverage shall have unique addresses. GDLPs which have a flying time less than T_r (Table 5-1) between their coverage areas shall be regarded as having overlapping coverage.

5.2.3.1.3.2 *Mobile DTE address.* The mobile DTE address shall have a total length of 10 BCD digits, as follows:

$X_0X_1X_2X_3X_4X_5X_6X_7X_8X_9$

X_0 shall be the most significant digit. The digits X_0 to X_7 shall contain the octal representation of the aircraft address coded in BCD. The digits X_8X_9 shall identify a sub-address for specific DTEs on board an aircraft. This sub-address shall be a decimal number in the range of 0 and 15 coded in BCD. The following sub-address assignments shall be used:

00	ATN router
01 to 15	Unassigned

5.2.3.1.3.3 *Illegal DTE addresses.* DTE addresses outside of the defined ranges or not conforming to the formats for the ground and mobile DTE addresses specified in 5.2.3.1.3.1 and 5.2.3.1.3.2 shall be defined to be illegal DTE addresses. The detection of an illegal DTE address in a CALL REQUEST packet shall lead to a rejection of the call as specified in 5.2.5.1.5.

5.2.3.1.4 *PACKET LAYER PROTOCOL REQUIREMENTS OF THE DTE/DCE INTERFACE*

5.2.3.1.4.1 *Capabilities.* The interface between the DTE and the DCE shall conform to ISO 8208 with the following capabilities:

a) expedited data delivery, i.e. the use of INTERRUPT packets with a user data field of up to 32 bytes;

b) priority facility (with two levels, 5.2.5.2.1.1.6);

c) fast select (5.2.5.2.1.1.13, 5.2.5.2.1.1.16); and

d) called/calling address extension facility, if required by local conditions (i.e. the XDLP is connected to the DTE via a network protocol that is unable to contain the Mode S address as defined).

Other ISO 8208 facilities and the D-bit and the Q-bit shall not be invoked for transfer over the Mode S packet layer protocol.

5.2.3.1.4.2 *Parameter values.* The timer and counter parameters for the DTE/DCE interface shall conform to the default ISO 8208 values.

5.2.3.2 MODE S SPECIFIC SERVICES INTERFACE

Note.— Mode S specific services consist of the broadcast Comm-A and Comm-B, GICB and MSP.

5.2.3.2.1 *ADLP*

5.2.3.2.1.1 *General provisions.* The ADLP shall support the accessing of Mode S specific services through the provision of one or more separate ADLP interfaces for this purpose.

5.2.3.2.1.2 *Functional capability.* Message and control coding via this interface shall support all of the capabilities specified in 5.2.7.1.

5.2.3.2.2 *GDLP*

5.2.3.2.2.1 *General provisions.* The GDLP shall support the accessing of Mode S specific services through the provision of a separate GDLP interface for this purpose and/or by providing access to these services through the DTE/DCE interface.

5.2.3.2.2.2 *Functional capability.* Message and control coding via this interface shall support all of the capabilities specified in 5.2.7.2.

5.2.3.3 ADLP/TRANSPONDER INTERFACE

5.2.3.3.1 *TRANSPONDER TO ADLP*

5.2.3.3.1.1 The ADLP shall accept an indication of protocol type from the transponder in connection with data transferred from the transponder to the ADLP. This shall include the following types of protocols:

a) surveillance interrogation;

b) Comm-A interrogation;

c) Comm-A broadcast interrogation; and

d) uplink ELM.

The ADLP shall also accept the II code of the interrogator used to transmit the surveillance, Comm-A or uplink ELM.

Note.— Transponders will not output all-call and ACAS information on this interface.

5.2.3.3.1.2 The ADLP shall accept control information from the transponder indicating the status of downlink transfers. This shall include:

a) Comm-B close-out;

b) Comm-B broadcast timeout; and

c) downlink ELM close-out.

5.2.3.3.1.3 The ADLP shall have access to current information defining the communication capability of the Mode S transponder with which it is operating. This information shall be used to generate the data link capability report (5.2.9).

5.2.3.3.2 *ADLP TO TRANSPONDER*

5.2.3.3.2.1 The ADLP shall provide an indication of protocol type to the transponder in connection with data transferred from the ADLP to the transponder. This shall include the following types of protocols:

a) ground-initiated Comm-B;

b) air-initiated Comm-B;

c) multisite-directed Comm-B;

d) Comm-B broadcast;

e) downlink ELM; and

f) multisite-directed downlink ELM.

The ADLP shall also provide the II code for transfer of a multisite-directed Comm-B or downlink ELM and the Comm-B data selector (BDS) code (3.1.2.6.11.2 of Annex 10, Volume IV) for a ground-initiated Comm-B.

5.2.3.3.2.2 The ADLP shall be able to perform frame cancellation as specified in 5.2.2.5.5.

5.2.3.4 GDLP/MODE S INTERROGATOR INTERFACE

5.2.3.4.1 *INTERROGATOR TO GDLP*

5.2.3.4.1.1 The GDLP shall accept an indication of protocol type from the interrogator in connection with data transferred from the interrogator to the GDLP. This shall include the following types of protocols:

a) ground-initiated Comm-B;

b) air-initiated Comm-B;

c) air-initiated Comm-B broadcast; and

d) downlink ELM.

The GDLP shall also accept the BDS code used to identify the ground-initiated Comm-B segment.

5.2.3.4.1.2 The GDLP shall accept control information from the interrogator indicating the status of uplink transfers and the status of the addressed Mode S aircraft.

5.2.3.4.2 *GDLP to interrogator.* The GDLP shall provide an indication of protocol type to the interrogator in connection with data transferred from the GDLP to the interrogator. This shall include the following types of protocols:

a) Comm-A interrogation;

b) Comm-A broadcast interrogation;

c) uplink ELM; and

d) ground-initiated Comm-B request.

The GDLP shall also provide the BDS code for the ground-initiated Comm-B protocol.

5.2.4 DCE operation

Note.— The DCE process within the XDLP acts as a peer process to the DTE. The DCE supports the operations of the DTE with the capability specified in 5.2.3.1.4. The following requirements do not specify format definitions and flow control on the DTE/DCE interface. The specifications and definitions in ISO 8208 apply for these cases.

5.2.4.1 *State transitions.* The DCE shall operate as a state machine. Upon entering a state, the DCE shall perform the actions specified in Table 5-2. State transitions and additional action(s) shall be as specified in Table 5-3 through Table 5-12.

Note.— The next state transition (if any) that occurs when the DCE receives a packet from the DTE is specified by Table 5-3 through Table 5-8. These tables are organized according to the hierarchy illustrated in Figure 5-2. The same transitions are defined in Table 5-9 through Table 5-12 when the DCE receives a packet from the XDCE (via the reformatting process).

5.2.4.2 DISPOSITION OF PACKETS

5.2.4.2.1 Upon receipt of a packet from the DTE, the packet shall be forwarded or not forwarded to the XDCE (via the reformatting process) according to the parenthetical instructions contained in Tables 5-3 to 5-8. If no parenthetical instruction is listed or if the parenthetical instruction indicates "do not forward", the packet shall be discarded.

5.2.4.2.2 Upon receipt of a packet from the XDCE (via the reformatting process), the packet shall be forwarded or not forwarded to the DTE according to the parenthetical instructions contained in Tables 5-9 to 5-12. If no parenthetical instruction is listed or if the parenthetical instruction indicates "do not forward", the packet shall be discarded.

5.2.5 Mode S packet layer processing

5.2.5.1 GENERAL REQUIREMENTS

5.2.5.1.1 *BUFFER REQUIREMENTS*

5.2.5.1.1.1 *ADLP buffer requirements*

5.2.5.1.1.1.1 The following requirements apply to the entire ADLP and shall be interpreted as necessary for each of the main processes (DCE, reformatting, ADCE, frame processing and SSE).

5.2.5.1.1.1.2 The ADLP shall be capable of maintaining sufficient buffer space for fifteen SVCs:

a) maintain sufficient buffer space to hold fifteen Mode S subnetwork packets of 152 bytes each in the uplink direction per SVC for a transponder with uplink ELM capability or 28 bytes otherwise;

b) maintain sufficient buffer space to hold fifteen Mode S subnetwork packets of 160 bytes each in the downlink direction per SVC for a transponder with downlink ELM capability or 28 bytes otherwise;

c) maintain sufficient buffer space for two Mode S subnetwork INTERRUPT packets of 35 bytes each, (user data field plus control information), one in each direction, for each SVC;

d) maintain sufficient resequencing buffer space for storing thirty-one Mode S subnetwork packets of 152 bytes each in the uplink direction per SVC for a transponder with uplink ELM capability or 28 bytes otherwise; and

e) maintain sufficient buffer space for the temporary storage of at least one Mode S packet of 160 bytes undergoing M-bit or S-bit processing in each direction per SVC.

5.2.5.1.1.1.3 The ADLP shall be capable of maintaining a buffer of 1 600 bytes in each direction to be shared among all MSPs.

5.2.5.1.1.2 *GDLP buffer requirements*

5.2.5.1.1.2.1 **Recommendation.—** *The GDLP should be capable of maintaining sufficient buffer space for an average of 4 SVCs for each Mode S aircraft in the coverage area of the interrogators connected to it, assuming all aircraft have ELM capability.*

Note.— Additional buffer space may be required if DTEs associated with end-systems are supported.

5.2.5.1.2 CHANNEL NUMBER POOLS

5.2.5.1.2.1 The XDLP shall maintain several SVC channel number pools; the DTE/DCE (ISO 8208) interface uses one set. Its organization, structure and use shall be as defined in the ISO 8208 standard. The other channel pools shall be used on the ADCE/GDCE interface.

5.2.5.1.2.2 The GDLP shall manage a pool of temporary channel numbers in the range of 1 to 3, for each ground DTE/ADLP pair. Mode S CALL REQUEST packets generated by the GDLP shall contain the ground DTE address and a temporary channel number allocated from the pool of that ground DTE. The GDLP shall not reuse a temporary channel number allocated to an SVC that is still in the CALL REQUEST state.

Note 1.— The use of temporary channel numbers allows the GDLP to have up to three call requests in process at the same time for a particular ground DTE and ADLP combination. It also allows the GDLP or ADLP to clear a channel before the permanent channel number is assigned.

Note 2.— The ADLP may be in contact with multiple ground DTEs at any one time. All the ground DTEs use temporary channel numbers ranging from 1 to 3.

5.2.5.1.2.3 The ADLP shall use the ground DTE address to distinguish the temporary channel numbers used by the various ground DTEs. The ADLP shall assign a permanent channel number (in the range of 1 to 15) to all SVCs and shall inform the GDLP of the assigned number by including it in the Mode S CALL REQUEST by ADLP or Mode S CALL ACCEPT by ADLP packets. The temporary channel number shall be included in the Mode S CALL ACCEPT by ADLP together with the permanent channel number in order to define the association of these channel numbers. The ADLP shall continue to associate the temporary channel number with the permanent channel number of an SVC until the SVC is returned to the READY (*p*1) state, or else, while in the DATA TRANSFER (*p*4) state, a Mode S CALL REQUEST by GDLP packet is received bearing the same temporary channel number. A non-zero permanent channel number in the Mode S CLEAR REQUEST by ADLP, CLEAR REQUEST by GDLP, CLEAR CONFIRMATION by ADLP or CLEAR CONFIRMATION by GDLP packet shall indicate that the permanent channel number shall be used and the temporary channel number shall be ignored. In the event that an XDLP is required to send one of these packets in the absence of a permanent channel number, the permanent channel number shall be set to zero, which shall indicate to the peer XDLP that the temporary channel number is to be used.

Note.— The use of a zero permanent channel number allows the ADLP to clear an SVC when no permanent channel number is available, and allows the GDLP to do likewise before it has been informed of the permanent channel number.

5.2.5.1.2.4 The channel number used by the DTE/DCE interface and that used by the ADCE/GDCE interface shall be assigned independently. The reformatting process shall maintain an association table between the DTE/DCE and the ADCE/GDCE channel numbers.

5.2.5.1.3 *Receive ready and receive not ready conditions.* The ISO 8208 interface and the ADCE/GDCE interface management procedures shall be independent operations since each system must be able to respond to separate receive ready and receive not ready indications.

5.2.5.1.4 PROCESSING OF M-BIT AND S-BIT SEQUENCES

Note.— M-bit processing applies to the sequencing of the DATA packet. S-bit processing applies to the sequencing of Mode S CALL REQUEST, CALL ACCEPT, CLEAR REQUEST and INTERRUPT packets.

5.2.5.1.4.1 *M-bit processing*

Note.— The packet size used on the DTE/DCE interface can be different from that used on the ADCE/GDCE interface.

5.2.5.1.4.1.1 M-bit processing shall be used when DATA packets are reformatted (5.2.5.2). M-bit processing shall utilize the specifications contained in the ISO 8208 standard. The M-bit sequence processing shall apply on a per channel basis. The M-bit set to 1 shall indicate that a user data field continues in the subsequent DATA packet. Subsequent packets in an M-bit sequence shall use the same header format (i.e. the packet format excluding the user data field).

5.2.5.1.4.1.2 If the packet size for the XDCE (5.2.6.4.2) interface is larger than that used on the DTE/DCE interface, packets shall be combined to the extent possible as dictated by the M-bit, when transmitting a Mode S DATA packet. If the packet size is smaller on the XDCE interface than that defined on the DTE/DCE interface, packets shall be fragmented to fit into the smaller Mode S packet using M-bit assembly.

5.2.5.1.4.1.3 A packet shall be combined with subsequent packets if the packet is filled and more packets exist in the M-bit sequence (M-bit = 1). A packet smaller than the maximum packet size defined for this SVC (partial packet) shall only be allowed when the M-bit indicates the end of an M-bit sequence. A received packet smaller than the maximum packet size with M-bit equal to 1 shall cause a reset to be generated as specified in ISO 8208 and the remainder of the sequence should be discarded.

5.2.5.1.4.1.4 **Recommendation.—** *In order to decrease delivery delay, reformatting should be performed on the partial receipt of an M-bit sequence, rather than delay reformatting until the complete M-bit sequence is received.*

5.2.5.1.4.2 *S-bit processing.* S-bit processing shall apply only to Mode S CALL REQUEST, CALL ACCEPT, CLEAR REQUEST and INTERRUPT packets. This processing shall be performed as specified for M-bit processing (5.2.5.1.4.1) except that the packets associated with any S-bit sequence whose reassembly is not completed in *Tq* seconds (Tables 5-1 and 5-13) shall be discarded (5.2.6.3.6, 5.2.6.4.5.2 and 5.2.6.9), and receipt of a packet shorter than the maximum packet size with S = 1 shall cause the entire S-bit sequence to be treated as a format error in accordance with Table 5-16.

5.2.5.1.5 *MODE S SUBNETWORK ERROR PROCESSING FOR ISO 8208 PACKETS*

5.2.5.1.5.1 *D-bit.* If the XDLP receives a DATA packet with the D-bit set to 1, the XDLP shall send a RESET REQUEST packet to the originating DTE containing a cause code *(CC)* = 133 and a diagnostic code *(DC)* = 166. If the D-bit is set to 1 in a CALL REQUEST packet, the D-bit shall be ignored by the XDLP. The D-bit of the corresponding CALL ACCEPT packet shall always be set to 0. The use of CC is optional.

5.2.5.1.5.2 *Q-bit.* If the XDLP receives a DATA packet with the Q-bit set to 1, the XDLP shall send a RESET REQUEST packet to the originating DTE containing *CC* = 133 and *DC* = 83. The use of CC is optional.

5.2.5.1.5.3 *Invalid priority.* If the XDLP receives a call request with a connection priority value equal to 2 through 254, the XDLP shall clear the virtual circuit using *DC* = 66 and *CC* = 131. The use of CC is optional.

5.2.5.1.5.4 *Unsupported facility.* If the XDLP receives a call request with a request for a facility that it cannot support, the XDLP shall clear the virtual circuit using *DC* = 65 and *CC* = 131. The use of CC is optional.

5.2.5.1.5.5 *Illegal calling DTE address.* If the XDLP receives a call request with an illegal calling DTE address (5.2.3.1.3.3), the XDLP shall clear the virtual circuit using *DC* = 68 and *CC* = 141. The use of CC is optional.

5.2.5.1.5.6 *Illegal called DTE address.* If the XDLP receives a call request with an illegal called DTE address (5.2.3.1.3.3), the XDLP shall clear the virtual circuit using *DC* = 67 and *CC* = 141. The use of CC is optional.

5.2.5.2 REFORMATTING PROCESS

Note.— The reformatting process is divided into two subprocesses: uplink formatting and downlink formatting. For the ADLP, the uplink process reformats Mode S packets into ISO 8208 packets and the downlink process reformats ISO 8208 packets into Mode S packets. For the GDLP, the uplink process reformats ISO 8208 packets into Mode S packets and the downlink process reformats Mode S packets into ISO 8208 packets.

5.2.5.2.1 *CALL REQUEST BY ADLP*

5.2.5.2.1.1 *Translation into Mode S packets*

5.2.5.2.1.1.1 *Translated packet format.* Reception by the ADLP reformatting process of an ISO 8208 CALL REQUEST packet from the local DCE shall result in the generation of corresponding Mode S CALL REQUEST by ADLP packet(s) (as determined by S-bit processing (5.2.5.1.4.2)) as follows:

DP:1	MP:1	SP:2	ST:2	FILL2:0 or 2	P:1	FILL:1	SN:6

CH:4	AM:4	AG:8	S:1	FS:2	F:1	LV:4	UD:v

5.2.5.2.1.1.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.2.1.1.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.2.1.1.4 *Supervisory packet (SP).* This field shall be set to 1.

5.2.5.2.1.1.5 *Supervisory type (ST).* This field shall be set to 0.

5.2.5.2.1.1.6 *Priority (P).* This field shall be set to 0 for a low priority SVC and to 1 for a high priority SVC. The value for this field shall be obtained from the data transfer field of the priority facility of the ISO 8208 packet, and shall be set to 0 if the ISO 8208 packet does not contain the priority facility or if a priority of 255 is specified. The other fields of the priority facility shall be ignored.

5.2.5.2.1.1.7 *Sequence number (SN).* For a particular SVC, each packet shall be numbered (5.2.6.9.4).

5.2.5.2.1.1.8 *Channel number (CH).* The channel number shall be chosen from the pool of SVC channel numbers available to the ADLP. The pool shall consist of 15 values from 1 through 15. The highest available channel number shall be chosen from the pool. An available channel shall be defined as one in state *p*1. The correspondence between the channel number used by the Mode S subnetwork and the number used by the DTE/DCE interface shall be maintained while the channel is active.

Note.— Also refer to 5.2.5.1.2 on channel pool management.

5.2.5.2.1.1.9 *Address, mobile (AM).* This address shall be the mobile DTE sub-address (5.2.3.1.3.2) in the range of 0 to 15. The address shall be extracted from the two least significant digits of the calling DTE address contained in the ISO 8208 packet and converted to binary representation.

Note.— The 24-bit aircraft address is transferred within the Mode S link layer.

5.2.5.2.1.1.10 *Address, ground (AG).* This address shall be the ground DTE address (5.2.3.1.3.1) in the range of 0 to 255. The address shall be extracted from the called DTE address contained in the ISO 8208 packet and converted to binary representation.

5.2.5.2.1.1.11 *Fill field.* The fill field shall be used to align subsequent data fields on byte boundaries. When indicated as "FILL:n", the fill field shall be set to a length of "n" bits. When indicated as "FILL1: 0 or 6", the fill field shall be set to a length of 6 bits for a non-multiplexed packet in a downlink SLM frame and 0 bit for all other cases. When indicated as "FILL2: 0 or 2", the fill field shall be set to a length of 0 bit for a non-multiplexed packet in a downlink SLM frame or for a multiplexing header and 2 bits for all other cases.

5.2.5.2.1.1.12 *S field (S).* A value of 1 shall indicate that the packet is part of an S-bit sequence with more packets in the sequence to follow. A value of 0 shall indicate that the sequence ends with this packet. This field shall be set as specified in 5.2.5.1.4.2.

5.2.5.2.1.1.13 *FS field (FS).* A value of 0 shall indicate that the packet does not contain fast select data. A value of 2 or 3 shall indicate that the packet contains fast select data. A value of 2 shall indicate normal fast select operation. A value of 3 shall indicate fast select with restricted response. An FS value of 1 shall be undefined.

5.2.5.2.1.1.14 *First packet flag (F).* This field shall be set to 0 in the first packet of an S-bit sequence and in a packet that is not part of an S-bit sequence. Otherwise it shall be set to 1.

5.2.5.2.1.1.15 *User data length (LV).* This field shall indicate the number of full bytes used in the last SLM or ELM segment as defined in 5.2.2.3.1.

5.2.5.2.1.1.16 *User data field (UD).* This field shall only be present if optional CALL REQUEST user data (maximum 16 bytes) or fast select user data (maximum 128 bytes) is contained in the ISO 8208 packet. The user data field shall be transferred from ISO 8208 packet unchanged using S-bit processing as specified in 5.2.5.1.4.2.

5.2.5.2.1.2 *Translation into ISO 8208 packets*

5.2.5.2.1.2.1 *Translation.* Reception by the GDLP reformat-ting process of a Mode S CALL REQUEST by ADLP packet (or an S-bit sequence of packets) from the GDCE shall result in the generation of a corresponding ISO 8208 CALL REQUEST packet to the local DCE. The translation from the Mode S packet to the ISO 8208 packet shall be the inverse of the processing defined in 5.2.5.2.1.1 with the exceptions as specified in the following paragraph.

5.2.5.2.1.2.2 *Called DTE, calling DTE address and length fields.* The calling DTE address shall be composed of the aircraft address and the value contained in the AM field of the Mode S packet, converted to BCD (5.2.3.1.3.2). The called DTE address shall be the ground DTE address contained in the AG field of the Mode S packet, converted to BCD. The length field shall be as defined in ISO 8208.

5.2.5.2.2 *CALL REQUEST BY GDLP*

5.2.5.2.2.1 *Translation into Mode S packets*

5.2.5.2.2.1.1 *General.* Reception by the GDLP reformat-ting process of an ISO 8208 CALL REQUEST packet from the local DCE shall result in the generation of corresponding Mode S CALL REQUEST by GDLP packet(s) (as determined by S-bit processing (5.2.5.1.4.2)) as follows:

DP:1	MP:1	SP:2	ST:2	FILL:2	P:1	FILL:1	SN:6	

	FILL:2	TC:2	AM:4	AG:8	S:1	FS:2	F:1	LV:4	UD:v

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1.

5.2.5.2.2.1.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.2.2.1.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.2.2.1.4 *Supervisory packet (SP).* This field shall be set to 1.

5.2.5.2.2.1.5 *Supervisory type (ST).* This field shall be set to 0.

5.2.5.2.2.1.6 *Temporary channel number field (TC).* This field shall be used to distinguish multiple call requests from a GDLP. The ADLP reformatting process, upon receipt of a temporary channel number, shall assign a channel number from those presently in the READY state, *p*1.

5.2.5.2.2.1.7 *Address, ground (AG).* This address shall be the ground DTE address (5.2.3.1.3.1) in the range of 0 to 255. The address shall be extracted from the calling DTE address contained in the ISO 8208 packet and converted to binary representation.

5.2.5.2.2.1.8 *Address, mobile (AM).* This address shall be the mobile DTE sub-address (5.2.3.1.3.2) in the range of 0 to 15. The address shall be extracted from the two least significant digits of the called DTE address contained in the ISO 8208 packet and converted to binary representation.

5.2.5.2.2.2 *Translation into ISO 8208 packets*

5.2.5.2.2.2.1 *Translation.* Reception by the ADLP reformatting process of a Mode S CALL REQUEST by GDLP packet (or an S-bit sequence of packets) from the ADCE shall result in the generation of a corresponding ISO 8208 CALL REQUEST packet to the local DCE. The translation from the Mode S packet to the ISO 8208 packet shall be the inverse of the processing defined in 5.2.5.2.2.1 with the exceptions as specified in the following paragraph.

5.2.5.2.2.2.2 *Called DTE, calling DTE address and length fields.* The called DTE address shall be composed of the aircraft address and the value contained in the AM field of the Mode S packet, converted to BCD (5.2.3.1.3.2). The calling DTE address shall be the ground DTE address contained in the AG field of the Mode S packet, converted to BCD. The length field shall be as defined in ISO 8208.

5.2.5.2.3 *CALL ACCEPT BY ADLP*

5.2.5.2.3.1 *Translation into Mode S packets*

5.2.5.2.3.1.1 *Translated packet format.* Reception by the ADLP reformatting process of an ISO 8208 CALL ACCEPT packet from the local DCE shall result in the generation of corresponding Mode S CALL ACCEPT by ADLP packet(s) (as determined by S-bit processing (5.2.5.1.4.2)) as follows:

DP:1	MP:1	SP:2	ST:2	FILL2:0 or 2	TC:2	SN:6	

	CH:4	AM:4	AG:8	S:1	FILL:2	F:1	LV:4	UD:v

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1.

5.2.5.2.3.1.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.2.3.1.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.2.3.1.4 *Supervisory packet (SP).* This field shall be set to 1.

5.2.5.2.3.1.5 *Supervisory type (ST).* This field shall be set to 1.

5.2.5.2.3.1.6 *Temporary channel number (TC).* The TC value in the originating Mode S CALL REQUEST by GDLP packet shall be returned to the GDLP along with the channel number (CH) assigned by the ADLP.

5.2.5.2.3.1.7 *Channel number (CH).* The field shall be set equal to the channel number assigned by the ADLP as determined during the CALL REQUEST procedures for the Mode S connection.

5.2.5.2.3.1.8 *Address, mobile and address, ground.* The AM and AG values in the originating Mode S CALL REQUEST by GDLP packet shall be returned in these fields. When present, DTE addresses in the ISO 8208 CALL ACCEPT packet shall be ignored.

5.2.5.2.3.2 *Translation into ISO 8208 packets*

5.2.5.2.3.2.1 *Translation.* Reception by the GDLP reformatting process of a Mode S CALL ACCEPT by ADLP packet (or an S-bit sequence of packets) from the GDCE shall result in the generation of a corresponding ISO 8208 CALL ACCEPT packet to the local DCE. The translation from the Mode S packet to the ISO 8208 packet shall be the inverse of the processing defined in 5.2.5.2.3.1 with the exceptions as specified in the following paragraph.

5.2.5.2.3.2.2 *Called DTE, calling DTE address and length fields.* Where present, the called DTE address shall be composed of the aircraft address and the value contained in the AM field of the Mode S packet, converted to BCD (5.2.3.1.3.2). Where present, the calling DTE address shall be the ground DTE address contained in the AG field of the Mode S packet, converted to BCD. The length field shall be as defined in ISO 8208.

Note.— The called and calling DTE addresses are optional in the corresponding ISO 8208 packet and are not required for correct operation of the Mode S subnetwork.

5.2.5.2.4 *CALL ACCEPT BY GDLP*

5.2.5.2.4.1 *Translation into Mode S packets*

5.2.5.2.4.1.1 *Translated packet format.* Reception by the GDLP reformatting process of an ISO 8208 CALL ACCEPT packet from the local DCE shall result in the generation of corresponding Mode S CALL ACCEPT by GDLP packet(s) (as determined by S-bit processing (5.2.5.1.4.2)) as follows:

DP:1	MP:1	SP:2	ST:2	FILL:2	FILL:2	SN:6	CH:4	AM:4	AG:8	S:1	FILL:2	F:1	LV:4	UD:v

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1.

5.2.5.2.4.1.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.2.4.1.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.2.4.1.4 *Supervisory packet (SP).* This field shall be set to 1.

5.2.5.2.4.1.5 *Supervisory type (ST).* This field shall be set to 1.

5.2.5.2.4.1.6 *Address, mobile and address, ground.* The AM and AG values in the originating Mode S CALL REQUEST by ADLP packet shall be returned in these fields. When present, DTE addresses in the ISO 8208 CALL ACCEPT packet shall be ignored.

5.2.5.2.4.2 *Translation into ISO 8208 packets*

5.2.5.2.4.2.1 *Translation.* Reception by the ADLP reformatting process of a Mode S CALL ACCEPT by GDLP packet (or an S-bit sequence of packets) from the ADCE shall result in the generation of a corresponding ISO 8208 CALL ACCEPT packet to the local DCE. The translation from the Mode S packet to the ISO 8208 packet shall be the inverse of the processing defined in 5.2.5.2.4.1 with the exceptions as specified in the following paragraph.

5.2.5.2.4.2.2 *Called DTE, calling DTE address and length fields.* Where present, the calling DTE address shall be composed of the aircraft address and the value contained in the AM field of the Mode S packet, converted to BCD (5.2.3.1.3.2). Where present, the called DTE address shall be the ground DTE address contained in the AG field of the Mode S packet, converted to BCD. The length field shall be as defined in ISO 8208.

Note.— The called and calling DTE addresses are optional in the corresponding ISO 8208 packet and are not required for correct operation of the Mode S subnetwork.

5.2.5.2.5 *CLEAR REQUEST BY ADLP*

5.2.5.2.5.1 *Translation into Mode S packets*

5.2.5.2.5.1.1 *Translated packet format.* Reception by the ADLP reformatting process of an ISO 8208 CLEAR REQUEST packet from the local DCE shall result in the generation of a corresponding Mode S CLEAR REQUEST by ADLP packet(s) (as determined by S-bit processing (5.2.5.1.4.2)) as follows:

DP:1	MP:1	SP:2	ST:2	FILL2:0 or 2	TC:2	SN:6	CH:4	AM:4	AG:8	CC:8	DC:8	S:1	FILL:2	F:1	LV:4	UD:v

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1 and 5.2.5.2.2.

5.2.5.2.5.1.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.2.5.1.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.2.5.1.4 *Supervisory packet (SP).* This field shall be set to 1.

5.2.5.2.5.1.5 *Channel number (CH)*: If a channel number has been allocated during the call acceptance phase, then CH shall be set to that value, otherwise it shall be set to zero.

5.2.5.2.5.1.6 *Temporary channel (TC)*: If a channel number has been allocated during the call acceptance phase, then TC shall be set to zero, otherwise it shall be set to the value used in the CALL REQUEST by GDLP.

5.2.5.2.5.1.7 *Supervisory type (ST).* This field shall be set to 2.

5.2.5.2.5.1.8 *Address, ground or address, mobile.* The AG and AM values in the originating Mode S CALL REQUEST by ADLP or CALL REQUEST by GDLP packets shall be returned in these fields. When present, DTE addresses in the ISO 8208 CLEAR REQUEST packet shall be ignored.

5.2.5.2.5.1.9 *Clearing cause (CC) and diagnostic code (DC) fields.* These fields shall be transferred without modification from the ISO 8208 packet to the Mode S packet when the

DTE has initiated the clear procedure. If the XDLP has initiated the clear procedure, the clearing cause field and diagnostic field shall be as defined in the state tables for the DCE and XDCE (see also 5.2.6.3.3). The coding and definition of these fields shall be as specified in ISO 8208.

5.2.5.2.5.2 *Translation into ISO 8208 packets*

5.2.5.2.5.2.1 *Translation.* Reception by the GDLP reformatting process of a Mode S CLEAR REQUEST by ADLP packet (or an S-bit sequence of packets) from the local GDCE shall result in the generation of a corresponding ISO 8208 CLEAR REQUEST packet to the local DCE. The translation from the Mode S packet to the ISO 8208 packet shall be the inverse of the processing defined in 5.2.5.2.5.1 with the exceptions specified in the following paragraphs.

5.2.5.2.5.2.2 *Called DTE, calling DTE and length fields.* These fields shall be omitted in the ISO 8208 CLEAR REQUEST packet.

5.2.5.2.5.2.3 *Clearing Cause Field.* This field shall be set taking account of 5.2.6.3.3.

5.2.5.2.6 *CLEAR REQUEST BY GDLP*

5.2.5.2.6.1 *Translation into Mode S packets*

5.2.5.2.6.1.1 *Translated packet format.* Reception by the GDLP reformatting process of an ISO 8208 CLEAR REQUEST packet from the local DCE shall result in the generation of corresponding Mode S CLEAR REQUEST by GDLP packet(s) (as determined by S-bit processing (5.2.5.1.4.2)) as follows:

DP:1	MP:1	SP:2	ST:2	FILL:2	TC:2	SN:6	CH:4	AM:4

AG:8	CC:8	DC:8	S:1	FILL:2	F:1	LV:4	UD:v

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1, 5.2.5.2.2 and 5.2.5.2.5.

5.2.5.2.6.1.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.2.6.1.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.2.6.1.4 *Supervisory packet (SP).* This field shall be set to 1.

5.2.5.2.6.1.5 *Channel number (CH)*: If a channel number has been allocated during the call acceptance phase, then CH shall be set to that value, otherwise it shall be set to zero.

5.2.5.2.6.1.6 *Temporary channel (TC)*: If a channel number has been allocated during the call acceptance phase, then TC shall be set to zero, otherwise it shall be set to the value used in the CALL REQUEST by GDLP.

5.2.5.2.6.1.7 *Supervisory type (ST).* This field shall be set to 2.

5.2.5.2.6.2 *Translation into ISO 8208 packets*

5.2.5.2.6.2.1 *Translation.* Reception by the ADLP reformatting process of a Mode S CLEAR REQUEST by GDLP packet (or an S-bit sequence of packets) from the local ADCE shall result in the generation of a corresponding ISO 8208 CLEAR REQUEST packet to the local DCE. The translation from the Mode S packet to the ISO 8208 packet shall be the inverse of the processing defined in 5.2.5.2.6.1.

5.2.5.2.6.2.2 *Called DTE, calling DTE and length fields.* These fields shall be omitted in the ISO 8208 CLEAR REQUEST packet.

5.2.5.2.7 *DATA*

5.2.5.2.7.1 *Translation into Mode S packets*

5.2.5.2.7.1.1 *Translated packet format.* Reception by the XDLP reformatting process of ISO 8208 DATA packet(s) from the local DCE shall result in the generation of corresponding Mode S DATA packet(s) as determined by M-bit processing (5.2.5.1.4.1), as follows:

DP:1	M:1	SN:6	FILL1:0 or 6	PS:4

PR:4	CH:4	LV:4	UD:v

5.2.5.2.7.1.2 *Data packet type (DP).* This field shall be set to 1.

5.2.5.2.7.1.3 *M field (M).* A value of 1 shall indicate that the packet is part of an M-bit sequence with more packets in the sequence to follow. A value of 0 shall indicate that the sequence ends with this packet. The appropriate value shall be placed in the M-bit field of the Mode S packet.

Note.— See 5.2.5.1.4 and ISO 8208 for a complete explanation.

5.2.5.2.7.1.4 *Sequence number (SN).* The sequence number field shall be set as specified in 5.2.5.2.1.1.7.

5.2.5.2.7.1.5 *Packet send sequence number (PS).* The packet send sequence number field shall be set as specified in 5.2.6.4.4.

5.2.5.2.7.1.6 *Packet receive sequence number (PR).* The packet receive sequence number field shall be set as specified in 5.2.6.4.4.

5.2.5.2.7.1.7 *Channel number (CH).* The channel number field shall contain the Mode S channel number that corresponds to the incoming ISO 8208 DATA packet channel number.

5.2.5.2.7.1.8 *User data length (LV).* This field shall indicate the number of full bytes used in the last SLM or ELM segment as defined in 5.2.2.3.1.

5.2.5.2.7.1.9 *Fill (FILL1).* This field shall be set as specified in 5.2.5.2.1.1.11.

5.2.5.2.7.1.10 *User data (UD).* The user data shall be transferred from the ISO 8208 packet to the Mode S packet utilizing the M-bit packet assembly processing as required.

5.2.5.2.7.2 *Translation into ISO 8208 packets.* Reception by the XDLP reformatting process of Mode S DATA packet(s) from the local XDCE shall result in the generation of corresponding ISO 8208 DATA packet(s) to the local DCE. The translation from Mode S packet(s) to the ISO 8208 packet(s) shall be the inverse of the processing defined in 5.2.5.2.7.1.

5.2.5.2.8 *INTERRUPT*

5.2.5.2.8.1 *Translation into Mode S packets*

5.2.5.2.8.1.1 *Translated packet format.* Reception by the XDLP reformatting process of an ISO 8208 INTERRUPT packet from the local DCE shall result in the generation of corresponding Mode S INTERRUPT packet(s) (as determined by S-bit processing (5.2.5.1.4.2)) as follows:

DP:1	MP:1	SP:2	ST:2	FILL2:0 or 2	S:1	

	F:1	SN:6	CH:4	LV:4	UD:v

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1.

5.2.5.2.8.1.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.2.8.1.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.2.8.1.4 *Supervisory packet (SP).* This field shall be set to 3.

5.2.5.2.8.1.5 *Supervisory type (ST).* This field shall be set to 1.

5.2.5.2.8.1.6 *User data length (LV).* This field shall be set as specified in 5.2.2.3.1.

5.2.5.2.8.1.7 *User data (UD).* The user data shall be transferred from the ISO 8208 packet to the Mode S packet using the S-bit packet reassembly processing as required. The maximum size of the user data field for an INTERRUPT packet shall be 32 bytes.

5.2.5.2.8.2 *Translation into ISO 8208 packets.* Reception by the XDLP reformatting process of Mode S INTERRUPT packet(s) from the local XDCE shall result in the generation of a corresponding ISO 8208 INTERRUPT packet to the local DCE. The translation from the Mode S packet(s) to the ISO 8208 packet shall be the inverse of the processing defined in 5.2.5.2.8.1.

5.2.5.2.9 *INTERRUPT CONFIRMATION*

5.2.5.2.9.1 *Translation into Mode S packets*

5.2.5.2.9.1.1 *Translated packet format.* Reception by the XDLP reformatting process of an ISO 8208 INTERRUPT CONFIRMATION packet from the local DCE shall result in the generation of a corresponding Mode S INTERRUPT CONFIRMATION packet as follows:

DP:1	MP:1	SP:2	ST:2	SS:2	

	FILL2:0 or 2	SN:6	CH:4	FILL:4

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1.

5.2.5.2.9.1.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.2.9.1.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.2.9.1.4 *Supervisory packet (SP).* This field shall be set to 3.

5.2.5.2.9.1.5 *Supervisory type (ST).* This field shall be set to 3.

5.2.5.2.9.1.6 *Supervisory subset (SS).* This field shall be set to 0.

5.2.5.2.9.2 *Translation into ISO 8208 packets.* Reception by the XDLP reformatting process of a Mode S INTERRUPT CONFIRMATION packet from the local XDCE shall result in the generation of a corresponding ISO 8208 INTERRUPT CONFIRMATION packet to the local DCE. The translation from the Mode S packet to the ISO 8208 packet shall be the inverse of the processing defined in 5.2.5.2.9.1.

5.2.5.2.10 *RESET REQUEST*

5.2.5.2.10.1 *Translation into Mode S packets*

5.2.5.2.10.1.1 *Translated packet format.* Reception by the XDLP reformatting process of an ISO 8208 RESET REQUEST packet from the local DCE shall result in the generation of a corresponding Mode S RESET REQUEST packet as follows:

DP:1	MP:1	SP:2	ST:2	FILL2:0 or 2	FILL:2	

	SN:6	CH:4	FILL:4	RC:8	DC:8

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1.

5.2.5.2.10.1.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.2.10.1.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.2.10.1.4 *Supervisory packet (SP).* This field shall be set to 2.

5.2.5.2.10.1.5 *Supervisory type (ST).* This field shall be set to 2.

5.2.5.2.10.1.6 *Reset cause code (RC) and diagnostic code (DC).* The reset cause and diagnostic codes used in the Mode S RESET REQUEST packet shall be as specified in the ISO 8208 packet when the reset procedure is initiated by the DTE. If the reset procedure originates with the DCE, the DCE state tables shall specify the diagnostic fields coding. In this case, bit 8 of the reset cause field shall be set to 0.

5.2.5.2.10.2 *Translation into ISO 8208 packets.* Reception by the XDLP reformatting process of a Mode S RESET packet from the local XDCE shall result in the generation of a corresponding ISO 8208 RESET packet to the local DCE. The translation from the Mode S packet to the ISO 8208 packet shall be the inverse of the processing defined in 5.2.5.2.10.1.

5.2.5.2.11 *ISO 8208 RESTART REQUEST to Mode S CLEAR REQUEST.* The receipt of an ISO 8208 RESTART REQUEST from the local DCE shall result in the reformatting process generating a Mode S CLEAR REQUEST by ADLP or Mode S CLEAR REQUEST by GDLP for all SVCs associated with the requesting DTE. The fields of the Mode S CLEAR REQUEST packets shall be set as specified in 5.2.5.2.5 and 5.2.5.2.6.

Note.— There are no restart states in the Mode S packet layer protocol.

5.2.5.3 PACKETS LOCAL TO THE MODE S SUBNETWORK

Note.— Packets defined in this section do not result in the generation of an ISO 8208 packet.

5.2.5.3.1 *MODE S RECEIVE READY*

5.2.5.3.1.1 *Packet format.* The Mode S RECEIVE READY packet arriving from an XDLP is not related to the control of the DTE/DCE interface and shall not cause the generation of an ISO 8208 packet. The format of the packet shall be as follows:

DP:1	MP:1	SP:2	ST:2	FILL2:0 or 2	

	FILL:2	SN:6	CH:4	PR:4

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1. The packet shall be processed as specified in 5.2.6.5.

5.2.5.3.1.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.3.1.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.3.1.4 *Supervisory packet (SP).* This field shall be set to 2.

5.2.5.3.1.5 *Supervisory type (ST).* This field shall be set to 0.

5.2.5.3.1.6 *Packet receive sequence number (PR).* This field shall be set as specified in 5.2.6.4.4.

5.2.5.3.2 *MODE S RECEIVE NOT READY*

5.2.5.3.2.1 *Packet format.* The Mode S RECEIVE NOT READY packet arriving from an XDLP is not related to the control of the DTE/DCE interface and shall not cause the generation of an ISO 8208 packet. The format of the packet shall be as follows:

DP:1	MP:1	SP:2	ST:2	FILL2:0 or 2	

	FILL:2	SN:6	CH:4	PR:4

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1. The packet shall be processed as specified in 5.2.6.6.

5.2.5.3.2.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.3.2.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.3.2.4 *Supervisory packet (SP).* This field shall be set to 2.

5.2.5.3.2.5 *Supervisory type (ST).* This field shall be set to 1.

5.2.5.3.2.6 *Packet receive sequence number (PR).* This field shall be set as specified in 5.2.6.4.4.

5.2.5.3.3 *MODE S ROUTE*

5.2.5.3.3.1 *Packet format.* The format for the packet shall be as follows:

DP:1	MP:1	SP:2	ST:2	OF:1	IN:1	

	RTL:8	RT:v	ODL:0 or 8	OD:v

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1. The packet shall only be generated by the GDLP. It shall be processed by the ADLP as specified in 5.2.8.1.2 and shall have a maximum size as specified in 5.2.6.4.2.1.

5.2.5.3.3.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.3.3.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.3.3.4 *Supervisory packet (SP).* This field shall be set to 3.

5.2.5.3.3.5 *Supervisory type (ST).* This field shall be set to 0.

5.2.5.3.3.6 *Option flag (OF).* This field shall indicate the presence of the optional data length (ODL) and optional data (OD) fields. OF shall be set to 1 if ODL and OD are present. Otherwise it shall be set to 0.

5.2.5.3.3.7 *Initialization bit (IN).* This field shall indicate the requirement for subnetwork initialization. It shall be set by the GDLP as specified in 5.2.8.1.2 d).

Note.— Initialization causes the clearing of any open SVCs associated with the DTE addresses contained in the ROUTE packet. This is needed to assure that all channels are closed at acquisition and for initialization following recovery after a GDLP failure.

5.2.5.3.3.8 *Route table length (RTL).* This field shall indicate the size of the route table, expressed in bytes.

5.2.5.3.3.9 *Route table (RT)*

5.2.5.3.3.9.1 *Contents.* This table shall consist of a variable number of entries each containing information specifying the addition or deletion of entries in the II code-DTE cross-reference table (5.2.8.1.1).

5.2.5.3.3.9.2 *Entries.* Each entry in the route table shall consist of the II code, a list of up to 8 ground DTE addresses, and a flag indicating whether the resulting II code-DTE pairs shall be added or deleted from the II code-DTE cross-reference table. A route table entry shall be coded as follows:

II:4	AD:1	ND:3	DAL:v

5.2.5.3.3.9.3 *Interrogator identifier (II).* This field shall contain the 4-bit II code.

5.2.5.3.3.9.4 *Add/delete flag (AD).* This field shall indicate whether the II code-DTE pairs shall be added ($AD = 1$) or deleted ($AD = 0$) from the II code-DTE cross-reference table.

5.2.5.3.3.9.5 *Number of DTE addresses (ND).* This field shall be expressed in binary in the range from 0 to 7 and shall indicate the number of DTE addresses present in DAL minus 1 (in order to allow from 1 to 8 DTE addresses).

5.2.5.3.3.9.6 *DTE address list (DAL).* This list shall consist of up to 8 DTE addresses, expressed in 8-bit binary representation.

5.2.5.3.3.10 *Optional data length (ODL).* This field shall contain the length in bytes of the following OD field.

5.2.5.3.3.11 *Optional data (OD).* This variable length field shall contain optional data.

5.2.5.3.4 *MODE S CLEAR CONFIRMATION BY ADLP*

5.2.5.3.4.1 *Packet format.* The format for this packet shall be as follows:

DP:1	MP:1	SP:2	ST:2	FILL2:0 or 2	

	TC:2	SN:6	CH:4	AM:4	AG:8

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1 and 5.2.5.2.5. This packet shall be processed as specified in 5.2.6.3.

5.2.5.3.4.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.3.4.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.3.4.4 *Supervisory packet (SP).* This field shall be set to 1.

5.2.5.3.4.5 *Channel number (CH)*: If a channel number has been allocated during the call acceptance phase, then CH shall be set to that value, otherwise it shall be set to zero.

5.2.5.3.4.6 *Temporary channel (TC)*: If a channel number has been allocated during the call acceptance phase, then TC shall be set to zero, otherwise it shall be set to the value used in the CALL REQUEST by GDLP.

5.2.5.3.4.7 *Supervisory type (ST).* This field shall be set to 3.

5.2.5.3.5 *MODE S CLEAR CONFIRMATION BY GDLP*

5.2.5.3.5.1 *Packet format.* The format for this packet shall be as follows:

DP:1	MP:1	SP:2	ST:2	FILL:2	

	TC:2	SN:6	CH:4	AM:4	AG:8

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1 and 5.2.5.2.6. This packet shall be processed as specified in 5.2.6.3.

5.2.5.3.5.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.3.5.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.3.5.4 *Supervisory packet (SP).* This field shall be set to 1.

5.2.5.3.5.5 *Channel number (CH)*: If a channel number has been allocated during the call acceptance phase, then CH shall be set to that value, otherwise it shall be set to zero.

5.2.5.3.5.6 *Temporary channel (TC)*: If a channel number has been allocated during the call acceptance phase, then TC shall be set to zero, otherwise it shall be set to the value used in the CALL REQUEST by GDLP.

5.2.5.3.5.7 *Supervisory type (ST).* This field shall be set to 3.

5.2.5.3.6 *MODE S RESET CONFIRMATION*

5.2.5.3.6.1 *Packet format.* The format for this packet shall be as follows:

DP:1	MP:1	SP:2	ST:2	FILL2:0 or 2	

	FILL:2	SN:6	CH:4	FILL:4

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1. This packet shall be processed as specified in Table 5-14.

5.2.5.3.6.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.3.6.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.3.6.4 *Supervisory packet (SP).* This field shall be set to 2.

5.2.5.3.6.5 *Supervisory type (ST).* This field shall be set to 3.

5.2.5.3.7 *MODE S REJECT*

5.2.5.3.7.1 *Packet format.* The format for this packet shall be as follows:

DP:1	MP:1	SP:2	ST:2	SS:2	

	FILL2:0 or 2	SN:6	CH:4	PR:4

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1. This packet shall be processed as specified in 5.2.6.8.

5.2.5.3.7.2 *Data packet type (DP).* This field shall be set to 0.

5.2.5.3.7.3 *MSP packet type (MP).* This field shall be set to 1.

5.2.5.3.7.4 *Supervisory packet (SP).* This field shall be set to 3.

5.2.5.3.7.5 *Supervisory type (ST).* This field shall be set to 3.

5.2.5.3.7.6 *Supervisory subset (SS).* This field shall be set to 1.

5.2.5.3.7.7 *Packet receive sequence number (PR).* This field shall be set as specified in 5.2.6.4.4.

5.2.6 XDCE operation

Note.— The ADCE process within the ADLP acts as a peer process to the GDCE process in the GDLP.

5.2.6.1 *State transitions.* The XDCE shall operate as a state machine. Upon entering a state, the XDCE shall perform the actions specified in Table 5-14. State transition and additional action(s) shall be as specified in Table 5-15 through Table 5-22.

Note 1.— The next state transition (if any) that occurs when the XDCE receives a packet from the peer XDCE is specified by Table 5-15 through Table 5-19. The same transitions are defined in Table 5-20 through Table 5-22 when the XDCE receives a packet from the DCE (via the reformatting process).

Note 2.— The XDCE state hierarchy is the same as for the DCE as presented in Figure 5-2, except that states r2, r3 and p5 are omitted.

5.2.6.2 DISPOSITION OF PACKETS

5.2.6.2.1 Upon receipt of a packet from the peer XDCE, the packet shall be forwarded or not forwarded to the DCE (via the reformatting process) according to the parenthetical instructions contained in Tables 5-15 to 5-19. If no parenthetical instruction is listed or if the parenthetical instruction indicates "do not forward" the packet shall be discarded.

5.2.6.2.2 Upon receipt of a packet from the DCE (via the reformatting process), the packet shall be forwarded or not forwarded to the peer XDCE according to the parenthetical instructions contained in Tables 5-20 to 5-22. If no parenthetical instruction is listed or if the parenthetical instruction indicates "do not forward" the packet shall be discarded.

5.2.6.3 SVC CALL SETUP AND CLEAR PROCEDURE

5.2.6.3.1 *Setup procedures.* Upon receipt of a CALL REQUEST from the DCE or peer XDCE, the XDLP shall determine if sufficient resources exist to operate the SVC. This shall include: sufficient buffer space (refer to 5.2.5.1.1 for buffer requirements) and an available *p*1 state SVC. Upon acceptance of the CALL REQUEST from the DCE (via the reformatting process), the Mode S CALL REQUEST packet shall be forwarded to frame processing. Upon acceptance of a Mode S CALL REQUEST from the peer XDCE (via frame processing), the Mode S CALL REQUEST shall be sent to the reformatting process.

5.2.6.3.2 *Aborting a call request.* If the DTE and/or the peer XDCE abort a call before they have received a CALL ACCEPT packet, they shall indicate this condition by issuing a CLEAR REQUEST packet. Procedures for handling these cases shall be as specified in Table 5-16 and Table 5-20.

5.2.6.3.3 *VIRTUAL CALL CLEARING*

5.2.6.3.3.1 If the XDCE receives a Mode S CALL REQUEST from the reformatting process that it cannot support, it shall initiate a Mode S CLEAR REQUEST packet that is sent to the DCE (via the reformatting process) for transfer to the DTE (the DCE thus enters the DCE CLEAR REQUEST to DTE state, *p*7).

5.2.6.3.3.2 If the XDCE receives a Mode S CALL REQUEST packet from the peer XDCE (via frame processing) which it cannot support, it shall enter the state *p*7.

5.2.6.3.3.3 A means shall be provided to advise the DTE whether an SVC has been cleared due to the action of the peer DTE or due to a problem within the subnetwork itself.

5.2.6.3.3.4 **Recommendation.—** *The requirement of 5.2.6.3.3.3 should be satisfied by setting bit 8 of the cause field to 1 to indicate that the problem originated in the Mode S subnetwork and not in the DTE. The diagnostic and cause codes should be set as follows:*

a) no channel number available, DC = 71, CC = 133;

b) buffer space not available, DC = 71, CC = 133;

c) DTE not operational, DC = 162, CC = 141; and

d) link failure, DC = 225, CC = 137.

5.2.6.3.3.5 If the ADLP receives a Mode S ROUTE packet with the IN bit set to ONE, the ADLP shall perform local initialization by clearing Mode S SVCs associated with the DTE addresses contained in the ROUTE packet. If the GDLP receives a search request (Table 5-23) from an ADLP, the GDLP shall perform local initialization by clearing Mode S SVCs associated with that ADLP. Local initialization shall be accomplished by:

a) releasing all allocated resources associated with these SVCs (including the resequencing buffers);

b) returning these SVCs to the ADCE ready state (*p*1); and

c) sending Mode S CLEAR REQUEST packets for these SVCs to the DCE (via the reformatting process) for transfer to the DTE.

Note.— This action will allow all ISO 8208 SVCs attached to the Mode S SVCs to be cleared and return to their ready states (p1).

5.2.6.3.4 *Clear confirmation.* When the XDCE receives a Mode S CLEAR CONFIRMATION packet, the remaining allocated resources to manage the SVC shall be released (including the resequencing buffers) and the SVC shall be returned to the *p*1 state. Mode S CLEAR CONFIRMATION packets shall not be transferred to the reformatting process.

5.2.6.3.5 *Clear collision.* A clear collision occurs at the XDCE when it receives a Mode S CLEAR REQUEST packet from the DCE (via the reformatting process) and then receives a Mode S CLEAR REQUEST packet from the peer XDCE (or vice versa). In this event, the XDCE does not expect to receive a Mode S CLEAR CONFIRMATION packet for this SVC and shall consider the clearing complete.

5.2.6.3.6 *Packet processing.* The XDCE shall treat an S-bit sequence of Mode S CALL REQUEST, CALL ACCEPT and CLEAR REQUEST packets as a single entity.

5.2.6.4 DATA TRANSFER AND INTERRUPT PROCEDURES

5.2.6.4.1 *GENERAL PROVISIONS*

5.2.6.4.1.1 Data transfer and interrupt procedures shall apply independently to each SVC. The contents of the user data field shall be passed transparently to the DCE or to the peer XDCE. Data shall be transferred in the order dictated by the sequence numbers assigned to the data packets.

5.2.6.4.1.2 To transfer DATA packets, the SVC shall be in a FLOW CONTROL READY state (*d*1).

5.2.6.4.2 *MODE S PACKET SIZE*

5.2.6.4.2.1 The maximum size of Mode S packets shall be 152 bytes in the uplink direction and 160 bytes in the downlink direction for installations that have full uplink and downlink ELM capability. The maximum downlink packet size for level four transponders with less than 16 segment downlink ELM capability shall be 10 bytes times the maximum number of downlink ELM segments that the transponder specifies in its data link capability report. If there is no ELM capability, the maximum Mode S packet size shall be 28 bytes.

5.2.6.4.2.2 The Mode S subnetwork shall allow packets of less than the maximum size to be transferred.

5.2.6.4.3 *FLOW CONTROL WINDOW SIZE*

5.2.6.4.3.1 The flow control window size of the Mode S subnetwork shall be independent of that used on the DTE/DCE interface. The Mode S subnetwork window size shall be 15 packets in the uplink and downlink directions.

5.2.6.4.4 *SVC FLOW CONTROL*

5.2.6.4.4.1 Flow control shall be managed by means of a sequence number for received packets (PR) and one for packets that have been sent (PS). A sequence number (PS) shall be assigned for each Mode S DATA packet generated by the XDLP for each SVC. The first Mode S DATA packet transferred by the XDCE to frame processing when the SVC has just entered the flow control ready state shall be numbered zero. The first Mode S packet received from the peer XDCE after an SVC has just entered the flow control ready state shall be numbered zero. Subsequent packets shall be numbered consecutively.

5.2.6.4.4.2 A source of Mode S DATA packets (the ADCE or GDCE) shall not send (without permission from the receiver) more Mode S DATA packets than would fill the flow control window. The receiver shall give explicit permission to send more packets.

5.2.6.4.4.3 The permission information shall be in the form of the next expected packet sequence number, and shall be denoted PR. If a receiver wishes to update the window and it has data to transmit to the sender, a Mode S DATA packet shall be used for information transfer. If the window must be updated and no data are to be sent, a Mode S RECEIVE READY (RR) or Mode S RECEIVE NOT READY (RNR) packet shall be sent. At this point, the "sliding window" shall be moved to begin at the new PR value. The XDCE shall now be authorized to transfer more packets without acknowledgement up to the window limit.

5.2.6.4.4.4 When the sequence number (PS) of the next Mode S DATA packet to be sent is in the range $PR \leq PS \leq PR + 14$ (modulo 16), the sequence number shall be defined to be "in the window" and the XDCE shall be authorized to transmit the packet. Otherwise, the sequence number (PS) of the packet shall be defined to be "outside the window" and the XDCE shall not transmit the packet to the peer XDCE.

5.2.6.4.4.5 When the sequence number (PS) of the packet received is next in sequence and within the window, the XDCE shall accept this packet. Receipt of a packet with a PS:

a) outside the window; or

b) out of sequence; or

c) not equal to 0 for the first data packet after entering FLOW CONTROL READY state (*d*1);

shall be considered an error (5.2.6.8).

5.2.6.4.4.6 The receipt of a Mode S DATA packet with a valid PS number (i.e. the next PS in sequence) shall cause the lower window PR to be changed to that PS value plus 1. The packet receive sequence number (PR) shall be conveyed to the originating XDLP by a Mode S DATA, RECEIVE READY, RECEIVE NOT READY, or REJECT packet. A valid PR value shall be transmitted by the XDCE to the peer XDCE after the receipt of 8 packets provided that sufficient buffer space exists to store 15 packets. Incrementing the PR and PS fields shall be performed using modulo 16 arithmetic.

Note.— The loss of a packet which contains the PR value may cause the ADLP/GDLP operations for that SVC to cease.

5.2.6.4.4.7 A copy of a packet shall be retained until the user data has been successfully transferred. Following successful transfer, the PS value shall be updated.

5.2.6.4.4.8 The PR value for user data shall be updated as soon as the required buffer space for the window (as determined by flow control management) is available within the DCE.

5.2.6.4.4.9 Flow control management shall be provided between the DCE and XDCE.

5.2.6.4.5 *INTERRUPT PROCEDURES FOR SWITCHED VIRTUAL CIRCUITS*

5.2.6.4.5.1 If user data is to be sent via the Mode S subnetwork without following the flow control procedures, the interrupt procedures shall be used. The interrupt procedure shall have no effect on the normal data packet and flow control procedures. An interrupt packet shall be delivered to the DTE (or the transponder or interrogator interface) at or before the point in the stream of data at which the interrupt was generated. The processing of a Mode S INTERRUPT packet shall occur as soon as it is received by the XDCE.

Note.— The use of clear, reset, and restart procedures can cause interrupt data to be lost.

5.2.6.4.5.2 The XDCE shall treat an S-bit sequence of Mode S INTERRUPT packets as a single entity.

5.2.6.4.5.3 Interrupt processing shall have precedence over any other processing for the SVC occurring at the time of the interrupt.

5.2.6.4.5.4 The reception of a Mode S INTERRUPT packet before the previous interrupt of the SVC has been confirmed (by the receipt of a Mode S INTERRUPT CONFIRMATION packet) shall be defined as an error. The error results in a reset (see Table 5-18).

5.2.6.5 RECEIVE READY PROCEDURE

5.2.6.5.1 The Mode S RECEIVE READY packet shall be sent if no Mode S DATA packets (that normally contain the updated PR value) are available for transmittal and it is necessary to transfer the latest PR value. It also shall be sent to terminate a receiver not ready condition.

5.2.6.5.2 Receipt of the Mode S RECEIVE READY packet by the XDCE shall cause the XDCE to update its value of PR for the outgoing SVC. It shall not be taken as a demand for retransmission of packets that have already been transmitted and are still in the window.

5.2.6.5.3 Upon receipt of the Mode S RECEIVE READY packet, the XDCE shall go into the ADLP(GDLP) RECEIVE READY state (*g*1).

5.2.6.6 RECEIVE NOT READY PROCEDURE

5.2.6.6.1 The Mode S RECEIVE NOT READY packet shall be used to indicate a temporary inability to accept additional DATA packets for the given SVC. The Mode S RNR condition shall be cleared by the receipt of a Mode S RR packet or a Mode S REJECT packet.

5.2.6.6.2 When the XDCE receives a Mode S RECEIVE NOT READY packet from the peer XDCE, it shall update its value of PR for the SVC and stop transmitting Mode S DATA packets on the SVC to the XDLP. The XDCE shall go into the ADLP(GDLP) RECEIVE NOT READY state (*g*2).

5.2.6.6.3 The XDCE shall transmit a Mode S RECEIVE NOT READY packet to the peer XDCE if it is unable to receive from the peer XDCE any more Mode S DATA packets on the indicated SVC. Under these conditions, the XDCE shall go into the ADCE(GDCE) RECEIVE NOT READY state (*f*2).

5.2.6.7 RESET PROCEDURE

5.2.6.7.1 When the XDCE receives a Mode S RESET REQUEST packet from either the peer XDCE or the DCE (via the reformatting process) or due to an error condition performs its own reset, the following actions shall be taken:

a) those Mode S DATA packets that have been transmitted to the peer XDCE shall be removed from the window;

b) those Mode S DATA packets that are not transmitted to the peer XDCE but are contained in an M-bit sequence for which some packets have been transmitted shall be deleted from the queue of DATA packets awaiting transmission;

c) those Mode S DATA packets received from the peer XDCE that are part of an incomplete M-bit sequence shall be discarded;

d) the lower window edge shall be set to 0 and the next packet sent shall have a sequence number (PS) of 0;

e) any outstanding Mode S INTERRUPT packets to or from the peer XDCE shall be left unconfirmed; and

f) any Mode S INTERRUPT packet awaiting transfer shall be discarded;

g) data packets awaiting transfer shall not be discarded (unless they are part of a partially transferred M-bit sequence); and

h) the transition to *d*1 shall also include a transition to *i*1, *j*1, *f*1 and *g*1.

5.2.6.7.2 The reset procedure shall apply to the DATA TRANSFER state (*p*4). The error procedure in Table 5-16 shall be followed. In any other state the reset procedure shall be abandoned.

5.2.6.8 REJECT PROCEDURE

5.2.6.8.1 When the XDCE receives a Mode S DATA packet from the peer XDCE with incorrect format or whose packet sequence number (PS) is not within the defined window (Table 5-19) or is out of sequence, it shall discard the received packet and send a Mode S REJECT packet to the peer XDCE via frame processing. The Mode S REJECT packet shall indicate a value of PR for which retransmission of the Mode S DATA packets is to begin. The XDCE shall discard subsequent out-of-sequence Mode S DATA packets whose receipt occurs while the Mode S REJECT packet response is still outstanding.

5.2.6.8.2 When the XDCE receives a Mode S REJECT packet from the peer XDCE, it shall update its lower window value with the new value of PR and begin to (re)transmit packets with a sequence number of PR.

5.2.6.8.3 Reject indications shall not be transferred to the DCE. If the ISO 8208 interface supports the reject procedures, the reject indications occurring on the ISO 8208 interface shall not be transferred between the DCE and the XDCE.

5.2.6.9 PACKET RESEQUENCING AND DUPLICATE SUPPRESSION

Note 1.— If the frames for an SVC include both types (SLM and ELM), the sequence of packets may be lost due to the different delivery times. The order may also be lost if multiple interrogators are used to deliver frames for the same SVC to a given XDLP. The following procedure will correct for a limited amount of desequencing.

Note 2.— This process serves as an interface between frame processing and the XDCE function.

5.2.6.9.1 *Resequencing.* Resequencing shall be performed independently for the uplink and downlink transfers of each Mode S SVC. The following variables and parameters shall be used:

SNR A 6-bit variable indicating the sequence number of a received packet on a specific SVC. It is contained in the SN field of the packet (5.2.5.2.1.1.7).

NESN The next expected sequence number following a series of consecutive sequence numbers.

HSNR The highest value of SNR in the resequencing window.

Tq Resequencing timers (see Tables 5-1 and 5-13) associated with a specific SVC.

All operations involving the sequence number (SN) shall be performed modulo 64.

5.2.6.9.2 *Duplication window.* The range of *SNR* values between *NESN* – 32 and *NESN* – 1 inclusive shall be denoted the duplication window.

5.2.6.9.3 *Resequencing window.* The range of *SNR* values between *NESN* + 1 and *NESN* + 31 inclusive shall be denoted the resequencing window. Received packets with a sequence number value in this range shall be stored in the resequencing window in sequence number order.

5.2.6.9.4 *TRANSMISSION FUNCTIONS*

5.2.6.9.4.1 For each SVC, the first packet sent to establish a connection (the first Mode S CALL REQUEST or first Mode S CALL ACCEPT packet) shall cause the value of the *SN* field to be initialized to zero. The value of the *SN* field shall be incremented after the transmission (or retransmission) of each packet.

5.2.6.9.4.2 The maximum number of unacknowledged sequence numbers shall be 32 consecutive *SN* numbers. Should this condition be reached, then it shall be treated as an error and the channel cleared.

Note.— A limit on the number of unacknowledged packets is required since the SN field is six bits long and therefore has a maximum of 64 different values before the values repeat.

5.2.6.9.5 *RECEIVE FUNCTIONS*

5.2.6.9.5.1 *Resequencing.* The resequencing algorithm shall maintain the variables *HSNR* and *NESN* for each SVC. *NESN* shall be initialized to 0 for all SVCs and shall be reset to 0 when the SVC re-enters the channel number pool (5.2.5.1.2).

5.2.6.9.5.2 *Processing of packets within the duplication window.* If a packet is received with a sequence number value within the duplication window, the packet shall be discarded.

5.2.6.9.5.3 *Processing of packets within the resequencing window.* If a packet is received with a sequence number within the resequencing window, it shall be discarded as a duplicate if a packet with the same sequence number has already been received and stored in the resequencing window. Otherwise, the packet shall be stored in the resequencing window. Then, if no *Tq* timers are running, *HSNR* shall be set to the value of *SNR* for this packet and a *Tq* timer shall be started with its initial value (Tables 5-1 and 5-13). If at least one *Tq* timer is running, and *SNR* is not in the window between *NESN* and *HSNR* + 1 inclusive, a new *Tq* timer shall be started and the value of *HSNR* shall be updated. If at least one *Tq* timer is running, and *SNR* for this packet is equal to *HSNR* + 1, the value of *HSNR* shall be updated.

5.2.6.9.5.4 *Release of packets to the XDCE.* If a packet is received with a sequence number equal to *NESN*, the following procedure shall be applied:

a) the packet and any packets already stored in the resequencing window up to the next missing sequence number shall be passed to the XDCE;

b) *NESN* shall be set to 1 + the value of the sequence number of the last packet passed to the XDCE; and

c) the *Tq* timer associated with any of the released packets shall be stopped.

5.2.6.9.6 *Tq timer expiration.* If a *Tq* timer expires, the following procedure shall be applied:

a) *NESN* shall be incremented until the next missing sequence number is detected after that of the packet associated with the *Tq* timer that has expired;

b) any stored packets with sequence numbers that are no longer in the resequencing window shall be forwarded to the XDCE except that an incomplete S-bit sequence shall be discarded; and

c) the *Tq* timer associated with any released packets shall be stopped.

5.2.7 Mode S specific services processing

The data formats and protocols for messages transferred via Mode S specific services shall be as specified in the Appendix to this chapter. Mode S specific services shall be processed by an entity in the XDLP termed the Mode S specific services entity (SSE).

Note 1.— This section describes the processing of control and message data received from the Mode S specific services interface.

Note 2.— Control data consists of information permitting the determination of, for example, message length, BDS code used to access the data format for a particular register, and aircraft address.

5.2.7.1 ADLP PROCESSING

5.2.7.1.1 *DOWNLINK PROCESSING*

5.2.7.1.1.1 *Specific services capability.* The ADLP shall be capable of receiving control and message data from the Mode S specific services interface(s) and sending delivery notices to this interface. The control data shall be processed to determine the protocol type and the length of the message data. When the message or control data provided at this interface are erroneous (i.e. incomplete, invalid or inconsistent), the ADLP shall discard the message and deliver an error report at the interface.

Note.— The diagnostic content and error reporting mechanism are a local issue.

5.2.7.1.1.2 *Broadcast processing.* The control and message data shall be used to format the Comm-B broadcast message as specified in 5.2.7.5 and transferred to the transponder.

5.2.7.1.1.3 *GICB processing.* The 8-bit BDS code shall be determined from the control data. The 7-byte register content shall be extracted from the received message data. The register content shall be transferred to the transponder, along with an indication of the specified register number. A request to address one of the air-initiated Comm-B registers or the airborne collision avoidance system (ACAS) active resolution advisories register shall be discarded. The assignment of registers shall be as specified in Table 5-24.

5.2.7.1.1.4 *MSP processing*

5.2.7.1.1.4.1 The MSP message length, channel number (M/CH) (5.2.7.3.1.3) and optionally the interrogator identifier (II) code shall be determined from the control data. The MSP message content shall be extracted from the received message data. If the message length is 26 bytes or less, the SSE shall format an air-initiated Comm-B message (5.2.7.1.1.4.2) for transfer to the transponder using the short form MSP packet (5.2.7.3.1). If the message length is 27 to 159 bytes and the transponder has adequate downlink ELM capability, the SSE shall format an ELM message for transfer using the short form MSP packet. If the message length is 27 to 159 bytes and the transponder has a limited downlink ELM capability, the SSE shall format multiple long form MSP packets (5.2.7.3.2) using ELM messages, as required utilizing the L-bit and M/SN fields for association of the packets. If the message length is 27 to 159 bytes and the transponder does not have downlink ELM capability, the SSE shall format multiple long form MSP packets (5.2.7.3.2) using air initiated Comm-B messages, as required utilizing the L-bit and M/SN fields for association of the packets. Different frame types shall never be used in the delivery of an MSP message. Messages longer than 159 bytes shall be discarded. The assignment of downlink MSP channel numbers shall be as specified in Table 5-25.

5.2.7.1.1.4.2 For an MSP, a request to send a packet shall cause the packet to be multisite-directed to the interrogator which II code is specified in control data. If no II code is specified, the packet shall be downlinked using the air-initiated protocol. A message delivery notice for this packet shall be provided to the Mode S specific interface when the corresponding close-out(s) have been received from the transponder. If a close-out has not been received from the transponder in *Tz* seconds, as specified in Table 5-1, the MSP packet shall be discarded. This shall include the cancellation in the transponder of any frames associated with this packet. A delivery failure notice for this message shall be provided to the Mode S specific services interface.

5.2.7.1.2 *UPLINK PROCESSING*

Note.— This section describes the processing of Mode S specific services messages received from the transponder.

5.2.7.1.2.1 *Specific services capability.* The ADLP shall be capable of receiving Mode S specific services messages from the transponder via frame processing. The ADLP shall be capable of delivering the messages and the associated control data at the specific services interface. When the resources allocated at this interface are insufficient to accommodate the output data, the ADLP shall discard the message and deliver an error report at this interface.

Note.— The diagnostic content and the error reporting mechanism are a local issue.

5.2.7.1.2.2 *Broadcast processing.* If the received message is a broadcast Comm-A, as indicated by control data received over the transponder/ADLP interface, the broadcast ID and user data (5.2.7.5) shall be forwarded to the Mode S specific services interface (5.2.3.2.1) along with the control data that identifies this as a broadcast message. The assignment of uplink broadcast identifier numbers shall be as specified in Table 5-23.

5.2.7.1.2.3 *MSP processing.* If the received message is an MSP, as indicated by the packet format header (5.2.7.3), the user data field of the received MSP packet shall be forwarded to the Mode S specific services interface (5.2.3.2.1) together with the MSP channel number (M/CH), the IIS subfield (5.2.2.1.1.1) together with control data that identifies this as an MSP message. L-bit processing shall be performed as specified in 5.2.7.4. The assignment of uplink MSP channel numbers shall be as specified in Table 5-25.

5.2.7.2 GDLP PROCESSING

5.2.7.2.1 *UPLINK PROCESSING*

5.2.7.2.1.1 *Specific services capability.* The GDLP shall be capable of receiving control and message data from the Mode S specific services interface(s) (5.2.3.2.2) and sending delivery notices to the interface(s). The control data shall be processed to determine the protocol type and the length of the message data.

5.2.7.2.1.2 *Broadcast processing.* The GDLP shall determine the interrogator(s), broadcast azimuths and scan times from the control data and format the broadcast message for transfer to the interrogator(s) as specified in 5.2.7.5.

5.2.7.2.1.3 *GICB processing.* The GDLP shall determine the register number and the aircraft address from the control data. The aircraft address and BDS code shall be passed to the interrogator as a request for a ground-initiated Comm-B.

5.2.7.2.1.4 *MSP processing.* The GDLP shall extract from the control data the message length, the MSP channel number (M/CH) and the aircraft address, and obtain the message content from the message data. If the message length is 27 bytes or less, the SSE shall format a Comm-A message for transfer to the interrogator using the short form MSP packet (5.2.7.3.1). If the message length is 28 to 151 bytes and the transponder has uplink ELM capability, the SSE shall format an ELM message for transfer to the interrogator using the short form MSP packet. If the message length is 28 to 151 bytes and the transponder does not have uplink ELM capability, the SSE shall format multiple long form MSP packets (5.2.7.3.2) utilizing the L-bit and the M/SN fields for association of the packets. Messages longer than 151 bytes shall be discarded. The interrogator shall provide a delivery notice to the Mode S specific services interface(s) indicating successful or unsuccessful delivery, for each uplinked packet.

5.2.7.2.2 *DOWNLINK PROCESSING*

5.2.7.2.2.1 *Specific services capability.* The GDLP shall be capable of receiving Mode S specific services messages from the interrogator via frame processing.

5.2.7.2.2.2 *Broadcast processing.* If the received message is a broadcast Comm-B, as indicated by the interrogator/GDLP interface, the GDLP shall:

a) generate control data indicating the presence of a broadcast message and the 24-bit address of the aircraft from which the message was received;

b) append the 7-byte MB field of the broadcast Comm-B; and

c) forward this data to the Mode S specific services interface(s) (5.2.3.2.2).

5.2.7.2.2.3 *GICB processing.* If the received message is a GICB, as indicated by the interrogator/GDLP interface, the GDLP shall:

a) generate control data indicating the presence of a GICB message, the register number and the 24-bit address of the aircraft from which the message was received;

b) append the 7-byte MB field of the GICB; and

c) forward this data to the Mode S specific services interface(s) (5.2.3.2.2).

5.2.7.2.2.4 *MSP processing.* If the received message is an MSP as indicated by the packet format header (5.2.7.3), the GDLP shall:

a) generate control data indicating the transfer of an MSP, the length of the message, the MSP channel number (M/CH) and the 24-bit address of the aircraft from which the message was received;

b) append the user data field of the received MSP packet; and

c) forward this data to the Mode S specific services interface(s) (5.2.3.2.2).

L-bit processing shall be performed as specified in 5.2.7.4.

5.2.7.3 MSP PACKET FORMATS

5.2.7.3.1 *Short form MSP packet.* The format for this packet shall be as follows:

DP:1	MP:1	M/CH:6	FILL1:0 or 6	UD:v

5.2.7.3.1.1 *Data packet type (DP).* This field shall be set to 0.

5.2.7.3.1.2 *MSP packet type (MP).* This field shall be set to 0.

5.2.7.3.1.3 *MSP channel number (M/CH).* The field shall be set to the channel number derived from the SSE control data.

5.2.7.3.1.4 *Fill field (FILL1:0 or 6).* The fill length shall be 6 bits for a downlink SLM frame. Otherwise the fill length shall be 0.

5.2.7.3.1.5 *User data (UD).* The user data field shall contain message data received from the Mode S specific services interface (5.2.3.2.2).

5.2.7.3.2 *Long form MSP packet.* The format for this packet shall be as follows:

DP:1	MP:1	SP:2	L:1	M/SN:3	FILL2:0 or 2	M/CH:6	UD:v

Fields shown in the packet format and not specified in the following paragraphs shall be set as specified in 5.2.5.2.1 and 5.2.7.3.1.

5.2.7.3.3 *Data packet type (DP).* This field shall be set to 0.

5.2.7.3.3.1 *MSP packet type (MP).* This field shall be set to 1.

5.2.7.3.3.2 *Supervisory packet (SP).* This field shall be set to 0.

5.2.7.3.3.3 *L field (L).* A value of 1 shall indicate that the packet is part of an L-bit sequence with more packets in the sequence to follow. A value of 0 shall indicate that the sequence ends with this packet.

5.2.7.3.3.4 *MSP sequence number field (M/SN).* This field shall be used to detect duplication in the delivery of L-bit sequences. The first packet in an L-bit sequence shall be assigned a sequence number of 0. Subsequent packets shall be numbered sequentially. A packet received with the same sequence number as the previously received packet shall be discarded.

5.2.7.4 *L-bit processing.* L-bit processing shall be performed only on the long form MSP packet and shall be performed as specified for M-bit processing (5.2.5.1.4.1) except as specified in the following paragraphs.

5.2.7.4.1 Upon receipt of a long form MSP packet, the XDLP shall construct the user data field by:

a) verifying that the packet order is correct using the M/SN field (5.2.7.3.2);

b) assuming that the user data field in the MSP packet is the largest number of integral bytes that is contained within the frame;

c) associating each user data field in an MSP packet received with a previous user data field in an MSP packet that has an L-bit value of 1; and

Note.— Truncation of the user data field is not permitted as this is treated as an error condition.

d) if an error is detected in the processing of an MSP packet, the packet shall be discarded.

5.2.7.4.2 In the processing of an L-bit sequence, the XDLP shall discard any MSP packets that have duplicate M/SN values. The XDLP shall discard the entire L-bit sequence if a long form MSP packet is determined to be missing by use of the M/SN field.

5.2.7.4.3 The packets associated with any L-bit sequence whose reassembly is not completed in *Tm* seconds (Tables 5-1 and 5-13) shall be discarded.

5.2.7.5 *BROADCAST FORMAT*

5.2.7.5.1 *Uplink Broadcast*. The format of the broadcast Comm-A shall be as follows: The 83-bit uplink broadcast shall be inserted in an uplink Comm-A frame. The MA field of the Comm-A frame shall contain the broadcast identifier specified in Table 5-23 in the first 8 bits, followed by the first 48 user data bits of the broadcast message. The last 27 user data bits of the broadcast message shall be placed in the 27 bits immediately following the UF field of the Comm-A frame.

5.2.7.5.2 *Downlink Broadcast.* The format of broadcast Comm-B shall be as follows: The 56-bit downlink broadcast message shall be inserted in the MB field of the broadcast Comm-B. The MB field shall contain the broadcast identifier specified in Table 5-23 in the first 8 bits, followed by the 48 user data bits.

5.2.8 Mode S subnetwork management

5.2.8.1 INTERROGATOR LINK DETERMINATION FUNCTION

Note.— The ADLP interrogator link determination function selects the II code of the Mode S interrogator through which a Mode S subnetwork packet may be routed to the desired destination ground DTE.

5.2.8.1.1 *II code-DTE address correlation.* The ADLP shall construct and manage a Mode S interrogator-data terminal equipment (DTE) cross-reference table whose entries are Mode S interrogator identifier (II) codes and ground DTE addresses associated with the ground ATN routers or other ground DTEs. Each entry of the II code-DTE cross-reference table shall consist of the 4-bit Mode S II code and the 8-bit binary representation of the ground DTE.

Note 1.— Due to the requirement for non-ambiguous addresses, a DTE address also uniquely identifies a GDLP.

Note 2.— An ATN router may have more than one ground DTE address.

5.2.8.1.2 *Protocol.* The following procedures shall be used:

a) when the GDLP initially detects the presence of an aircraft, or detects contact with a currently acquired aircraft through an interrogator with a new II code, the appropriate fields of the DATA LINK CAPABILITY report shall be examined to determine if, and to what level, the aircraft has the capability to participate in a data exchange. After positive determination of data link capability, the GDLP shall uplink one or more Mode S ROUTE packets as specified in 5.2.5.3.3. This information shall relate the Mode S II code with the ground DTE addresses accessible through that interrogator. The ADLP shall update the II code-DTE cross-reference table and then discard the Mode S ROUTE packet(s);

b) a II code-DTE cross-reference table entry shall be deleted when commanded by a Mode S ROUTE packet or when the ADLP recognizes that the transponder has not been selectively interrogated by a Mode S interrogator with a given II code for *Ts* seconds by monitoring the IIS subfield in Mode S surveillance or Comm-A interrogations (Table 5-1);

c) when the GDLP determines that modification is required to the Mode S interrogator assignment, it shall transfer one or more Mode S ROUTE packets to the ADLP. The update information contained in the Mode S ROUTE packet shall be used by the ADLP to modify its cross-reference table. Additions shall be processed before deletions;

d) when the GDLP sends the initial ROUTE packet after acquisition of a Mode S data link-equipped aircraft, the IN bit shall be set to ONE. This value shall cause the ADLP to perform the procedures as specified in 5.2.6.3.3.3. Otherwise, the IN bit shall be set to ZERO;

e) when the ADLP is initialized (e.g. after a power-up procedure), the ADLP shall issue a search request by sending a broadcast Comm-B message with broadcast identifier equal to 255 (FF_{16}, as specified in Table 5-23) and the remaining 6 bytes unused. On receipt of a search request, a GDLP shall respond with one or more Mode S ROUTE packets, clear all SVCs associated with the ADLP, as specified in 5.2.6.3.3, and discard the search request. This shall cause the ADLP to initialize the II code-DTE cross-reference table; and

f) on receipt of an update request (Table 5-23), a GDLP shall respond with one or more Mode S ROUTE packets and discard the update request. This shall cause the ADLP to update the II code-DTE cross-reference table.

Note.— The update request may be used by the ADLP under exceptional circumstances (e.g. changeover to standby unit) to verify the contents of its II code-DTE cross-reference table.

5.2.8.1.3 *PROCEDURES FOR DOWNLINKING MODE S PACKETS*

5.2.8.1.3.1 When the ADLP has a packet to downlink, the following procedures shall apply:

a) *CALL REQUEST packet.* If the packet to be transferred is a Mode S CALL REQUEST, the ground DTE address field shall be examined and shall be associated with a connected Mode S interrogator using the II code-DTE cross-reference table. The packet shall be downlinked using the multisite-directed protocol. A request to transfer a packet to a DTE address not in the cross-reference table shall result in the action specified in 5.2.6.3.3.1.

b) *Other SVC packets.* For an SVC, a request to send a packet to a ground DTE shall cause the packet to be multisite-directed to the last Mode S interrogator used to successfully transfer (uplink or downlink) a packet to that DTE, provided that this Mode S interrogator is currently in the II code-DTE cross-reference table. Otherwise, an SVC packet shall be downlinked using the multisite-directed protocol to any other Mode S interrogator associated with the specified ground DTE address.

Level 5 transponders shall be permitted to use additional interrogators for downlink transfer as indicated in the II code-DTE cross-reference table.

5.2.8.1.3.2 A downlink frame transfer shall be defined to be successful if its Comm-B or ELM close-out is received from the transponder within *Tz* seconds as specified in Table 5-1. If the attempt is not successful and an SVC packet is to be sent, the II code-DTE cross-reference table shall be examined for another entry with the same called ground DTE address and a different Mode S II code. The procedure shall be retried using the multisite-directed protocol with the new Mode S interrogator. If there are no entries for the required called DTE, or all entries result in a failed attempt, a link failure shall be declared (5.2.8.3.1).

5.2.8.2 SUPPORT FOR THE DTE(S)

5.2.8.2.1 *GDLP connectivity reporting.* The GDLP shall notify the ground DTE(s) of the availability of a Mode S data link-equipped aircraft ("join event"). The GDLP shall also inform the ground DTEs when such an aircraft is no longer in contact via that GDLP ("leave event"). The GDLP shall provide for notification (on request) of all Mode S data link-equipped aircraft currently in contact with that GDLP. The notifications shall provide the ground ATN router with the subnetwork point of attachment (SNPA) address of the mobile ATN router, with the position of the aircraft and quality of service as optional parameters. The SNPA of the mobile ATN router shall be the DTE address formed by the aircraft address and a sub-address of 0 (5.2.3.1.3.2).

5.2.8.2.2 *ADLP connectivity reporting.* The ADLP shall notify all aircraft DTEs whenever the last remaining entry for a ground DTE is deleted from the II code-DTE cross-reference table (5.2.8.1.1). This notification shall include the address of this DTE.

5.2.8.2.3 *Communications requirements.* The mechanism for communication of changes in subnetwork connectivity shall be a confirmed service, such as the join/leave events that allow notification of the connectivity status.

5.2.8.3 ERROR PROCEDURES

5.2.8.3.1 *Link failure.* The failure to deliver a packet to the referenced XDLP after an attempt has been made to deliver this packet via all available interrogators shall be declared to be a link level failure. For an SVC, the XDCE shall enter the state *p*1, and release all resources associated with that channel. This shall include the cancellation in the transponder of any frames associated with this SVC. A Mode S CLEAR REQUEST packet shall be sent to the DCE via the reformatting process and shall be forwarded by the DCE as an ISO 8208 packet to the local DTE as described in 5.2.6.3.3. On the aircraft side, the channel shall not be returned to the ADCE channel pool, i.e. does not return to the state *p*1, until *Tr* seconds after the link failure has been declared (Table 5-1).

5.2.8.3.2 *ACTIVE CHANNEL DETERMINATION*

5.2.8.3.2.1 *Procedure for d1 state.* The XDLP shall monitor the activity of all SVCs, not in a READY state (*p*1). If an SVC is in the (XDCE) FLOW CONTROL READY state (*d*1) for more than *Tx* seconds (the active channel timer, Tables 5-1 and 5-13) without sending a Mode S RR, RNR, DATA, or REJECT packet, then:

a) if the last packet sent was a Mode S REJECT packet to which a response has not been received, then the XDLP shall resend that packet;

b) otherwise, the XDLP shall send a Mode S RR or RNR packet as appropriate to the peer XDLP.

5.2.8.3.2.2 *Procedure for other states.* If an XDCE SVC is in the *p*2, *p*3, *p*6, *p*7, *d*2 or *d*3 state for more than *Tx* seconds, the link failure procedure of 5.2.8.3.1 shall be performed.

5.2.8.3.2.3 Link failure shall be declared if either a failure to deliver, or a failure to receive, keep-alive packets has occurred. In which case the channel shall be cleared.

5.2.9 The data link capability report format

5.2.9.1 This report shall be transferred using the ground-initiated Comm-B protocol, as specified in 3.1.2.6.10.2 of Annex 10, Volume IV.

5.2.9.2 *Format.* The format of the MB field shall be as follows:

Bit	*Content*
1-8	BDS = 10_{16}
9	Continuation flag 0 = No continuation 1 = Continues in the next register

10-15 Unassigned

16 Reserved for ACAS

17-23 Mode S Subnetwork Version No.
0 = Mode S subnetwork not available
1 = Version No. 1 (1996)
2 = Version No. 2 (1998)
3 = Version No. 3 (2002)
4-127 = Unassigned

24 Transponder level (2.1.5 of Annex 10, Volume IV)
0 = Level 2-4
1 = Level 5

25 Mode S specific services capability
0 = Not available
1 = Available

26-28 Uplink ELM Average Throughput Capability
0 = No UELM Capability
1 = 16 UELM segments in 1 second
2 = 16 UELM segments in 500 ms
3 = 16 UELM segments in 250 ms
4 = 16 UELM segments in 125 ms
5 = 16 UELM segments in 60 ms
6 = 16 UELM segments in 30 ms
7 = Unassigned

29-32 Downlink ELM: Throughput Capability of downlink ELM containing the maximum number of ELM segments that the transponder can deliver in response to a single requesting interrogation (UF = 24).
0 = No DELM capability
1 = One 4-segment DELM every second
2 = One 8-segment DELM every second
3 = One 16-segment DELM every second
4 = One 16-segment DELM every 500 ms
5 = One 16-segment DELM every 250 ms
6 = One 16-segment DELM every 125 ms
7-15 = Unassigned

33 Aircraft Identification Capability (Table 5-24)
0 = No aircraft identification capability
1 = Aircraft identification capability

34 Squitter capability subfield

35 Surveillance identifier capability

36 Common usage GICB capability report

37-40 Reserved for ACAS

41-56 Bit array indicating the support status of DTE sub-address 0 to 15
Bit value 0 = DTE not supported
Bit value 1 = DTE supported

Note.— The Mode S transponder may update bits 1-8, 16 and 37-40 independent of the ADLP. Bits 1-8 are provided by the transponder when the data link capability report is broadcast as a result of a transponder-detected change in capability reported by the ADLP (3.1.2 of Annex 10, Volume IV).

5.2.9.3 *Protocol.* In all cases, the first bit shall be the high order bit and shall be the first bit transmitted. ADLP frame processing shall generate the data link capability report at least once per second and transfer it to the transponder at least once every second.

5.2.10 System timers

5.2.10.1 The values for timers shall conform to the values given in Tables 5-1 and 5-13.

5.2.10.2 Tolerance for all timers shall be plus or minus one percent.

5.2.10.3 Resolution for all timers shall be one second.

5.2.11 System requirements

5.2.11.1 *Data integrity.* The maximum bit error rates for data presented at the ADLP/transponder interface or the GDLP/interrogator interface measured at the local DTE/XDLP interface (and vice versa) shall not exceed 10^{-9} for undetected errors and 10^{-7} for detected errors.

Note.— The maximum error rate includes all errors resulting from data transfers across the interfaces and from XDLP internal operation.

5.2.11.2 TIMING

5.2.11.2.1 *ADLP timing.* ADLP operations shall not take longer than 0.25 seconds for regular traffic and 0.125 seconds for interrupt traffic. This interval shall be defined as follows:

a) *Transponders with downlink ELM capability.* The time that the final bit of a 128-byte data packet is presented to the DCE for downlink transfer to the time that the final bit of the first encapsulating frame is available for delivery to the transponder.

b) *Transponders with Comm-B capability.* The time that the final bit of a user data field of 24 bytes is presented to the DCE for downlink transfer to the time that the final bit of the last of the four Comm-B segments that forms the frame encapsulating the user data is available for delivery to the transponder.

c) *Transponders with uplink ELM capability.* The time that the final bit of the last segment of an ELM of 14 Comm-C segments that contains a user data field of 128 bytes is received by the ADLP to the time that the final bit of the corresponding packet is available for delivery to the DTE.

d) *Transponders with Comm-A capability.* The time that the final bit of the last segment of four linked Comm-A segments that contains a user data field of 25 bytes is received by the ADLP to the time that the final bit of the corresponding packet is available for delivery to the DTE.

5.2.11.2.2 *GDLP TIMING*

Recommendation.— *The total time delay across the GDLP, exclusive of transmission delay, should not be greater than 0.125 seconds.*

5.2.11.3 *Interface rate.* The physical interface between the ADLP and the transponder shall have a minimum bit rate of 100 kilobits per second.

5.3 DCE AND XDCE STATE TABLES

5.3.1 *State table requirements.* The DCE and XDCE shall function as specified in state Tables 5-3 to 5-22. State Tables 5-15 through 5-22 shall be applied to:

a) ADLP state transitions when the XDCE or XDLP terms in parenthesis are omitted; and

b) GDLP state transitions when the terms in parenthesis are used and the XDCE or XDLP preceding them are omitted.

5.3.2 *Diagnostic and cause codes.* The table entries for certain conditions indicate a diagnostic code that shall be included in the packet generated when entering the state indicated. The term, "*D =* ," shall define the diagnostic code. When "*A = DIAG*," the action taken shall be to generate an ISO 8208 DIAGNOSTIC packet and transfer it to the DTE; the diagnostic code indicated shall define the entry in the diagnostic field of the packet. The cause field shall be set as specified in 5.2.6.3.3. The reset cause field shall be set as specified in ISO 8208.

Note 1.— The tables provided below specify state requirements in the following order:

5-3 DCE special cases

5-4 DTE effect on DCE restart states

5-5 DTE effect on DCE call setup and clearing states

5-6 DTE effect on DCE reset states

5-7 DTE effect on DCE interrupt transfer states

5-8 DTE effect on DCE flow control transfer states

5-9 XDCE effect on DCE restart states

5-10 XDCE effect on DCE call setup and clearing states

5-11 XDCE effect on DCE reset states

5-12 XDCE effect on DCE interrupt transfer states

5-15 GDLP (ADLP) effect on ADCE (GDCE) packet layer ready states

5-16 GDLP (ADLP) effect on ADCE (GDCE) call setup and clearing states

5-17 GDLP (ADLP) effect on ADCE (GDCE) reset states

5-18 GDLP (ADLP) effect on ADCE (GDCE) interrupt transfer states

5-19 GDLP (ADLP) effect on ADCE (GDCE) flow control transfer states

5-20 DCE effect on ADCE (GDCE) call setup and clearing states

5-21 DCE effect on ADCE (GDCE) reset states

5-22 DCE effect on ADCE (GDCE) interrupt transfer states

Note 2.— All tables specify both ADLP and GDLP actions.

Note 3.— Within the Mode S subnetwork, states p6 *and* d2 *are transient states.*

Note 4.— References to "notes" in the state tables refer to table-specific notes that follow each state table.

Note 5.— All diagnostic and cause codes are interpreted as decimal numbers.

Note 6.— An SVC between an ADCE and a GDCE may be identified by a temporary and/or permanent channel number, as defined in 5.2.5.1.2.

5.4 MODE S PACKET FORMATS

5.4.1 *Formats.* The Mode S packet formats shall be as specified in Figures 5-3 to 5-22.

5.4.2 *Significance of control fields.* The structure of the format control fields used in Mode S packets shall be as specified in Figure 5-23. The significance of all control fields used in these packet formats shall be as follows:

Field symbol	*Definition*
AG	Address, Ground; the 8-bit binary representation of the ground DTE address (5.2.3.1.3.1)
AM	Address, Mobile; the 4-bit binary representation of the last two BCD digits of the mobile DTE address (5.2.3.1.3.2)
CC	Clearing cause as defined in ISO 8208
CH	Channel number (1 to 15)
DC	Diagnostic code as defined in ISO 8208
DP	Data packet type (Figure 5-23)
F	S-bit sequence, first packet flag
FILL	Fill field
FILL1	Has a length of 6 bits for a non-multiplexed packet in a downlink SLM frame; otherwise it is 0 bit
FILL2	Has a length of 0 bit for a non-multiplexed packet in a downlink SLM frame and for a multiplexing header; otherwise it is 2 bits
FIRST PACKET	The contents of the first of the multiplexed packets
FS	Fast select present
IN	Initialization bit
L	"More bit" for long-form MSP packets as specified in 5.2.7.4
LAST PACKET	The contents of the last of the multiplexed packets
LENGTH	The length of a multiplexed packet in bytes expressed as an unsigned binary number
LV	User data field length; number of user bytes as specified in 5.2.2.3.1
M	"More bit" for SVC DATA packets as specified in 5.2.5.1.4.1
M/CH	MSP channel number
MP	MSP packet type (Figure 5-23)
M/SN	Sequence number; the sequence number for the long form MSP packet
OD	Optional data
ODL	Optional data length
OF	Option flag
P	Priority field
PR	Packet receive sequence number
PS	Packet send sequence number
RC	Resetting cause code as defined in ISO 8208
RT	Route table as defined in 5.2.5.3.3.8
RTL	Route table length expressed in bytes
S	"More bit" for CALL REQUEST, CALL ACCEPT, CLEAR REQUEST and INTERRUPT packets as specified in 5.2.5.1.4.2
SN	Sequence number; the sequence number for this packet type
SP	Supervisory packet (Figure 5-23)
SS	Supervisory subset number (Figure 5-23)
ST	Supervisory type (Figure 5-23)
TC	Temporary channel number (1 to 3)
UD	User data field

TABLES FOR CHAPTER 5

Table 5-1. ADLP Mode S subnetwork timers

Timer name	*Timer label*	*Nominal value*	*Reference*
Channel retirement	*Tr*	600 s	5.2.8.3.1
Active channel-ADLP	*Tx*	420 s	5.2.8.3.2
Interrogator interrogation	*Ts*	60 s	5.2.8.1.2
Interrogator link	*Tz*	30 s	5.2.7.1.1.4.2, 5.2.8.1.3.2
Link frame cancellation	*Tc*	60 s	5.2.2.1.1.4.5
L-bit delivery-ADLP	*Tm*	120 s	5.2.7.4.3
Packet resequencing and S-bit delivery	*Tq*	60 s	5.2.6.9

Table 5-2. DCE actions at state transition

DCE state	*State definition*	*Action that shall be taken when entering the state*
*r*1	PACKET LEVEL READY	Return all SVCs to the *p*1 state (see *p*1 state explanation).
*r*2	DTE RESTART REQUEST	Return each SVC to the *p*1 state (see *p*1 state explanation). Issue a RESTART CONFIRMATION to the DTE.
*r*3	DCE RESTART REQUEST	Issue a RESTART REQUEST to the DTE. Unless entered via the *r*2 state, send a RESTART REQUEST to the reformatting process.
*p*1	READY	Release all resources assigned to SVC. Break the correspondence between the DTE/DCE SVC and the ADCE/GDCE SVC (the ADCE/GDCE SVC may not yet be in the *p*1 state).
*p*2	DTE CALL REQUEST	Determine if sufficient resources exist to support request; if so, allocate resources and forward CALL REQUEST packet to reformatting process; if not, enter DCE CLEAR REQUEST to DTE state (*p*7). Determination of resources and allocation is as defined in ISO 8208.
*p*3	DCE CALL REQUEST	Determine if sufficient resources exist to support request; if so allocate resources and forward CALL REQUEST packet to DTE; if not, send a CLEAR REQUEST packet to the reformatting process. Determination of resources and allocation is as defined in ISO 8208.
*p*4	DATA TRANSFER	No action.
*p*5	CALL COLLISION	Reassign outgoing call to another SVC (the DTE in its call collision state ignores the incoming call) and enter the DCE CALL REQUEST state (*p*3) for that new SVC. Enter the *p*2 state to process the CALL REQUEST from the DTE.
*p*6	DTE CLEAR REQUEST	Release all resources assigned to SVC, send a CLEAR CONFIRMATION packet to the DTE and enter *p*1 state.
*p*7	DCE CLEAR REQUEST to DTE	Forward CLEAR REQUEST packet to DTE.
*d*1	FLOW CONTROL READY	No action.
*d*2	DTE RESET REQUEST	Remove DATA packets transmitted to DTE from window; discard any DATA packets that represent partially transmitted M-bit sequences and discard any INTERRUPT packet awaiting transfer to the DTE; reset all window counters to 0; set any timers and retransmission parameters relating to DATA and INTERRUPT transfer to their initial value. Send RESET CONFIRMATION packet to DTE. Return SVC to *d*1 state.

DCE state	*State definition*	*Action that shall be taken when entering the state*
*d*3	DCE RESET REQUEST to DTE	Remove DATA packets transmitted to DTE from window; discard any DATA packets that represent partially transmitted M-bit sequences and discard any INTERRUPT packet awaiting transfer to the DTE; reset all window counters to 0; set any timers and retransmission parameters relating to DATA and INTERRUPT transfer to their initial value. Forward RESET REQUEST packet to DTE.
*i*1	DTE INTERRUPT READY	No action.
*i*2	DTE INTERRUPT SENT	Forward INTERRUPT packet received from DTE to reformatting process.
*j*1	DCE INTERRUPT READY	No action.
*j*2	DCE INTERRUPT SENT	Forward INTERRUPT packet received from reformatting process to DTE.
*f*1	DCE RECEIVE READY	No action.
*f*2	DCE RECEIVE NOT READY	No action.
*g*1	DTE RECEIVE READY	No action.
*g*2	DTE RECEIVE NOT READY	No action.

Table 5-3. DCE special cases

Received from DTE	*DCE special cases* *Any state*
Any packet less than 2 bytes in length (including a valid data link level frame containing no packet)	A=DIAG *D*=38
Any packet with an invalid general format identifier	A=DIAG *D*=40
Any packet with a valid general format identifier and an assigned logical channel identifier (includes a logical channel identifier of 0)	See Table 5-4

Table 5-4. DTE effect on DCE restart states

Packet received from DTE	DCE restart states (see Note 5) PACKET LEVEL READY (see Note 1) *r*1	DTE RESTART REQUEST *r*2	DCE RESTART REQUEST *r*3
Packets having a packet type identifier shorter than 1 byte and logical channel identifier not equal to 0	See Table 5-5	*A=ERROR* *S=r*3 *D*=38 (see Note 4)	*A=DISCARD*
Any packet, except RESTART, REGISTRATION (if supported) with a logical channel identifier of 0	*A=DIAG* *D*=36	*A=DIAG* *D*=36	*A=DIAG* *D*=36
Packet with a packet type identifier which is undefined or not supported by DCE	See Table 5-5	*A=ERROR* *S=r*3 *D*=33 (see Note 4)	*A=DISCARD*
RESTART REQUEST, RESTART CONFIRMATION, or REGISTRATION (if supported) packet with a logical channel identifier unequal to 0	See Table 5-5	*A=ERROR* *S=r*3 *D*=41 (see Note 4)	*A=DISCARD*
RESTART REQUEST	*A=NORMAL* (forward) *S=r*2	*A=DISCARD*	*A=NORMAL* *S=p*1 or *d*1 (see Note 2)
RESTART CONFIRMATION	*A=ERROR* *S=r*3 *D*=17 (see Note 6)	*A=ERROR* *S=r*3 *D*=18 (see Note 4)	*A=NORMAL* *S=p*1 or *d*1 (see Note 2)
RESTART REQUEST OR RESTART CONFIRMATION packet with a format error	*A=DIAG* *D*=38, 39, 81 or 82	*A=DISCARD*	*A=ERROR* *D*=38, 39, 81 or 82
REGISTRATION REQUEST or REGISTRATION CONFIRMATION packets (see Note 3)	*A=NORMAL*	*A=NORMAL*	*A=NORMAL*
REGISTRATION REQUEST or REGISTRATION CONFIRMATION packet with a format error (see Note 3)	*A=DIAG* *D*=38, 39, 81 or 82	*A=ERROR* *S=r*3 *D*=38, 39, 81 or 82 (see Note 4)	*A=ERROR* *D*=38, 39, 81 or 82
Call setup, call clearing, DATA, interrupt, flow control, or reset packet	See Table 5-5	*A=ERROR* *S*=r3 *D*=18	*A=DISCARD*

NOTES:

1. The Mode S subnetwork has no restart states. Receipt of a RESTART REQUEST causes the DCE to respond with a RESTART CONFIRMATION. The RESTART REQUEST packet is forwarded to the reformatting process, which issues clear requests for all SVCs associated with the DTE. The DCE enters the *r*3 state only as a result of an error detected on the DTE/DCE interface.
2. The SVC channels are returned to state *p*1, the permanent virtual circuits (PVC) channels are returned to state *d*1.
3. The use of the registration facility is optional on the DTE/DCE interface.
4. No action is taken within the Mode S subnetwork.
5. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared for the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.
6. The error procedure consists of entering the *r*3 state, and sending a RESTART REQUEST to the reformatting process.

Table 5-5. DTE effect on DCE call setup and clearing states

Packet received from DTE	DCE call setup and clearing states (see Note 5) READY *p*1	DTE CALL REQUEST *p*2	DCE CALL REQUEST *p*3	DATA TRANSFER *p*4	CALL COLLISION *p*5 (see Notes 1 and 4)	DTE CLEAR REQUEST *p*6	DCE CLEAR REQUEST to DTE *p*7
Packets having a packet type identifier shorter than 1 byte	*A*=*ERROR* *S*=*p*7 *D*=38	*A*=*ERROR* *S*=*p*7 *D*=38 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=38 (see Note 2)	See Table 5-6	*A*=*ERROR* *S*=*p*7 *D*=38 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=38 (see Note 2)	*A*=*DISCARD*
Packets having a packet type identifier which is undefined or not supported by DCE	*A*=*ERROR* *S*=*p*7 *D*=33	*A*=*ERROR* *S*=*p*7 *D*=33 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=33 (see Note 2)	See Table 5-6	*A*=*ERROR* *S*=*p*7 *D*=33 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=33 (see Note 2)	*A*=*DISCARD*
RESTART REQUEST, RESTART CONFIRMATION or REGISTRATION packet with logical channel identifier unequal to 0	*A*=*ERROR* *S*=*p*7 *D*=41	*A*=*ERROR* *S*=*p*7 *D*=41 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=41 (see Note 2)	See Table 5-6	*A*=*ERROR* *S*=*p*7 *D*=41 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=41 (see Note 2)	*A*=*DISCARD*
CALL REQUEST	*A*=*NORMAL* *S*=*p*2 (forward)	*A*=*ERROR* *S*=*p*7 *D*=21 (see Note 2)	*A*=*NORMAL* *S*=*p*5	*A*=*ERROR* *S*=*p*7 *D*=23 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=24 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=25 (see Note 2)	*A*=*DISCARD*
CALL ACCEPT	*A*=*ERROR* *S*=*p*7 *D*=20	*A*=*ERROR* *S*=*p*7 *D*=21 (see Note 2)	*A*=*NORMAL* *S*=*p*4 (Forward) or *A*=*ERROR* *S*=*p*7 *D*=42 (see Notes 2 and 3)	*A*=*ERROR* *S*=*p*7 *D*=23 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=24 (see Notes 2 and 4)	*A*=*ERROR* *S*=*p*7 *D*=25 (see Note 2)	*A*=*DISCARD*
CLEAR REQUEST	*A*=*NORMAL* *S*=*p*6	*A*=*NORMAL* *S*=*p*6 (forward)	*A*=*NORMAL* *S*=*p*6 (forward)	*A*=*NORMAL* *S*=*p*6 (forward)	*A*=*NORMAL* *S*=*p*6 (forward)	*A*=*DISCARD*	*A*=*NORMAL* *S*=*p*1 (do not forward)
CLEAR CONFIRMATION	*A*=*ERROR* *S*=*p*7 *D*=20	*A*=*ERROR* *S*=*p*7 *D*=21 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=22 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=23 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=24 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=25 (see Note 2)	*A*=*NORMAL* *S*=*p*1 (do not forward)
DATA, interrupt, flow control or reset packets	*A*=*ERROR* *S*=*p*7 *D*=20	*A*=*ERROR* *S*=*p*7 *D*=21 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=22 (see Note 2)	See Table 5-6	*A*=*ERROR* *S*=*p*7 *D*=24 (see Note 2)	*A*=*ERROR* *S*=*p*7 *D*=25 (see Note 2)	*A*=*DISCARD*

NOTES:

1. On entering the *p*5 state, the DCE reassigns the outgoing call to the DTE to another channel (no CLEAR REQUEST is issued) and responds to incoming DTE call as appropriate with a CLEAR REQUEST or CALL ACCEPT packet.
2. The error procedure consists of performing the actions specified when entering the *p*7 state (including sending a CLEAR REQUEST packet to the DTE) and additionally sending a CLEAR REQUEST packet to the XDCE (via the reformatting process).
3. The use of the fast select facility with a restriction on the response prohibits the DTE from sending a CALL ACCEPT packet.
4. The DTE in the event of a call collision must discard the CALL REQUEST packet received from the DCE.
5. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.

Table 5-6. DTE effect on DCE reset states

	DCE reset states (see Note 2)		
Packet received from DTE	FLOW CONTROL READY *d*1	RESET REQUEST by DTE *d*2	DCE RESET REQUEST to DTE *d*3
Packet with a packet type identifier shorter than 1 byte	*A=ERROR* *S=d*3 *D*=38 (see Note 1)	*A=ERROR* *S=d*3 *D*=38 (see Note 1)	*A=DISCARD*
Packet with a packet type identifier which is undefined or not supported by DCE	*A=ERROR* *S=d*3 *D*=33 (see Note 1)	*A=ERROR* *S=d*3 *D*=33 (see Note 1)	*A=DISCARD*
RESTART REQUEST, RESTART CONFIRMATION, or REGISTRATION (if supported) packet with logical channel identifier unequal to 0	*A=ERROR* *S=d*3 *D*=41 (see Note 1)	*A=ERROR* *S=d*3 *D*=41 (see Note 1)	*A=DISCARD*
RESET REQUEST	*A=NORMAL* *S=d*2 (forward)	*A=DISCARD*	*A=NORMAL* *S=d*1 (do not forward)
RESET CONFIRMATION	*A=ERROR* *S=d*3 *D*=27 (see Note 1)	*A=ERROR* *S=d*3 *D*=28 (see Note 1)	*A=NORMAL* *S=d*1 (do not forward)
INTERRUPT packet	See Table 5-7	*A=ERROR* *S=d*3 *D*=28 (see Note 1)	*A=DISCARD*
INTERRUPT CONFIRMATION packet	See Table 5-7	*A=ERROR* *S=d*3 *D*=28 (see Note 1)	*A=DISCARD*
DATA or flow control packet	See Table 5-8	*A=ERROR* *S=d*3 *D*=28 (see Note 1)	*A=DISCARD*
REJECT supported but not subscribed to	*A=ERROR* *S=d*3 *D*=37 (see Note 1)	*A=ERROR* *S=d*3 *D*=37 (see Note 1)	*A=DISCARD*

NOTES:

1. The error procedure consists of performing the specified actions when entering the *d*3 state (which includes forwarding a RESET REQUEST packet to the DTE) and sending a RESET REQUEST packet to the XDCE (via the formatting function).
2. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared for the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.

Table 5-7. DTE effect on DCE interrupt transfer states

Packet received from DTE	DTE/DCE interrupt transfer states (see Note 2) DTE INTERRUPT READY *i*1	DTE/DCE interrupt transfer states (see Note 2) DTE INTERRUPT SENT *i*2
INTERRUPT (see Note 1)	*A=NORMAL* *S=i*2 (forward)	*A=ERROR* *S=d*3 *D*=44 (see Note 3)

Packet received from DTE	DTE/DCE interrupt transfer states (see Note 2) DCE INTERRUPT READY *j*1	DTE/DCE interrupt transfer states (see Note 2) DCE INTERRUPT SENT *j*2
INTERRUPT CONFIRMATION (see Note 1)	*A=ERROR* *S=d*3 *D*=43 (see Note 3)	*A=NORMAL* *S=j*1 (forward)

NOTES:

1. If the packet has a format error, then the error procedure applies (see Note 3). Interrupt packets with user data greater than 32 bytes should be treated as a format error.
2. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.
3. The error procedure consists of performing the specified actions when entering the *d*3 state (which includes forwarding a RESET REQUEST packet to the DTE) and sending a RESET REQUEST packet to the XDCE (via the reformatting process).

Table 5-8. DTE effect on DCE flow control transfer states

Packet received from DTE	DCE flow control transfer states (see Notes 2 and 3) DCE RECEIVE READY *f*1	DCE flow control transfer states (see Notes 2 and 3) DCE RECEIVE NOT READY *f*2
DATA packet with less than 4 bytes when using modulo 128 numbering	*A*=*ERROR* *S*=*d*3 *D*=38 (see Note 4)	*A*=*DISCARD*
DATA packet with invalid PR	*A*=*ERROR* *S*=*d*3 *D*=2 (see Note 4)	*A*=*ERROR* *S*=*d*3 *D*=2 (see Note 4)
DATA packet with valid PR but invalid PS or user data field with improper format	*A*=*ERROR* *S*=*d*3 *D*=1 (invalid PS) *D*=39 (UD > max negotiated length) *D*=82 (UD unaligned) (see Note 4)	*A*=*DISCARD* (process PR data)
DATA packet with valid PR with M-bit set to 1 when the user data field is partially full	*A*=*ERROR* *S*=*d*3 *D*=165 (see Note 4)	*A*=*DISCARD* (process PR data)
DATA packet with valid PR, PS and user data field format	*A*=*NORMAL* (forward)	*A*=*DISCARD* (process PR data)

Packet received from DTE	DCE flow control transfer states (see Notes 2 and 3) DTE RECEIVE READY *g*1	DCE flow control transfer states (see Notes 2 and 3) DTE RECEIVE NOT READY *g*2
RR, RNR, or REJECT packet with less than 3 bytes when using modulo 128 numbering (see Note 1)	*A*=*DISCARD*	*A*=*DISCARD*
RR, RNR, or REJECT packet with an invalid PR	*A*=*ERROR* *S*=*d*3 *D*=2 (see Note 4)	*A*=*ERROR* *S*=*d*3 *D*=2 (see Note 4)
RR packet with a valid PR	*A*=*NORMAL*	*A*=*NORMAL* *S*=*g*1
RNR packet with a valid PR	*A*=*NORMAL* *S*=*g*2	*A*=*NORMAL*
REJECT packet with a valid PR	*A*=*NORMAL*	*A*=*NORMAL* *S*=*g*1

NOTES:

1. The reject procedures are not required.
2. The RR, RNR and REJECT procedures are a local DTE/DCE matter and the corresponding packets are not forwarded to the XDCE.
3. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.
4. The error procedure consists of performing the specified actions when entering the *d*3 state (which includes forwarding a RESET REQUEST packet to the DTE) and sending a RESET REQUEST packet to the XDCE (via the reformatting process).

Table 5-9. XDCE effect on DCE restart states

Packet received from XDCE	DCE restart states (see Note) PACKET LEVEL READY *r*1	DTE RESTART REQUEST *r*2	DCE RESTART REQUEST *r*3
CALL REQUEST	See Table 5-10	Send CLEAR REQUEST to reformatting process with *D*=244	Send CLEAR REQUEST to reformatting process with *D*=244
CALL ACCEPT, CLEAR REQUEST, DATA, INTERRUPT, INTERRUPT CONFIRMATION, RESET REQUEST	See Table 5-10	*A=DISCARD*	*A=DISCARD*

Note.— Table entries are defined as follows: A = *action to be taken,* S = *the state to be entered,* D = *the diagnostic code to be used in packets generated as a result of this action,* DISCARD *indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.*

Table 5-10. XDCE effect on DCE call setup and clearing states

Packet received from XDCE	DCE call setup and clearing states (see Note) READY *p*1	DTE CALL REQUEST *p*2	DCE CALL REQUEST *p*3	DATA TRANSFER *p*4	CALL COLLISION *p*5	DTE CLEAR REQUEST *p*6	DCE CLEAR REQUEST to DTE *p*7
CALL REQUEST	*A=NORMAL* *S=p*3 (forward)	INVALID	INVALID	INVALID	INVALID	INVALID	INVALID
CALL ACCEPT	*A=DISCARD*	*A=NORMAL* *S=p*4 (forward)	INVALID	INVALID	INVALID	*A=DISCARD*	*A=DISCARD*
CLEAR REQUEST	*A=DISCARD*	*A=NORMAL* *S=p*7 (forward)	*A=NORMAL* *S=p*7 (forward)	*A=NORMAL* *S=p*7 (forward)	INVALID	*A=DISCARD*	*A=DISCARD*
DATA, INTERRUPT, INTERRUPT CONFIRMATION, or RESET REQUEST	*A=DISCARD*	INVALID	INVALID	See Table 5-11	INVALID	*A=DISCARD*	*A=DISCARD*

Note.— Table entries are defined as follows: A = *action to be taken,* S = *the state to be entered,* D = *the diagnostic code to be used in packets generated as a result of this action,* DISCARD *indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.*

Table 5-11. XDCE effect on DCE reset states

Packet received from XDCE	DCE reset states (see Note) FLOW CONTROL READY *d*1	DTE RESET REQUEST *d*2	DCE RESET REQUEST to DTE *d*3
RESET REQUEST	*A=NORMAL* *S=d*3 (forward)	*A=NORMAL* *S=d*1 (forward)	*A=DISCARD*
INTERRUPT	See Table 5-12	*A=DISCARD*	*A=DISCARD*
INTERRUPT CONFIRMATION	See Table 5-12	*A=DISCARD*	INVALID
DATA	*A=NORMAL* (forward)	*A=DISCARD*	*A=DISCARD*

Note.— Table entries are defined as follows: A = *action to be taken,* S = *the state to be entered,* D = *the diagnostic code to be used in packets generated as a result of this action,* DISCARD *indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.*

Table 5-12. XDCE effect on DCE interrupt transfer states

Packet received from XDCE	DCE interrupt transfer states (see Note) DTE INTERRUPT READY *i*1	 DTE INTERRUPT SENT *i*2
INTERRUPT CONFIRMATION	INVALID	*A=NORMAL* *S=i*1 (forward)
Packet received from XDCE	**DCE interrupt transfer states (see Note) DCE INTERRUPT READY *j*1**	** DCE INTERRUPT SENT *j*2**
INTERRUPT	*A=NORMAL* *S=j*2 (forward)	INVALID

Note.— Table entries are defined as follows: A = *action to be taken,* S = *the state to be entered,* D = *the diagnostic code to be used in packets generated as a result of this action,* DISCARD *indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.*

Table 5-13. GDLP Mode S subnetwork timers

Timer name	*Timer label*	*Nominal value*	*Reference*
Active channel-GDLP	*Tx*	300 s	5.2.8.3.2
L-bit delivery-GDLP	*Tm*	120 s	5.2.7.4.3
Packet resequencing and S-bit delivery	*Tq*	60 s	5.2.6.9

Table 5-14. XDCE actions at state transition

XDCE state	*State definition*	*Action that shall be taken when entering the state*
*r*1	PACKET LEVEL READY	Return all SVCs to the *p*1 state.
*p*1	READY	Release all resources assigned to the SVC. Break the correspondence between the ADCE/GDCE SVC and the DTE/DCE SVC (the DTE/DCE SVC may not yet be in a *p*1 state).
*p*2	GDLP(ADLP) CALL REQUEST	Determine if sufficient resources exist to support request; if so allocate resources and forward Mode S CALL REQUEST packet to reformatting process; if not, enter ADCE(GDCE) CLEAR REQUEST to GDLP(ADLP) state (*p*7).
*p*3	ADCE(GDCE) CALL REQUEST	Determine if sufficient resources exist to support request; if so, allocate resources and forward Mode S CALL REQUEST packet to frame processing; if not, send Mode S CLEAR REQUEST to reformatting process and go to state *p*1. Do not forward the Mode S CALL REQUEST to the peer XDCE.
*p*4	DATA TRANSFER	No action.
*p*6	GDLP(ADLP) CLEAR REQUEST	Release all resources, send a Mode S CLEAR CONFIRMATlON packet to the peer XDCE and enter the *p*1 state.
*p*7	ADCE(GDCE) CLEAR REQUEST to GDLP(ADLP)	Forward Mode S CLEAR REQUEST packet to the peer XDCE via frame processing.
*d*1	FLOW CONTROL READY	No action.
*d*2	GDLP(ADLP) RESET REQUEST	Remove Mode S DATA packets transmitted to peer XDCE from window; discard any DATA packets that represent partially transmitted M-bit sequences and discard any Mode S INTERRUPT packets awaiting transfer to the peer XDCE; reset all flow control window counters to 0 (5.2.6.7.1). Send Mode S RESET CONFIRMATION packet to the peer XDCE. Return SVC to *d*1 state. Forward Mode S RESET REQUEST packet to reformatting process.
*d*3	ADCE(GDCE) RESET REQUEST to GDLP(ADLP)	Remove Mode S DATA packets transmitted to peer XDCE from window; discard any DATA packets that represent partially transmitted M-bit sequences and discard any Mode S INTERRUPT packets awaiting transfer to the peer XDCE; reset all flow control window counters to 0 (5.2.6.7.1). Forward Mode S RESET REQUEST packet to peer XDCE via frame processing.
*i*1	GDLP(ADLP) INTERRUPT READY	No action.
*i*2	GDLP(ADLP) INTERRUPT SENT	Forward Mode S INTERRUPT packet received from peer XDCE to the reformatting process.
*j*1	ADCE(GDCE) INTERRUPT READY	No action.
*j*2	ADCE(GDCE) INTERRUPT SENT	Forward Mode S INTERRUPT packet received from the reformatting process.
*f*1	ADCE(GDCE) RECEIVE READY	No action.
*f*2	ADCE(GDCE) RECEIVE NOT READY	No action.
*g*1	GDLP(ADLP) RECEIVE READY	No action.
*g*2	GDLP(ADLP) RECEIVE NOT READY	No action.

Table 5-15. GDLP (ADLP) effect on ADCE (GDCE) packet layer ready states

Packet received from GDLP (ADLP) (see Note 2)	ADCE (GDCE) states (see Notes 1 and 3) PACKET LEVEL READY *r*1
CH=0 with no TC present (see Note 4) or CH=0 in a CALL ACCEPT by ADLP packet	*A=DISCARD*
Unassigned packet header	*A=DISCARD*
Call setup, call clearing, DATA, interrupt, flow control, or reset	See Table 5-16

NOTES:

1. The XDCE state is not necessarily the same state as the DTE/DCE interface.
2. All packets from the peer XDLP have been checked for duplication before evaluation as represented by this table.
3. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.
4. Where CH=0 and a valid TC is present in a CLEAR REQUEST by ADLP or GDLP packet or a CLEAR CONFIRMATION by ADLP or GDLP packet, it is handled as described in 5.2.5.1.2.3 and Table 5-16.

Table 5-16. GDLP (ADLP) effect on ADCE (GDCE) call setup and clearing states

Packet received from GDLP (ADLP) (see Note 2)	ADCE (GDCE) call setup and clearing States (See Notes 1, 7 and 8) READY *p*1	GDLP (ADLP) CALL REQUEST *p*2	ADCE (GDCE) CALL REQUEST *p*3	DATA TRANSFER *p*4	GDLP (ADLP) CLEAR REQUEST *p*6	ADCE (GDCE) CLEAR REQUEST to GDLP (ADLP) *p*7
Format error (see Note 3)	*A=ERROR* (see Note 10) *S=p*7 *D*=33 (see Note 9)	*A=ERROR* *S=p*7 *D*=33 (see Note 6)	*A=ERROR* *S=p*7 *D*=33 (see Notes 6 & 9)	See Table 5-17	*A=ERROR* *S=p*7 *D*=25 (see Note 6)	*A=DISCARD*
CALL REQUEST	*A=NORMAL* (5.2.6.3.1) *S=p*2 (forward request to DCE)	*A=ERROR* *S=p*7 *D*=21 (see Note 6)	Not applicable (see Note 4)	Not applicable (see Note 4)	*A=ERROR* *S=p*7 *D*=25 (see Note 6)	*A=DISCARD*
CALL ACCEPT	*A=ERROR* *S=p*7 *D*=20 (see Note 10)	*A=ERROR* *S=p*7 *D*=21 (see Note 6)	*A=NORMAL* (5.2.6.3.1) *S=p*4 (forward to DCE), or *A=ERROR* *S=p*7 *D*=42 (see Note 6)	*A=ERROR* *S=p*7 *D*=23 (see Note 6)	*A=ERROR* *S=p*7 *D*=25 (see Note 6)	*A=DISCARD*
CLEAR REQUEST	*A=NORMAL* (5.2.6.3.3) *S=p*6 (do not forward)	*A=NORMAL* (5.2.6.3.3) *S=p*6 (forward to DCE)	*A=NORMAL* (5.2.6.3.3) *S=p*6 (forward to DCE)	*A=NORMAL* (5.2.6.3.3) *S=p*6 (forward to DCE)	*A=DISCARD*	*A=NORMAL* (5.2.6.3.3) *S=p*1 (do not forward)
CLEAR CONFIRMATION	*A=ERROR* *S=p*7 *D*=20 (see Note 10)	*A=ERROR* *S=p*7 *D*=21 (see Note 6)	*A=ERROR* *S=p*7 *D*=22 (see Note 6)	*A=ERROR* *S=p*7 *D*=23 (see Note 6)	*A=ERROR* *S=p*7 *D*=25 (see Note 6)	*A=NORMAL* (5.2.6.3.3) *S=p*1 (do not forward)
DATA, interrupt, flow control or reset packets	*A=ERROR* *S=p*7 *D*=20 (see Note 10)	*A=ERROR* *S=p*7 *D*=21 (see Notes 6 & 9)	*A=ERROR* *S=p*7 *D*=22 (see Notes 5 & 6)	See Table 5-17	*A=ERROR* *S=p*7 *D*=25 (see Note 6)	*A=DISCARD*

NOTES:

1. The XDCE is not necessarily in the same state as the DTE/DCE interface.
2. All packets from the peer XDLP have been checked for duplication before evaluation as represented by this table.
3. A format error may result from an S-bit sequence having a first or intermediate packet shorter than the maximum length, or else from an invalid LV field in a CALL REQUEST, CALL ACCEPT, CLEAR REQUEST or INTERRUPT packet. There are no other detectable Mode S format errors.
4. The ADCE assigns all channel numbers used between the ADLP and GDLP, hence call collisions are not possible. When a CALL REQUEST by GDLP packet is received bearing a temporary channel number associated with an SVC in the *p*4 state, the association of the temporary to permanent channel number is broken (5.2.5.1.2.3).
5. Not applicable to the GDLP.
6. The error procedure consists of performing the actions specified when entering the *p*7 state (including sending a CLEAR REQUEST packet to the peer XDLP) and additionally sending a CLEAR REQUEST packet to the DCE (via the reformatting process).
7. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.
8. The number in parentheses below an *"A = NORMAL"* table entry is the paragraph number in this document that defines the actions to be taken to perform normal processing on the received packet. If no paragraph number is referenced, the normal processing is defined in the table entry.
9. An error condition is declared and transfer to the *p*7 state is possible only if the ground DTE address is known unambiguously. Otherwise the action is to discard the packet.
10. The error procedure consists of performing the action when entering the *p*7 state (including sending a CLEAR REQUEST packet to the XDLP) but without sending a CLEAR REQUEST packet to the local DCE.

Table 5-17. GDLP (ADLP) effect on ADCE (GDCE) reset states

Packet received from GDLP (ADLP) (see Note 2)	ADCE (GDCE) reset states (see Notes 1, 4 and 5) FLOW CONTROL READY *d*1	GDLP (ADLP) RESET REQUEST *d*2	ADCE (GDCE) RESET REQUEST to GDLP (ADLP) *d*3
RESET REQUEST	*A=NORMAL* (5.2.6.7) *S=d*2 (forward to DCE)	*A=DISCARD*	*A=NORMAL* (5.2.6.7) *S=d*1 (do not forward)
RESET CONFIRMATION	*A=ERROR* *S=d*3 *D*=27 (see Note 3)	*A=ERROR* *S=d*3 *D*=28 (see Note 3)	*A=NORMAL* (5.2.6.7) *S=d*1 (do not forward)
INTERRUPT	See Table 5-18	*A=ERROR* *S=d*3 *D*=28 (see Note 3)	*A=DISCARD*
INTERRUPT CONFIRMATION	See Table 5-18	*A=ERROR* *S=d*3 *D*=28 (see Note 3)	*A=DISCARD*
DATA or flow control packet	See Table 5-19	*A=ERROR* *S=d*3 *D*=28 (see Note 3)	*A=DISCARD*
Format error (see Note 6)	*A=ERROR* *S=d*3 *D*=33 (see Note 3)	*A=ERROR* *S=d*3 *D*=33 (see Note 3)	*A=DISCARD*

NOTES:

1. The XDCE is not necessarily in the same state as the DTE/DCE interface.
2. All packets from the peer XDLP have been checked for duplication before evaluation as represented by this table.
3. The error procedure consists of performing the specified actions when entering the *d*3 state (which includes forwarding a RESET REQUEST packet to the peer XDLP) and sending a RESET REQUEST packet to the DCE (via the formatting function).
4. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared for the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.
5. The number in parentheses below an *"A = NORMAL"* table entry is the paragraph number in this document that defines the actions to be taken to perform normal processing on the received packet. If no paragraph number is referenced, the normal processing is defined in the table entry.
6. A format error may result from an S-bit sequence having a first or intermediate packet shorter than the maximum length, or else from an invalid LV field in a CALL REQUEST, CALL ACCEPT, CLEAR REQUEST, or INTERRUPT packet. There are no other detectable Mode S format errors.

Table 5-18. GDLP (ADLP) effect on ADCE (GDCE) interrupt transfer states

Packet received from GDLP (ADLP) (see Note 2)	ADCE/GDCE interrupt transfer states (see Notes 1, 3 & 4) GDLP (ADLP) INTERRUPT READY *i*1	GDLP (ADLP) INTERRUPT SENT *i*2
INTERRUPT (see Note 6)	*A=NORMAL* (5.2.6.4.5) *S=i*2 (forward to DCE)	*A=ERROR* *S=d*3 *D*=44 (see Note 5)
Packet received from GDLP (ADLP) (see Note 2)	**ADCE (GDCE) interrupt transfer states (see Notes 1, 3 & 4) ADCE (GDCE) INTERRUPT READY *j*1**	**ADCE (GDCE) INTERRUPT SENT *j*2**
INTERRUPT CONFIRMATION	*A=ERROR* *S=d*3 *D*=43 (see Note 5)	*A=NORMAL* (5.2.6.4.5) *S=j*1 (forward confirmation to DCE)

NOTES:

1. The XDCE is not necessarily in the same state as the DTE/DCE interface.
2. All packets from the peer XDLP have been checked for duplication before evaluation as represented by this table.
3. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared for the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.
4. The number in parentheses below an *"A = NORMAL"* table entry is the paragraph number in this document that defines the actions to be taken to perform normal processing on the received packet. If no paragraph number is referenced, the normal processing is defined in the table entry.
5. The error procedure consists of performing the specified actions when entering the *d*3 state (which includes forwarding a RESET REQUEST packet to the peer XDLP) and sending a RESET REQUEST packet to the DCE (via the reformatting process).
6. User data length for INTERRUPT packets greater than 32 bytes, or an out of sequence INTERRUPT packet, are considered as errors.

Table 5-19. GDLP (ADLP) effect on ADCE (GDCE) flow control transfer states

Packet received from GDLP (ADLP) (see Note 2)	ADCE (GDCE) flow control transfer states (see Notes 1, 6 and 7) ADCE (GDCE) RECEIVE READY *f*1	ADCE (GDCE) RECEIVE NOT READY *f*2
DATA packet with invalid PR (see Note 3)	*A=ERROR* *S=d*3 *D*=2 (see Note 8)	*A=ERROR* *S=d*3 *D*=2 (see Note 8)
DATA packet with valid PR, invalid PS or LV subfield (see Notes 4 & 5)	*A=DISCARD,* but process the PR value and send REJECT packet containing the expected PS value (see Note 5)	*A=DISCARD*, but process the PR value and send REJECT packet containing the expected PS value when busy condition ends
DATA packet with valid PR, PS and LV subfield	*A=NORMAL* (5.2.6.4.4) (forward)	*A=PROCESS*, if possible; or *A=DISCARD*, but process the PR value and send REJECT containing the expected PS value when busy condition ends

Packet received from GDLP (ADLP) (see Note 2)	ADCE (GDCE) flow control transfer states (see Notes 1, 6 and 7) GDLP (ADLP) RECEIVE READY *g*1	GDLP (ADLP) RECEIVE NOT READY *g*2
RR, RNR, REJECT packet with invalid PR (see Note 3)	*A=ERROR* *S=d*3 *D*=2 (see Note 8)	*A=ERROR* *S=d*3 *D*=2 (see Note 8)
RR with valid PR field (see Note 9)	*A=NORMAL* (5.2.6.5)	*A=NORMAL* (5.2.6.6) *S=g*1
RNR with valid PR value (see Note 9)	*A=NORMAL* (5.2.6.5) *S=g*2	*A=NORMAL* (5.2.6.6)
REJECT with valid PR (see Note 9)	*A=NORMAL* (5.2.6.5)	*A=NORMAL* (5.2.6.6) *S=g*1

NOTES:

1. The XDCE is not necessarily in the same state as the DTE/DCE interface.
2. All packets from the peer XDLP have been checked for duplication before evaluation as represented by this table.
3. An invalid PR value is one which is less than the PR value (modulo 16) of the last packet sent by the peer XDLP, or greater than the PS value of the next data packet to be transmitted by the XDLP.
4. An invalid PS value is one which is different from the next expected value for PS.
5. An invalid LV subfield is one which represents a value that is too large for the size of the segment received. In the event of an LV field error which gives rise to a loss of confidence in the correctness of the other fields in the packet, the packet is discarded without any further action.
6. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.

7. The number in parentheses below an *"A = NORMAL"* table entry is the paragraph number in this document that defines the actions to be taken to perform normal processing on the received packet. If no paragraph number is referenced, the normal processing is defined in the table entry.
8. The error procedure consists of performing the specified actions when entering the *d*3 state (which includes forwarding a RESET REQUEST packet to the peer XDLP) and sending a RESET REQUEST packet to the DCE (via the reformatting process).
9. RR, RNR, and REJECT packets have no end-to-end significance and are not forwarded to the DCE.
10. The receipt of a packet smaller than the maximum packet size with M-bit = 1 shall cause a reset to be generated and the remainder of the sequence shall be discarded.

Table 5-20. DCE effect on ADCE (GDCE) call setup and clearing states

Packet received from DCE (see Notes 2 & 4)	ADCE (GDCE) call setup and clearing states (see Notes 1, 7 and 8)					
	READY *p*1	GDLP (ADLP) CALL REQUEST *p*2	ADCE (GDCE) CALL REQUEST *p*3	DATA TRANSFER *p*4	GDLP (ADLP) CLEAR REQUEST *p*6	ADCE (GDCE) to GDLP (ADLP) CLEAR REQUEST *p*7
CALL REQUEST (see Note 6)	*A=NORMAL* (5.2.6.3.1) *S=p*3 (forward)	INVALID (see Note 5)	INVALID (see Note 3)	INVALID (see Note 3)	INVALID (see Note 3)	INVALID (see Note 3)
CALL ACCEPT (see Note 4)	*A=DISCARD*	*A=NORMAL* *S=P*4 (forward)	INVALID (see Note 3)	INVALID (see Note 3)	*A=DISCARD*	*A=DISCARD*
CLEAR REQUEST (see Note 4)	*A=DISCARD*	*A=NORMAL* (5.2.6.3.3) *S=p*7 (forward)	*A=NORMAL* (5.2.6.3.3) *S=p*7 (forward)	*A=NORMAL* (5.2.6.3.3) *S=p*7 (forward)	*A=DISCARD*	*A=DISCARD*
DATA, INTERRUPT or RESET packets (see Note 4)	*A=DISCARD*	INVALID (see Note 3)	INVALID (see Note 3)	See Table 5-21	*A=DISCARD*	*A=DISCARD*

NOTES:

1. The XDCE is not necessarily in the same state as the DTE/DCE interface.
2. This is the DTE packet received via the DCE after all DTE/DCE processing has occurred. Procedures local to the DTE/DCE interface (such as RR, RNR, and REJECT if in effect), do not affect the XDCE directly. All error procedures as documented in ISO 8208 have been performed. Hence certain packets are rejected by the interface and are not represented in this table.
3. The DCE in its protocol operation with the DTE will detect this error condition, hence the erroneous packet can be said never to "reach" the XDCE; see also Note 2.
4. The channel number for the DTE/DCE need not be the same channel number used for the ADCE/GDCE; a packet from the DTE which contains a channel number is associated with an air/ground channel by means of a previously established cross-reference table. If none exists then the DTE/DCE channel by definition references an air/ground channel in the *p*1 state.
5. The ADCE assigns all channel numbers used between the ADLP and GDLP; hence call collisions (denoted *p*5 ISO 8208) are not possible; see also Note 4.
6. A CALL REQUEST from the DTE can never be associated with an XDCE channel number which is not in the *p*1 state.
7. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.
8. The number in parentheses below an *"A = NORMAL"* table entry is the paragraph number in this document that defines the actions to be taken to perform normal processing on the received packet. If no paragraph number is referenced, the normal processing is defined in the table entry.

Table 5-21. DCE effect on ADCE (GDCE) reset states

Packet received from DCE	ADCE (GDCE) reset states (see Notes 1, 4 and 5) FLOW CONTROL READY *d*1	GDLP (ADLP) RESET REQUEST *d*2	ADCE (GDCE) RESET REQUEST to GDLP (ADLP) *d*3
RESET REQUEST	*A=NORMAL* (5.2.6.7) *S=d*3 (forward)	*A=NORMAL* (5.2.6.7) *S=d*1 (forward)	*A=DISCARD*
RESET CONFIRMATION	INVALID (see Note 3)	INVALID (see Note 3)	INVALID (see Note 3)
INTERRUPT	See Table 5-22	*A=DISCARD*	Hold interrupt until Mode S reset complete
INTERRUPT CONFIRMATION	See Table 5-22	*A=DISCARD*	INVALID (see Note 3)
DATA (see Note 2)	*A=NORMAL* (5.2.6.4) (forward)	*A=DISCARD*	Hold data until Mode S reset complete

NOTES:

1. The XDCE is not necessarily in the same state as the DTE/DCE interface.
2. This is the DTE packet received via the DCE after all DTE/DCE processing has occurred. Procedures local to the DTE/DCE interface (such as RR, RNR, and REJECT if in effect), do not affect the XDCE directly. All error procedures as documented in ISO 8208 have been performed. Hence certain packets are rejected by the interface and are not represented in this table.
3. The DCE in its protocol operation with the DTE will detect this error condition, hence the erroneous packet can be said never to "reach" the XDCE; see also Note 2.
4. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.
5. The number in parentheses below an *"A = NORMAL"* table entry is the paragraph number in this document that defines the actions to be taken to perform normal processing on the received packet. If no paragraph number is referenced, the normal processing is defined in the table entry.

Table 5-22. DCE effect on ADCE (GDCE) interrupt transfer states

Packet received from DCE (see Note 2)	ADCE (GDCE) interrupt transfer state (see Notes 1, 4 and 5) GDLP (ADLP) INTERRUPT READY *i*1	 GDLP (ADLP) INTERRUPT SENT *i*2
INTERRUPT CONFIRMATION	INVALID (See Note 3)	*A=NORMAL* (5.2.6.4.5) *S=i*1 (forward)
Packet received from DCE (see Note 2)	**ADCE (GDCE) interrupt transfer states (see Notes 1, 4 and 5) ADCE (GDCE) INTERRUPT READY *j*1**	** ADCE (GDCE) INTERRUPT SENT *j*2**
INTERRUPT	*A=NORMAL* (5.2.6.4.5) *S=j*2 (forward)	INVALID (see Note 3)

NOTES:

1. The XDCE is not necessarily in the same state as the DTE/DCE interface.
2. This is the DTE packet received via the DCE after all DTE/DCE processing has occurred. Procedures local to the DTE/DCE interface (such as RR, RNR, and REJECT if in effect), do not affect the XDCE directly. All error procedures as documented in ISO 8208 have been performed. Hence certain packets are rejected by the interface and are not represented in this state.
3. The DCE in its protocol operation with the DTE will detect this error condition, hence the erroneous packet can be said never to "reach" the XDCE; see also Note 2.
4. Table entries are defined as follows: *A* = action to be taken, *S* = the state to be entered, *D* = the diagnostic code to be used in packets generated as a result of this action, *DISCARD* indicates that the received packet is to be cleared from the XDLP buffers, and INVALID indicates that the packet/state combination cannot occur.
5. The number in parentheses below an *"A = NORMAL"* table entry is the paragraph number in this document that defines the actions to be taken to perform normal processing on the received packet. If no paragraph number is referenced, the normal processing is defined in the table entry.

Table 5-23. Broadcast identifier number assignments

Uplink broadcast identifier	*Assignment*
00_{16}	Not valid
01_{16}	Reserved (differential GNSS correction)
30_{16}	Not valid
31_{16}	Reserved for ACAS (RA broadcast)
32_{16}	Reserved for ACAS (ACAS broadcast)
Others	Unassigned
Downlink broadcast identifier	*Assignment*
00_{16}	Not valid
02_{16}	Reserved (traffic information service)
10_{16}	Data link capability report
20_{16}	Aircraft identification
FE_{16}	Update request
FF_{16}	Search request
Others	Unassigned

Table 5-24. Register number assignments

Register Number	*Assignment*
00_{16}	Not valid
01_{16}	Unassigned
02_{16}	Linked Comm-B, segment 2
03_{16}	Linked Comm-B, segment 3
04_{16}	Linked Comm-B, segment 4
05_{16}	Extended squitter airborne position
06_{16}	Extended squitter surface position
07_{16}	Extended squitter status
08_{16}	Extended squitter identification and type
09_{16}	Extended squitter airborne velocity
$0A_{16}$	Extended squitter event-driven information
$0B_{16}$	Air/air information 1 (aircraft state)
$0C_{16}$	Air/air information 2 (aircraft intent)
$0D_{16}$-$0E_{16}$	Reserved (other air-air information)
$0F_{16}$	Reserved (ACAS)
10_{16}	Data link capability report
11_{16}-16_{16}	Extension to data link capability report
17_{16}	Common usage GICB capability report
18_{16}-$1F_{16}$	Mode S specific services capability reports
20_{16}	Aircraft identification
21_{16}	Aircraft registration number
22_{16}	Antenna positions
23_{16}	Reserved (antenna position)
24_{16}	Reserved (static aircraft parameter)
25_{16}	Aircraft type
26_{16}-$2F_{16}$	Unassigned
30_{16}	ACAS active resolution advisory (RA)
31_{16}-$3F_{16}$	Unassigned
40_{16}	Aircraft intention
41_{16}	Next waypoint identifier
42_{16}	Next waypoint position
43_{16}	Next waypoint information
44_{16}	Meteorological routine air report
45_{16}	Meteorological hazard report
46_{16}	Flight management system Mode 1
47_{16}	Flight management system Mode 2
48_{16}	VHF channel report
49_{16}-$4F_{16}$	Unassigned
50_{16}	Track and turn report
51_{16}	Position report coarse

Register Number	*Assignment*
52_{16}	Position report fine
53_{16}	Air referenced state vector
54_{16}	Waypoint 1
55_{16}	Waypoint 2
56_{16}	Waypoint 3
57_{16}-$5E_{16}$	Unassigned
$5F_{16}$	Quasi-static parameter monitoring
60_{16}	Heading and speed report
61_{16}	Extended squitter emergency/priority status
62_{16}	Current trajectory change point
63_{16}	Next trajectory change point
64_{16}	Aircraft operational coordination message
65_{16}	Aircraft operational status
66_{16}-$6F_{16}$	Reserved for extended squitter
70_{16}-75_{16}	Reserved for future downlink parameters
76_{16}-$E0_{16}$	Unassigned
$E1_{16}$-$E2_{16}$	Reserved for Mode S byte
$E3_{16}$-$F0_{16}$	Unassigned
$F1_{16}$-$F2_{16}$	Military applications
$F3_{16}$-FF_{16}	Unassigned

Table 5-25. MSP channel number assignments

Uplink channel number	*Assignment*
0	Not valid
1	Reserved (specific services management)
2	Reserved (traffic information service)
3	Reserved (ground-to-air alert)
4	Reserved (ground derived position)
5	ACAS sensitivity level control
6	Reserved (ground-to-air service request)
7	Reserved (air-to-ground service response)
8-63	Unassigned
Downlink channel number	*Assignment*
0	Not valid
1	Reserved (specific services management)
2	Unassigned
3	Reserved (data flash)
4	Reserved (position request)
5	Unassigned
6	Reserved (ground-to-air service response)
7	Reserved (air-to-ground service request)
8-63	Unassigned

FIGURES FOR CHAPTER 5

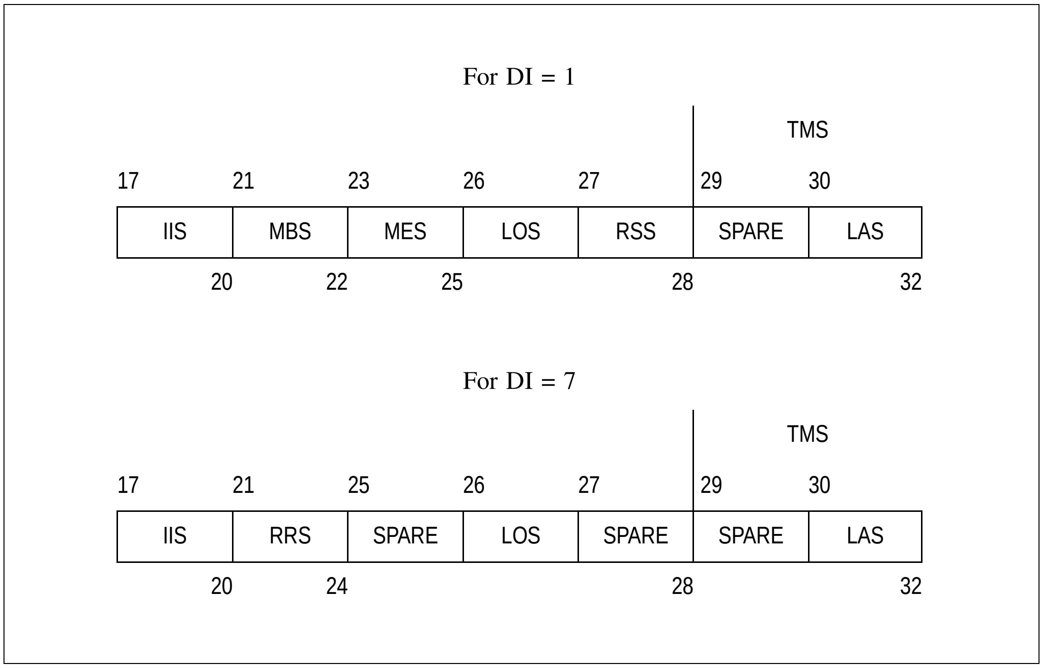


Figure 5-1. The SD field structure

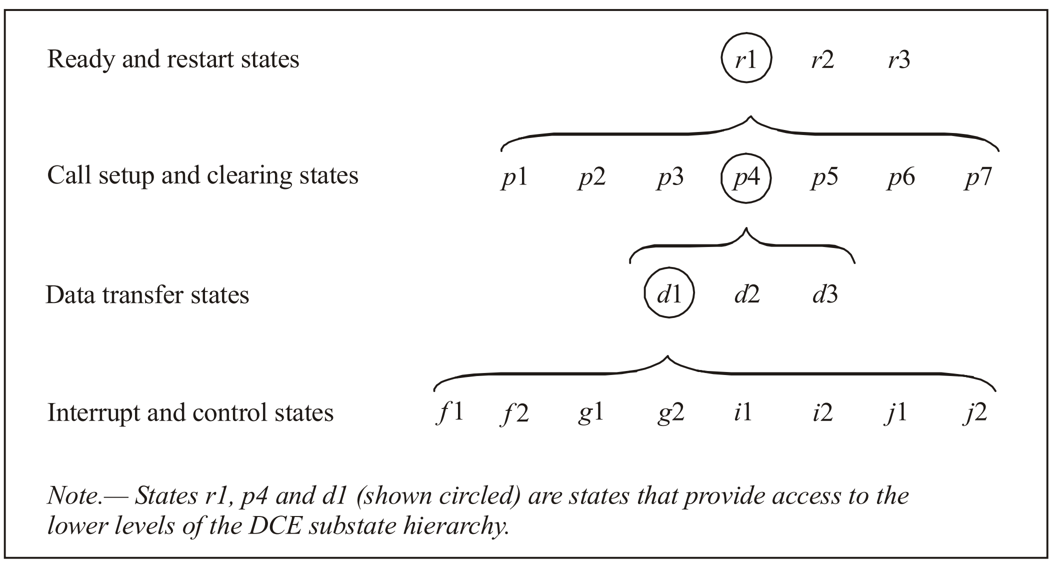


Figure 5-2. DCE substate hierarchy

1 2 3 4 5 6 7 8

<table>
<tr><td>DP=0</td><td>MP=1</td><td colspan="2">SP=1</td><td>ST=0</td><td>FILL2</td></tr>
<tr><td>P</td><td>FILL</td><td colspan="4">SN</td></tr>
<tr><td colspan="4">CH</td><td colspan="2">LAM</td></tr>
<tr><td colspan="6">AG</td></tr>
<tr><td>S</td><td colspan="2">FS</td><td>F</td><td colspan="2">LV</td></tr>
<tr><td colspan="6">UD</td></tr>
</table>

Figure 5-3. CALL REQUEST by ADLP packet

1 2 3 4 5 6 7 8

<table>
<tr><td>DP=0</td><td>MP=1</td><td colspan="2">SP=1</td><td>ST=0</td><td>FILL</td></tr>
<tr><td>P</td><td>FILL</td><td colspan="4">SN</td></tr>
<tr><td colspan="2">FILL</td><td colspan="2">TC</td><td colspan="2">AM</td></tr>
<tr><td colspan="6">AG</td></tr>
<tr><td>S</td><td colspan="2">FS</td><td>F</td><td colspan="2">LV</td></tr>
<tr><td colspan="6">UD</td></tr>
</table>

Figure 5-4. CALL REQUEST by GDLP packet

1 2 3 4 5 6 7 8

<table>
<tr><td>DP=0</td><td>MP=1</td><td colspan="2">SP=1</td><td>ST=1</td><td>FILL2</td></tr>
<tr><td colspan="2">TC</td><td colspan="4">SN</td></tr>
<tr><td colspan="4">CH</td><td colspan="2">AM</td></tr>
<tr><td colspan="6">AG</td></tr>
<tr><td>S</td><td colspan="2">FILL</td><td>F</td><td colspan="2">LV</td></tr>
<tr><td colspan="6">UD</td></tr>
</table>

Figure 5-5. CALL ACCEPT by ADLP packet

<table>
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<tr><td colspan="2">DP=0</td><td colspan="2">MP=1</td><td colspan="2">SP=1</td><td colspan="2">ST=1</td><td colspan="2">FILL</td></tr>
<tr><td colspan="4">FILL</td><td colspan="6">SN</td></tr>
<tr><td colspan="6">CH</td><td colspan="4">AM</td></tr>
<tr><td colspan="10">AG</td></tr>
<tr><td colspan="2">S</td><td colspan="3">FILL</td><td colspan="1">F</td><td colspan="4">LV</td></tr>
<tr><td colspan="10">UD</td></tr>
</table>

Figure 5-6. CALL ACCEPT by GDLP packet

<table>
<tr><td colspan="2">1</td><td colspan="2">2</td><td colspan="2">3</td><td colspan="2">4 5</td><td colspan="2">6 7 8</td></tr>
<tr><td colspan="2">DP=0</td><td colspan="2">MP=1</td><td colspan="2">SP=1</td><td colspan="2">ST=2</td><td colspan="2">FILL2</td></tr>
<tr><td colspan="4">TC</td><td colspan="6">SN</td></tr>
<tr><td colspan="6">CH</td><td colspan="4">AM</td></tr>
<tr><td colspan="10">AG</td></tr>
<tr><td colspan="10">CC</td></tr>
<tr><td colspan="10">DC</td></tr>
<tr><td colspan="2">S</td><td colspan="3">FILL</td><td colspan="1">F</td><td colspan="4">LV</td></tr>
<tr><td colspan="10">UD</td></tr>
</table>

Figure 5-7. CLEAR REQUEST by ADLP packet

<table>
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<tr><td colspan="2">DP=0</td><td colspan="2">MP=1</td><td colspan="2">SP=1</td><td colspan="2">ST=2</td><td colspan="2">FILL</td></tr>
<tr><td colspan="4">TC</td><td colspan="6">SN</td></tr>
<tr><td colspan="6">CH</td><td colspan="4">AM</td></tr>
<tr><td colspan="10">AG</td></tr>
<tr><td colspan="10">CC</td></tr>
<tr><td colspan="10">DC</td></tr>
<tr><td colspan="2">S</td><td colspan="3">FILL</td><td colspan="1">F</td><td colspan="4">LV</td></tr>
<tr><td colspan="10">UD</td></tr>
</table>

Figure 5-8. CLEAR REQUEST by GDLP packet

1	2	3 4	5 6	7 8
DP=0	MP=1	SP=1	ST=3	FILL2
TC		SN		
CH			AM	
AG				

Figure 5-9. CLEAR CONFIRMATION by ADLP packet

1	2	3 4	5 6	7 8
DP=0	MP=1	SP=1	ST=3	FILL
TC		SN		
CH			AM	
AG				

Figure 5-10. CLEAR CONFIRMATION by GDLP packet

1	2	3 4	5 6	7 8
DP=1	M	SN		
FILL1				
PS			PR	
CH			LV	
UD				

Figure 5-11. DATA packet

1	2	3 4	5 6	7 8
DP=0	MP=1	SP=3	ST=1	FILL2
S	F	SN		
CH			LV	
UD				

Figure 5-12. INTERRUPT packet

1 2 3 4 5 6 7 8

<table>
<tr><td>DP=0</td><td>MP=1</td><td>SP=3</td><td>ST=3</td><td>SS=0</td></tr>
<tr><td colspan="2">FILL2</td><td colspan="3">SN</td></tr>
<tr><td colspan="3">CH</td><td colspan="2">FILL</td></tr>
</table>

Figure 5-13. INTERRUPT CONFIRMATION packet

1 2 3 4 5 6 7 8

<table>
<tr><td>DP=0</td><td>MP=1</td><td>SP=3</td><td>ST=3</td><td>SS=1</td></tr>
<tr><td colspan="2">FILL2</td><td colspan="3">SN</td></tr>
<tr><td colspan="3">CH</td><td colspan="2">PR</td></tr>
</table>

Figure 5-14. REJECT packet

1 2 3 4 5 6 7 8

<table>
<tr><td>DP=0</td><td>MP=1</td><td>SP=2</td><td>ST=0</td><td>FILL2</td></tr>
<tr><td colspan="2">FILL</td><td colspan="3">SN</td></tr>
<tr><td colspan="3">CH</td><td colspan="2">PR</td></tr>
</table>

Figure 5-15. RECEIVE READY packet

1 2 3 4 5 6 7 8

<table>
<tr><td>DP=0</td><td>MP=1</td><td>SP=2</td><td>ST=1</td><td>FILL2</td></tr>
<tr><td colspan="2">FILL</td><td colspan="3">SN</td></tr>
<tr><td colspan="3">CH</td><td colspan="2">PR</td></tr>
</table>

Figure 5-16. RECEIVE NOT READY packet

1 2 3 4 5 6 7 8

<table>
<tr><td>DP=0</td><td>MP=1</td><td>SP=2</td><td>ST=2</td><td>FILL2</td></tr>
<tr><td colspan="2">FILL</td><td colspan="3">SN</td></tr>
<tr><td colspan="3">CH</td><td colspan="2">FILL</td></tr>
<tr><td colspan="5">RC</td></tr>
<tr><td colspan="5">DC</td></tr>
</table>

Figure 5-17. RESET REQUEST packet

1	2	3	4 5	6 7	8
	DP=0	MP=1	SP=2	ST=3	FILL2
	FILL		SN		
	CH			FILL	

Figure 5-18. RESET CONFIRMATION packet

1	2	3	4 5	6 7	8
DP=0	MP=1	SP=3	ST=0	OF	IN
RTL					
RT					
ODL					
OD					

Figure 5-19. ROUTE packet

1	2	3	4 5	6 7	8
	DP=0	MP=1	SP=3	ST=2	FILL2
	LENGTH				
	FIRST PACKET				
	LENGTH				
	LAST PACKET				
	LENGTH = 0				

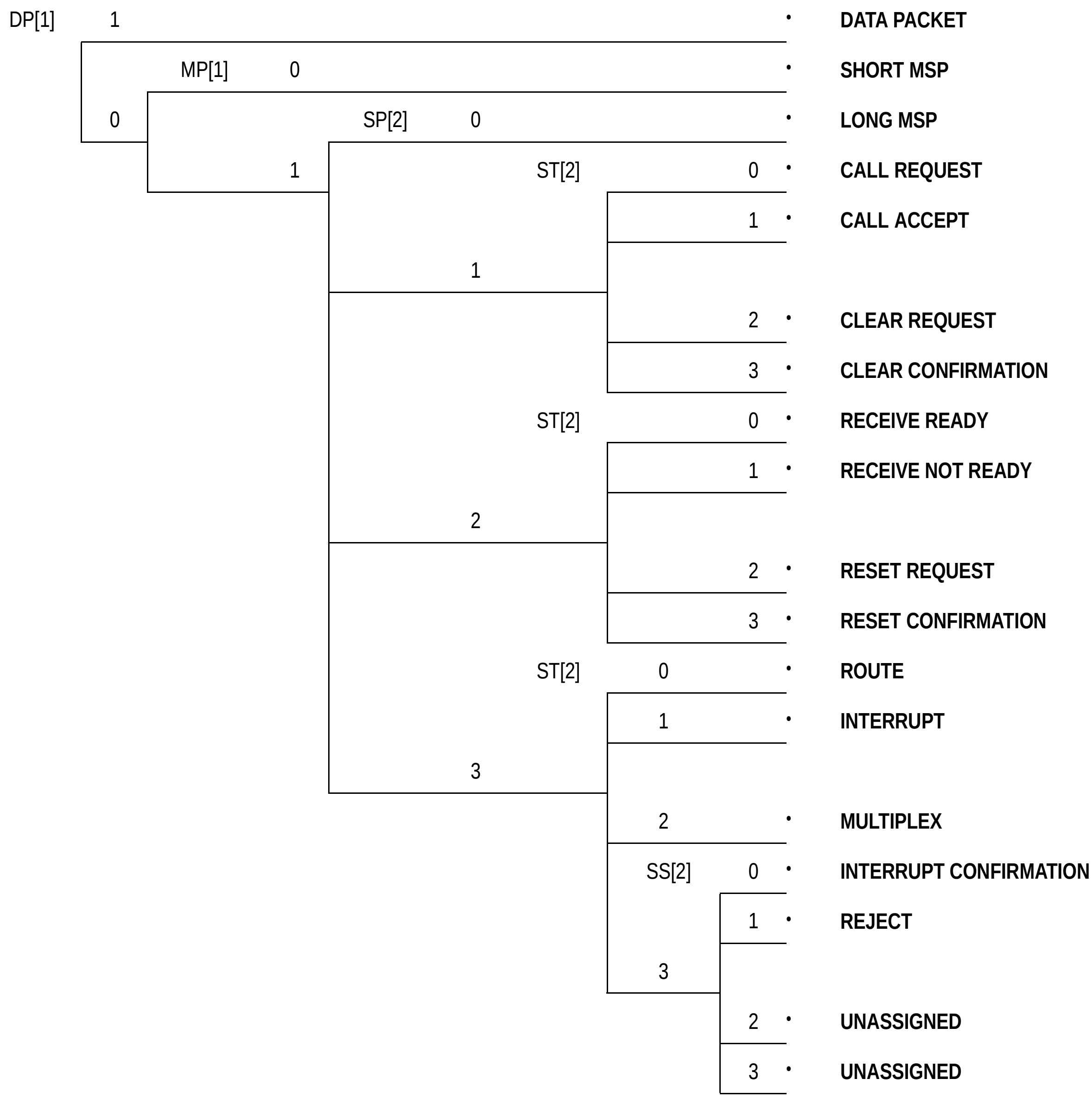
Figure 5-20. MULTIPLEX packet

1	2	3	4	5	6	7	8
DP=0	MP=0	M/CH					
FILL1							
UD							

Figure 5-21. SHORT FORM MSP packet

1	2	3	4	5	6	7	8
DP=0	MP=1	SP=0		L		M/SN	
FILL2		M/CH					
UD							

Figure 5-22. LONG FORM MSP packet



LEGEND:

DP = DATA packet type

MP = MSP packet type

SP = SUPERVISORY packet

ST = SUPERVISORY type

SS = SUPERVISORY subset

Figure 5-23. Control fields used in MODE S packets

APPENDIX TO CHAPTER 5. DATA FORMATS AND CONTROL PARAMETERS FOR COMMUNICATIONS VIA MODE S SPECIFIC SERVICES

TECHNICAL SUPPORT FOR SSR MODE S AIR-GROUND DATA LINK

This appendix defines data formats and control parameters that shall be used for communications using Mode S specific services.

Appendix 1 is arranged in the following manner:

Section 1 List of acronyms

Section 2 Data formats for transponder registers

Section 3 Formats for Mode S specific protocols (MSP)

Section 4 Mode S broadcast protocols

Note.— Guidance material on possible data sources, the use of control parameters, and the protocols involved is given in the Manual on Mode S Specific Services *(Doc 9688).*

1. LIST OF ACRONYMS

ACAS	Airborne collision avoidance system
ADLP	Airborne data link processor
ADS-B	Automatic dependent surveillance-broadcast
ATN	Aeronautical telecommunication network
ATS	Air traffic service
A/V	Aircraft/vehicle
BDS	Comm-B data selector
CPR	Compact position reporting
ELM	Extended length message
GDLP	Ground data link processor
GICB	Ground-initiated Comm-B
GFM	General formatter/manager
GNSS	Global navigation satellite system
II	Interrogator identifier
MA	Message, Comm-A
MB	Message, Comm-B
MC	Message, Comm-C
MD	Message, Comm-D
MSP	Mode S specific protocol
NUC_P	Navigational uncertainty category — position
NUC_R	Navigational uncertainty category — rate
RNP	Required navigation performance
SI	Surveillance identifier
SLM	Standard length message
SPI	Special position identification
SSR	Secondary surveillance radar
TIS	Traffic information service
UTC	Coordinated universal time

2. DATA FORMATS FOR TRANSPONDER REGISTERS

2.1 REGISTER ALLOCATION

Applications shall use the allocated register numbers as shown in the table below:

Register No.	*Assignment*	*Minimum update rate*
00_{16}	Not valid	N/A
01_{16}	Unassigned	N/A
02_{16}	Linked Comm-B, segment 2	N/A
03_{16}	Linked Comm-B, segment 3	N/A
04_{16}	Linked Comm-B, segment 4	N/A
05_{16}	Extended squitter airborne position	0.2 s
06_{16}	Extended squitter surface position	0.2 s
07_{16}	Extended squitter status	1.0 s
08_{16}	Extended squitter identification and type	15.0 s
09_{16}	Extended squitter airborne velocity	0.2 s
$0A_{16}$	Extended squitter event-driven information	variable
$0B_{16}$	Air/air information 1 (aircraft state)	1.0 s
$0C_{16}$	Air/air information 2 (aircraft intent)	1.0 s
$0D_{16}$-$0E_{16}$	Reserved for air/air state information	To be determined
$0F_{16}$	Reserved for ACAS	To be determined
10_{16}	Data link capability report	≤4.0 s (see 2.1.3)
11_{16}-16_{16}	Reserved for extension to data link capability reports	5.0 s
17_{16}	Common usage GICB capability report	5.0 s
18_{16}-$1F_{16}$	Mode S specific services capability reports	5.0 s
20_{16}	Aircraft identification	5.0 s
21_{16}	Aircraft and airline registration markings	15.0 s
22_{16}	Antenna positions	15.0 s
23_{16}	Reserved for antenna position	15.0 s
24_{16}	Reserved for aircraft parameters	15.0 s
25_{16}	Aircraft type	15.0 s
26_{16}-$2F_{16}$	Unassigned	N/A
30_{16}	ACAS active resolution advisory	see ACAS SARPs (4.3.8.4.2.2)
31_{16}-$3F_{16}$	Unassigned	N/A
40_{16}	Aircraft intention	1.0 s
41_{16}	Next waypoint identifier	1.0 s
42_{16}	Next waypoint position	1.0 s

Register No.	*Assignment*	*Minimum update rate*
43_{16}	Next waypoint information	0.5 s
44_{16}	Meteorological routine air report	1.0 s
45_{16}	Meteorological hazard report	1.0 s
46_{16}	Reserved for flight management system Mode 1	To be determined
47_{16}	Reserved for flight management system Mode 2	To be determined
48_{16}	VHF channel report	5.0 s
49_{16}-$4F_{16}$	Unassigned	N/A
50_{16}	Track and turn report	1.0 s
51_{16}	Position report coarse	0.5 s
52_{16}	Position report fine	0.5 s
53_{16}	Air-referenced state vector	0.5 s
54_{16}	Waypoint 1	5.0 s
55_{16}	Waypoint 2	5.0 s
56_{16}	Waypoint 3	5.0 s
57_{16}-$5E_{16}$	Unassigned	N/A
$5F_{16}$	Quasi-static parameter monitoring	0.5 s
60_{16}	Heading and speed report	1.0 s
61_{16}	Extended squitter emergency/priority status	1.0 s
62_{16}	Current trajectory change point	1.7 s
63_{16}	Next trajectory change point	1.7 s
64_{16}	Aircraft operational coordination message	2.0 s or 5.0 s (2.3.10.1)
65_{16}	Aircraft operational status	1.7 s
66_{16}-$6F_{16}$	Reserved for extended squitter	N/A
70_{16}-75_{16}	Reserved for future aircraft downlink parameters	N/A
76_{16}-$E0_{16}$	Unassigned	N/A
$E1_{16}$-$E2_{16}$	Reserved for Mode S byte	N/A
$E3_{16}$-$F0_{16}$	Unassigned	N/A
$F1_{16}$-$F2_{16}$	Military applications	15 s
$F3_{16}$-FF_{16}	Unassigned	N/A

2.1.1 The details of the data to be entered into the assigned registers shall be as defined in the following pages of this section. The above table specifies the minimum update rates at which the appropriate transponder register(s) shall be reloaded with valid data. If the defined update rate is not maintained, the status bit (if provided) shall indicate that the data in that field are invalid.

2.1.2 The time between the availability of the data at the SSE and the time that the data are processed and appear in the relevant transponder register shall be less than the minimum update rate specified in the table above.

2.1.3 **Recommendation**.—*The time between the availability of data at the SSE and the time that the data are processed and appears in the relevant transponder register should be as short as possible.*

2.1.4 The register number shall be equivalent to the Comm-B data selector (BDS) value used to address that register, (see 3.1.2.6.11.2.1 of Annex 10, Volume IV). Register $0A_{16}$ shall not be used for GICB or ACAS cross-link read-out. The data link capability report (register number 10_{16}) shall be updated within one second of the data changing and at least every four seconds thereafter.

2.2 GENERAL CONVENTIONS ON DATA FORMATS

2.2.1 VALIDITY OF DATA

The bit patterns contained in the 56-bit transponder registers shall be considered as valid application data only if:

1) the data link capability report is contained in register number 10_{16}. This is indicated by bit 25 of the data link capability report contained in register number 10_{16} being set to "ONE".

2) the GICB service corresponding to the application is shown as "supported" by the corresponding bit in the GICB capability report register numbers 17_{16} to $1C_{16}$ being set to "ONE".

Note 1.— The intent of the capability bits in register number 17_{16} is to indicate that useful data are contained in the corresponding transponder register. For this reason, each bit for a register is cleared if data becomes unavailable (2.5.4.1) and set again when data insertion into the register resumes.

Note 2.— A bit set in register numbers 18_{16} to $1C_{16}$ indicates that the application using this register has been installed on the aircraft. These bits are not cleared to reflect the real-time loss of an application, as is done for register number 17_{16} (2.5.4.2).

3) the data value is valid at the time of extraction. This is indicated by a data field status bit (if provided). When this status bit is set to "ONE", the data field(s) which follow, up to the next status bit, are valid. When this status bit is set to "ZERO", the data field(s) are invalid.

2.2.2 REPRESENTATION OF NUMERICAL DATA

Numerical data shall be represented as follows:

1) Numerical data shall be represented as binary numerals. When the value is signed, 2's complement representation shall be used, and the bit following the status bit shall be the sign bit.

2) Unless otherwise specified, whenever more bits of resolution are available from the data source than in the data field into which that data are to be loaded, the data shall be rounded to the nearest value that can be encoded in that data field.

3) In all cases where a status bit is used it shall be set to "ONE" to indicate VALID and to "ZERO" to indicate INVALID.

Note.— This facilitates partial loading of the registers.

4) When present, a switch bit shall indicate which of two alternative data types is being used to update the parameter in the transponder register.

5) Bit numbering in the MB field shall be as specified in Annex 10, Volume IV (3.1.2.3.1.3).

6) Registers containing data intended for broadcast Comm-B shall have the broadcast identifier located in the eight most significant bits of the MB field.

Note.— Tables are numbered Table 2-X where "X" is the decimal equivalent of the BDS code to which the format applies.

2.2.3 RESERVED FIELDS

Unless specified in this Annex, these bit fields shall be reserved for future allocation by ICAO.

2.3 EXTENDED SQUITTER FORMATS

This section defines the formats and coding that shall be used for extended squitter ADS-B messages. When the extended squitter capability is implemented as an extended squitter/non-transponder device (ES/NT, Annex 10, Volume IV, 3.1.2.8.7), the convention for register numbering shall not apply. The data content and the transmit times shall be the same as specified for the transponder case.

2.3.1 FORMAT TYPE CODES

The format type code shall differentiate the Mode S extended squitter messages into several classes as specified in the following table:

"TYPE" Subfield Code Definitions (DF = 17 or 18)					
Type code	*Format*	*Horizontal protection limit, (HPL)*	*95% Containment radius, μ and v, on horizontal and vertical position error*	*Altitude type (2.3.2.4)*	*NUC_P*
0	No position information			Baro altitude or no altitude information	0
1	Identification (Category Set D)			*Not applicable*	
2	Identification (Category Set C)			*Not applicable*	
3	Identification (Category Set B)			*Not applicable*	
4	Identification (Category Set A)			*Not applicable*	
5	Surface position	HPL < 7.5 m	μ < 3 m	No altitude information	9
6	Surface position	HPL < 25 m	3 m ≤ μ < 10 m	No altitude information	8
7	Surface position	HPL < 185.2 m (0.1 NM)	10 m ≤ μ < 92.6 m (0.05 NM)	No altitude information	7
8	Surface position	HPL > 185.2 m (0.1 NM)	(0.05 NM) 92.6 m ≤ μ	No altitude information	6
9	Airborne position	HPL < 7.5 m	μ < 3 m	Baro altitude	9
10	Airborne position	7.5 m ≤ HPL < 25 m	3 m ≤ μ < 10 m	Baro altitude	8
11	Airborne position	25 m ≤ HPL < 185.2 m (0.1 NM)	10 m ≤ μ < 92.6 m (0.05 NM)	Baro altitude	7
12	Airborne position	185.2 m (0.1 NM) ≤ HPL < 370.4 m (0.2 NM)	92.6 m (0.05 NM) ≤ μ < 185.2 m (0.1 NM)	Baro altitude	6
13	Airborne position	380.4 m (0.2 NM) ≤ HPL < 92.6 m (0.5 NM)	185.2 m (0.1 NM) ≤ μ < 463 m (0.25 NM)	Baro altitude	5
14	Airborne position	26 m (0.5 NM) ≤ HPL < 185.2 m (1.0 NM)	463 m (0.25 NM) ≤ μ < 92.6 m (0.5 NM)	Baro altitude	4
15	Airborne position	185.2 m (1.0 NM) ≤ HPL < 370.4 m (2.0 NM)	92.6 m (0.5 NM) ≤ μ < 185.2 km (1.0 NM)	Baro altitude	3
16	Airborne position	7.704 km (2.0 NM) ≤ HPL < 18.52 km (10 NM)	1.852 km (1.0 NM) ≤ μ < 9.26 km (5.0 NM)	Baro altitude	2
17	Airborne position	18.52 km (10 NM) ≤ HPL < 37.04 km (20 NM)	9.26 km (5.0 NM) ≤ μ < 18.52 km (10.0 NM)	Baro altitude	1
18	Airborne position	HPL ≥ 37.04 km (20 NM)	8.52 km (10.0 NM) ≤ μ	Baro altitude	0
19	Airborne velocity	*Not applicable*	*Not applicable*	*Difference between "Baro altitude" and "GNSS height (HAE) or GNSS altitude (MSL)" (2.3.5.7)*	*N/A*
20	Airborne position	HPL < 7.5 m	μ < 3 m and v < 4 m	GNSS height (HAE)	9
21	Airborne position	HPL < 25 m	μ < 10 m and v < 15 m	GNSS height (HAE)	8

"TYPE" Subfield Code Definitions (DF = 17 or 18)					
Type code	*Format*	*Horizontal protection limit, (HPL)*	*95% Containment radius, μ and v, on horizontal and vertical position error*	*Altitude type (2.3.2.4)*	*NUC_P*
22	Airborne position	HPL ≥ 25 m	μ ≥ 10 m or *v* ≥ 15 m	GNSS height (HAE)	Reserved
23	Reserved for test purposes				
24	Reserved for surface system status				
25 - 27	Reserved				
28	Extended squitter aircraft status				
29	Current/next trajectory change point				
30	Aircraft operational coordination				
31	Aircraft operational status				

The 95 per cent containment limit, μ, on horizontal position error shall be derived from, HFOM (horizontal figure of merit). Likewise, the 95 per cent containment limit, *v*, on vertical position error shall be derived from, VFOM (vertical figure of merit). The horizontal protection level (HPL) shall be derived from AHIL (autonomous horizontal integrity limit).

Note.— The term "broadcast" when applied to extended squitter, refers to a spontaneous transmission by the transponder. This is distinct from the Comm-B broadcast protocol.

2.3.2 AIRBORNE POSITION FORMAT

The airborne position squitter format shall be formatted as specified in the definition of BDS 0,5. Additional details are specified in the following paragraphs.

2.3.2.1 *COMPACT POSITION REPORTING (CPR) FORMAT (F)*

In order to achieve coding that is unambiguous worldwide, CPR shall use two format types, known as even and odd. This 1-bit field (bit 22) shall be used to define the CPR format type. F = 0 shall denote an even format coding, while F = 1 shall denote an odd format coding (2.6.7).

2.3.2.2 *TIME SYNCHRONIZATION (T)*

This 1-bit field (bit 21) shall indicate whether or not the time of applicability of the message is synchronized with UTC time. T = 0 shall denote that the time is not synchronized to UTC. T = 1 shall denote that the time of applicability is synchronized to UTC time. Synchronization shall only be used for airborne position messages having the top two horizontal position precision categories (format types codes 9, 10, 20 and 21).

When T = 1, the time of validity in the airborne position message format shall be encoded in the 1-bit F field which, in addition to CPR format type, indicates the 0.2 second time tick for UTC time of position validity. The F bit shall alternate between 0 and 1 for successive 0.2 second time ticks, beginning with F = 0 when the time of applicability is an exact even-numbered UTC second.

2.3.2.3 *LATITUDE/LONGITUDE*

The latitude/longitude field in the airborne position message shall be a 34-bit field containing the latitude and longitude of the aircraft airborne position. The latitude and longitude shall each occupy 17 bits. The airborne latitude and longitude encodings shall contain the high-order 17 bits of the 19-bit CPR-encoded values defined in 2.6.

Note.— The unambiguous range for the local decoding of airborne messages is 666 km (360 NM). The positional accuracy maintained by the airborne CPR encoding is approximately 5.1 metres. The latitude/longitude encoding is also a function of the CPR format value (the "F" bit) described above.

2.3.2.3.1 *Extrapolating position (when T = 1)*

If T is set to one, airborne position messages with format type codes 9, 10, 20 and 21 shall have times of applicability which are exact 0.2 s UTC epochs. In that case, the F bit shall be 0 if the time of applicability is an even-numbered 0.2 s UTC epoch, or 1 if the time of applicability is an odd-numbered 0.2 s UTC epoch.

Note.— In such a case, an "even-numbered 0.2 s epoch" means an epoch which occurs an even number of 200-ms time intervals after an even-numbered UTC second. An "odd-numbered 0.2 s epoch" means an epoch which occurs an odd number of 200-ms time intervals after an even-numbered UTC second. Examples of even-numbered 0.2 s UTC epochs are 12.0 s, 12.4 s, 12.8 s, 13.2 s, 13.6 s, etc. Examples of odd-numbered UTC epochs are 12.2 s, 12.6 s, 13.0 s, 13.4 s, 13.8 s, etc.

The CPR-encoded latitude and longitude that are loaded into the airborne position register shall comprise an estimate of the aircraft/vehicle (A/V) position at the time of applicability of that latitude and longitude, which is an exact 0.2 s UTC epoch. The register shall be loaded no earlier than 150 ms before the time of applicability of the data being loaded, and no later than 50 ms before the time of applicability of that data.

This timing shall ensure that the receiving ADS-B system may recover the time of applicability of the data in the airborne position message, as follows:

1) If F = 0, the time of applicability shall be the nearest even-numbered 0.2 s UTC epoch to the time that the airborne position message is received.

2) If F = 1, the time of applicability shall be the nearest odd-numbered 0.2 s UTC epoch to the time that the airborne position message is received.

Recommendation.— *If the airborne position register is updated at its minimum (every 200 ms), that register should be loaded 100 ms before the time of applicability. The register should then be reloaded, with data applicable at the next subsequent 0.2 s UTC epoch, 100 ms before that next subsequent 0.2 s epoch.*

Note 1.— In this way, the time of transmission of an airborne position message would never differ by more than 100 ms from the time of applicability of the data in that message. By specifying "100 ms ± 50 ms" rather than 100 ms exactly, some tolerance is allowed for variations in implementation.

Note 2.— The position may be estimated by extrapolating the position from the time of validity of the fix (included in the position fix) to the time of applicability of the data in the register (which, if T = 1, is an exact 0.2 s UTC time tick). This may be done by a simple linear extrapolation using the velocity provided with the position fix and the time difference between the position fix validity time and the time of applicability of the transmitted data. Alternatively, other methods of estimating the position, such as alpha-beta trackers or Kalman filters, may be used.

Every 200 ms, the contents of the position registers shall be updated by estimating the A/V position at the next subsequent 0.2 s UTC epoch. This process shall continue with new position fixes as they become available from the source of navigation data.

2.3.2.3.2 *Extrapolating position (when T = 0)*

T shall be set to zero if the time of applicability of the data being loaded into the position register is not synchronized to any particular UTC epoch. In that case, the position register shall be reloaded with position data at intervals that are no more than 200 ms apart. The position being loaded into the register shall have a time of applicability that is never more than 200 ms different from any time during which the register holds that data.

Note.— This may be accomplished by loading the airborne position register at intervals that are, on average, no more than 200 ms apart, with data for which the time of applicability is between the time the register is loaded and the time that it is loaded again. (Shorter intervals than 200 ms are permitted, but not required.)

If T = 0, receiving ADS-B equipment shall accept airborne position messages as being current as of the time of receipt. The transmitting ADS-B equipment shall reload the airborne position register with updated estimates of the A/V position, at intervals that are no more than 200 ms apart. The process shall continue with new position reports as they become available.

2.3.2.3.3 *Timeout when new position data are unavailable*

In the event that the navigation input ceases, the extrapolation described in 2.3.2.3.1 and 2.3.2.3.2 shall be limited to no more than two seconds. At the end of this timeout of two seconds, all fields of the airborne position register, except the altitude field, shall be cleared (set to zero). When the appropriate register fields are cleared, the zero type code field shall serve to notify ADS-B receiving equipment that the data in the latitude and longitude fields are invalid.

2.3.2.4 *ALTITUDE*

This 12-bit field shall provide the aircraft altitude. Depending on the type code, this field shall contain either:

1) Barometric altitude encoded in 25 or 100 foot increments (as indicated by the Q bit) or,

2) GNSS height above ellipsoid (HAE).

"Baro-Altitude" shall be interpreted as barometric pressure altitude, relative to a standard pressure of 1013.25 hectopascals (29.92 in Hg). It shall not be interpreted as baro corrected altitude.

Format type code 20 to 22 shall be reserved for the reporting of GNSS height (HAE) which represents the height above the surface of the WGS-84 ellipsoid and may be used when baro altitude is not available.

Note.— GNSS altitude (MSL) is not accurate enough for use in the position report.

2.3.2.5 *SINGLE ANTENNA FLAG (SAF)*

This 1-bit field shall indicate the type of antenna system that is being used to transmit extended squitters. SAF = 1 shall signify a single transmit antenna. SAF = 0 shall signify a dual transmit antenna system.

At any time that the diversity configuration cannot guarantee that both antenna channels are functional, then the single antenna subfield shall be set to ONE.

2.3.2.6 *SURVEILLANCE STATUS*

The surveillance status field in the airborne position message format shall encode information from the aircraft's Mode A code and SPI condition indication as specified in Annex 10, Volume IV, 3.1.2.8.6.3.1.1.

2.3.3 SURFACE POSITION FORMAT

The surface position squitter shall be formatted as specified in the definition of register number 06_{16} in the following paragraphs.

2.3.3.1 *MOVEMENT*

This 7-bit field shall provide information on the ground speed of the aircraft. A non-linear scale shall be used as defined in the following table where speeds are given in km/h (kt).

Encoding	*Meaning*	*Quantization*
0	no information available	
1	aircraft stopped (ground speed < 0.2315 km/h (0.125 kt))	
2-8	0.2315 km/h (0.125 kt) ≤ ground speed < 1.852 km/h (1 kt)	(in 0.2315 km/h (0.125 kt) steps)
9-12	1.852 km/h (1 kt) ≤ ground speed < 3.704 km/h (2 kt)	(in 0.463 km/h (0.25 kt) steps)

Encoding	*Meaning*	*Quantization*
13-38	3.704 km/h (2 kt) ≤ ground speed < 27.78 km/h (15 kt)	(in 0.926 km/h (0.5 kt) steps)
39-93	27.78 km/h (15 kt) ≤ ground speed < 129.64 km/h (70 kt)	(in 1.852 km/h (1.0 kt) steps)
94-108	129.64 km/h (70 kt) ≤ ground speed < 185.2 km/h (100 kt)	(in 3.704 km/h (2.0 kt) steps)
109-123	185.2 km/h (100 kt) ≤ ground speed < 324.1 km/h (175 kt)	(in 9.26 km/h (5.0 kt) steps)
124	ground speed ≥ 324.1 km/h (175 kt)	
125	Reserved	
126	Reserved	
127	Reserved	

2.3.3.2 *GROUND TRACK (TRUE)*

2.3.3.2.1 *Ground track status*

This 1-bit field shall define the validity of the ground track value. Coding for this field shall be as follows: 0 = invalid and 1 = valid.

2.3.3.2.2 *Ground track value*

This 7-bit (14-20) field shall define the direction (in degrees clockwise from true north) of aircraft motion on the surface. The ground track shall be encoded as an unsigned angular weighted binary numeral, with an MSB of 180 degrees and an LSB of 360/128 degrees, with zero indicating true north. The data in the field shall be rounded to the nearest multiple of 360/128 degrees.

2.3.3.3 *COMPACT POSITION REPORTING (CPR) FORMAT (F)*

The 1-bit (22) CPR format field for the surface position message shall be encoded as specified for the airborne message. That is, F = 0 shall denote an even format coding, while F = 1 shall denote an odd format coding (2.6.7).

2.3.3.4 *TIME SYNCHRONIZATION (T)*

This 1-bit field (21) shall indicate whether or not the time of applicability of the message is synchronized with UTC time. T = 0 shall denote that the time is not synchronized to UTC. T = 1 shall denote that time of applicability is synchronized to UTC time. Synchronization shall only be used for surface position messages having the top two horizontal position precision categories (format type codes 5 and 6).

When T = 1, the time of validity in the surface message format shall be encoded in the 1-bit F field which (in addition to CPR format type) indicates the 0.2 second time tick for UTC time of position validity. The F bit shall alternate between 0 and 1 for successive 0.2 second time ticks, beginning with F = 0 when the time of applicability is an exact even-numbered UTC second.

2.3.3.5 *LATITUDE/LONGITUDE*

The latitude/longitude field in the surface message shall be a 34-bit field containing the latitude and longitude coding of the aircraft's surface position. The latitude (*Y*) and longitude (*X*) shall each occupy 17 bits. The surface latitude and longitude encodings shall contain the low-order 17 bits of the 19-bit CPR-encoded values defined in 2.6.

Note.— The unambiguous range for local decoding of surface messages is 166.5 km (90 NM). The positional accuracy maintained by the surface CPR encoding is approximately 1.25 metres. The latitude/longitude encoding is also a function of the CPR format value (the "F" bit) described above.

2.3.3.5.1 *Extrapolating position (when T = 1)*

This extrapolation shall conform to 2.3.2.3.1 (substitute “surface” for “airborne” where appropriate).

2.3.3.5.2 *Extrapolating position (when T = 0)*

This extrapolation shall conform to 2.3.2.3.2 (substitute “surface” for “airborne” where appropriate).

2.3.3.5.3 *Timeout when new position data are unavailable*

This timeout shall conform to 2.3.2.3.3 (substitute “surface” for “airborne” where appropriate).

2.3.4 IDENTIFICATION AND CATEGORY FORMAT

The identification and category squitter shall be formatted as specified in the definition of BDS 0,8.

2.3.5 AIRBORNE VELOCITY FORMAT

The airborne velocity squitter shall be formatted as specified in the definition of register number 09_{16} and in the following paragraphs.

2.3.5.1 *SUBTYPES 1 AND 2*

Subtypes 1 and 2 of the airborne velocity format shall be used when the transmitting aircraft’s velocity over ground is known. Subtype 1 shall be used at subsonic velocities while subtype 2 shall be used when the velocity exceeds 1 022 kt.

This message shall not be broadcast if the only valid data are the intent change flag and the IFR capability flag (2.3.5.3, 2.3.5.4). After initialization, the broadcast shall be suppressed by loading register 09_{16} with all zeros and then discontinuing the updating of the register until data input is available again.

The supersonic version of the velocity coding shall be used if either the east-west OR north-south velocities exceed 1 022 kt. A switch to the normal velocity coding shall be made if both the east-west AND north-south velocities drop below 1 000 kt.

2.3.5.2 *SUBTYPES 3 AND 4*

Subtypes 3 and 4 of the airborne velocity format shall be used when the transmitting aircraft’s velocity over ground is not known. These subtypes substitute airspeed and heading for the velocity over ground. Subtype 3 shall be used at subsonic velocities, while subtype 4 shall be used when the velocity exceeds 1 022 kt.

This message shall not be broadcast if the only valid data are the intent change flag and the IFR capability flag (2.3.5.3, 2.3.5.4). After initialization, broadcast shall be suppressed by loading register 09_{16} with all zeros and then discontinuing the updating of the register until data input is available again.

The supersonic version of the velocity coding shall be used if the airspeed exceeds 1 022 kt. A switch to the normal velocity coding shall be made if the airspeed drops below 1 000 kt.

2.3.5.3 *INTENT CHANGE FLAG IN AIRBORNE VELOCITY MESSAGES*

An intent change event shall be triggered 4 seconds after the detection of new information being inserted in registers 4,0 to 4,2. The code shall remain set for 18 ± 1 second following an intent change.

Intent change flag coding:
0 = no change in intent
1 = intent change

Note 1.— Register 43_{16} is not included since it contains dynamic data which will be continuously changing.

Note 2.— A four-second delay is required to provide for settling time for intent data derived from manually set devices.

2.3.5.4 *IFR capability flag (IFR) in airborne velocity messages*

The IFR capability flag shall be a 1-bit (bit 10) subfield in the subtypes 1, 2, 3 and 4 airborne velocity messages. IFR = 1 shall signify that the transmitting aircraft has a capability for applications requiring ADS-B equipage class A1 or above. Otherwise, IFR shall be set to 0.

2.3.5.5 *Magnetic heading in airborne velocity messages*

2.3.5.5.1 *Magnetic heading status*

This 1-bit field shall define the availability of the magnetic heading value. Coding for this field shall be: 0 = not available and 1 = available.

2.3.5.6 *Magnetic heading value*

This 10-bit field shall contain the aircraft magnetic heading (in degrees clockwise from magnetic north) when velocity over ground is not available. The magnetic heading shall be encoded as an unsigned angular weighted binary numeral with an MSB of 180 degrees and an LSB of 360/1 024 degrees, with zero indicating magnetic north. The data in the field shall be rounded to the nearest multiple of 360/1 024 degrees.

2.3.5.7 *Difference from baro altitude in airborne velocity messages*

This 8-bit field shall contain the signed difference between barometric and GNSS altitude. (Coding for this field shall be as indicated in Tables 2-9a and 2-9b.)

The difference between baro altitude and GNSS height above ellipsoid (HAE) shall be used if available. If GNSS HAE is not available, GNSS altitude (MSL) shall be used when airborne position is being reported using format type codes 11 through 18.

If airborne position is being reported using format type code 9 or 10, only GNSS (HAE) shall be used. For format type code 9 or 10, if GNSS (HAE) is not available, the field shall be coded with all zeros. The basis for the baro altitude difference (either GNSS (HAE) or GNSS altitude MSL) shall be used consistently for the reported difference.

2.3.6 Status register format

The status register shall be formatted as specified in the definition of register number 07_{16} and in the following paragraphs.

2.3.6.1 *Purpose*

Unlike the other extended squitter registers, the contents of this register shall not be broadcast. The purpose of this register shall be to serve as an interface between the transponder function and the general formatter/manager function (GFM, 2.5). The two fields defined for this format shall be the transmission rate subfield and the altitude type subfield.

2.3.6.2 *TRANSMISSION RATE SUBFIELD (TRS)*

This field is only used for a transponder implementation of extended squitter.

The TRS shall be used to notify the transponder of the aircraft motion status while on the surface. If the aircraft is moving, the surface position squitter shall be broadcast at a rate of twice per second, and identity squitters at a rate of once per 5 seconds. If the aircraft is stationary, the surface position squitter shall be broadcast at a rate of once per 5 seconds and the identity squitter at a rate of once per 10 seconds.

The algorithm specified in the definition of register number 07_{16} shall be used by the GFM (2.5) to determine motion status and the appropriate code shall be set in the TRS subfield. The transponder shall examine the TRS subfield to determine which rate to use when it is broadcasting surface squitters.

2.3.6.3 *ALTITUDE TYPE SUBFIELD (ATS)*

This field shall only be used for a transponder implementation of extended squitter.

The transponder shall load the altitude field of the airborne position squitter from the same digital source as used for addressed replies.

Note.— This is done to minimize the possibility that the altitude in the squitter is different from the altitude that would be obtained by direct interrogation.

If the GFM (2.5) inserts GNSS height (HAE) into the airborne position squitter, it shall instruct the transponder not to insert the baro altitude into the altitude field. The ATS subfield shall be set to ONE for this purpose.

2.3.7 EVENT-DRIVEN PROTOCOL

The event-driven protocol register shall be as specified in the definition of register numbers $0A_{16}$ in 2.5.5 and in the following paragraphs.

2.3.7.1 *PURPOSE*

The event-driven protocol shall be used as a flexible means to support the broadcast of messages beyond those defined for position, velocity, and identification.

Note.— These typically will be messages that are broadcast regularly for a period of time based on the occurrence of an event. An example is the broadcast of emergency/priority status every second during a declared aircraft emergency. A second example is the periodic broadcast of intent information for the duration of the operational condition.

2.3.8 EMERGENCY/PRIORITY STATUS

The emergency/priority status squitter shall be formatted as specified in the definition of register number 61_{16} and in the following paragraphs.

2.3.8.1 *TRANSMISSION RATE*

This message shall be broadcast once per second for the duration of the emergency.

2.3.8.2 *MESSAGE DELIVERY*

Message delivery shall be accomplished using the event-driven protocol (2.3.7). The broadcast of this message shall take priority over the event-driven protocol broadcast of all other message types, as specified in 2.5.5.3.

2.3.9 CURRENT/NEXT TRAJECTORY CHANGE POINT (TCP/TCP+1)

The current/next trajectory change point (TCP) squitter shall be formatted as specified in the definition of register numbers 62_{16} and 63_{16} and in the following paragraphs.

2.3.9.1 *TRANSMISSION RATE*

This message shall be broadcast once per 1.7 seconds for the duration of the operation.

2.3.9.2 *MESSAGE DELIVERY*

Message delivery shall be accomplished using the event-driven protocol (2.3.7).

2.3.9.3 *TRAJECTORY POINT/LEG TYPE*

This 4-bit (7-10) subfield shall be used to identify the type of TCP for which data are being provided in the message. The TCP type subfield shall be encoded as follows:

Encoding	*Meaning*
0000	No specific trajectory change point description information
0001	“Straight” (geodesic) course to a “fly by” waypoint
0010	“Straight” (geodesic) course to a “fly over” waypoint
0011	“Straight” (geodesic) course to a “speed change” waypoint
0100	“Straight” (geodesic) course to a “vertical speed change” waypoint
0101	Arc course to a “fly by” waypoint
0110	Arc course to a “fly over” waypoint
0111	Arc course to a “speed change” waypoint
1000	Arc course to a “vertical speed change” waypoint
1001	Holding pattern to a holding fix
1010	Course FROM the waypoint, termination point unknown
1011	Reserved for future use
1100	Reserved for future use
1101	Reserved for future use
1110	Reserved for future use
1111	Reserved for future use

If the trajectory point/leg can be classified in more than one of the categories identified in the table above, then the type having the largest encoded value shall be used.

2.3.9.4 *TCP DATA VALID*

This 1-bit (11) subfield shall be used to indicate the validity of the TCP/TCP+1 message. A value of ONE shall indicate a valid message. A value of ZERO shall indicate an invalid message.

2.3.9.5 *TCP FORMAT*

This 1-bit (12) subfield shall indicate whether the TCP is specified as position and time (4D), or position only (3D). A value ZERO shall indicate a 4D TCP. A value ONE shall indicate a 3D TCP. The 3D TCP/TCP+1 format shall be used if the distance to the TCP/TCP+1 is greater than 160 NM from the current position of the aircraft transmitting the TCP/TCP+1 message.

2.3.9.6 *TCP/TCP + 1 ALTITUDE*

This 10-bit subfield (13-22) shall be used to provide the binary encoded altitude of the current TCP/TCP+1 message. The altitude subfield shall be encoded as follows:

TCP/TCP + 1 ALTITUDE

Coding (binary)	*Coding (decimal)*	*Meaning (TCP altitude in feet)*
00 0000 0000	0	No TCP altitude information available
00 0000 0001	1	TCP altitude is ZERO
00 0000 0010	2	TCP altitude = 128 feet
00 0000 0011	3	TCP altitude = 256 feet
***	***	***
11 1111 1110	1022	TCP altitude = 130 688 feet
11 1111 1111	1023	TCP altitude > 130 752 feet

2.3.9.7 *TCP/TCP + 1 LATITUDE*

2.3.9.7.1 *4D TCP latitude*

This 14-bit (23-36) subfield shall be used to provide the airborne CPR encoded latitude for the 4D TCP or TCP + 1 message.

Encoding of the 4D TCP/TCP + 1 latitude data shall be accomplished as specified in 2.6.3.

2.3.9.7.2 *3D TCP latitude*

This 17-bit (23-39) subfield shall be used to provide the angular weighted binary encoded latitude for the 3D TCP or TCP + 1 message. The latitude shall be encoded as a 17-bit two's complement signed binary numeral in which the LSB (bit 39) has a weight of 2^{-17} times 360 degrees. North latitudes shall have a positive sign, and south latitudes shall have a negative sign.

2.3.9.8 *TCP/TCP + 1 LONGITUDE*

2.3.9.8.1 *4D TCP/TCP + 1 longitude*

This 14-bit (37-50) subfield shall be used to provide the airborne CPR encoded longitude for the 4D TCP or TCP + 1 message.

Encoding of the 4D TCP/TCP +1 longitude data shall be accomplished as specified in 2.6.3.

2.3.9.8.2 *3D TCP/TCP + 1 longitude*

This 17-bit (40-56) subfield shall be used to provide the angular weighted binary encoded longitude for the 3D TCP or TCP + 1 message. The field shall be encoded as a 17-bit two's complement signed binary numeral, in which the LSB (bit 56) has a weight of 2^{-17} times 360 degrees. The prime (Greenwich) meridian shall be defined as zero longitude. Longitudes to the east of Greenwich shall be positive, and those to the west of Greenwich shall be negative.

2.3.9.9 *TCP/TCP + 1 TIME-TO-GO (TTG)*

This 6-bit (51-56) subfield shall be used to provide the binary encoded time-to-go to the TCP or TCP + 1 message. The TCP time-to-go subfield shall be encoded as follows:

TCP/TCP + 1 time-to-go (TTG)

Coding (binary)	*Coding (decimal)*	*Meaning (TCP/TCP + 1 time-to-go in minutes)*
00 0000	0	No TCP time-to-go information available
00 0001	1	TCP time-to-go is ZERO
00 0010	2	TCP time-to-go = 0.25 minutes
00 0011	3	TCP time-to-go = 0.50 minutes
***	***	***
11 1110	62	TCP time-to-go = 15.25 minutes
11 1111	63	TCP time-to-go > 15.375 minutes

2.3.10 AIRCRAFT OPERATIONAL COORDINATION MESSAGE

The aircraft operational coordination message squitter shall be formatted as specified in the definition of register number 64_{16} and in the following paragraphs.

2.3.10.1 *TRANSMISSION RATE*

This message shall be broadcast once per 5 seconds for the duration of the operation, except that it shall be broadcast once per 2 seconds for 30 seconds when the message content changes.

2.3.10.2 *MESSAGE DELIVERY*

Message delivery shall be accomplished using the event-driven protocol (2.3.7).

2.3.10.3 *PAIRED ADDRESS*

This 24-bit (9-32) subfield shall be used to provide the ICAO 24-bit address of the aircraft that the ADS-B transmitting aircraft is paired with when participating in coordinated operations with another aircraft.

2.3.10.4 *RUNWAY THRESHOLD SPEED*

This 5-bit subfield (33-37) shall be used to provide the runway threshold speed of the aircraft. Encoding of the subfield shall be as follows:

RUNWAY THRESHOLD SPEED

Coding (binary)	*Coding (decimal)*	*Meaning (Runway threshold speed in knots)*
0 0000	0	No runway threshold speed information available
0 0001	1	Runway threshold speed < 100 knots
0 0010	2	Runway threshold speed = 100 knots
0 0011	3	Runway threshold speed = 105 knots
0 0100	4	Runway threshold speed = 110 knots
***	***	***
1 1110	30	Runway threshold speed = 240 knots
1 1111	31	Runway threshold speed > 242.5 knots

Note.— The encoding shown in the table represents positive magnitude data only.

2.3.10.5 *ROLL ANGLE SIGN*

This 1-bit (38) subfield shall be used to provide the direction or sign of the roll angle of the aircraft. Encoding of the subfield shall be as follows:

ROLL ANGLE SIGN BIT

Coding	*Meaning*
0	Roll angle is +, i.e. right wing down
1	Roll angle is –, i.e. left wing down

2.3.10.6 *ROLL ANGLE*

This 5-bit subfield (39-43) shall be used to provide the roll angle of the aircraft. Encoding of the subfield shall be as follows:

ROLL ANGLE

Coding (binary)	*Coding (decimal)*	*Meaning (Roll angle in degrees)*
0 0000	0	No roll angle information available
0 0001	1	Roll angle is ZERO
0 0010	2	Roll angle = 1.0 degree
0 0011	3	Roll angle = 2.0 degrees
***	***	***
1 1110	30	Roll angle = 29.0 degrees
1 1111	31	Roll angle > 29.5 degrees

Note.— The encoding shown in the table represents positive magnitude data only. The direction is given completely by the roll angle sign bit.

2.3.10.7 *GO-AROUND*

This 2-bit (44-45) subfield shall be used to indicate the condition when the aircraft is executing a go-around. Encoding of the subfield shall be as follows:

GO-AROUND SUBFIELD

Coding	*Meaning*
0	No information
1	Aircraft IS NOT executing a "go-around"
2	Aircraft IS executing a "go-around"
3	Reserved

2.3.10.8 *ENGINE-OUT*

This 2-bit (46-47) subfield shall be used to indicate an engine-out condition on the aircraft. Encoding of the subfield shall be as follows:

ENGINE-OUT SUBFIELD

Coding	*Meaning*
0	No information
1	Aircraft IS NOT experiencing an engine-out condition
2	Aircraft IS experiencing an engine-out condition
3	Reserved

2.3.11 AIRCRAFT OPERATIONAL STATUS

The aircraft operational status message squitter shall be formatted as specified in the definition of register number 64_{16} and in the following paragraphs.

2.3.11.1 *TRANSMISSION RATE*

This message shall be broadcast once per 1.7 seconds for the duration of the operation.

2.3.11.2 *MESSAGE DELIVERY*

Message delivery shall be accomplished using the event-driven protocol (2.3.7).

2.3.11.3 *EN-ROUTE OPERATIONAL CAPABILITIES (CC-4)*

This 4-bit (9-12) subfield shall be used to indicate en-route operational capabilities of the ADS-B transmitting system to other aircraft as specified by the following encoding.

CC-4 ENCODING: EN-ROUTE OPERATIONAL CAPABILITIES

CC-4 CODING		
Bit 9, 10	*Bit 11, 12*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

2.3.11.4 TERMINAL AREA OPERATIONAL CAPABILITIES (CC-3)

This 4-bit (13-16) subfield shall be used to indicate terminal area operational capabilities of the ADS-B transmitting system to other aircraft as specified by the following encoding.

CC-3 ENCODING: TERMINAL AREA OPERATIONAL CAPABILITIES

CC-3 CODING		
Bit 13, 14	*Bit 15, 16*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

2.3.11.5 *Approach and landing operational capabilities (CC-2)*

This 4-bit (17-20) subfield shall be used to indicate approach and landing operational capabilities of the ADS-B transmitting system to other aircraft as specified by the following encoding.

CC-2 ENCODING: APPROACH AND LANDING OPERATIONAL CAPABILITIES

CC-2 CODING		
Bit 17, 18	*Bit 19, 20*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

2.3.11.6 *Surface operational capabilities (CC-1)*

This 4-bit (21-24) subfield shall be used to indicate surface operational capabilities of the ADS-B transmitting system to other aircraft as specified by the following encoding.

CC-1 ENCODING: SURFACE OPERATIONAL CAPABILITIES

CC-1 CODING		
Bit 21, 22	*Bit 23, 24*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

2.3.11.7 *EN-ROUTE OPERATIONAL CAPABILITY STATUS (OM-4)*

This 4-bit (25-28) subfield shall be used to indicate the en-route operational capability status of the ADS-B transmitting system to other aircraft as specified by the following encoding.

OM-4 ENCODING: EN-ROUTE OPERATIONAL CAPABILITY STATUS

OM-4 CODING		
Bit 25, 26	*Bit 27, 28*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

2.3.11.8 *TERMINAL AREA OPERATIONAL CAPABILITY STATUS (OM-3)*

This 4-bit (29-32) subfield shall be used to indicate the terminal area operational capability status of the ADS-B transmitting system to other aircraft as specified by the following encoding.

OM-3 ENCODING: TERMINAL AREA OPERATIONAL CAPABILITY STATUS

OM-3 CODING		
Bit 29, 30	*Bit 31, 32*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

2.3.11.9 *APPROACH AND LANDING OPERATIONAL CAPABILITY STATUS (OM-2)*

This 4-bit (33-36) subfield shall be used to indicate the approach and landing operational capability status of the ADS-B transmitting system to other aircraft as specified by the following encoding.

OM-2 ENCODING: APPROACH AND LANDING OPERATIONAL CAPABILITY STATUS

OM-2 CODING		
Bit 33, 34	*Bit 35, 36*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

2.3.11.10 *SURFACE OPERATIONAL CAPABILITY STATUS (OM-1)*

This 4-bit (37-40) subfield shall be used to indicate the surface operational capability status of the ADS-B transmitting system to other aircraft as specified by the following encoding.

OM-1 ENCODING: SURFACE OPERATIONAL CAPABILITY STATUS

OM-1 CODING		
Bit 37, 38	*Bit 39, 40*	*MEANING*
0 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

0 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 0	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*
1 1	0 0	*Reserved*
	0 1	*Reserved*
	1 0	*Reserved*
	1 1	*Reserved*

2.4 EXTENDED SQUITTER INITIALIZATION AND TIMEOUT

Initialization and timeout functions for extended squitter broadcast shall be performed by the transponder and are specified in Annex 10, 3.1.2.

Note.— A description of these functions is presented in the following paragraphs to serve as reference material for the section on the general formatter/manager (GFM) (see 2.5).

2.4.1 INITIATION OF EXTENDED SQUITTER BROADCAST

At power-up initialization, the transponder shall commence operation in a mode in which it broadcasts only acquisition squitters. The transponder shall initiate the broadcast of extended squitters for airborne position, surface position, airborne velocity and aircraft identification when data are inserted into register numbers 05_{16}, 06_{16}, 09_{16} and 08_{16}, respectively. This determination shall be made individually for each squitter type. The insertion of altitude or surveillance status data into register number 05_{16} by the transponder shall not satisfy the minimum requirement for broadcast of the airborne position squitter.

Note.— This suppresses the transmission of extended squitters from aircraft that are unable to report position, velocity or identity information.

2.4.2 REGISTER TIMEOUT

The transponder shall clear all but the altitude and surveillance status subfields in the airborne position register (register 05_{16}) and all 56 bits of the surface position, squitter status and airborne velocity registers (register numbers 06_{16}, 07_{16} and 09_{16}) if these registers are not updated within two seconds of the previous update. This timeout shall be determined separately for each of these registers. The insertion of altitude or surveillance status data by the transponder into these registers shall not qualify as a register update for the purposes of this timeout condition.

Note 1.— These registers are cleared to prevent the reporting of outdated position, velocity and squitter rate information.

Note 2.— The identification register, 08_{16}, is not cleared since it contains data that rarely changes in flight and is less frequently updated. The event-driven register, $0A_{16}$ or equivalent transmit register, does not need to be cleared since its contents are only broadcast once each time that the register is loaded (2.5.5).

Note 3.— During a register timeout event, the ME field of the extended squitter may contain all zeros, except for any data inserted by the transponder.

2.4.3 Termination of extended squitter broadcast

If input to the register for a squitter type stops for 60 seconds, broadcast of that extended squitter type shall be discontinued until data insertion is resumed. The insertion of altitude by the transponder satisfies the minimum requirement for continuing to broadcast the airborne position squitter.

Note 1.— Until timeout, a squitter type may contain an ME field of all zeros.

Note 2.— Continued transmission for 60 seconds is required so that receiving aircraft will know that the data source for the message has been lost.

2.5 GENERAL FORMATTER/MANAGER (GFM)

The general formatter/manager (GFM) shall format messages for insertion in the transponder registers.

Note.— In addition to data formatting, there are other tasks that are performed by this function.

2.5.1 Navigation source selection

The GFM shall be responsible for the selection of the default source for aircraft position and velocity, the commanded altitude source, and for the reporting of the associated position and altitude errors.

2.5.2 Loss of input data

The GFM shall be responsible for loading the registers for which it is programmed at the required update rate. If for any reason data are unavailable for a time equal to twice the update interval or 2 seconds (whichever is greater), the GFM shall zero old data (on a per field basis) and insert the resulting message into the appropriate register.

For register 05_{16} and 06_{16}, a loss of position data shall cause the GFM to set the format type code to zero as the means of indicating "no position data" since all zeros in the latitude/longitude fields is a legal value.

2.5.3 Special processing for format type code zero

2.5.3.1 *Significance of format type code equal to zero*

Format type code 0 shall signify "no position information". This shall be used when the latitude/longitude information is not available or invalid and still permit the reporting of baro altitude loaded by the transponder.

Note 1.— The principal use of this message is to provide ACAS the ability to passively receive altitude.

Note 2.— Special handling is required for the airborne and surface position messages because a CPR encoded value of all zeros in the latitude/longitude field is a valid value.

2.5.3.2 *Broadcast of format type code equal to zero*

Format type code 0 shall only be set by the following events:

1) An extended squitter register monitored by the transponder (register numbers 05_{16}, 06_{16}, 07_{16} and 09_{16}) has not been loaded by the GFM for 2 seconds. In this case, the transponder shall clear the entire 56 bits of the register that timed out. In the case of the airborne position register, the altitude subfield shall only be zeroed if no altitude data are available. Transmission of the extended squitter that broadcasts the timed out register shall itself stop in 60 seconds. Broadcast of this extended squitter shall resume when the GFM begins to insert data into the register.

2) The GFM determines that all navigation sources that can be used for the extended squitter airborne or surface position message are either missing or invalid. In this case, the GFM shall clear the format type code and all other fields of the airborne or surface position message and insert this zeroed message in the appropriate register. This shall only be done once so that the transponder can detect the loss of data insertion and suppress the broadcast of the related squitter.

Note.— In all of the above cases, a format type code of zero contains a message of all zeros. The only exception is the airborne position format that may contain barometric altitude and surveillance status data as set by the transponder. There is no analogous case for the other extended squitter message types, since a zero value in any of the fields indicates no information.

2.5.3.3 *RECEPTION OF FORMAT TYPE CODE EQUAL TO ZERO*

If a squitter with a format type code equal to zero is received, it shall be checked to see if the altitude is present. If the altitude is not present, the message shall be discarded. An extended squitter containing format type code zero shall only be used to update the altitude of an aircraft already in track.

2.5.4 TRANSPONDER CAPABILITY REPORTING

The GFM shall be responsible for setting the transponder capability register numbers 10_{16}, and 18_{16} to $1C_{16}$. It shall also clear individual bits in register number 17_{16} in the event of a loss of a data source or an application.

A particular bit shall remain set if at least one field in the corresponding register message is being updated.

2.5.4.1 *COMMON USAGE CAPABILITY REPORT (REGISTER NUMBER 17_{16})*

A bit in register number 17_{16} shall be cleared if there is a loss of corresponding input data (2.5.2) and shall be set when data insertion into the register resumes. Bit 36 of register 10_{16} shall be toggled to indicate a change of capability.

2.5.4.2 *MODE S SPECIFIC SERVICES CAPABILITY REPORT (REGISTER NUMBERS 18_{16} to $1C_{16}$)*

A bit set in one of these registers shall indicate that the service loading the register indicated by that bit has been installed on the aircraft. In this regard, these bits shall not be cleared to reflect a real time loss of an application, as is done for register 17_{16}.

2.5.4.3 *TRANSPONDER MONITORING*

As indicated in 2.4, the transponder's role in this process shall be to serve as a backup in the event of the loss of GFM functionality. For this reason, the transponder shall:

1) clear the extended squitter registers (05_{16}, 06_{16}, 07_{16} and 09_{16}) if they have not been updated in 2 seconds.

2) clear all of the registers loaded by the GFM if it detects a loss of GFM capability (e.g. a bus failure). In this case, it would also clear all of the bits in register number 17_{16} since a bit in this register means "application installed and operational".

The transponder shall not clear the other capability register numbers (18_{16} to $1C_{16}$) since they are intended to mean only "application installed".

2.5.5 HANDLING OF EVENT-DRIVEN PROTOCOL

The event-driven interface protocol provides a general purpose interface into the transponder function for messages beyond those that are regularly transmitted all the time (provided input data are available). This protocol shall operate by having the transponder broadcast a message once each time the event-driven register is loaded by the GFM.

Note.— This gives the GFM complete freedom in setting the update rate (up to a maximum) and duration of broadcast for applications such as emergency status and intent reporting.

In addition to formatting, the GFM shall control the timing of message insertion so that it provides the necessary pseudo-random timing variation and does not exceed the maximum transponder broadcast rate for the event-driven protocol.

2.5.5.1 *Transponder support for event-driven messages*

A message shall only be transmitted once by the transponder each time that register number $0A_{16}$ is loaded. Transmission shall be delayed if the transponder is busy at the time of insertion.

Note 1.— Delay times are short. They are usually a maximum of several milliseconds for the longest transponder transaction.

The maximum transmission rate for the event-driven protocol shall be limited by the transponder to twice per second. If a message is inserted in the event-driven register and cannot be transmitted due to rate limiting, it shall be held and transmitted when the rate limiting condition has cleared. If a new message is received before transmission is permitted, it shall overwrite the earlier message.

Note 2.— The squitter transmission rate and the duration of squitter transmissions are application dependent. The minimum rate and duration consistent with the needs of the application should be chosen.

2.5.5.2 *GFM use of event-driven protocol*

An application that selects the event-driven protocol shall notify the GFM of the format type and required update rate. The GFM shall then locate the necessary input data for this format type and begin inserting data into register number $0A_{16}$ at the required rate. The GFM shall also insert this message into the register for this format type. This register image shall be maintained to allow read-out of this information by air-ground or air-air register read-out. When broadcast of a format type ceases, the GFM shall clear the corresponding register assigned to this message.

The maximum rate that shall be supported by the event-driven protocol is twice per second from one or a collection of applications. For each event-driven format type being broadcast, the GFM shall retain the time of the last insertion into register number $0A_{16}$. The next insertion shall be scheduled at a random interval that shall be uniformly distributed over the range of the update interval ± 0.1 second (using a time quantization no greater than 15 ms) relative to the previous insertion into register number $0A_{16}$ for this format type.

The GFM shall monitor the number of insertions scheduled in any one second interval. If more than two would occur, it shall add a delay as necessary to ensure that the limit of two messages per second is observed.

2.5.5.3 *Event-driven priority*

If the event-driven message transmission rate must be reduced in order not to exceed the maximum rate specified in 2.5.5.2, transmission priority shall be assigned as follows:

1) If the emergency/priority status message (2.3.8) is active, it shall be transmitted at the specified rate of once per second. Other active event-driven messages shall be assigned equal priority for the remaining capacity.

2) If the emergency/priority status message is not active, transmission priority shall be allocated equally to all active event-driven messages.

2.5.6 Derivation of mode field bits for aircraft intention parameters

For aircraft architectures that do not present the GFM with a dedicated status word (containing the mode field definitions associated with aircraft intention parameters), the GFM shall derive the status from each of the appropriate FCC status words in order to set the respective bits in each of the mode fields of the register number 40_{16}.

2.6 LATITUDE/LONGITUDE CODING USINGCOMPACT POSITION REPORTING (CPR)

2.6.1 PRINCIPLE OF THE CPR ALGORITHM

The Mode S extended squitters use compact position reporting (CPR) to encode latitude and longitude efficiently into messages.

Notes.—

1. *The resulting messages are compact in the sense that several higher-order bits, which are normally constant for long periods of time, are not transmitted in every message. For example, in a direct binary representation of latitude, one bit would designate whether the aircraft is in the northern or southern hemisphere. This bit would remain constant for a long time, possibly the entire life of the aircraft. To repeatedly transmit this bit in every position message would be inefficient.*

2. *Because the higher-order bits are not transmitted, it follows that multiple locations on the earth will produce the same encoded position. If only a single position message were received, the decoding would involve ambiguity as to which of the multiple solutions is the correct location of the aircraft. The CPR technique includes a provision to enable a receiving system to unambiguously determine the location of the aircraft. This is done by encoding in two ways that differ slightly. The two formats, called even-format and odd-format, are each transmitted 50 per cent of the time. Upon reception of both types within a short period (approximately 10 seconds), the receiving system can unambiguously determine the location of the aircraft.*

3. *Once this process has been carried out, the higher-order bits are known at the receiving station, so subsequent single message receptions serve to unambiguously indicate the location of the aircraft as it moves.*

4. *In certain special cases, a single reception can be decoded into the correct location without an even/odd pair. This decoding is based on the fact that the multiple locations are spaced by at least 360 NM. In addition to the correct locations, the other locations are separated by integer multiples of 360 NM to the north and south and also integer multiples of 360 NM to the east and west. In a special case in which it is known that reception is impossible beyond a range of 180 NM, the nearest solution is the correct location of the aircraft.*

5. *The parameter values in the preceding paragraph (360 and 180 NM) apply to the airborne CPR encoding. For aircraft on the surface, the CPR parameters are smaller by a factor of 4. This encoding yields better resolution but reduces the spacing of the multiple solutions.*

2.6.2 CPR ALGORITHM PARAMETERS AND INTERNAL FUNCTIONS

The CPR algorithm shall utilize the following parameters whose values are set as follows for the Mode S extended squitter application:

a) The number of bits used to encode a position coordinate, *Nb*, is set as follows:

For airborne encoding: *Nb* = 17

For surface encoding: *Nb* = 19

For TCP, TCP+1 encoding: *Nb* = 14.

Note 1.— The Nb *parameter determines the encoded position precision (approximately 5 m for the airborne encoding, 1.25 m for the surface encoding, and 41 m for the TCP, TCP+1 encoding).*

b) The number of geographic latitude zones between the equator and a pole, denoted *NZ*, is set to 15.

Note 2.— The NZ *parameter determines the unambiguous airborne range for decoding (360 NM). The surface latitude/longitude encoding omits the high-order 2 bits of the 19-bit CPR encoding, so the effective unambiguous range for surface position reports is 90 NM.*

The CPR algorithm shall define internal functions to be used in the encoding and decoding processes.

c) The notation **floor**(x) denotes the floor of x, which is defined as the greatest integer value k such that $k \leq x$.

*Note 3.— For example, **floor**(3.8) = 3, while **floor**(–3.8) = –4.*

d) The notation $|x|$ denotes the absolute value of x, which is defined as the value x when $x \geq 0$ and the value $-x$ when $x < 0$.

e) The notation **MOD**(x,y) denotes the "modulus" function, which is defined to return the value

$$\text{MOD}(x,y) = x - y \cdot \text{floor}\left(\frac{x}{y}\right) \text{ where } y \neq 0.$$

Note 4.— The value y *is always positive in the following CPR algorithms. When* x *is non-negative,* ***MOD***(x,y) *is equivalent to the remainder of* x *divided by* y. *When* x *represents a negative angle, an alternative way to calculate* ***MOD***(x,y) *is to return the remainder of* (x+360°) *divided by* y.

For example, MOD(–40°,6°) = MOD(320°,6°) = 2°.

f) The notation **NL**(x) denotes the "number of longitude zones" function of the latitude angle x. The value returned by **NL**(x) is constrained to the range from 1 to 59. **NL**(x) is defined for most latitudes by the equation,

$$\text{NL}(lat) = \text{floor}\left(2\pi \cdot \left[\text{arc}\ \cos\left(\frac{1-\cos\left(\frac{\pi}{2 \cdot NZ}\right)}{\cos^2\left(\frac{\pi}{180°} \cdot |lat|\right)}\right)\right]^{-1}\right),$$

where *lat* denotes the latitude argument in degrees. For latitudes at or near the N or S pole, where the above formula would either be undefined or yield **NL**(*lat*) = 0, the value returned by the NL( ) function shall be 1. Likewise, at the equator, where the above formula might otherwise yield NL(*lat*) = 60, the value returned by the NL( ) function shall be 59.

Note 5.— This equation for NL( ) is impractical for real time implementation. A table of transition latitudes can be pre-computed using the following equation:

$$lat = \frac{180°}{\pi} \cdot \text{arc}\ \cos\left(\sqrt{\frac{1-\cos\left(\frac{\pi}{2 \cdot NZ}\right)}{1-\cos\left(\frac{2\pi}{NL}\right)}}\right) \text{for } NL = 2 \text{ to } 4 \cdot NZ - 1,$$

and a table search procedure used to obtain the return value for NL( ). The table value for NL = 1 is 90 degrees.

2.6.3 CPR ENCODING PROCESS

The CPR encoding process shall calculate the encoded position values XZ_i and YZ_i for either airborne, surface or TCP, TCP+1 latitude and longitude fields from the global position *lat* (latitude in degrees), *lon* (longitude in degrees), and the CPR encoding type i (0 for even format and 1 for odd format), by performing the following sequence of computations. The CPR encoding for TCP, TCP+1 shall always use the even format (i = 0), whereas the airborne and surface encoding shall use both even (i = 0) and odd (i = 1) formats.

a) Δlat_i (the latitude zone size in the N-S direction) is computed from the equation:

$$\Delta lat_i = \frac{360°}{4 \cdot NZ - i}$$

YZ_i (the <u>Y</u>-coordinate within the <u>Z</u>one) is then computed from Δlat_i and *lat* using separate equations:

For airborne encoding: $$YZ_i = \text{floor}\left(2^{17} \cdot \frac{\text{MOD}(lat,\Delta lat_i)}{\Delta lat_i} + \frac{1}{2}\right)$$

For surface encoding: $YZ_i = \text{floor}\left(2^{19} \cdot \frac{\text{MOD}(lat, \Delta lat_i)}{\Delta lat_i} + \frac{1}{2}\right)$

For TCP, TCP+1 encoding: $YZ_0 = \text{floor}\left(2^{14} \cdot \frac{\text{MOD}(lat, \Delta lat_0)}{\Delta lat_i} + \frac{1}{2}\right)$

b) $Rlat_i$ (the latitude that a receiving ADS-B system will extract from the transmitted message) is then computed from *lat*, YZ_i, and Δlat_i using separate equations:

For airborne encoding: $Rlat_i = \Delta lat_i \cdot \left(\frac{YZ_i}{2^{17}} + \text{floor}\left(\frac{lat}{\Delta lat_i}\right)\right)$

For surface encoding: $Rlat_i = \Delta lat_i \cdot \left(\frac{YZ_i}{2^{19}} + \text{floor}\left(\frac{lat}{\Delta lat_i}\right)\right)$

For TCP, TCP+1 encoding: $Rlat_0 = \Delta lat_0 \cdot \left(\frac{YZ_i}{2^{14}} + \text{floor}\left(\frac{lat}{\Delta lat_0}\right)\right)$

c) Δlon_i (the longitude zone size in the E-W direction) is then computed from $Rlat_i$ using the equation:

$$\Delta lon_i = \begin{cases} \dfrac{360°}{\text{NL}(Rlat_i) - i} & \text{when } \text{NL}(Rlat_i) - i > 0 \\ 360°, & \text{when } \text{NL}(Rlat_i) - i = 0 \end{cases}$$

d) XZ_i (the X-coordinate within the Zone) is then computed from *lon* and Δlon_i using separate equations:

For airborne encoding: $XZ_i = \text{floor}\left(2^{17} \cdot \frac{\text{MOD}(lon, \Delta lon_i)}{\Delta lon_i} + \frac{1}{2}\right)$

For surface encoding: $XZ_i = \text{floor}\left(2^{19} \cdot \frac{\text{MOD}(lon, \Delta lon_i)}{\Delta lon_i} + \frac{1}{2}\right)$

For TCP, TCP+1 encoding: $XZ_0 = \text{floor}\left(2^{14} \cdot \frac{\text{MOD}(lon, \Delta lon_0)}{\Delta lon_0} + \frac{1}{2}\right)$

e) Finally, limit the values of XZ_i and YZ_i to fit in the 17-bit or 14-bit field allotted to each coordinate:

For airborne encoding: $YZ_i = \text{MOD}(YZ_i, 2^{17})$,
$XZ_i = \text{MOD}(XZ_i, 2^{17})$

For surface encoding: $YZ_i = \text{MOD}(YZ_i, 2^{17})$,
$XZ_i = \text{MOD}(XZ_i, 2^{17})$

For TCP, TCP+1 encoding: $YZ_0 = \text{MOD}(YZ_0, 2^{14})$,
$XZ_0 = \text{MOD}(XZ_0, 2^{14})$

2.6.4 LOCALLY UNAMBIGUOUS CPR DECODING

The CPR algorithm shall decode a geographic position (latitude, $Rlat_i$, and longitude, $Rlon_i$,) that is locally unambiguous with respect to a reference point (lat_s, lon_s) known to be within 180 NM of the true airborne position (or within 45 NM for a surface message).

Note.— This reference point may be a previously tracked position that has been confirmed by global decoding (see 2.6.7) or it may be the own-aircraft position, which would be used for decoding a new tentative position report.

The encoded position coordinates XZ_i and YZ_i and the CPR encoding type i (0 for the even encoding and 1 for the odd encoding) contained in a Mode S extended squitter message shall be decoded by performing the sequence of computations given in 2.6.5 for the airborne and TCP, TCP+1 format types and in 2.6.6 for the surface format type.

2.6.5 COMPUTATIONS FOR THE AIRBORNE MESSAGE AND TCP, TCP+1 MESSAGE

The following computations shall be performed to obtain the decoded latitude/longitude for the airborne and TCP, TCP+1 message formats. For the TCP, TCP+1 format, i shall always be set to 0 (even encoding), whereas the airborne format shall use both even (i = 0) and odd (i = 1) encoding. For the airborne format, Nb shall equal 17, and for the TCP, TCP+1 format, Nb shall equal 14.

a) Δlat_i is computed from the equation:

$$\Delta lat_i = \frac{360°}{4 \cdot NZ - i}$$

b) The latitude zone index number, j, is then computed from the values of lat_s, Δlat_i and YZ_i using the equation:

$$j = \text{floor}\left(\frac{lat_s}{\Delta lat_i}\right) + \text{floor}\left(\frac{1}{2} + \frac{\text{MOD}(lat_s, \Delta lat_i)}{\Delta lat_i} - \frac{YZ_i}{2^{Nb}}\right)$$

c) The decoded position latitude, $Rlat_i$, is then computed from the values of j, Δlat_i, and YZ_i using the equation:

$$Rlat_i = \Delta lat_i \cdot \left(j + \frac{YZ_i}{2^{Nb}}\right)$$

d) Δlon_i (the longitude zone size in the E-W direction) is then computed from $Rlat_i$ using the equation:

$$\Delta lon_i = \begin{cases} \dfrac{360°}{\text{NL}(Rlat_i) - i}, & \text{when } \text{NL}(Rlat_i) - i > 0 \\ 360°, & \text{when } \text{NL}(Rlat_i) - i = 0 \end{cases}$$

e) The longitude zone coordinate m is then computed from the values of lon_s, Δlon_i, and XZ_i using the equation:

$$m = \text{floor}\left(\frac{lon_s}{\Delta lon_i}\right) + \text{floor}\left(\frac{1}{2} + \frac{\text{MOD}(lon_s, \Delta lon_i)}{\Delta lon_i} - \frac{YZ_i}{2^{Nb}}\right)$$

f) The decoded position longitude, $Rlon_i$, is then computed from the values of m, XZ_i, and Δlon_i using the equation:

$$Rlon_i = \Delta lon_i \cdot \left(m + \frac{YZ_i}{2^{Nb}}\right)$$

2.6.6 COMPUTATIONS FOR THE SURFACE MESSAGE

The following computations shall be performed to obtain the decoded latitude and longitude for the surface position format.

a) Δlat_i is computed from the equation:

$$\Delta lat_i = \frac{90°}{4 \cdot NZ - i}$$

b) The latitude zone index, j, is then computed from the values of lat_s, Δlat_i and YZ_i using the equation:

$$j = \text{floor}\left(\frac{lat_s}{\Delta lat_i}\right) + \text{floor}\left(\frac{1}{2} + \frac{\text{MOD}(lat_s, \Delta lat_i)}{\Delta lat_i} - \frac{YZ_i}{2^{17}}\right)$$

c) The decoded position latitude, $Rlat_i$, is then computed from the values of j, Δlat_i, and YZ_i using the equation:

$$Rlat_i = \Delta lat_i \cdot \left(j + \frac{YZ_i}{2^{17}}\right)$$

d) Δlon_i (the longitude zone size, in the E-W direction) is then computed from $Rlat_i$ using the equation:

$$\Delta lon_i = \begin{cases} \dfrac{90°}{\text{NL}(Rlat_i) - i}, & \text{when } \text{NL}(Rlat_i) - i > 0 \\ 90°, & \text{when } \text{NL}(Rlat_i) - i = 0 \end{cases}$$

e) The longitude zone coordinate m is then computed from the values of lon_s, Δlon_i, and XZ_i using the equation:

$$m = \text{floor}\left(\frac{lon_s}{\Delta lon_i}\right) + \text{floor}\left(\frac{1}{2} + \frac{\text{MOD}(lon_s, \Delta lon_i)}{\Delta lon_i} - \frac{YZ_i}{2^{17}}\right)$$

f) The decoded position longitude, $Rlon_i$, is then computed from the values of m, XZ_i, and Δlon_i using the equation:

$$Rlon_i = \Delta lon_i \cdot \left(m + \frac{YZ_i}{2^{17}}\right)$$

2.6.7 GLOBALLY UNAMBIGUOUS AIRBORNE POSITION DECODING

The CPR algorithm shall utilize one airborne-encoded "**even**" format reception (denoted XZ_0, YZ_0), together with one airborne-encoded "**odd**" format reception (denoted XZ_1, YZ_1), to regenerate the global geographic position latitude, *Rlat*, and longitude, *Rlon*. The time between the "**even**" and "**odd**" format encoded position reports shall be no longer than 10 seconds.

Note 1.— This algorithm might be used to obtain globally unambiguous position reports for aircraft out of the range of ground sensors, whose position reports are coming via satellite data links. It might also be applied to ensure that local positions are being correctly decoded over long ranges from the receiving sensor.

Note 2.— The time difference limit of 10 seconds between the even- and odd-format position reports is determined by the maximum permitted separation of 3 NM. Positions greater than 3 NM apart cannot be used to solve a unique global position. An aircraft capable of a speed of 1 850 km/h (1 000 kt) will fly about 5.1 km (2.8 NM) in 10 seconds. Therefore, the CPR algorithm will be able to unambiguously decode its position over a 10-second delay between position reports.

Given a 17-bit airborne position encoded in the "**even**" format (XZ_0, YZ_0) and another encoded in the "**odd**" format (XZ_1, YZ_1), separated by no more than 10 seconds (= 3 NM), the CPR algorithm shall regenerate the geographic position from the encoded position reports by performing the following sequence of steps:

a) Compute Δlat_0 and Δlat_1 from the equation:

$$\Delta lat_i = \frac{360°}{4 \cdot NZ - i}$$

b) Compute the latitude index:

$$j = \text{floor}\left(\frac{59 \cdot YZ_0 - 60 \cdot YZ_1}{2^{17}} + \frac{1}{2}\right)$$

c) Compute the values of $Rlat_0$ and $Rlat_1$ using the following equation:

$$Rlat_i = \Delta lat_i \cdot \left(\text{MOD}(j, 60 - i) + \frac{YZ_i}{2^{17}}\right)$$

Southern hemisphere values of $Rlat_i$ will fall in the range from 270° to 360°. Subtract 360° from such values, thereby restoring $Rlat_i$ to the range from –90° to +90°.

d) If **NL**($Rlat_0$) is not equal to **NL**($Rlat_1$) then the two positions straddle a transition latitude, thus a solution for global longitude is not possible. Wait for positions where they are equal.

e) If **NL**($Rlat_0$) is equal to **NL**($Rlat_1$) then proceed with computation of Δlon_i, according to whether the most recently received airborne position message was encoded with the even format ($i = 0$) or the odd format ($i = 1$) :

$$\Delta lon_i = \frac{360°}{n_i},$$

where n_i = greater of [NL($Rlat_i$) – i] and 1.

f) Compute m, the longitude index:

$$m = \text{floor}\left(\frac{XZ_0 \cdot (NL - 1) - XZ_1 \cdot NL}{2^{17}} + \frac{1}{2}\right),$$

where NL = NL ($Rlat_i$).

g) Compute the global longitude, $Rlon_0$ or $Rlon_1$, according to whether the most recently received airborne position message was encoded using the even format (that is, with $i = 0$) or the odd format ($i = 1$):

$$Rlon_i = \Delta lon_i \cdot \left(\text{MOD}(m, n_i) + \frac{YZ_i}{2^{17}}\right),$$

where n_i = greater of [NL($Rlat_i$) – i] and 1.

2.6.8 CPR DECODING OF RECEIVED POSITION REPORTS

2.6.8.1 *OVERVIEW*

The techniques described in the preceding paragraphs (locally and globally unambiguous decoding) shall be used together to decode the latitude/longitude contained in airborne, surface, and TCP or TCP+1 position reports. The process shall begin with globally unambiguous decoding based upon the receipt of an even and an odd encoded position squitter. Once the globally unambiguous position is determined, either of two approaches shall be used to support subsequent decoding based upon a single position report, either even or odd encoding. The two techniques shall be range monitoring and emitter centered local decoding.

2.6.8.2 RANGE MONITORING LOCAL DECODING

2.6.8.2.1 *Range monitoring technique*

In this approach, local decoding for the airborne format (2.6.4) shall be performed based upon the current position of the receiver. This shall provide the position of a transmitting aircraft that is unambiguous to plus or minus 180 NM.

Note 1.— If the transmitting aircraft is within 180 NM, the local decoding technique will correctly decode the location of the aircraft.

The range of the transmitting aircraft shall be checked at detection and tracks shall only be initiated if the range is less than 180 NM. Once initiated, the range of the tracked aircraft shall be checked at each update and the track shall be dropped if the range becomes equal to or greater than 180 NM.

For the surface format, the same process shall be used except that the transmitting aircraft must be within 45 NM for detection and tracking.

Note 2.— The range limits are reduced since the ambiguity limit for the surface position reports is one-fourth that of the airborne case.

2.6.8.2.2 *Range monitoring example*

2.6.8.2.2.1 Decoding of airborne position

2.6.8.2.2.1.1 *Detection.* At detection, a globally unambiguous decode shall be performed. If range is greater than 160 NM, the detection attempt shall be discontinued and the track information discarded. Detection shall be attempted if squitters continue to be received. If the globally decoded range remains greater than 160 NM, the track information shall continue to be discarded.

Note.— If the aircraft is approaching, detection will succeed when the range decreases to less than or equal to 160 NM.

2.6.8.2.2.1.2 *Track monitoring.* After detection, range shall be monitored during each surveillance update. If range is greater than 170 NM, the track shall be dropped.

Note.— The use of 160 NM for detection and 170 NM for track drop provides hysteresis that avoids reacquiring a track that was just dropped due to long range. Thus a track dropped at 170 NM would not be reacquired unless its range dropped to less than or equal to 160 NM.

2.6.8.2.2.2 *Decoding of surface position.* Using the range monitoring technique for decoding squitters in the surface format, the same process as above shall be used except that the track shall be initiated at 40 NM and dropped at 42.5 NM.

2.6.8.2.3 Emitter centered local decoding

In this approach, the most recent position of the emitter shall be used as the basis for the local decoding.

Note.— This produces an unambiguous decoding at each update, since the transmitting aircraft cannot move more than 360 NM between position updates.

2.6.8.2.4 *Technique application*

The range monitoring technique shall only be used for ranges less than or equal to 180 NM, for example in air-to-air applications. For ground stations (i.e. non-aircraft implementations) that are required to operate at ranges in excess of 180 NM, only the emitter centred technique can shall be used.

Note.— The emitter centered technique can be used for both airborne receivers and ground stations.

TABLES FOR SECTION 2

Tables are numbered 2-X where "X" is the decimal equivalent of the BDS code Y,Z where Y is the BDS1 code and Z is the BDS2 code, used to access the data format for a particular register. The following tables are not included:

2-1
2-2 to 2-4 (Used by the linked Comm-B protocol)
2-13 to 2-14 (Reserved for air/air state information)
2-15 (Reserved for ACAS)
2-17 to 2-22
2-35 (Reserved for antenna position)
2-36 (Reserved for aircraft parameters)
2-38 to 2-47
2-49 to 2-63
2-70 to 2-71
2-73 to 2-79
2-87 to 2-94
2-102 to 2-111 (Reserved for extended squitter)
2-112 to 2-224
2-225 to 2-226 (Reserved for Mode S byte)
2-227 to 2-240
2-243 to 2-255

Table 2-5. BDS code 0,5 — Extended squitter airborne position

MB FIELD

Bits	Field
1–5	FORMAT TYPE CODE (specified in 2.3.1)
6–7	SURVEILLANCE STATUS (specified in 2.3.2.6)
8	SINGLE ANTENNA FLAG (SAF) (specified in 2.3.2.5)
9–20	ALTITUDE (specified by the format type code) This is (1) the altitude code (AC) as specified in 3.1.2.6.5.4 of Annex 10, Volume IV but with the M-bit removed or (2) the GNSS height (HAE)
21	TIME (T) (specified in 2.3.2.2)
22	CPR FORMAT (F) (specified in 2.3.2.1)
23–39	MSB (23) ENCODED LATITUDE (CPR airborne format specified in 2.6.1 to 2.6.5) LSB (39)
40–56	MSB (40) ENCODED LONGITUDE (CPR airborne format specified in 2.6.1 to 2.6.5) LSB (56)

PURPOSE: To provide accurate airborne position information.

Surveillance status shall be coded as follows:

0 = No condition information
1 = Permanent alert (emergency condition)
2 = Temporary alert (change in Mode A identity code other than emergency condition)
3 = SPI condition

Codes 1 and 2 shall take precedence over code 3.

When horizontal position information is unavailable, but altitude information is available, the airborne position message shall be transmitted with a format type code of zero in bits 1-5 and the barometric pressure altitude in bits 9 to 20. If neither horizontal position nor barometric altitude information is available, then all 56 bits of BDS 0,5 shall be zeroed. The zero format type code field shall indicate that latitude and longitude information is unavailable, while the zero altitude field shall indicate that altitude information is unavailable.

Table 2-6. BDS code 0,6 — Extended squitter surface position

MB FIELD

PURPOSE: To provide accurate surface position information.

Bit	Field
1	
2	FORMAT TYPE CODE
3	(specified in 2.2.3.1)
4	
5	
6	
7	
8	
9	MOVEMENT
10	(specified in 2.3.3.1)
11	
12	
13	STATUS for ground track: 0 = Invalid, 1 = Valid
14	MSB = 180
15	
16	(specified in 2.3.3.2)
17	GROUND TRACK (TRUE)
18	
19	
20	LSB = 360/128
21	TIME (T) (specified in 2.3.2.2)
22	CPR FORMAT (F) (specified in 2.3.2.1)
23	MSB
24	
25	
26	
27	
28	
29	ENCODED LATITUDE 17 bits
30	(specified in 2.6.1 to 2.6.4 and 2.6.6)
31	
32	
33	
34	
35	
36	
37	
38	
39	LSB
40	MSB
41	
42	
43	
44	
45	
46	ENCODED LONGITUDE 17 bits
47	(specified in 2.6.1 to 2.6.4 and 2.6.6)
48	
49	
50	
51	
52	
53	
54	
55	
56	LSB

Table 2-7. BDS code 0,7 — Extended squitter status

MB FIELD

Bit	Subfield
1	TRANSMISSION RATE
2	SUBFIELD (TRS)
3	ALTITUDE TYPE SUBFIELD (ATS)
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	RESERVED
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	
42	
43	
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	

PURPOSE: To provide information on the capability and status of the extended squitter rate of the transponder.

Transmission rate subfield (TRS) shall be coded as follows:

0 = No capability to determine surface squitter rate
1 = High surface squitter rate selected
2 = Low surface squitter rate selected
3 = Reserved

Altitude type subfield (ATS) shall be coded as follows:

0 = Barometric altitude
1 = GNSS height (HAE)

Aircraft determination of surface squitter rate:

For aircraft that have the capability to automatically determine their surface squitter rate, the method used to switch between the high and low transmission rates shall be as follows:

a) Switching from high to low rate: Aircraft shall switch from high to low rate when the on-board navigation unit reports that the aircraft's position has not changed more than 10 metres in a 30 second sampling interval. The algorithm used to control the squitter rate shall save the aircraft's position at the time that low rate is selected.

b) Switching from low to high rate: Aircraft shall switch from low to high rate as soon as the aircraft's position has changed by 10 metres or more since the low rate was selected

For transponder-based implementations, the automatically selected transmission rate shall be subject to being overridden by commands received from ground control.

Table 2-8. BDS code 0,8 — Extended squitter aircraft identification and category

MB FIELD

Bit	Field
1–5	FORMAT TYPE CODE (specified in 2.2.3.1)
6–8	AIRCRAFT CATEGORY
9–14	MSB CHARACTER 1
15–20	MSB CHARACTER 2
21–26	MSB CHARACTER 3
27–32	MSB CHARACTER 4
33–38	MSB CHARACTER 5
39–44	MSB CHARACTER 6
45–50	MSB CHARACTER 7
51–56	MSB CHARACTER 8

PURPOSE: To provide aircraft identification and category.

Note.— Since there is no internationally agreed criteria for wake vortex categorization, code 4 (set "A") should be interpreted as indicating a medium category aircraft exhibiting higher than typical wake vortex characteristics.

Format type shall be coded as follows:

1 = Identification, aircraft category set D
2 = Identification, aircraft category set C
3 = Identification, aircraft category set B
4 = Identification, aircraft category set A

Aircraft/vehicle category shall be coded as follows:

Set A

0 = No aircraft category information
1 = Light (<15 500 lbs or 7 031 kg)
2 = Medium 1 (15 500 to 75 000 lbs or 7 031 to 34 019 kg)
3 = Medium 2 (75 000 to 300 000 lbs or 34 019 to 136 078 kg)
4 = High vortex aircraft
5 = Heavy (>300 000 lbs or 136 078 kg)
6 = High performance (>5 g acceleration) and high speed (> 400 kt)
7 = Rotorcraft

Set B

0 = No aircraft category information
1 = Glider/sailplane
2 = Lighter-than-air
3 = Parachutist/skydiver
4 = Ultralight/hang-glider/paraglider
5 = Reserved
6 = Unmanned aerial vehicle
7 = Space/transatmospheric vehicle

Set C

0 = No aircraft category information
1 = Surface vehicle – emergency vehicle
2 = Surface vehicle – service vehicle
3 = Fixed ground or tethered obstruction
4 - 7 = Reserved

Set D: Reserved

Aircraft identification coding shall be:

As specified in Table 2-32.

Table 2-9a. BDS code 0,9 — Extended squitter airborne velocity (Subtypes 1 and 2: velocity over ground)

MB FIELD

1	MSB	1		
2		0		
3	FORMAT TYPE CODE = 19	0		
4		1		
5	LSB	1		
6	SUBTYPE 1	0	SUBTYPE 2	0
7		0		1
8		1		0
9	INTENT CHANGE FLAG (specified in 2.3.5.3)			
10	IFR CAPABILITY FLAG			
11	NAVIGATION UNCERTAINTY			
12	CATEGORY – VELOCITY			
13	(NUC_R)			
14	DIRECTION BIT for E-W velocity: 0 = East, 1 = West			
15	EAST-WEST VELOCITY			
16	NORMAL: LSB = 1 knot		SUPERSONIC: LSB = 4 knots	
17	All zeros = no velocity information		All zeros = no velocity information	
18	Value	Velocity	Value	Velocity
19	1	0 kt	1	0 kt
20	2	1 kt	2	4 kt
21	3	2 kt	3	8 kt
22	–	–	–	–
23	1 022	1 021 kt	1 022	4 084 kt
24	1 023	>1 021.5 kt	1 023	>4 086 kt
25	DIRECTION BIT for N-S Velocity, 0 = North, 1 = South			
26	NORTH-SOUTH VELOCITY			
27	NORMAL: LSB = 1 knot		SUPERSONIC: LSB = 4 knots	
28	All zeros = no velocity information		All zeros = no velocity information	
29	Value	Velocity	Value	Velocity
30	1	0 kt	1	0 kt
31	2	1 kt	2	4 kt
32	3	2 kt	3	8 kt
33	–	–	–	–
34	1 022	1 021 kt	1 022	4 084 kt
35	1 023	>1 021.5 kt	1 023	>4 086 kt
36	SOURCE BIT for vertical rate: 0 = GNSS, 1 = Baro			
37	SIGN BIT for vertical rate: 0 = Up, 1 = Down			
38	VERTICAL RATE			
39	All zeros = no vertical rate information; LSB = 64 ft/min			
40	Value	Vertical rate		
41	1	0 ft/min		
42	2	64 ft/min		
43		–		
44	510	32 576 ft/min		
45	511	>32 608 ft/min		
46				
47	RESERVED FOR TURN INDICATOR			
48				
49	GNSS ALT. SIGN BIT: 0 = Above baro alt, 1 = Below baro alt			
50	GNSS ALT. DIFFERENCE FROM BARO. ALT.			
51	All zeros = no information; LSB = 25 ft			
52	Value	Difference		
53	1	0 ft		
54	2	25 ft		
55	–	–		
56	126	3 125 ft		
	127	>3 137.5 ft		

PURPOSE: To provide additional state information for both normal and supersonic flight.

Subtype shall be coded as follows:

Code	Velocity	Type
0	Reserved	
1	Ground Speed	Normal
2		Supersonic
3	Airspeed, Heading	Normal
4		Supersonic
5	Reserved	
6	Reserved	
7	Reserved	

IFR capability shall be coded as follows:

0 = Transmitting aircraft has no capability for ADS-B-based conflict detection or higher level applications.

1 = Transmitting aircraft has capability for ADS-B-based conflict detection and higher level applications.

NUC shall be coded as follows:

NUC_R	Horizontal Velocity Error (95%)	Vertical Velocity Error (95%)
0	Unknown	Unknown
1	<10 m/s	<15.2 m/s (50 fps)
2	<3 m/s	<4.6 m/s (15 fps)
3	<1 m/s	<1.5 m/s (5 fps)
4	<0.3 m/s	<0.46 m/s (1.5 fps)

Table 2-9b. BDS code 0,9 — Extended squitter airborne velocity (Subtypes 3 and 4: airspeed and heading)

MB FIELD

1	MSB	1		
2		0		
3	FORMAT TYPE CODE = 19	0		
4		1		
5	LSB	1		
6	SUBTYPE 3	0	SUBTYPE 4	1
7		1		0
8		1		0
9	INTENT CHANGE FLAG (specified in 2.3.5.3)			
10	IFR CAPABILITY FLAG			
11	NAVIGATION UNCERTAINTY			
12	CATEGORY – VELOCITY			
13	(NUC$_R$)			
14	STATUS BIT – 0 = Magnetic heading not available, 1 = available			
15	MSB = 180°			
16				
17				
18	MAGNETIC HEADING (specified in 2.3.5.5)			
19				
20				
21				
22				
23				
24	LSB = 360/1 024°			
25	AIRSPEED TYPE: 0 = IAS, 1 = TAS			
26	AIRSPEED			
27	NORMAL: LSB = 1 knot		SUPERSONIC: LSB = 4 knots	
28	All zeros = no velocity information		All zeros = no velocity information	
29	Value	Velocity	Value	Velocity
30	1	0 kt	1	0 kt
31	2	1 kt	2	4 kt
32	3	2 kt	3	8 kt
33	–	–	–	–
34	1 022	1 021 kt	1 022	4 084 kt
35	1 023	>1 021.5 kt	1 023	>4 086 kt
36	SOURCE BIT FOR VERTICAL RATE: 0 = GNSS, 1 = Baro			
37	SIGN BIT FOR VERTICAL RATE: 0 = Up, 1 = Down			
38	VERTICAL RATE			
39	All zeros = no vertical rate information; LSB = 64 ft/min			
40	Value	Vertical rate		
41	1	0 ft/min		
42	2	64 ft/min		
43	–	–		
44	510	32 576 ft/min		
45	511	>32 608 ft/min		
46				
47	RESERVED FOR TURN INDICATOR			
48				
49	DIFFERENCE SIGN BIT (0 = Above baro alt, 1 = Below baro alt)			
50	GEOMETRIC HEIGHT DIFFERENCE FROM BARO. ALT.			
51	All zeros = no information; LSB = 25 ft			
52	Value	Difference		
53	1	0ft		
54	2	25 ft		
55	–	–		
56	126	3 125 ft		
	127	>3 137.5 ft		

PURPOSE: To provide additional state information for both normal and supersonic flight based on airspeed and heading.

This format shall only be used if velocity over ground is not available.

Subtype shall be coded as follows:

Code	Velocity	Type
0	Reserved	
1	Ground speed	Normal
2	Ground speed	Supersonic
3	Airspeed, heading	Normal
4	Airspeed, heading	Supersonic
5	Reserved	
6	Reserved	
7	Reserved	

IFR capability shall be coded as follows:

0 = Transmitting aircraft has no capability for ADS-B-based conflict detection or higher level applications.

1 = Transmitting aircraft has capability for ADS-B-based conflict detection and higher level applications.

Table 2-10. BDS code 0,A — Extended squitter event-driven information

MB FIELD

Bit	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	
42	
43	
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	

PURPOSE: To provide a flexible means to squitter messages other than position, velocity and identification.

1) A message inserted in this register (or an equivalent transmit buffer) shall be broadcast once by the transponder at the earliest opportunity.

2) Formats for messages using this protocol shall be specified in BDS 6,1 to 6,F.

3) The GFM (2.5) shall be responsible for ensuring pseudo-random timing and for observing the maximum transmission rate for this register of 2 per second (2.5.5.1).

4) Read-out (if required) of this register shall be accomplished by extracting the contents of the appropriate BDS register 6,1 to 6,F.

Note.— The data in this register is not intended for extraction using the GICB or ACAS cross-link protocols.

Table 2-11. BDS code 0,B — Air/air state information 1 (aircraft state)

MB FIELD

Bit	Field
1	STATUS
2	MSB = 1 024 kt
3	
4	
5	
6	TRUE AIR SPEED
7	
8	
9	Range = [0-,2 047 kt]
10	
11	
12	LSB = 1,0 kt
13	SWITCH (0 = Magnetic heading, 1 = True heading)
14	STATUS
15	SIGN
16	MSB = 90 degrees
17	
18	HEADING
19	
20	
21	Range = [–180, + 179]
22	
23	
24	LSB = 360/1 024 degrees
25	STATUS
26	SIGN
27	MSB = 90 degrees
28	
29	
30	
31	
32	TRUE TRACK ANGLE
33	
34	
35	Range = [–180, +179]
36	
37	
38	
39	
40	LSB = 360/32 768 degrees
41	MSB = 1 024 kt
42	
43	
44	
45	
46	GROUND SPEED
47	
48	
49	Range = [0, 2 047]
50	
51	
52	
53	
54	
55	LSB = 1/16 kt
56	RESERVED

PURPOSE: To report threat aircraft state information in order to improve the ability of ACAS to evaluate the threat and select a resolution manoeuvre.

Table 2-12. BDS code 0,C — Air/air state information 2 (aircraft intent)

MB FIELD

1	STATUS
2	MSB = 51 200 ft
3	
4	
5	LEVEL OFF ALTITUDE
6	
7	Range = [0, 102 375]
8	
9	
10	
11	
12	
13	LSB = 16 ft
14	STATUS
15	SIGN
16	MSB = 90 degrees
17	
18	
19	NEXT COURSE (TRUE GROUND TRACK)
20	Range = [+179, –180]
21	
22	
23	
24	LSB = 360/1 024 degrees
25	STATUS
26	MSB = 128 seconds
27	
28	
29	TIME TO NEXT WAYPOINT
30	All ones = time exceeds 254 seconds
31	
32	Range = [0, 254]
33	
34	LSB = 1 second
35	STATUS
36	SIGN
37	MSB 8 192 ft/min
38	
39	VERTICAL VELOCITY (UP IS POSITIVE)
40	
41	
42	Range = [+16 352, –16 352]
43	
44	LSB = 32 ft/min
45	STATUS
46	SIGN
47	MSB = 45 degrees
48	
49	ROLL ANGLE
50	Range = [+89, –89]
51	
52	
53	LSB = 360/256 degrees
54	MIL INTERCEPT BIT (0 = no intercept; 1 = intercept)
55	
56	RESERVED

PURPOSE: To provide threat aircraft intent information in order to improve the ability of ACAS to evaluate the threat and select a resolution manoeuvre.

Table 2-16. BDS code 1,0 — Data link capability report

MB FIELD

Bits	Field
1–8	BDS code 1,0
9	Continuation flag (see 9)
10–15	RESERVED
16	Reserved for ACAS
17–23	Mode S subnetwork version number
24	Transponder enhanced protocol indicator (see 4)
25	Mode S specific services capability (see 2)
26–28	Uplink ELM capability
29–32	Downlink ELM capability
33	Aircraft identification capability
34	Squitter capability subfield (SCS) (see 5)
35	Surveillance identifier (SI) (see 6)
36	Common usage GICB capability report (see 7)
37–40	RESERVED FOR ACAS
41–56	Bit array indicating the support status of DTE subaddresses 0 to 15 (see 3 and 8); 41 = MSB, 56 = LSB

PURPOSE: To report the data link capability of the Mode S transponder/data link installation.

The coding of this register shall conform to:

1) Annex 10, Volume III, 5.2.9.

2) When bit 25 is set to 1, it shall indicate that at least one Mode S specific service is supported and the particular capability reports shall be checked.

Note.— Registers accessed by BDS codes 0,2; 0,3; 0,4; 1,0; 2,0 and 3,0 do not affect the setting of bit 25.

3) Starting from the MSB, each subsequent bit position shall represent the DTE subaddress in the range from 0 to 15.

4) The enhanced protocol indicator shall denote a Level 5 transponder when set to 1 and a Level 2 to 4 transponder when set to 0.

5) The squitter capability subfield (SCS) shall be interpreted as follows:

0 = squitter registers are not updated
1 = squitter registers are being updated

6) The surveillance identifier (SI) bit shall be interpreted as follows:

0 = no surveillance identifier code capability
1 = surveillance identifier code capability

7) Bit 36 shall be toggled each time the common usage GICB capability report (BDS code 1,7) changes. To avoid the generation of too many broadcast capability report changes, BDS code 1,7 shall be sampled at approximately one minute intervals to check for changes.

8) The current status of the on-board DTE shall be periodically reported to the GDLP by on-board sources. Since a change in this field results in a broadcast of the capability report, status inputs shall be sampled at approximately one minute intervals.

9) In order to determine the extent of any continuation of the data link capability report (into those registers reserved for this purpose: BDS 1,1 to BDS 1,6), bit 9 shall be reserved as a ‘continuation flag’ to indicate if the subsequent register shall be extracted. For example: upon detection of bit 9 = 1 in BDS 1,0 then BDS 1,1 shall be extracted. If bit 9 = 1 in BDS 1,1 then BDS 1,2 shall be extracted, and so on (up to BDS 1,5). Note that if bit 9 = 1 in BDS 1,6 then this shall be considered as an error condition.

Table 2-23. BDS code 1,7 — Common usage GICB capability report

MB FIELD

1	0,5 Extended squitter airborne position
2	0,6 Extended squitter ground position
3	0,7 Extended squitter status
4	0,8 Extended squitter type and identification
5	0,9 Extended squitter airborne velocity information
6	0,A Extended squitter event-driven information
7	2,0 Aircraft identification
8	2,1 Aircraft registration number
9	4,0 Aircraft intention
10	4,1 Next waypoint identifier
11	4,2 Next way-out position
12	4,3 Next way-out information
13	4,4 Meteorological routine report
14	4,5 Meteorological hazard report
15	4,8 VHF channel report
16	5,0 Track and turn report
17	5,1 Position coarse
18	5,2 Position fine
19	5,3 Air-referenced state vector
20	5,4 Waypoint 1
21	5,5 Waypoint 2
22	5,6 Waypoint 3
23	5,F Quasi-static parameter monitoring
24	6,0 Heading and speed report
25	Reserved for aircraft capability
26	Reserved for aircraft capability
27	E,1 Reserved for Mode S byte
28	E,2 Reserved for Mode S byte
29–56	RESERVED

PURPOSE: To indicate common usage GICB services currently supported.

1) Each bit position shall indicate that the associated BDS is available in the aircraft installation when set to 1.

2) Registers 1,8 to 1,C shall be independent of register 1,7

All registers shall be constantly monitored at a rate consistent with their individual required update rate and the corresponding capability bit shall be set to 1 only when valid data is being input to that register at the required rate or above.

The capability bit shall be set to a 1 if at least one field in the register is receiving valid data at the required rate with the status bits for all fields not receiving valid data at the required rate set to ZERO.

Tables 2-24 to 2-28. BDS codes 1,8 to 1,C — Mode S specific services GICB capability reports

MB FIELD

Bit	
1	MSB
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
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21	
22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	
42	
43	
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	LSB

PURPOSE: To indicate GICB services that are installed.

Each bit position shall indicate that the GICB service that it represents has been implemented in the aircraft installation when set to 1.

Starting from the LSB, each bit position shall represent the register number, in accordance with the following table:

BDS code	**Capability installed for**
BDS 1,8	BDS 0,1 to 3,8
BDS 1,9	BDS 3,9 to 7,0
BDS 1,A	BDS 7,1 to A,8
BDS 1,B	BDS A,9 to E,0
BDS 1,C	BDS E,1 to F,F

The 25 most significant bits of BDS 1,C shall not be used.

Tables 2-29 to 2-31. BDS codes 1,D to 1,F — Mode S specific services MSP capability reports

MB FIELD

1	MSB
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	UPLINK
15	MSP
16	CHANNELS
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	LSB
29	MSB
30	
31	
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	DOWNLINK
42	MSP
43	CHANNELS
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	LSB

PURPOSE: To indicate MSP services that are installed and require a service.

Each bit shall indicate that the MSP it represents requires service when set to 1.

Starting from the MSB, each bit position shall represent the MSP channel number for both uplink and downlink channel fields, in accordance with the following table:

BDS code	**MSP channels**
BDS 1,D	1 to 28 up and down
BDS 1,E	29 to 56 up and down
BDS 1,F	57 to 63 up and down

1) In BDS 1,F the least significant bits of both uplink and downlink channel fields shall not be used.

2) The conditions for setting the capability bits shall be as defined in the specification of the corresponding service, see section 3.

Table 2-32. BDS code 2,0 — Aircraft identification

MB FIELD

1	
2	
3	
4	BDS code 2,0
5	
6	
7	
8	
9	MSB
10	
11	CHARACTER 1
12	
13	
14	LSB
15	MSB
16	
17	CHARACTER 2
18	
19	
20	LSB
21	MSB
22	
23	CHARACTER 3
24	
25	
26	LSB
27	MSB
28	
29	
30	CHARACTER 4
31	
32	LSB
33	MSB
34	
35	CHARACTER 5
36	
37	
38	LSB
39	MSB
40	
41	CHARACTER 6
42	
43	
44	LSB
45	MSB
46	
47	CHARACTER 7
48	
49	
50	LSB
51	MSB
52	
53	CHARACTER 8
54	
55	
56	LSB

PURPOSE: To report aircraft identification to the ground.

1) Annex 10, Volume IV, 3.1.2.9.

2) The character coding to be used shall be identical to that defined in Table 3-6 of Chapter 3, Annex 10, Volume IV.

3) This data may be input to the transponder from sources other than the Mode S ADLP.

4) This format shall be used by the extended squitter application.

5) Capability to support this register shall be indicated by setting bit 33 in BDS 1,0 and the relevant bits in BDS 1,7 and 1,8.

6) The aircraft identification shall be that employed in the flight plan. When no flight plan is available the registration marking of the aircraft shall be used.

Table 2-33. BDS code 2,1 — Aircraft and airline registration markings

MB FIELD

Bit			
1	STATUS		
2	MSB		
3			
4		CHARACTER 1	
5			
6			
7	LSB		
8	MSB		
9			
10		CHARACTER 2	
11			
12			
13	LSB		
14	MSB		
15			
16		CHARACTER 3	
17			
18			
19	LSB		
20	MSB		
21			
22		CHARACTER 4	AIRCRAFT
23			REGISTRATION
24			NUMBER
25	LSB		
26	MSB		
27			
28		CHARACTER 5	
29			
30			
31	LSB		
32	MSB		
33			
34		CHARACTER 6	
35			
36			
37	LSB		
38	MSB		
39			
40		CHARACTER 7	
41			
42			
43	LSB		
44	STATUS		
45	MSB		
46			
47		CHARACTER 1	
48			
49			
50	LSB		ICAO AIRLINE
51	MSB		REGISTRATION
52			MARKING
53		CHARACTER 2	
54			
55			
56	LSB		

PURPOSE: To permit ground systems to identify the aircraft without the necessity of compiling and maintaining continuously updated data banks.

The character coding shall be as defined in Table 3-6 of Chapter 3, Annex 10, Volume IV.

Table 2-34. BDS code 2,2 — Antenna positions

MB FIELD

MB bits	Field	
1–3	ANTENNA TYPE	ANTENNA 1
4–9	MSB = 32 m X POSITION Range = [1,63] LSB = 1 m	ANTENNA 1
10–14	MSB = 16 m Z POSITION Range = [1,31] LSB = 1 m	ANTENNA 1
15–17	ANTENNA TYPE	ANTENNA 2
18–23	MSB = 32 m X POSITION Range = [1, 63] LSB = 1 m	ANTENNA 2
24–28	MSB = 16 m Z POSITION Range = [1, 31] LSB = 1 m	ANTENNA 2
29–31	ANTENNA TYPE	ANTENNA 3
32–37	MSB = 32 m X POSITION Range = [1, 63] LSB = 1 m	ANTENNA 3
38–42	MSB = 16 m Z POSITION Range = [1, 31] LSB = 1 m	ANTENNA 3
43–45	ANTENNA TYPE	ANTENNA 4
46–51	MSB = 32 m X POSITION Range = [1, 63] LSB = 1 m	ANTENNA 4
52–56	MSB = 16 m Z POSITION Range = [1, 31] LSB = 1 m	ANTENNA 4

PURPOSE: To provide information on the position of Mode S and GNSS antennas on the aircraft in order to make very accurate measurements of aircraft position possible.

1) The antenna type field shall be interpreted as follows:

   0 = Invalid
   1 = Mode S bottom antenna
   2 = Mode S top antenna
   3 = GNSS antenna
   4 to 7 = Reserved

2) The X position field shall be the distance in metres along the aircraft centre line measured from the nose of the aircraft. The field shall be interpreted as invalid if the value is 0 and the value of 63 shall mean that the antenna position is 63 metres or more from the nose.

3) The Z position field shall be the distance in metres of the antenna from the ground, measured with the aircraft unloaded and on the ground. The field shall be interpreted as invalid if the value is 0 and the value 31 shall mean that the antenna position is 31 metres or more from the ground.

Table 2-37. BDS code 2,5 — Aircraft type

MB FIELD

Bit		Field	
1	MSB		
2			
3		AIRCRAFT TYPE	
4			
5			
6	LSB		
7	MSB		
8		NUMBER OF ENGINES	
9	LSB		
10	MSB		
11			
12		ENGINE TYPE	
13			
14			
15	LSB		
16	MSB		
17			
18		CHARACTER 1	
19			
20			
21	LSB		
22	MSB		
23			
24		CHARACTER 2	
25			
26			
27	LSB		
28	MSB		
29			
30		CHARACTER 3	MODEL
31			DESIGNATION
32			
33	LSB		
34	MSB		
35			
36			
37		CHARACTER 4	
38			
39	LSB		
40	MSB		
41			
42		CHARACTER 5	
43			
44			
45	LSB		
46	MSB		
47			
48		WAKE TURBULENCE	
49		CATEGORY	
50			
51	LSB		
52			
53			
54		RESERVED	
55			
56			

PURPOSE: To provide information on aircraft type.

1) Subfield coding

The coding shall be as in Doc 8643 — *Aircraft Type Designators*. All the subfields that contain characters shall be encoded using the 6-bit subset of 1A-5 as specified in Table 3-6 of Annex 10, Volume IV.

2) Model designation

Coding shall consist of four characters as specified in Doc 8643. The fifth character shall be reserved for future expansion and shall contain all zeros until it is specified. 2222 in the first four characters shall mean that the designator is not specified.

3) Number of engines

This subfield shall be encoded as a binary number where number 7 means 7 or more engines.

Table 2-48. BDS code 3,0 — ACAS active resolution advisory

MB FIELD

Bits	Field
1–8	BDS code 3,0
9–22	ACTIVE RESOLUTION ADVISORIES
23–26	RACs RECORD
27	RA TERMINATED
28	MULTIPLE THREAT ENCOUNTER
29–30	THREAT-TYPE INDICATOR
31–56	THREAT IDENTITY DATA

PURPOSE: To report resolution advisories (RAs) generated by ACAS equipment. The coding of this register shall conform to:

1) Annex 10, Volume IV, 4.3.8.4.2.2.

2) Bit 27 shall mean RA terminated when set to 1.

Table 2-64 BDS 4,0 — Selected Vertical Intention

MB FIELD

1	STATUS	
2	MSB = 32 768 ft	
3		
4	MCP/FCU SELECTED ALTITUDE	
5		
6		
7		
8	Range = 0 to 65 520 ft (Resolution)	
9		
10		
11		
12		
13	LSB = 16 ft (Resolution)	
14	STATUS	
15	MSB = 32 768 ft	
16		
17	FMS SELECTED	
18	ALTITUDE	
19		
20		
21	Range = 0 to 65 520 ft	
22		
23		
24		
25		
26	LSB = 16 ft (Resolution)	
27	STATUS	
28	MSB = 204.8 mb	
29		
30		
31		
32		
33		
34	Range = 0 to 409.5 mb	
35		
36		
37		
38		
39		BAROMETRIC
40	LSB = 0.1 mb (Resolution)	PRESSURE SETTING
41		MINUS 800 mb
42		
43		
44	RESERVED	
45		
46		
47		
48	STATUS OF MCP/FCU MODE BITS	
49	VNAV MODE	
50	ALT HOLD MODE	
51	APPROACH MODE	
52	RESERVED	
53		
54	STATUS OF TARGET ALT SOURCE BITS	
55	TARGET ALTITUDE SOURCE	
56	TARGET ALTITUDE SOURCE	

PURPOSE: To provide ready access to information about the pilot's current vertical intentions, in order to improve the effectiveness of conflict probes and to provide additional tactical information to controllers.

1) Target altitude shall be the short-term intent value, at which the aircraft will level off (or has levelled off) at the end of the current manoeuvre. The data source that the aircraft is currently using to determine the target altitude shall be indicated in the altitude source bits (54 to 56) as detailed below.

   Note.— This information which represents the real "aircraft intent", when available, represented by the altitude control panel selected altitude, the flight management system selected altitude, or the current aircraft altitude according to the aircraft's mode of flight (the intent may not be available at all when the pilot is flying the aircraft).

2) The data entered into bits 1 to 13 shall be derived from the mode control panel/flight control unit or equivalent equipment. Alerting devices may be used to provide data if it is not available from "control" equipment. The associated mode bits for this field (48 to 51) shall be as detailed below.

3) The data entered into bits 14 to 26 shall be derived from the flight management system or equivalent equipment managing the vertical profile of the aircraft.

4) The current barometric pressure setting shall be calculated from the value contained in the field (bits 28 to 39) plus 800 mb.

   When the barometric pressure setting is less than 800 mb or greater than 1 209.5 mb, the status bit for this field (bit 27) shall be set to indicate invalid data.

5) Bits 48 to 56 shall indicate the status of the values provided in bits 1 to 26 as follows:

   Bit 48 shall indicate whether the mode bits (49, 50 and 51) are actively being populated:

   0 = No mode information provided
   1 = Mode information deliberately provided

   Bits 49, 50 and 51:

   0 = Not active
   1 = Active

   Bit 54 shall indicate whether the target altitude source bits (55 and 56) are actively being populated.

   0 = No source information provided
   1 = Source information deliberately provided

   Bits 55 and 56, shall indicate target altitude source:

   00 = Unknown
   01 = Aircraft altitude
   10 = FCU/MCP selected altitude
   11 = FMS selected altitude

Tables 2-65 to 2-67. BDS codes 4,1 to 4,3 — Next waypoint details

PURPOSE: To provide ready access to details about the next waypoint on an aircraft's route, without the need to establish a data link dialogue with the flight management system. This will assist with short- and medium-term tactical control. Register BDS code 4,1 contains 9 characters in the compressed 6-bit character form giving the waypoint name.

	BDS code 4,1 MB FIELD		BDS code 4,2 MB FIELD		BDS code 4,3 MB FIELD
1	STATUS	1	STATUS	1	STATUS
2	MSB	2	SIGN	2	SIGN
3		3	MSB = 90 degrees	3	MSB = 90 degrees
4	CHARACTER 1	4		4	BEARING TO WAYPOINT
5		5		5	
6		6		6	
7	LSB	7		7	
8	MSB	8	WAYPOINT	8	
9		9	LATITUDE	9	
10	CHARACTER 2	10		10	Range = [–180, +180]
11		11		11	
12		12		12	LSB = 360/2 048 degrees
13	LSB	13		13	STATUS
14	MSB	14	Range = [–180, +180]	14	MSB = 204.8 min
15		15		15	
16	CHARACTER 3	16		16	
17		17		17	
18		18		18	TIME TO GO
19	LSB	19		19	
20	MSB	20	LSB = 90/131 072 degrees	20	
21		21	STATUS	21	
22	CHARACTER 4	22	SIGN	22	
23		23	MSB = 90 degrees	23	Range = [0,409.6]
24		24		24	
25	LSB	25		25	LSB = 0.1 min
26	MSB	26		26	STATUS
27		27		27	MSB = 3 276.8 NM
28	CHARACTER 5	28	WAYPOINT	28	
29		29	LONGITUDE	29	
30		30		30	
31	LSB	31		31	
32	MSB	32		32	
33		33		33	DISTANCE TO GO
34	CHARACTER 6	34		34	
35		35		35	
36		36	Range = [–180, +180]	36	
37	LSB	37		37	
38	MSB	38		38	Range = [0, 6 553.6]
39		39		39	
40	CHARACTER 7	40	LSB = 90/131 072 degrees	40	
41		41	STATUS	41	
42		42	SIGN	42	LSB = 0.1 NM
43	LSB	43	MSB = 65 536 ft	43	
44	MSB	44		44	
45		45		45	
46	CHARACTER 8	46	WAYPOINT	46	
47		47	CROSSING	47	
48		48	ALTITUDE	48	
49	LSB	49		49	
50	MSB	50		50	RESERVED
51		51		51	
52	CHARACTER 9	52	Range = [0, 131 068]	52	
53		53		53	
54		54		54	
55	LSB	55		55	
56	RESERVED	56	LSB = 8 ft	56	

Table 2-68. BDS code 4,4 — Meteorological routine air report

MB FIELD

1	
2	FOM/SOURCE
3	
4	
5	STATUS (wind speed and direction)
6	MSB = 256 kt
7	
8	
9	WIND SPEED
10	
11	
12	Range = [0, 512]
13	
14	LSB = 1 kt
15	SIGN
16	MSB = 90 degrees
17	
18	WIND DIRECTION (True)
19	
20	
21	Range = [–180, +180]
22	
23	LSB = 180/256 degrees
24	STATUS
25	SIGN
26	MSB = 64°C
27	
28	
29	STATIC AIR TEMPERATURE
30	
31	
32	Range = [–128, +128]
33	
34	LSB = 0.25°
35	STATUS
36	MSB = 1 024 hPa
37	
38	
39	
40	AVERAGE STATIC PRESSURE
41	
42	
43	Range = [0,2 048]
44	
45	
46	LSB = 1 hPa
47	STATUS
48	TURBULENCE (see 1)
49	
50	STATUS
51	MSB = 100%
52	
53	Range = [0, 100]
54	HUMIDITY
55	
56	LSB = 100/64%

PURPOSE: To allow meteorological data to be collected by ground systems.

FOM/SOURCE coding:

The decimal value of the binary coded (figure of merit) FOM/SOURCE parameter shall be interpreted as follows:

0 = Invalid
1 = INS
2 = GNSS
3 = DME/DME
4 = VOR/DME
5 to 15 = Reserved

1) The interpretation of the two bits assigned to TURBULENCE shall be as shown in the table for BDS code 4,5.

Note.— The average static pressure is not a requirement of ICAO Annex 3.

Table 2-69. BDS code 4,5 — Meteorological hazard report

MB FIELD

Bit	Field
1	STATUS
2	TURBULENCE
3	
4	STATUS
5	WIND SHEAR
6	
7	STATUS
8	MICROBURST
9	
10	STATUS
11	ICING
12	
13	STATUS
14	WAKE VORTEX
15	
16	STATUS
17	SIGN
18	MSB = 64°C
19	STATIC AIR TEMPERATURE
20	
21	
22	Range = [–128, +128]
23	
24	
25	
26	LSB = 0.25°C
27	STATUS
28	MSB = 1 024 hPa
29	
30	
31	
32	AVERAGE STATIC PRESSURE
33	
34	
35	
36	Range = [0, 2 048]
37	
38	LSB = 1 hPa
39	STATUS
40	MSB = 32 768 ft
41	
42	
43	RADIO HEIGHT
44	
45	
46	
47	Range = [0, 65 528]
48	
49	
50	
51	LSB = 16 ft
52	RESERVED
53	
54	
55	
56	

PURPOSE: To provide reports on the severity of meteorological hazards, in particular for low flight.

Hazard coding:

The interpretation of the two bits assigned to each hazard shall be as defined in the table below:

Bit 1	Bit 2	
0	0	NIL
0	1	LIGHT
1	0	MODERATE
1	1	SEVERE

The definition of the terms LIGHT, MODERATE and SEVERE shall be those defined in the PANS-ATM (Doc 4444), where applicable.

Table 2-72. BDS code 4,8 — VHF channel report

MB FIELD

Bits	Field
1–15	VHF 1
16	STATUS
17–18	VHF 1 AUDIO STATUS
19–33	VHF 2
34	STATUS
35–36	VHF 2 AUDIO STATUS
37–51	VHF 3
52	STATUS
53–54	VHF 3 AUDIO STATUS
55–56	121.5 MHz AUDIO STATUS

PURPOSE: To allow the ATC system to monitor the settings of the VHF communications channel and to determine the manner in which each channel is being monitored by the aircrew.

Channel report coding:
Each VHF communications channel shall be determined from the 15-bit positive binary number, N in kHz, according to the formula.

Channel (MHz) = Base + N × 0.001 (MHz)

where Base = 118.000 MHz

Notes.—

1) *The use of binary to define the channel improves the coding efficiency.*
2) *This coding is compatible with analogue channels on 25 kHz, 8.33 kHz channel spacing and VDL as described below.*
3) *VDL has a full four bits allocated such that the active status of each of its four multiplex channels can be ascertained.*

25 kHz VDL: Mode 3

Bit	
16	Status
15	MSB (12 800 kHz)
...	range 118.000 to 143.575 136.975 (military uses)
6	LSB (25 kHz)
5	4 × channel active flags
4	
3	
2	
1	VDL indicator = 1

25 kHz analogue

Bit	
16	Status
15	MSB (12 800 kHz)
...	range 118.000 to 143.575 136.975 (military uses)
6	LSB (25 kHz)
5	unused
4	unused
3	unused
2	8.33 indicator = 0
1	VDL indicator = 0

8.33 kHz analogue

Bit	
16	Status
15	MSB (17 066 kHz)
...	range 118.000 to 152.112 136.975 (military uses)
4	LSB (17 066/2 048 kHz)
3	unused
2	8.33 indicator = 1
1	VDL indicator = 0

Audio status coding:

Each pair of audio status bits shall be used to describe the aircrew monitoring of that audio channel according to the following table:

Bit 1	Bit 2	
0	0	UNKNOWN
0	1	NOBODY
1	0	HEADPHONES ONLY
1	1	LOUDSPEAKER

Table 2-80. BDS code 5,0 — Track and turn report

MB FIELD

1	STATUS
2	SIGN 1 = Left (left wing down)
3	MSB = 45 degrees
4	
5	ROLL ANGLE
6	
7	
8	Range = [–90, +90]
9	
10	
11	LSB = 45/256 degrees
12	STATUS
13	SIGN 1 = West (e.g. 315° = –45°)
14	MSB = 90 degrees
15	
16	
17	TRUE TRACK ANGLE
18	
19	
20	Range = [–180, +180]
21	
22	
23	LSB = 90/512 degrees
24	STATUS
25	MSB = 1 024 kt
26	
27	
28	GROUND SPEED
29	
30	
31	Range = [0, 2 046]
32	
33	
34	LSB = 1 024/512 kt
35	STATUS
36	SIGN 1 = Minus
37	MSB = 8 degrees/second
38	
39	TRACK ANGLE RATE
40	
41	
42	Range = [–16, +16]
43	
44	
45	LSB = 8/256 degrees/second
46	STATUS
47	MSB = 1 024 kt
48	
49	TRUE AIRSPEED
50	
51	
52	Range = [0, 2 046]
53	
54	
55	
56	LSB = 1 023/512 kt

PURPOSE: To provide track and turn data to the ground systems.

1) The maximum acceptable data age at time of transmission to the ground shall be 1 second for all parameters.

2) The register update rate shall be sufficient to ensure that the maximum acceptable data age of all parameters is not exceeded in normal operations.

3) If maximum acceptable data age is exceeded for any parameter, then the status bit for that parameter shall be actively set to 0 by the GFM.

   Note.— This applies if any parameter becomes unavailable due to abnormal operations.

4) If the value of a parameter from the data source exceeds the range allowable in the register definition, the maximum allowable value in the correct positive or negative sense shall be used instead.

   Note.— This requires active intervention by the GFM.

5) The data entered into this register shall, whenever possible, be derived from the sources that are controlling the aircraft.

6) If any parameter is not available on an aircraft, all bits corresponding to that parameter shall be actively set to 0 by the BDS servicing process.

7) The LSB of all fields shall be obtained by rounding.

Table 2-81. BDS code 5,1 — Position report coarse

MB FIELD

Bit	Field
1	STATUS (see 1)
2	SIGN
3	MSB = 90 degrees
4	
5	
6	
7	
8	
9	LATITUDE
10	
11	
12	
13	
14	Range = [–180, +180]
15	(see 2)
16	
17	
18	
19	
20	
21	LSB = 360/1 048 576 degrees
22	SIGN
23	MSB = 90 degrees
24	
25	
26	
27	
28	LONGITUDE
29	
30	
31	
32	
33	
34	Range = [–180, +180]
35	
36	
37	
38	
39	
40	
41	LSB = 360/1 048 576 degrees
42	SIGN
43	MSB = 65 536 ft
44	
45	
46	
47	PRESSURE
48	ALTITUDE
49	
50	Range = [–1 000, +126 752]
51	
52	
53	
54	
55	
56	LSB = 8 ft

PURPOSE: To provide a three-dimensional report of aircraft position.

1) The single status bit (bit 1) shall be set to 0 if any of the three parameters are invalid and is identical to the status bit in BDS 5,2.

2) The required valid range for latitude is +90 degrees to –90 degrees, but the parameter shall be coded with an MSB of 90 degrees to allow the use of the same coding algorithm as for longitude.

3) The source of the information in this register shall be the same as that indicated in the FOM/SOURCE field of BDS 5,2.

Table 2-82. BDS code 5,2 — Position report fine

MB FIELD

Bit	Field
1	STATUS (see 1)
2	FOM/SOURCE
3	
4	
5	
6	MSB = 90/128 degrees
7	
8	
9	
10	
11	LATITUDE FINE
12	
13	
14	
15	
16	Range = [0, 180/128]
17	
18	
19	
20	
21	
22	
23	LSB = 90/16 777 216 degrees
24	MSB = 90/128 degrees
25	
26	
27	
28	LONGITUDE FINE
29	
30	
31	Range = [0, 180/128]
32	
33	
34	
35	
36	
37	
38	
39	
40	
41	LSB = 90/16 777 216 degrees
42	SIGN
43	MSB = 65 536 ft
44	
45	
46	
47	PRESSURE
48	ALTITUDE
49	or
50	GNSS HEIGHT (HAE)
51	Range = [–1 000, 126 752]
52	
53	
54	
55	
56	LSB = 8 ft

PURPOSE: To provide a high-precision three-dimensional report on aircraft position when used in conjunction with BDS 5,1. Information on the source of the data is included.

FOM/SOURCE coding:

The decimal value of the binary-coded (figure of merit) FOM/SOURCE parameter shall be interpreted as follows:

0	=	Loss of navigational capability
1	=	RNP 20 (e.g. INS data) pressure altitude
2	=	RNP 5 (e.g. VOR/DME) pressure altitude
3	=	RNP 1 (e.g. DME/DME or GNSS) pressure altitude
4	=	Reserved for differential GNSS (circular position error (CPE) 10 m) pressure altitude
5	=	Reserved for differential GNSS (CPE 2.5 m) pressure altitude
6-10	=	Reserved
11	=	RNP 1 (e.g. DME/DME or GNSS) GNSS height
12	=	Reserved for differential GNSS (CPE 10 m) height
13	=	Reserved for differential GNSS (CPE 2.5 m) height
14-15	=	Reserved

Note.— RNP signifies required navigation performance. Suitable RNP categories have not yet been defined for values below 1; therefore, CPE is used.

1) *The single status bit (bit 1) shall be set to 0 if any of the three parameters are invalid and is identical to the status bit in BDS 5,1.*

2) *The LATITUDE (fine) and LONGITUDE (fine) parameters are in 2's complement coding so they shall be interpreted in conjunction with the corresponding parameters in BDS 5,1.*

Note.— When GNSS height is contained in bits 42 to 56, the pressure altitude can be obtained from BDS 5,1.

Table 2-83. BDS code 5,3 — Air-referenced state vector

MB FIELD

1	STATUS
2	SIGN
3	MSB = 90 degrees
4	
5	MAGNETIC HEADING
6	
7	
8	Range = [–180, +180]
9	
10	
11	
12	LSB = 90/512 degrees
13	STATUS
14	MSB = 512 kt
15	
16	
17	INDICATED AIRSPEED (IAS)
18	
19	
20	Range = [0, 1 024]
21	
22	
23	LSB = 1 kt
24	STATUS
25	MSB = Mach 2.048
26	
27	MACH NUMBER
28	
29	
30	Range = [0, 4.096]
31	
32	
33	LSB = Mach 0.008
34	STATUS
35	MSB = 1 024 kt
36	
37	
38	
39	TRUE AIRSPEED (TAS)
40	
41	
42	
43	Range = [0, 2 048]
44	
45	
46	LSB = 0,5 kt
47	STATUS
48	SIGN
49	MSB = 8 192 ft/min
50	ALTITUDE RATE
51	
52	
53	Range = [–16 384, +16 384]
54	
55	
56	LSB = 64 ft/min

PURPOSE: To provide the ATC system with the current measured values of magnetic heading IAS/Mach, altitude rate and TAS.

Table 2-84 to 2-86. BDS codes 5,4 to 5,6 — Waypoints 1, 2 and 3

MB FIELD

Bit	Field
1	STATUS (see 1)
2	MSB
3	
4	CHARACTER 1
5	
6	
7	LSB
8	MSB
9	
10	CHARACTER 2
11	
12	
13	LSB
14	MSB
15	
16	CHARACTER 3
17	
18	
19	LSB
20	MSB
21	
22	CHARACTER 4
23	
24	
25	LSB
26	MSB
27	
28	CHARACTER 5
29	
30	
31	LSB
32	MSB = 30 min
33	
34	
35	ESTIMATED TIME OF ARRIVAL
36	(NORMAL FLIGHT)
37	
38	Range = [0, 59]
39	
40	LSB = 60/512 min
41	MSB = 320
42	
43	ESTIMATED FLIGHT LEVEL
44	(NORMAL FLIGHT)
45	Range = [0, 640]
46	LSB = 10
47	MSB = 30 min
48	
49	
50	TIME TO GO
51	(DIRECT ROUTE)
52	
53	Range = [0, 59]
54	
55	LSB = 60/512 min
56	RESERVED

PURPOSE: To provide information on the next three waypoints. BDS 5,4 contains details of the next waypoint, BDS 5,5 contains details of the next waypoint plus 1, and BDS 5,6 contains details of the next waypoint plus 2.

1) The single status bit (bit 1) shall be set to 0 if any of the parameters are invalid.

2) The estimated time or flight level shall be calculated from the trajectory scheduled in the FMS.

   Note.— More detailed information on the next waypoint is given in BDS 4,1 to 4,3.

3) When the waypoint identity has only three characters, two leading 0 characters shall be added (e.g. CDN becomes 00CDN).

4) Estimated time is in minutes and a value of all ones shall be used to indicate that the waypoint referred to is more than one hour away.

Table 2-95. BDS code 5,F — Quasi-static parameter monitoring

MB FIELD

Bit	Field
1–2	SELECTED ALTITUDE
3–4	SELECTED HEADING
5–6	SELECTED SPEED
7–8	SELECTED MACH NUMBER
9–10	SELECTED ALTITUDE RATE
11–12	SELECTED FLIGHT PATH ANGLE
13–14	NEXT WAYPOINT
15–16	FMS HORIZONTAL MODE
17–18	FMS VERTICAL MODE
19–20	VHF CHANNEL REPORT
21–22	METEOROLOGICAL HAZARDS
23–24	TARGET ALTITUDE
25–56	RESERVED

PURPOSE: To permit the monitoring of changes in parameters that do not normally change very frequently, i.e. those expected to be stable for 5 minutes or more by accessing a single register.

Parameter monitor coding:

The changing of each parameter shall be monitored by 2 bits. The value 00 shall indicate that no valid data are available on this parameter. The decimal value for this 2-bit field shall be cycled through 1,2 and 3, each step indicating a change in the monitored parameter.

The meteorological hazards subfield shall report changes to turbulence, wind shear, wake vortex, icing and microburst, as in register number 45_{16}.

Table 2-96. BDS code 6,0 — Heading and speed report

MB FIELD

1	STATUS
2	SIGN 1 = West (e.g. 315° = –45°)
3	MSB = 90 degrees
4	
5	
6	MAGNETIC HEADING
7	
8	
9	Range = [–180, +180]
10	
11	
12	LSB = 90/512 degrees
13	STATUS
14	MSB = 512 kt
15	
16	
17	INDICATED AIRSPEED
18	
19	
20	Range = [0, 1 023]
21	
22	
23	LSB = 512/512 = 1 kt
24	STATUS
25	MSB = 2.048
26	
27	MACH
28	
29	
30	Range = [0, 4.096]
31	
32	
33	
34	LSB = 2.048/512
35	STATUS
36	SIGN 1 = Below
37	MSB = 8 192 ft/min
38	
39	BAROMETRIC ALTITUDE
40	RATE
41	
42	Range = [–16 384, +16 352]
43	
44	
45	LSB = 8 192/256 = 32 ft/min
46	STATUS
47	SIGN 1 = Below
48	MSB = 8 192 ft/min
49	
50	INERTIAL VERTICAL
51	VELOCITY
52	
53	Range = [–16 384, +16 352]
54	
55	
56	LSB = 8 192/256 = 32 ft/min

PURPOSE: To provide heading and speed data to ground systems.

1) The maximum acceptable data age at time of transmission to the ground shall be 1 second for all parameters.

2) The register update rate shall be sufficient to ensure that the maximum acceptable data age of all parameters is not exceeded in normal operations.

3) If maximum acceptable data age is exceeded for any parameter, then the status bit for that parameter shall be actively set to 0 by the GFM.

4) If the value of a parameter from the data source exceeds the range allowable in the register definition, the maximum allowable value in the correct positive or negative sense shall be used instead.

Note.— This requires active intervention by the GFM.

5) The data entered into this register shall, whenever possible, be derived from the sources that are controlling the aircraft.

6) All parameters shall be required except for inertial vertical velocity which shall be supplied only by aircraft with a suitable inertial source. If inertial vertical velocity is not available, bits 46 to 56 inclusive shall be actively set to 0 by the GFM.

7) The LSB of all fields shall be obtained by rounding.

Table 2-97. BDS code 6,1 — Emergency/priority status

MB FIELD

Bit	Field
1	
2	
3	FORMAT TYPE CODE = 28
4	
5	
6	
7	SUBTYPE CODE = 1
8	
9	EMERGENCY/PRIORITY
10	STATUS
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	
33	RESERVED
34	
35	
36	
37	
38	
39	
40	
41	
42	
43	
44	
45	
46	
47	
48	
49	
50	
51	
52	
53	
54	
55	
56	

PURPOSE: To provide additional information on aircraft status.

Subtype shall be coded as follows:

0 = No information
1 = Emergency/priority status
2 to 7 = Reserved

Emergency/priority status shall be coded as follows:

Value	Meaning
0	No emergency
1	General emergency
2	Lifeguard/Medical
3	Minimum fuel
4	No communications
5	Unlawful interference
6	Reserved
7	Reserved

1) Message delivery shall be accomplished once per second using the event-driven protocol.

2) Termination of emergency state shall be detected by coding in the surveillance status field of the airborne position message.

Table 2-98/99. BDS codes 6,2/6,3 — Current/next trajectory change point (TCP/TCP+1)

MB FIELD

1		
2		
3	FORMAT TYPE CODE = 29	
4		
5		
6	TCP Type (0 = current, 1 = next)	
7	TRAJECTORY POINT/LEG TYPE	
8		
9	(See 2.3.9.3)	
10		
11	TCP DATA VALID (0 = invalid, 1 = valid)	
12	TCP Format (0 = 4D TCP)	TCP Format (1 = 3D TCP)
13	MSB	MSB
14	TCP/TCP+1	TCP/TCP+1
15	ALTITUDE	ALTITUDE
16		
17	(See 2.3.9.6)	(See 2.3.9.6)
18		
19		
20		
21		
22	LSB	LSB
23	MSB = 180 degrees	MSB = 180 degrees
24	TCP/TCP+1	TCP/TCP+1
25	LATITUDE	LATITUDE
26	(CPR even format coding)	(Angular weighted binary coding)
27	(See 2.3.9.7.1)	(See 2.3.9.7.2)
28		
29		
30		
31		
32		
33		
34		
35		
36	LSB	
37	MSB	
38	TCP/TCP+1	
39	LONGITUDE	LSB = 2^{-17} x 360 degrees
40	(CPR even format coding)	MSB = 180 degrees
41		TCP/TCP+1
42	(See 2.3.9.8.1)	LONGITUDE
43		(Angular weighted binary coding)
44		(See 2.3.9.8.2)
45		
46		
47		
48		
49		
50	LSB	
51	MSB	
52	TCP/TCP+1	
53	TIME-TO-GO (TTG)	
54		
55	(See 2.3.9.9)	
56	LSB	LSB = 2^{-17} x 360 degrees

PURPOSE: To provide aircraft intent as defined by the current or next trajectory change point.

1) Message delivery shall be accomplished using the event-driven protocol.

Table 2-100. BDS code 6,4 — Aircraft operational coordination message

MB FIELD

Bit	Field
1–5	FORMAT TYPE CODE = 30
6–8	SUBTYPE CODE = 0
9–32	MSB (9) PAIRED ADDRESS (specified in 2.3.10.3) LSB (32)
33–37	MSB (33) RUNWAY THRESHOLD SPEED (specified in 2.3.10.4) LSB (37)
38	ROLL ANGLE SIGN BIT (specified in 2.3.10.5)
39–43	MSB (39) ROLL ANGLE (specified in 2.3.10.6) LSB (43)
44–45	GO-AROUND (specified in 2.3.10.7)
46–47	ENGINE-OUT (specified in 2.3.10.8)
48–56	RESERVED

PURPOSE: To provide the current state of the various aircraft parameters required to support operational applications, particularly those involving paired aircraft.

1) Message delivery shall be accomplished using the event-driven protocol.

Table 2-101. BDS code 6,5 — Aircraft operational status

MB FIELD

Bit	Field
1	MSB
2	
3	FORMAT TYPE CODE = 31
4	
5	LSB
6	MSB
7	SUBTYPE CODE = 0
8	LSB
9	MSB
10	EN-ROUTE OPERATIONAL CAPABILITIES (CC-4)
11	(specified in 2.3.11.3)
12	LSB
13	MSB
14	TERMINAL AREA OPERATIONAL CAPABILITIES
15	(CC-3)
16	LSB (specified in 2.3.11.4)
17	MSB
18	APPROACH/LANDING OPERATIONAL
19	CAPABILITIES (CC-2)
20	LSB (specified in 2.3.11.5)
21	MSB
22	SURFACE OPERATIONAL CAPABILITIES (CC-1)
23	(specified in 2.3.11.6)
24	LSB
25	MSB
26	EN-ROUTE OPERATIONAL CAPABILITY
27	STATUS (OM-4)
28	LSB (specified in 2.3.11.7)
29	MSB
30	TERMINAL AREA OPERATIONAL CAPABILITY
31	STATUS (OM-3)
32	LSB (specified in 2.3.11.8)
33	MSB
34	APPROACH/LANDING OPERATIONAL
35	CAPABILITY STATUS (OM-2)
36	LSB (specified in 2.3.11.9)
37	MSB
38	SURFACE OPERATIONAL CAPABILITY
39	STATUS (OM-1)
40	LSB (specified in 2.3.11.10)
41	
42	
43	
44	
45	
46	
47	RESERVED
48	
49	
50	
51	
52	
53	
54	
55	
56	

PURPOSE: To provide the capability class and current operational mode of ATC-related applications on board the aircraft.

1) Message delivery shall be accomplished using the event-driven protocol.

Table 2-241. BDS code F,1 — Military applications

MB FIELD

Bit	Content	Field
1	STATUS	
2	Character Field (see 1)	
3	C1	MODE 1 CODE
4	A1	
5	C2	
6	A2	
7	C4	
8	A4	
9	X	
10	B1	
11	D1	
12	B2	
13	D2	
14	B4	
15	D4	
16	STATUS	
17	C1	MODE 2 CODE
18	A1	
19	C2	
20	A2	
21	C4	
22	A4	
23	X	
24	B1	
25	D1	
26	B2	
27	D2	
28	B4	
29	D4	
30–56		RESERVED

PURPOSE: To provide data in support of military applications.

1) The character field shall be used to indicate whether 2 characters or 4 characters are used in the Mode 1 code. The logic shall be as follows:

   0 = 2 octal codes
   (A1-A4 and B1-B4)

   1 = 4 octal codes
   (A1-A4, B1-B4, C1-C4 and D1-D4)

2) The status fields shall be used to indicate whether the data are available or unavailable. The logic shall be as follows:

   0 = Unavailable
   1 = Available

Table 2-242. BDS code F,2 — Military applications

MB FIELD

1–5	TYPE CODE = 0	
6	STATUS	
7	Character Field (see 1)	
8	C1	MODE 1 CODE
9	A1	
10	C2	
11	A2	
12	C4	
13	A4	
14	X	
15	B1	
16	D1	
17	B2	
18	D2	
19	B4	
20	D4	
21	STATUS	
22	C1	MODE 2 CODE
23	A1	
24	C2	
25	A2	
26	C4	
27	A4	
28	X	
29	B1	
30	D1	
31	B2	
32	D2	
33	B4	
34	D4	
35	STATUS	
36	C1	MODE A CODE
37	A1	
38	C2	
39	A2	
40	C4	
41	A4	
42	X	
43	B1	
44	D1	
45	B2	
46	D2	
47	B4	
48	D4	
49–56	RESERVED	

PURPOSE. This register is used for military applications involving DF=19. Its purpose is to provide data in support of military applications.

'TYPE CODE' shall be encoded as follows:

0 = Mode code information
1 – 31 = Unassigned

1) The character field shall be used to indicate whether 2 characters or 4 characters are used in the Mode 1 code. The logic shall be as follows:

   0 = 2 octal codes
   (A1-A4 and B1-B4)

   1 = 4 octal codes
   (A1-A4, B1-B4, C1-C4, and D1-D4)

2) The status fields shall be used to indicate whether the data are available or unavailable. The logic shall be as follows:

   0 = Unavailable
   1 = Available

3. FORMATS FOR MODE S SPECIFIC PROTOCOLS (MSP)

3.1 MSP CHANNEL NUMBER ALLOCATIONS

The details of protocols and data transfers shall be as specified in the following paragraphs.

Note.— Some MSP channel numbers have been assigned (see Chapter 5, Table 5-25).

3.2 UPLINK MSP CHANNELS

The following sections are numbered 3.2.X, where 'X' is the decimal equivalent of the uplink MSP channel number. This shall be done to allow definitions of the hitherto undefined formats to be inserted without affecting the paragraph numbers.

For MSP packet formats refer to Chapter 5.

3.2.1 UPLINK MSP CHANNEL 1

(Reserved for specific services management)

The description of this channel has not yet been developed.

3.2.2 UPLINK MSP CHANNEL 2

(Traffic information service (TIS))

3.2.2.1 *PURPOSE*

The TIS shall have the capability to generate automatic alert information on any aircraft that carries an operating transponder (Mode A/C or Mode S) or aircraft that are under primary radar tracking integrated with the SSR system.

Note.— The traffic information service (TIS) is intended to improve the safety and efficiency of "see and avoid" flight by providing the pilot with an automatic display of nearby traffic and warnings of any potentially threatening traffic conditions. The TIS is functionally equivalent to ACAS I, providing traffic advisories but no resolution advisory information. By utilizing the surveillance database maintained by Mode S ground interrogators and its data link, the TIS can provide airborne traffic alerting with a minimum airborne equipage requirement. The TIS is provided without any ATC involvement.

3.2.2.2 *TIS UPLINK MESSAGE FORMATS*

All TIS uplink messages shall be structured as shown below. Each TIS uplink message shall be 56 bits. TIS traffic data messages shall consist of one or more short-form MSP packets. There shall be three types of TIS uplink messages as follows:

1) "Keep-alive"

2) "Goodbye"

3) "Traffic data"

Header	*Message type*	*Traffic block 1*	*Traffic block 2*
8 bits	6 bits	21 bits	21 bits

Note.— The formats of TIS downlink messages are defined in section 4 of this appendix under broadcast identifier 02_{16}.

3.2.2.2.1 *Message header*

The 8-bit header shall be present in all TIS messages. The message header for TIS shall have the value 02 (hexadecimal), since all TIS messages utilize the short-form MSP protocol and TIS is assigned MSP channel 2.

3.2.2.2.2 *Message type*

The 6-bit message type field shall be used to differentiate the different types of uplink messages:

Message type value	*TIS message uplink type*
0 to 59	Traffic data, first segment (own-heading)
60	Traffic data, intermediate segment(s)
61	Traffic data, final segment
62	Goodbye
63	Keep-alive

In the case of "first segment" traffic data messages, the 6-bit message type field shall contain the Mode S interrogator-derived tracked own-heading of the aircraft receiving the TIS message. This heading shall be quantized in 6 degree increments and shall be expressed with reference to magnetic north at the interrogator. The own-heading value in traffic data messages shall be provided to permit display heading correction on board the TIS-equipped aircraft by using an airborne heading sensor.

Note.— Such a heading correction may be necessary when the aircraft is manoeuvring or crabbing due to wind.

Since there may be several TIS traffic data messages to a given aircraft during a given scan, TIS processing shall be able to group the TIS traffic data uplinks together correctly. The "first", "intermediate", and "final" segment type values shall provide the necessary information to perform this grouping process. The mechanism for this shall be as specified below. Buffer space for at least 4 TIS traffic data messages (eight aircraft) shall be provided.

3.2.2.2.2.1 Keep-alive message

The TIS keep-alive message shall contain the message header and the message type fields as described above. The message type field shall be set to 63 decimal. The remaining bits of the message shall be unused.

3.2.2.2.2.2 Goodbye message

The TIS goodbye message shall contain the message header and the message type fields as described above. The message type field shall be set to 62 decimal. The remaining bits of the message shall be unused.

3.2.2.2.3 *Traffic information block*

Each TIS traffic data message shall contain two 21-bit traffic information blocks whose structure is shown below. The six fields in a traffic information block shall describe one TIS alert aircraft. One TIS traffic data message shall be able to define one or two alert aircraft.

Note.— A number 'n' of TIS traffic data messages may be uplinked in a given scan to convey information on up to 2n alert aircraft.

Traffic bearing	*Traffic range*	*Relative altitude*	*Altitude rate*	*Traffic heading*	*Traffic status*
6 bits	4 bits	5 bits	2 bits	3 bits	1 bit

3.2.2.2.3.1 Traffic bearing

The 6-bit traffic bearing field shall contain the bearing angle from the own-aircraft heading to the alert aircraft, quantized in 6 degree increments. The valid range for the traffic bearing field shall be 0 to 59 (with the exception described below).

Note.— Since this bearing angle is defined by TIS with respect to its measured own-aircraft heading, corrections from an airborne heading source can be applied.

If there is only one alert aircraft in a given TIS traffic data message, the traffic bearing field in the unused traffic information block shall be set to the value 63 (a bearing angle greater than 360 degrees) and the remainder of the bits in the traffic information block shall be ignored. This shall be termed as a "null alert" block.

3.2.2.2.3.2 Traffic range

The 4-bit traffic range field shall contain the distance between own-aircraft and the alert aircraft. A non-linear range encoding shall be used to minimize the number of bits required for this field as follows:

Traffic range value (r)	*Range (in increments of 230 m (0.125 NM))*
0	$0 \le r \le 1$
1	$1 < r \le 3$
2	$3 < r \le 5$
3	$5 < r \le 7$
4	$7 < r \le 9$
5	$9 < r \le 11$
6	$11 < r \le 13$
7	$13 < r \le 15$
8	$15 < r \le 18$
9	$18 < r \le 22$
10	$22 < r \le 28$
11	$28 < r \le 36$
12	$36 < r \le 44$
13	$44 < r \le 52$
14	$52 < r \le 56$
15	$r > 56$

3.2.2.2.3.3 Relative altitude

The 5-bit relative altitude field shall contain the difference in altitude between the own-aircraft and the alert aircraft. A non-linear encoding shall be used to minimize the number of bits required for this field. A special encoding value shall be used to indicate that the alert aircraft has no reported altitude. By convention, a positive value in the relative altitude field shall indicate that the alert aircraft is above the own-aircraft.

Relative altitude shall be given by:

$$\text{Relative altitude} = \text{Altitude}_{\text{Alert aircraft}} - \text{Altitude}_{\text{Own-aircraft}}$$

where altitudes are indicated in feet.

The TIS encoding for relative altitude shall be:

Relative altitude value (alt)	*Relative altitude (feet)*
0	$0 \le alt \le +100$
1	$+100 < alt \le +200$
2	$+200 < alt \le +300$
3	$+300 < alt \le +400$
4	$+400 < alt \le +500$

Relative altitude value (alt)	*Relative altitude (feet)*
5	+500 < alt ≤ +600
6	+600 < alt ≤ +700
7	+700 < alt ≤ +800
8	+800 < alt ≤ +900
9	+900 < alt ≤ +1 000
10	+1 000 < alt ≤ +1 500
11	+1 500 < alt ≤ +2 000
12	+2 000 < alt ≤ +2 500
13	+2 500 < alt ≤ +3 000
14	+3 000 < alt ≤ +3 500
15	+3 500 < alt
16	No reported altitude
17	–100 ≤ alt < 0
18	–200 ≤ alt < –100
19	–300 ≤ alt < –200
20	–400 ≤ alt < –300
21	–500 ≤ alt < –400
22	–600 ≤ alt < –500
23	–700 ≤ alt < –600
24	–800 ≤ alt < –700
25	–900 ≤ alt < –800
26	–1 000 ≤ alt < –900
27	–1 500 ≤ alt < –1 000
28	–2 000 ≤ alt < –1 500
29	–2 500 ≤ alt < –2 000
30	–3 000 ≤ alt < –2 500
31	alt < –3 000

3.2.2.2.3.4 Altitude rate

The 2-bit altitude rate field shall indicate whether the alert aircraft is climbing, descending, or level. An altitude rate of 500 ft/min shall be used as a threshold. The encoding of the TIS altitude rate field shall be:

Altitude rate field value	*Altitude rate*
0	Unused
1	Climbing (>500 ft/min)
2	Descending (>500 ft/min)
3	Level

3.2.2.2.3.5 Traffic heading

The 3-bit traffic heading field shall contain the heading of the alert aircraft quantized to 45 degree increments. This heading shall be based on the Mode S ground interrogator track for the alert aircraft.

Note.— The coarse quantization of traffic heading is sufficient to aid the pilot receiving the TIS alert message to visually acquire the traffic alert aircraft.

3.2.2.2.3.6 Traffic status

The 1-bit traffic status field shall identify the type of alert represented by this traffic information block. A status value of “ZERO” shall indicate a “proximity” alert and a status value of “ONE” shall indicate a “threat” alert.

3.2.2.2.4 *Handling multiple TIS alerts*

As described above, the traffic data information for a given scan shall consist of one or more TIS traffic data messages. The last traffic information block of the last TIS uplink message for this scan shall be a null-alert block if there is an odd number of alert aircraft in this message. The null-alert condition shall be indicated by the value 63 decimal in the traffic bearing field of the traffic information block.

3.2.2.2.4.1 The TIS traffic information blocks within a given TIS traffic data message shall be arranged with the highest priority alerts first. All traffic information blocks with the status "threat" shall precede traffic information blocks with the status "proximity". Within a status class, the traffic information blocks shall be put in order of increasing traffic range.

Note.— This ordering ensures that the most critical traffic alerts will be at the head of the list of traffic information blocks. Therefore, TIS will report on the most significant aircraft up to the limit of the number of messages transferable in one scan.

3.2.2.3 *TIS TRAFFIC DATA MESSAGES GROUPING MECHANISM*

3.2.2.3.1 The mechanism for grouping TIS traffic data messages for a given scan shall be based on the message type field in each message as described in 3.2.2.2.

3.2.2.3.2 Since the Mode S Comm-A protocol can deliver multiple copies of the same message, the initial step in message grouping shall be a check to eliminate duplicate messages. This shall be accomplished by a bit comparison of successive messages received with the same message type.

3.2.2.3.3 After duplicate elimination, the TIS traffic data for a given grouping shall always begin with a "first" segment message. This message shall contain the own-heading value for the group. Additional TIS traffic data messages in the grouping (if present) shall be structured as indicated in the table below:

Number of traffic aircraft	*Structure of group*
1	First
2	First
3	First and final
4	First and final
5	First, 1 intermediate, and final
6	First, 1 intermediate, and final
7	First, 2 intermediates, and final
8	First, 2 intermediates, and final
etc.	First, intermediates, and final

3.2.2.3.4 The receipt of a "first" segment shall start the formation of a message group. Subsequent TIS traffic data uplink messages shall be added to the group until one of the following conditions occurs:

a) a TIS uplink of type "final" is received (the final is part of the group);

b) a TIS uplink of type "first" segment, "keep-alive", or "goodbye" is received; or

c) more than 6 seconds have elapsed since the start of the group.

3.2.2.3.5 All the traffic blocks in the TIS traffic data message group (1 to n) shall form the display for the current time. A new group shall then be initiated by the receipt of another TIS traffic data uplink "first" segment message. TIS traffic data uplink messages of type "intermediate" or "final" shall be ignored if a new group has not been initiated by receipt of a "first" segment.

3.2.2.4 *TIS ESTABLISHMENT/DISCONNECTION PROTOCOLS*

The processing required to establish/disconnect TIS with Mode S ground interrogators when coverage boundaries are crossed shall be based upon information contained in the capability registers within the aircraft's Mode S transponder as well as two specific TIS uplink messages.

3.2.2.4.1 *Mode S capability report*

Transponder register 10_{16} within the Mode S transponder shall contain bits that indicate the level of the aircraft with respect to Mode S functions. This register shall be read by each Mode S ground interrogator that acquires the aircraft. Bit 25 of this register shall be set to "ONE" if the aircraft carries any MSP data link services (i.e. TIS).

Note.— This bit merely indicates the presence of MSP data link services on board the aircraft — it does NOT indicate whether any of these services are in use by the aircrew at a given time.

3.2.2.4.2 *MSP capability report*

Transponder registers $1D_{16}$ to $1F_{16}$ within the Mode S transponder contain bits which indicate the dynamic state of certain MSP data services on board the aircraft (where defined in applications, e.g. TIS). These registers shall be read by each Mode S ground interrogator that acquires the aircraft if the Mode S capability report indicates that the aircraft carries MSP data link services. Bit 2 of the MSP capability report register $1D_{16}$ shall be set to "ONE" if TIS support is desired; otherwise, the bit shall be set to "ZERO". Setting and resetting this bit shall be done in conjunction with the generation of TIS "service connect requests" (TSCR) and "service disconnect requests" (TSDR) downlink messages as specified in section 4 for downlink broadcast identifier 02_{16}.

3.2.2.4.3 *Keep-alive timer*

In the absence of TIS traffic data messages, TIS keep-alive messages shall be uplinked by the Mode S ground interrogator. The TIS airborne processor shall keep a timer that measures the time interval between TIS uplink messages received. The timer shall be reset each time a TIS uplink message is received. If this "keep-alive" timer reaches 60 seconds (the "keep-alive" time parameter for TIS), the TIS ground-to-air service shall be declared to have failed and TIS support is no longer available from the Mode S ground interrogator.

Note.— The data link service processing for TIS must receive periodic uplink messages from the Mode S ground interrogator in order to ensure that the ground-to-air link is maintained and that the ground TIS support is continuing.

3.2.2.4.4 *TIS principal interrogator identifier (II) code protocol*

Each TIS uplink message shall be accompanied by a 4-bit interrogator identifier (II) code that identifies which Mode S ground interrogator (or interrogators cluster) generated it. At any given moment, only one Mode S ground interrogator shall be declared as the "principal interrogator" (PI). In areas having overlapping Mode S coverage by interrogators with different II codes, an "alternate interrogator" (AI) shall also be declared. The TIS protocol for handling II codes shall be as defined below.

Note.— II codes are assigned to Mode S interrogators in such a way that interrogators with overlapping surveillance coverage that are not clustered cannot have identical II codes.

3.2.2.4.5 *TIS display generation*

If TIS messages are received from more than one interrogator at a time, only those TIS messages from the interrogator currently declared as the PI shall be displayed to the pilot. TIS messages from interrogators other than the PI shall be discarded, except for the AI processing described below.

3.2.2.4.6 *Alternate interrogator (AI) identification*

The II code of the most recently received TIS message not from the PI shall be retained as the AI. In the case that no TIS messages have been received from interrogators other than the PI (as described below), no current AI shall be defined. The AI definition shall be initialized to the "none state" when TIS is enabled (TSCR) or disabled (TSDR) by the pilot.

3.2.2.4.7 *Principal interrogator (PI) identification*

The II code of the first Mode S ground interrogator to respond to the TSCR downlink message with a TIS uplink message becomes the PI. The PI shall be retained until either:

a) the PI sends a TIS "goodbye" uplink message; or

b) there is a TIS "keep-alive" time-out on the PI.

In either case, the AI (if one is present) shall be promoted to PI and its TIS messages shall now be displayed. A new AI shall now be identified. If there was no available AI, no PI is now available and the airborne TIS processor shall be in the "no TIS supported" state. This state shall continue until a TIS message (either traffic or keep-alive) is received from a Mode S ground interrogator. When such an uplink message is received, the II code contained in the message shall become the PI and the airborne processing shall resume the display of TIS. The PI definition shall be initialized to the "none" state when TIS is enabled (TSCR) or disabled (TSDR) by the pilot.

3.2.3 UPLINK MSP CHANNEL 3

(Reserved for ground-to-air alert)

The description of this channel has not yet been developed.

3.2.4 UPLINK MSP CHANNEL 4

(Reserved for ground-derived position)

The description of this channel has not yet been developed.

3.2.5 UPLINK MSP CHANNEL 5

(ACAS sensitivity level control)

The description of this channel has not yet been developed.

3.2.6 UPLINK MSP CHANNEL 6

(Ground-to-air request)

3.2.6.1 *PURPOSE*

This service shall provide a means of requesting access to services supported by the aircraft. When implemented, bit 6 of the register accessed by BDS code 1,D shall be set to a 1.

3.2.6.2 *FORMAT*

The request shall be transferred in an uplink MSP packet with the channel number set to 6 and, in the case of a long form MSP packet, with SP set to "ZERO". The first byte of the user data field shall contain a service request (SR) header. The contents and format of the service request are specified by the application.

3.2.6.3 *SR HEADER ASSIGNMENTS*

Decimal value of SR	
0	Unassigned
1	Dataflash
2	Local system management
3 to 255	Unassigned

3.2.6.3.1 *Dataflash*

3.2.6.3.1.1 Dataflash request format

The format of the user data field shall be as specified in Table 3-1. The user data field of the requesting MSP packet shall contain the decimal value of "ONE" in the first byte (SR header), followed by one or more requests for dataflash services. Each request shall contain a 2-byte dataflash request header (DH), followed by a 1-byte field to define the minimum time interval permitted between reports (MT field), a 4-bit field to determine the event criterion (EC field), a 4-bit field to determine stable time (ST field), and if indicated in EC, a change quanta field (CQ) and a change threshold (CT) field. The 4-bit ST field shall indicate the decimal value in seconds and how long the changed data has been stable before a message shall be initiated. All zeros in the dataflash header (DH) shall indicate that there are no more dataflash requests in the packet. When an MSP packet is completely filled with dataflash requests, or when there is not sufficient room in the packet for another dataflash request header, it shall be assumed that the dataflash request sequence is complete.

3.2.6.3.1.1.1 All aircraft dataflash equipment and installations shall support 16 dataflash contracts. Aircraft equipment and installations originally certified after 1 January 2001 shall support 64 dataflash contracts.

Note 1.— A single dataflash contract relates to a single contract number (see 3.2.6.3.1.2.1) for a single register for a particular II code. Therefore, dataflash services, with different DH values for each II code, can be established simultaneously with the same aircraft. These may be modified or discontinued independently of each other.

3.2.6.3.1.1.2 **Recommendation.—** *When a request has been accepted by the aircraft system, a dataflash response should be triggered immediately regardless of thresholds or event criteria. If no response is received in 30 seconds then a check should be made that the aircraft is still available on roll call, and if so a new request should be generated. In order to avoid repeated dataflash requests that produce no response, the number of such requests (N) should be limited (N = 3).*

3.2.6.3.1.1.3 When a new contract request is received for a contract already in existence, the old contract shall be discontinued and replaced immediately by the latest one.

3.2.6.3.1.2 Dataflash header (DH) 16 bits

The 16-bit DH field is divided into four subfields separated by 3 reserved bits (14 through 16) see Table 3-1.

3.2.6.3.1.2.1 Contract number subfield (CNS) 4 bits
(Bits 9 to 12 of the uplink MSP 6
user data field when SR = 1)

This subfield shall be interpreted as a contract number permitting 16 different contracts to be associated with the register specified by the BDS1 and BDS2 codes of this contract request. Contract numbers available are 0 to 15 and shall be associated with the II code of the contract request.

3.2.6.3.1.2.2 Request data subfield (RDS) 1 bit
(Bit 13 of the uplink MSP 6
user data field when SR = 1

This subfield shall indicate whether or not the contents of the register being monitored by the requested contract must be sent in the MSP packets on downlink channel 3 that are sent each time the criterion for the contract is met. The subfield shall be interpreted as follows:

RDS = 0 Send only bits 1 to 40 of the user data field on downlink MSP 3 when the contract criterion is met.

RDS = 1 Send bits 1 to 96 of the user data field on downlink MSP 3 when the contract criterion is met.

Note.— RDS only indicates the length of the user data field in downlink MSP3 when responding with a value zero in the CI field (see 3.3.3.4.3.1).

3.2.6.3.1.2.3 BDS1 and BDS2 codes 8 bits
(Bits 17 to 24 of the uplink MSP6 user data field)

BDS1 and BDS2 codes of the register for which the contract is required shall be as specified in Annex 10, Volume IV.

3.2.6.3.1.3 Minimum time (MT) 8 bits

The decimal value of the 8-bit MT field shall represent the minimum time in seconds that shall elapse after a report has been event-triggered and sent to the transponder, before a new report can be initiated. The report sent to the transponder shall always be the most current data available.

3.2.6.3.1.4 Event initiation

Event initiation shall be controlled by the two following fields.

3.2.6.3.1.4.1 Event criterion subfield (EC) 4 bits

The EC field shall be the four most significant bits following the MT field. If multiple events occur within a single register being monitored by a dataflash contract, (e.g. if more than one parameter shows a significant change) only one message shall be triggered. The decimal value of the EC field shall be interpreted as follows:

0 No report required, discontinue service for the contract specified in the DH field.

1 Report any change.

2 56-bit change field (CQ) follows ST. Only report changes to bits indicated by a “ONE” in CQ.

3 56-bit field CQ follows ST. For each parameter report all status changes and all changes of the parameter greater than the quantum value indicated in the same units and resolution of the field in CQ corresponding to that parameter. A zero in the field in CQ corresponding to the parameter indicates that no reports are required.

4 112 bits of CQ plus CT follow ST. The first 56 bits are as for the EC value 3 above. The second 56 bits are the CT field indicating a threshold value in the field corresponding to the parameter. Report all changes above the threshold where the value in CQ gives the change quantum.

5 112 bits of CQ plus CT follow ST. Same as for the EC value 4 above except: report all changes below the threshold.

6 112 bits of CQ plus CT follows ST. Same as for EC values 4 and 5 above except: report only when the threshold is crossed (in either direction).

7 to 14 Not assigned

15 Cancel all contracts for the II code in this request.

3.2.6.3.1.4.2 Stable time field (ST) 4 bits

The ST field shall be the 4 bits following the EC field. The decimal value of ST shall indicate in seconds how long the changed data have been stable, to within the change quanta specified in the CQ field, before a message shall be initiated. A value of “ZERO” in this subfield shall indicate that there is no minimum stable time and any change immediately initiates a message. The significance of the ST shall be dependent on which EC mode is being used. For EC modes 4 and 5, regarding stability whilst above/below a threshold, if a parameter value remains above/below the defined threshold for greater than the ST time then a dataflash message shall be generated even if the value does not remain stable to within one quantum. Subsequent quantum changes which are stable for greater than the ST time shall generate further dataflash messages until the value falls below/rises above the threshold.

3.2.6.3.1.5 Change fields — change quanta (CQ) and change threshold (CT)

These fields shall be present when indicated in EC. For a transponder register service (i.e. for BDS1 and BDS2 from 1 to 255 inclusive), CQ shall be contained in bits 41 to 96 of the MSP 6 user data field. CT, when required, shall be contained in bits 97 to 152 of the MSP 6 user data field. The quantum value in the CQ field shall be indicated in the same units and resolution as those specified for the register being monitored. It shall specify the amount by which the parameter must change, from its value at the initialization of the contract, and thereafter from the value last reported by a dataflash response, in order to trigger a new dataflash response on downlink MSP channel 3 (see Table 3-1).

3.2.6.3.2 *Local system management*

The purpose of the local system management is to provide a particular ground-air service request that can be defined locally to meet particular requirements (such as for ground station "remote setting" of parameters at the far-field monitor).

3.2.7 UPLINK MSP CHANNEL 7

(Reserved for response to air-to-ground service request)

The description of this channel has not yet been developed.

3.2.8 UPLINK MSP CHANNEL 8

(Reserved for trajectory negotiation)

The description of this channel has not yet been developed.

3.2.9 UPLINK MSP CHANNELS 9 TO 63

These channels have not been assigned.

3.3 DOWNLINK MSP CHANNELS

The following sections are numbered 3.3.X, where "X" is the decimal number equivalent to the downlink MSP channel number. This is done to allow definitions of the hitherto undefined formats to be inserted without affecting paragraph numbers.

3.3.1 DOWNLINK MSP CHANNEL 1

(Reserved for specific services management)

The description of this channel has not yet been developed.

3.3.2 DOWNLINK MSP CHANNEL 2

This channel has not been assigned.

3.3.3 DOWNLINK MSP CHANNEL 3

3.3.3.1 *PURPOSE*

Dataflash is a service which announces the availability of information from air-to-ground on an event-triggered basis. When implemented, bit 31 of the register accessed by BDS code 1,D shall be set to a 1.

Note.— This is an efficient means of downlinking information which changes occasionally and unpredictably.

3.3.3.2 *SERVICE INITIATION AND TERMINATION*

3.3.3.2.1 The dataflash service shall be initiated or discontinued by a service request and is received on uplink MSP channel 6 with a decimal value of ONE in the service request (SR) header, which is contained in the first byte of the user data field. This indicates that the rest of the user data field shall contain a dataflash request. On the receipt of such a request, a dataflash message from the register concerned with the request shall immediately be made available and announced to the ground regardless of the setting of the RDS field in the contract request and of any event criteria. The response shall be as follows.

3.3.3.2.2 When the requested register is being serviced, the contract shall be established and an MSP packet as specified in Table 3-2 shall be announced to the ground on MSP channel 3. The CI field must be set to a value of 1. The message shall be used by the ground system to confirm that the service has been initiated.

3.3.3.2.3 If the requested register is not being serviced, the contract shall not be established. This shall be indicated by announcing the MSP packet on downlink MSP channel 3 to the ground containing only bits 1 to 40 as specified in Table 3-2, and with a value of 2 in the CI field.

3.3.3.2.4 If the maximum number of contracts that can be supported are already established, then the new contract shall be refused. This shall be indicated by announcing to the ground an MSP packet on downlink channel 3, as specified in Table 3-2, and with a value of 3 in the CI field.

3.3.3.2.5 In the case of a request from the ground to terminate the service for a particular register, the termination of the service shall be confirmed by announcing to the ground an MSP packet on downlink channel 3, as shown in Table 3-2, and with a value of 4 in the CI field.

3.3.3.2.6 In the case of a request from the ground to terminate the service for all contracts to a particular II code, the termination of the service shall be confirmed by announcing to the ground an MSP packet on downlink channel 3, as shown in Table 3-2, and with a value of 5 in the CI field.

3.3.3.2.7 When the transponder register service fails for an established contract, the contract shall be terminated by the airborne application. This will be indicated by announcing to the ground an MSP packet on the downlink channel 3, as shown in Table 3-2, and with a value of 7 in the CI field. Transponder register service shall be deemed to have failed when any of the parameters specified to be monitored in the negotiation of the contract are not being updated at the specified minimum rate.

3.3.3.2.8 When a contract is refused due to an invalid value of the EC field in the contract request, this shall be indicated by announcing to the ground an MSP packet on downlink channel 3, as shown in Table 3-2, and with a value of 15 in the CI field.

3.3.3.2.9 If any message is not extracted from the transponder by a ground interrogator within 30 seconds, the aircraft subnetwork shall cancel the message and generate a delivery failure notice (i.e. the T_Z timer expires), which shall be delivered to the aircraft MSP service provider. When a delivery failure notice is received the service shall be automatically terminated by the dataflash function with no indication to the ground system.

Note.— This is to prevent the transponder message queues being blocked when the ground interrogator stops supplying the message extraction service, either due to a fault or loss of cover. It is the responsibility of the ground application to monitor the dataflash service taking this into account.

3.3.3.2.10 When the transponder has not been selectively interrogated by a Mode S interrogator with a particular II code for 60 seconds (determined by monitoring the IIS subfield in all accepted Mode S interrogations), all dataflash contracts related to that II code shall be cancelled with no indication to the ground system.

3.3.3.3 *SERVICE PROVISION*

On the receipt of a dataflash request, the requested parameters shall be monitored and transferred to the ground using the Mode S air-initiated protocols directed to the II code that was contained in the requesting interrogation. In order to prevent the flooding of the transponder with dataflash messages, an upper limit of ten messages in a six-second period shall be imposed. When the limit of ten messages within a six-second period is reached, further messages shall be queued until they can be sent. Messages queued in this way shall respond with a CI field value of 6. If after initiating a dataflash message to the ground, the change criterion is met again prior to the message being entered into the transponder for announcement, the message is considered stale and shall be replaced by the most up-to-date information.

3.3.3.4 *DOWNLINK MESSAGE STRUCTURE*

The information shall be transferred in a downlink MSP packet with the channel number M/CH = 3. The format is shown in Table 3-2. The first two bytes of the user data (UD) field shall contain a dataflash header (DH) which shall be identical to the DH field that was contained in the request for service.

3.3.3.4.1 Bits 17 to 31 of UD form the II code contract report (CR) field in which each bit shall indicate that at least one contract is active with the II code, which the bit represents when it is set to a ONE; otherwise, there are no active contracts with that II code.

3.3.3.4.2 Bits 32 to 36 of UD are not assigned.

3.3.3.4.3 Bits 37 to 40 of UD form the contract information (CI) field which shall be interpreted as follows:

CI field value	*Meaning*
0	Response to existing contract
1	New contract established
2	New contract not accepted, or existing contract terminated, due to no transponder register data service
3	New contract not accepted due to maximum number of contracts already being serviced
4	Contract terminated for the DH in this response due to a request from the ground
5	All contracts terminated for the II code that delivered the MSP packet having an EC value of 15 that requested this response
6	Response has been queued due to the limit of six dataflash messages in a ten-second period
7	Contract terminated due to failure of the register data service
8 to 14	Unassigned
15	New contract not accepted due to invalid number in EC field of requested uplink MSP packet

3.3.3.4.3.1 When the CI field is equal to zero, the response shall be as requested by the RDS field in the dataflash header of the contract (see 3.2.6.3.1.2.2). When the CI field is not equal to zero, the response shall only contain bits 1 to 40 of the user data field on downlink MSP 3 (see Table 3-2).

3.3.3.5 *DATA EXTRACTION BY MODE S GROUND STATIONS*

The dataflash transaction shall be announced as a downlink frame in response to interrogations UF 4, 5, 20, or 21. The transaction announced shall be either a single segment Comm-B frame or a two segment Comm-B frame, as requested by the contract negotiations. The air-directed Comm-B first segment shall contain the MSP header, dataflash header, and control information for that particular contract. In the case of a contract for a single segment response, if the data is required, it is acquired directly by the ground station extracting the register in question.

3.3.4 DOWNLINK MSP CHANNEL 4

(Reserved for position request)

The description of this channel has not yet been developed.

3.3.5 DOWNLINK MSP CHANNEL 5

This channel has not been assigned.

3.3.6 DOWNLINK MSP CHANNEL 6

(Reserved for response to ground-to-air service request.) (See Table 3-3.)

The first byte of the user data (UD) field in the downlink MSP channel 6 shall be used to define a response type (RT) field as follows:

RT = 0 Unassigned

RT = 1 (Reserved)

RT = 2 Local system management

RT = 3 to 255 Unassigned

When implemented, bit 34 of register $1D_{16}$ is set to a 1.

Note.— The response to a ground-air service request can be used to transfer information resulting from such a service.

3.3.7 DOWNLINK MSP CHANNEL 7

(Reserved for air-to-ground request)

The description of this channel has not yet been developed.

3.3.8 DOWNLINK MSP CHANNEL 8

(Reserved for trajectory negotiation)

The description of this channel has not yet been developed.

3.3.9 DOWNLINK MSP CHANNELS 9 TO 63

These channels have not been assigned.

TABLES FOR SECTION 3

Table 3-1. Request for dataflash monitoring service

Mode S SLM frame containing uplink MSP packet on channel 6 when SR = 1

MSP 6 USER DATA FIELD

Bits 1 to 40

Bit	Field	Group
	DP = 0 (1 BIT)	UPLINK MSP HEADER (1 BYTE)
	MP = 0 (1 BIT)	
	M/CH = 6 (6 BITS)	
1	SERVICE REQUEST (SR) = 1	
2		
3		
4		
5		
6		
7		
8		
9	CONTRACT NUMBER SUBFIELD (CNS)	DATAFLASH HEADER (DH)
10		
11		
12		
13	REQUEST DATA (RDS)	
14	RESERVED	
15		
16		
17	BDS1 CODE	
18		
19		
20		
21	BDS2 CODE	
22		
23		
24		
25	MINIMUM TIME (MT) INTERVAL LSB = 1 second	
26		
27		
28		
29		
30		
31		
32		
33	EVENT CRITERION (EC)	
34		
35		
36		
37	STABLE TIME (ST) LSB = 1 second	
38		
39		
40		

Bits 41 to 96 (if required)

Bits	Field
41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96	CHANGE QUANTA FIELD (CQ)

Bits 97 to 152 (if required)

Bits	Field
97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152	CHANGE THRESHOLD FIELD (CT)

The last byte of the final MA field shall always be unassigned.

Table 3-2. Dataflash for register monitoring service
Mode S frame containing downlink MSP packet on Channel 3

MSP 3 USER DATA FIELD

Bits 1 to 40	Field	Group	Bits 41 to 96	Content
	LINKED COMM B SUBFIELD (LBS) (2 BITS)		41	
			42	
	DP = 0 (1 BIT)	MSP HEADER	43	
	MP = 0 (1 BIT)		44	
	M/CH = 3 (6 BITS)		45	
			46	
			47	
			48	
			49	
			50	
	FILL 1 = 0 (6 BITS)		51	
			52	
			53	
			54	
			55	
			56	
1	CONTRACT NUMBER SUBFIELD (CNS)	DATAFLASH HEADER (DH)	57	REGISTER MESSAGE CONTENT
2			58	
3			59	
4			60	
5	REQUEST DATA (RDS)		61	
6	RESERVED		62	
7			63	
8			64	
9	BDS1 CODE		65	
10			66	
11			67	
12			68	
13	BDS2 CODE		69	
14			70	
15			71	
16			72	
17	II = 1	II CODE CONTRACT REPORT (CR)	73	
18	II = 2		74	
19	II = 3		75	
20	II = 4		76	
21	II = 5		77	
22	II = 6		78	
23	II = 7		79	
24	II = 8		80	
25	II = 9		81	
26	II = 10		82	
27	II = 11		83	
28	II = 12		84	
29	II = 13		85	
30	II = 14		86	
31	II = 15		87	
32			88	
33	NOT ASSIGNED		89	
34			90	
35			91	
36			92	
37	CONTRACT INFORMATION (CI)		93	
38			94	
39			95	
40			96	

See 5.2.7.3 for specification of MSP packets

Table 3-3. Response to ground-to-air service request
Mode S frame containing downlink MSP packet on channel 6

MSP 6 USER DATA FIELD

Bits 1 to 40

Bits	Field	
	LINKED COMM B SUBFIELD (LBS) (2 BITS)	
	DP = 0 (1 BIT)	MSP HEADER
	MP = 0 (1 BIT)	
	M/CH = 6 (6 BITS)	
	FILL 1 = 0 (6 BITS)	
1 2 3 4 5 6 7 8	RESPONSE TYPE	
9 10 11 12 13 14 15 16		
17 18 19 20 21 22 23 24	USER DEFINED	
25 26 27 28 29 30 31 32		
33 34 35 36 37 38 39 40		

Bits 41 to 96

Bits	Field
41 42 43 44 45 46 47 48	REGISTER MESSAGE CONTENT
49 50 51 52 53 54 55 56	
57 58 59 60 61 62 63 64	
65 66 67 68 69 70 71 72	
73 74 75 76 77 78 79 80	
81 82 83 84 85 86 87 88	
89 90 91 92 93 94 95 96	

This packet shall always be sent as a linked Comm-B. The second segment being a direct copy of the relevant register.

4. MODE S BROADCAST PROTOCOLS

4.1 BROADCAST CHANNEL NUMBER ALLOCATIONS

The broadcast identifiers shall be represented as a two-digit hexadecimal number, e.g. “XX_{16}”

Note.— There are 255 broadcast identifiers available on both the uplink and downlink. Broadcast identifier numbers have been assigned for some applications (see Chapter 5, Table 5-23).

The data formats for the data link capability report and for aircraft identification together with the assignment of the broadcast identifiers shall be as defined in Annex 10, Volumes III and IV, respectively.

4.2 UPLINK BROADCAST IDENTIFIERS

The following sections are numbered 4.2.X, where “X” is the decimal equivalent of the uplink broadcast identifier number. This is done to allow definitions of the hitherto undefined formats to be inserted without affecting the paragraph numbering.

4.2.1 UPLINK BROADCAST IDENTIFIER 01_{16}

(Reserved for differential GNSS correction)

The description of this identifier has not yet been developed.

4.2.2 TO 4.2.47 UPLINK BROADCAST IDENTIFIERS 02_{16} to $2F_{16}$

These identifiers have not been assigned.

4.2.48 UPLINK BROADCAST IDENTIFIER 30_{16}

(Not valid)

4.2.49 UPLINK BROADCAST IDENTIFIERS 31_{16}

(Reserved for RA broadcast (see Annex 10, Volume IV, 4.3.8.4.2.3.4)).

4.2.50 UPLINK BROADCAST IDENTIFIERS 32_{16}

(Reserved for ACAS (see Annex 10, Volume IV, 4.3.8.4.2.3.3)).

4.2.51 TO 4.2.255 UPLINK BROADCAST IDENTIFIERS 33_{16} to FF_{16}

These identifiers have not been assigned.

4.3 DOWNLINK BROADCAST IDENTIFIER

The following sections are numbered 4.3.X, where “X” is the decimal equivalent of the downlink broadcast identifier number. This is done to allow definitions of the hitherto undefined formats to be inserted without affecting the paragraph numbering.

4.3.1 Downlink broadcast identifier 01_{16}

This identifier has not been assigned.

4.3.2 Downlink broadcast identifier 02_{16}

(Traffic information service)

4.3.2.1 *Introduction*

The traffic information service shall be provided by uplinking information on proximate aircraft that may be of interest to own-aircraft by a Mode S interrogator on uplink MSP channel 2.

Note.— The service and uplink messages are specified in 3.2.2 under "Uplink MSP Channel 2".

It shall be possible for the aircraft to request to be either connected to or disconnected from the TIS service. These requests shall be made using the Mode S broadcast protocol using broadcast identifier 02_{16}. These requests shall be the only downlink messages used by the TIS.

4.3.2.2 *TIS downlink messages*

The TIS airborne data link service shall be able to generate two types of Mode S downlink messages:

a) TIS service connect request (TSCR); and

b) TIS service disconnect request (TSDR).

Both the TSCR and the TSDR shall be sent as Comm-B broadcast messages using the broadcast identifier 02_{16}.

Note.— The use of the Mode S Comm-B broadcast protocol deals with the case of multiple Mode S interrogators with overlapping coverage, which are in contact with a given TIS aircraft at the same time.

The format of a TIS downlink message (either TSCR or TSDR) shall be as specified below:

Header	DIN 1	DIN 2	DIN 3	DIN 4	DIN 5	DIN 6
8 bits	8 bits	8 bits	8 bits	8 bits	8 bits	8 bits

The message header shall be the standard message header for TIS described in uplink MSP channel 2 (see 3.2.2, uplink MSP channels). The 8-bit data link service identifier numbers (DIN) shall be read and processed sequentially from the TCSR or TSDR message until either:

a) DIN i = 0; or

b) all bits of the downlink message have been processed.

Note 1.— This structure and protocol for MSP downlink service requests allow for future expansion and use by other MSP data link services.

Note 2.— The principal and alternate TIS II codes in the TIS process (see 3.2.2, Uplink MSP Channel 2) are set to the "none" state when either a TSCR or TSDR is generated.

4.3.2.2.1 *TCSR format*

This TIS Comm-B downlink message shall be generated when the pilot requests the initiation of TIS service. The TSCR message shall be generated at the same time as the MSP capability report bit for TIS is set to "ONE". A TSCR shall be identified by a DIN value of 1. The TSCR shall be defined as a Comm-B broadcast message so that any Mode S ground interrogator capable of supporting TIS can respond to it.

4.3.2.2.2 *TSDR format*

This TIS Comm-B broadcast downlink message shall be generated when the pilot requests termination of TIS service. The TSDR message shall be generated at the same time as the MSP capability report bit for TIS is set to "ZERO". A TDSR shall be identified by a DIN value of 2. The TDSR shall be defined as a Comm-B broadcast message so that any Mode S interrogator supporting TIS can respond to it.

4.3.3 TO 4.3.15 DOWNLINK BROADCAST IDENTIFIERS 03_{16} to $0F_{16}$

These identifiers have not been assigned.

4.3.16 DOWNLINK BROADCAST IDENTIFIER 10_{16}

(Data link capability report)

See Table 2-16.

4.3.17 TO 4.3.31 DOWNLINK BROADCAST IDENTIFIERS 11_{16} to $1F_{16}$

These identifiers have not been assigned.

4.3.32 DOWNLINK BROADCAST IDENTIFIER 20_{16}

(Aircraft identification)

See Table 2-32.

4.3.33 TO 4.3.253 DOWNLINK BROADCAST IDENTIFIERS 21_{16} to FD_{16}

These identifiers have not been assigned.

4.3.254 DOWNLINK BROADCAST IDENTIFIER FE_{16}

(Reserved for update request)

See Chapter 5.

4.3.255 DOWNLINK BROADCAST IDENTIFIER FF_{16}

(Reserved for search request)

See Chapter 5.

CHAPTER 6. VHF AIR-GROUND DIGITAL LINK (VDL)

6.1 DEFINITIONS AND SYSTEM CAPABILITIES

Note 1.— The very high frequency (VHF) digital link (VDL) Mode 2 and the VDL Mode 4 provide data service capabilities. The VDL Mode 3 provides both voice and data service capabilities. The data capability is a constituent mobile subnetwork of the aeronautical telecommunication network (ATN). In addition, the VDL may provide non-ATN functions. Standards and Recommended Practices (SARPs) for the VDL are defined and referenced below.

Note 2.— Additional information on VDL is contained in the Manuals on VDL Mode 2, VDL Mode 3 and VDL Mode 4 Technical Specifications.

Note 3.— Sections 6.1.2 to 6.8.2 contain Standards and Recommended Practices for VDL Modes 2 and 3. Section 6.9 contains Standards and Recommended Practices for VDL Mode 4.

6.1.1 Definitions

Automatic dependent surveillance-broadcast (ADS-B). A surveillance technique in which aircraft automatically provide, via a broadcast mode data link, data derived from on-board navigation and position-fixing systems, including aircraft identification, four-dimensional position, and additional data as appropriate.

Broadcast. A transmission of information relating to air navigation that is not addressed to a specific station or stations.

Burst. A time-defined, contiguous set of one or more related signal units which may convey user information and protocols, signalling, and any necessary preamble.

***Current slot*.** The slot in which a received transmission begins.

Data circuit-terminating equipment (DCE). A DCE is a network provider equipment used to facilitate communications between DTEs.

Data link entity (DLE). A protocol state machine capable of setting up and managing a single data link connection.

Data link service (DLS) sublayer. The sublayer that resides above the MAC sublayer. For VDL Mode 4, the DLS sublayer resides above the VSS sublayer. The DLS manages the transmit queue, creates and destroys DLEs for connection-oriented communications, provides facilities for the LME to manage the DLS, and provides facilities for connectionless communications.

Data terminal equipment (DTE). A DTE is an endpoint of a subnetwork connection.

Extended Golay Code. An error correction code capable of correcting multiple bit errors.

Frame. The link layer frame is composed of a sequence of address, control, FCS and information fields. For VDL Mode 2, these fields are bracketed by opening and closing flag sequences, and a frame may or may not include a variable-length information field.

Gaussian filtered frequency shift keying (GFSK). A continuous-phase, frequency shift keying technique using two tones and a Gaussian pulse shape filter.

Global signalling channel (GSC). A channel available on a world-wide basis which provides for communication control.

Link. A link connects an aircraft DLE and a ground DLE and is uniquely specified by the combination of aircraft DLS address and the ground DLS address. A different subnetwork entity resides above every link endpoint.

Link layer. The layer that lies immediately above the physical layer in the Open Systems Interconnection protocol model. The link layer provides for the reliable transfer of information across the physical media. It is subdivided into the data link sublayer and the media access control sublayer.

Link management entity (LME). A protocol state machine capable of acquiring, establishing and maintaining a connection to a single peer system. An LME establishes data link and subnetwork connections, "hands-off" those connections, and manages the media access control sublayer and physical layer. An aircraft LME tracks how well it can communicate with the ground stations of a single ground system. An aircraft VME instantiates an LME for each ground station that it monitors. Similarly, the ground VME instantiates an LME for each aircraft that it monitors. An LME is deleted when communication with the peer system is no longer viable.

M burst. A management channel data block of bits used in VDL Mode 3. This burst contains signalling information needed for media access and link status monitoring.

Media access control (MAC). The sublayer that acquires the data path and controls the movement of bits over the data path.

Mode 2. A data-only VDL mode that uses D8PSK modulation and a carrier sense multiple access (CSMA) control scheme.

Mode 3. A voice and data VDL mode that uses D8PSK modulation and a TDMA media access control scheme.

Mode 4. A data-only VDL mode using a GFSK modulation scheme and self-organizing time division multiple access.

Physical layer. The lowest level layer in the Open Systems Interconnection protocol model. The physical layer is concerned with the transmission of binary information over the physical medium (e.g. VHF radio).

Quality of service. The information relating to data transfer characteristics used by various communication protocols to achieve various levels of performance for network users.

Reed-Solomon code. An error correction code capable of correcting symbol errors. Since symbol errors are collections of bits, these codes provide good burst error correction capabilities.

Self-organizing time division multiple access (STDMA). A multiple access scheme based on time-shared use of a radio frequency (RF) channel employing: (1) discrete contiguous time slots as the fundamental shared resource; and (2) a set of operating protocols that allows users to mediate access to these time slots without reliance on a master control station.

Slot. One of a series of consecutive time intervals of equal duration. Each burst transmission starts at the beginning of a slot.

Subnetwork connection. A long-term association between an aircraft DTE and a ground DTE using successive virtual calls to maintain context across link handoff.

Subnetwork dependent convergence function (SNDCF). A function that matches the characteristics and services of a particular subnetwork to those characteristics and services required by the internetwork facility.

Subnetwork entity. In this document, the phrase "ground DCE" will be used for the subnetwork entity in a ground station communicating with an aircraft; the phrase "ground DTE" will be used for the subnetwork entity in a ground router communicating with an aircraft station; and, the phrase "aircraft DTE" will be used for the subnetwork entity in an aircraft communicating with the station. A subnetwork entity is a packet layer entity as defined in ISO 8208.

Subnetwork layer. The layer that establishes, manages and terminates connections across a subnetwork.

System. A VDL-capable entity. A system comprises one or more stations and the associated VDL management entity. A system may either be an aircraft system or a ground system.

Time division multiple access (TDMA). A multiple access scheme based on time-shared use of an RF channel employing: (1) discrete contiguous time slots as the fundamental shared resource; and (2) a set of operating protocols that allows users to interact with a master control station to mediate access to the channel.

User group. A group of ground and/or aircraft stations which share voice and/or data connectivity. For voice communications, all members of a user group can access all communications. For data, communications include point-to-point connectivity for air-to-ground messages, and point-to-point and broadcast connectivity for ground-to-air messages.

VDL management entity (VME). A VDL-specific entity that provides the quality of service requested by the ATN-defined SN_SME. A VME uses the LMEs (that it creates and destroys) to enquire the quality of service available from peer systems.

VDL Mode 4 burst. A VHF digital link (VDL) Mode 4 burst is composed of a sequence of source address, burst ID, information, slot reservation and frame check sequence (FCS) fields, bracketed by opening and closing flag sequences.

Note.— The start of a burst may occur only at quantized time intervals and this constraint allows the propagation delay between the transmission and reception to be derived.

VDL Mode 4 DLS system. A VDL system that implements the VDL Mode 4 DLS and subnetwork protocols to carry ATN packets or other packets.

VDL Mode 4 specific services (VSS) sublayer. The sublayer that resides above the MAC sublayer and provides VDL Mode 4 specific access protocols including reserved, random and fixed protocols.

VDL station. An aircraft-based or ground-based physical entity, capable of VDL Mode 2, 3 or 4.

Note.— In the context of this chapter, a VDL station is also referred to as a "station".

Vocoder. A low bit rate voice encoder/decoder.

Voice unit. A device that provides a simplex audio and signalling interface between the user and VDL.

VSS user. A user of the VDL Mode 4 specific services. The VSS user could be higher layers in the VDL Mode 4 SARPs or an external application using VDL Mode 4.

6.1.2 Radio channels and functional channels

6.1.2.1 *Aircraft station radio frequency range.* An aircraft station shall be capable of tuning to any of the channels in the range specified in Section 6.1.4.1 within 100 milliseconds after the receipt of an autotune command. In addition, for VDL Mode 3, an aircraft station shall be able to tune to any channel in the range specified in Section 6.1.4.1 within 100 milliseconds after the receipt of any tuning command.

6.1.2.2 *Ground station radio frequency range.* A ground station shall be capable of operating on its assigned channel within the radio frequency range detailed in 6.1.4.1.

6.1.2.3 *Common signalling channel.* Frequency 136.975 MHz shall be reserved as a world-wide common signalling channel (CSC) for VDL Mode 2.

6.1.3 System capabilities

6.1.3.1 *Data transparency.* The VDL system shall provide code-independent, byte-independent transfer of data.

6.1.3.2 *Broadcast.* The VDL system shall provide link layer data broadcast services (Mode 2) and/or voice and data broadcast services (Mode 3). For VDL Mode 3, the data broadcast service shall support network multicasting capability originating from the ground.

6.1.3.3 *Connection management.* The VDL system shall establish and maintain a reliable communications path between the aircraft and the ground system while allowing but not requiring manual intervention.

Note.— In this context "reliable" is defined by the BER requirement specified in 6.3.5.1.

6.1.3.4 *Ground network transition.* A VDL-equipped aircraft shall transition from one ground station to another when circumstances dictate.

6.1.3.5 *Voice capability.* The VDL Mode 3 system shall support a transparent, simplex voice operation based on a "Listen-Before-Push-To-Talk" channel access.

6.1.4 Air-ground VHF digital link communications system characteristics

6.1.4.1 The radio frequencies used shall be selected from the radio frequencies in the band 117.975 – 137 MHz. The lowest assignable frequency shall be 118.000 MHz and the highest assignable frequency shall be 136.975 MHz. The separation between assignable frequencies (channel spacing) shall be 25 kHz.

Note.— Volume V specifies that the block of frequencies from 136.9 – 136.975 MHz inclusive is reserved for VHF air-ground digital communications.

6.1.4.2 The design polarization of emissions shall be vertical.

6.2 SYSTEM CHARACTERISTICS OF THE GROUND INSTALLATION

6.2.1 Ground station transmitting function

6.2.1.1 *Frequency stability.* The radio frequency of VDL ground station equipment operation shall not vary more than plus or minus 0.0002 per cent (2 parts per million) from the assigned frequency.

Note.— The frequency stability for VDL ground stations using DSB-AM modulation is specified in Volume III, Part II, Chapter 2 for 25 kHz channel spacing.

6.2.2 Power

Recommendation.— *The effective radiated power should be such as to provide a field strength of at least 75 microvolts per metre (minus 109 dBW/m^2) within the defined operational coverage of the facility, on the basis of free-space propagation.*

6.2.3 Spurious emissions

6.2.3.1 Spurious emissions shall be kept at the lowest value which the state of the technique and the nature of the service permit.

Note.— Appendix S3 to the Radio Regulations specifies the levels of spurious emissions to which transmitters must conform.

6.2.4 Adjacent channel emissions

6.2.4.1 The amount of power from a VDL ground transmitter under all operating conditions when measured over the 25 kHz channel bandwidth of the first adjacent channel shall not exceed 0 dBm.

6.2.4.1.1 After 1 January 2002, the amount of power from all new installations of a VDL ground transmitter under all operating conditions when measured over the 25 kHz channel bandwidth of the first adjacent channel shall not exceed 2 dBm.

6.2.4.2 The amount of power from a VDL ground transmitter under all operating conditions when measured over the 25 kHz channel bandwidth of the second adjacent channel shall be less than minus 25 dBm and from thereon it shall monotonically decrease at the minimum rate of 5 dB per octave to a maximum value of minus 52 dBm.

6.2.4.2.1 After 1 January 2002, the amount of power from all new installations of a VDL ground transmitter under all operating conditions when measured over the 25 kHz channel bandwidth of the second adjacent channel shall be less than minus 28 dBm.

6.2.4.2.2 After 1 January 2002, the amount of power from all new installations of a VDL ground transmitter under all operating conditions when measured over the 25 kHz channel bandwidth of the fourth adjacent channel shall be less than minus 38 dBm, and from thereon it shall monotonically decrease at the minimum rate of 5 dB per octave to a maximum value of minus 53 dBm.

6.2.4.3 The amount of power from a VDL ground transmitter under all operating conditions when measured over a 16 kHz channel bandwidth centered on the first adjacent channel shall not exceed minus 20 dBm.

6.2.4.3.1 After 1 January 2002, the amount of power from all new installations of a VDL ground transmitter under all operating conditions when measured over a 16 kHz channel bandwidth centred on the first adjacent channel shall not exceed minus 18 dBm.

6.2.4.4 After 1 January 2005, all VDL ground transmitters shall meet the provisions of 6.2.4.1.1, 6.2.4.2.1, 6.2.4.2.2 and 6.2.4.3.1, subject to the conditions of 6.2.4.5.

6.2.4.5 Requirements of mandatory compliance of the provisions of 6.2.4.4 shall be made on the basis of regional air navigation agreements which specify the airspace of operation and the implementation timescales. The agreements shall provide at least two years' notice of mandatory compliance of ground systems.

6.3 SYSTEM CHARACTERISTICS OF THE AIRCRAFT INSTALLATION

6.3.1 *Frequency stability.* The radio frequency of VDL aircraft equipment shall not vary more than plus or minus 0.0005 per cent (5 parts per million) from the assigned frequency.

6.3.2 *Power.* The effective radiated power shall be such as to provide a field strength of at least 20 microvolts per metre (minus 120 dBW/m^2) on the basis of free space propagation, at ranges and altitudes appropriate to the operational conditions pertaining to the areas over which the aircraft is operated.

6.3.3 Spurious emissions

6.3.3.1 Spurious emissions shall be kept at the lowest value which the state of the technique and the nature of service permit.

Note.— Appendix S3 to the Radio Regulations specifies the levels of spurious emission to which transmitters must conform.

6.3.4 Adjacent channel emissions

6.3.4.1 The amount of power from a VDL aircraft transmitter under all operating conditions when measured over the 25 kHz channel bandwidth of the first adjacent channel shall not exceed 0 dBm.

6.3.4.1.1 After 1 January 2002, the amount of power from all new installations of a VDL aircraft transmitter under all operating conditions when measured over the 25 kHz channel bandwidth of the first adjacent channel shall not exceed 2 dBm.

6.3.4.2 The amount of power from a VDL aircraft transmitter under all operating conditions when measured over the 25 kHz channel bandwidth of the second adjacent channel shall be less than minus 25 dBm and from thereon it shall monotonically decrease at the minimum rate of 5 dB per octave to a maximum value of minus 52 dBm.

6.3.4.2.1 After 1 January 2002, the amount of power from all new installations of a VDL aircraft transmitter under all operating conditions when measured over the 25 kHz channel bandwidth of the second adjacent channel shall be less than minus 28 dBm.

6.3.4.2.2 After 1 January 2002, the amount of power from all new installations of a VDL aircraft transmitter under all operating conditions when measured over the 25 kHz channel bandwidth of the fourth adjacent channel shall be less than minus 38 dBm, and from thereon it shall monotonically decrease at the minimum rate of 5 dB per octave to a maximum value of minus 53 dBm.

6.3.4.3 The amount of power from a VDL aircraft transmitter under all operating conditions when measured over a 16 kHz channel bandwidth centred on the first adjacent channel shall not exceed minus 20 dBm.

6.3.4.3.1 After 1 January 2002, the amount of power from all new installations of a VDL aircraft transmitter under all operating conditions when measured over a 16 kHz channel bandwidth centred on the first adjacent channel shall not exceed minus 18 dBm.

6.3.4.4 After 1 January 2005, all VDL aircraft transmitters shall meet the provisions of 6.3.4.1.1, 6.3.4.2.1, 6.3.4.2.2 and 6.3.4.3.1, subject to the conditions of 6.3.4.5.

6.3.4.5 Requirements of mandatory compliance of the provisions of 6.3.4.4 shall be made on the basis of regional air navigation agreements which specify the airspace of operation and the implementation timescales. The agreements shall provide at least two years' notice of mandatory compliance of aircraft systems.

6.3.5 Receiving function

6.3.5.1 *Specified error rate.* The specified error rate for Mode 2 operation shall be the maximum corrected Bit Error Rate (BER) of 1 in 10^4. The specified error rate for Mode 3 operation shall be the maximum uncorrected BER of 1 in 10^3. The specified error rate for Mode 4 operation shall be the maximum uncorrected BER of 1 in 10^4.

Note.— The above physical layer BER requirements are derived from the BER requirement imposed by ATN at the subnetwork interface.

6.3.5.2 *Sensitivity.* The receiving function shall satisfy the specified error rate with a desired signal strength of not more than 20 microvolts per metre (minus 120 dBW/m^2).

Note.— The required signal strength at the edge of the service volume takes into account the requirements of the system and signal losses within the system, and considers environmental noise sources.

6.3.5.3 *Out-of-band immunity performance.* The receiving function shall satisfy the specified error rate with a desired signal field strength of not more than 40 microvolts per metre (minus 114 dBW/m^2) and with an undesired DSB-AM D8PSK or GFSK signal on the adjacent or any other assignable channel being at least 40 dB higher than the desired signal.

6.3.5.3.1 After 1 January 2002, the receiving function of all new installations of VDL shall satisfy the specified error rate with a desired signal field strength of not more than 40 microvolts per metre (minus 114 dBW/m^2) and with an undesired VHF DSB-AM, D8PSK or GFSK signal at least 60 dB higher than the desired signal on any assignable channel 100 kHz or more away from the assigned channel of the desired signal.

Note.— This level of interference immunity performance provides a receiver performance consistent with the influence of the VDL RF spectrum mask as specified in Volume III, Part I, 6.3.4 with an effective isolation transmitter/receiver isolation of 69 dB. Better transmitter and receiver performance could result in less isolation required. Guidance material on the measurement technique is included in Annex 10, Volume V, Attachment A, section 7.

6.3.5.3.2 After 1 January 2005, the receiving function of all installations of VDL shall meet the provisions of 6.3.5.3.1, subject to the conditions of 6.3.5.3.3.

6.3.5.3.3 Requirements of mandatory compliance of the provisions of 6.3.5.3.2 shall be made on the basis of regional air navigation agreements which specify the airspace of operation and the implementation timescales. The agreement shall provide for at least two years' notice of mandatory compliance of aircraft systems.

6.3.5.4 INTERFERENCE IMMUNITY PERFORMANCE

6.3.5.4.1 The receiving function shall satisfy the specified error rate with a desired field strength of not more than 40 microvolts per metre, and with one or more out-of-band signals, except for VHF FM broadcast signals, having a total level at the receiver input of minus 33 dBm.

Note.— In areas where adjacent higher band signal interference exceeds this specification, a higher immunity requirement will apply.

6.3.5.4.2 The receiving function shall satisfy the specified error rate with a desired field strength of not more than 40 microvolts per metre, and with one or more VHF FM broadcast signals having a total level at the receiver input of minus 5 dBm.

6.4 PHYSICAL LAYER PROTOCOLS AND SERVICES

The aircraft and ground stations shall access the physical medium operating in simplex mode.

6.4.1 Functions

6.4.1.1 The physical layer shall provide the following functions:

a) transmitter and receiver frequency control;

b) digital reception by the receiver;

c) digital transmission by the transmitter; and

d) notification services.

6.4.1.1.1 *Transmitter/receiver frequency control.* The VDL physical layer shall set the transmitter or receiver frequency as commanded by the link management entity (LME).

Note.— The LME is a link layer entity as contained in the Manuals on VDL Mode 2 and VDL Mode 3 Technical Specifications.

6.4.1.1.2 *Digital reception by the receiver.* The receiver shall decode input signals and forward them to the higher layers for processing.

6.4.1.1.3 *Digital transmission.* The VDL physical layer shall appropriately encode and transmit information received from higher layers over the RF channel.

6.4.2 Modes 2 and 3 common physical layer

6.4.2.1 *Modulation scheme.* Modes 2 and 3 shall use differentially encoded 8 phase shift keying (D8PSK), using a raised cosine filter with $\alpha = 0.6$ (nominal value). The information to be transmitted shall be differentially encoded with 3 bits per symbol (baud) transmitted as changes in phase rather than absolute phase. The data stream to be transmitted shall be divided into groups of 3 consecutive data bits, least significant bit first. Zeros shall be padded to the end of the transmissions if needed for the final channel symbol.

6.4.2.1.1 *Data encoding.* A binary data stream entering a differential data encoder shall be converted into three separate binary streams X, Y, and Z so that bits 3n form X, bits 3n + 1 form Y, and bits 3n + 2 form Z. The triplet at time k (X_k, Y_k, Z_k) shall be converted to a change in phase as shown in Table 6-1*, and the absolute phase ϕ_k is the accumulated series of $\Delta\phi_k$, that is:

$$\phi_k = \phi_{k-1} + \Delta\phi_k$$

6.4.2.1.2 *Transmitted signal form.* The phase-modulated baseband signal as defined in 6.4.2.1.1 shall excite the pulse shape filter.

$$s(t) = \sum_{k=-\infty}^{+\infty} h(\phi_k, t-kT_s)$$

where:

h is the complex impulse response of the pulse shape filter;
k is defined in 6.4.2.1.1;
ϕ is defined by the equation in 6.4.2.1.1;
t is time;
T_s is time duration of each symbol.

* All tables are located at the end of this chapter.

The output (function of time) of the pulse shape filter (s(t)) shall modulate the carrier frequency. The pulse shape filter shall have a nominal complex frequency response of a raised-cosine filter with α=0.6.

6.4.2.2 *Modulation rate.* The symbol rate shall be 10 500 symbols/second, resulting in a nominal bit rate of 31 500 bits/s. The modulation stability requirements for Modes 2 and 3 are provided in Table 6-2.

6.4.3 Mode 2 specific physical layer

Note.— The Mode 2 specific physical layer specification includes a description of the Mode 2 training sequence, forward error correction (FEC), interleaving, bit scrambling, channel sensing, and physical layer system parameters.

6.4.3.1 To transmit a sequence of frames, a station shall insert the bit numbers and flags (per the data link service description for Mode 2 as contained in the Manual on VDL Mode 2 Technical Specifications), compute the FEC (per 6.4.3.1.2), interleave (per 6.4.3.1.3), prepend the training sequence (per 6.4.3.1.1), carry out bit scrambling (per 6.4.3.1.4) and finally encode and modulate the RF signal (per 6.4.2.1).

6.4.3.1.1 *Training sequence.* Data transmission shall begin with a demodulator training sequence consisting of five segments:

a) transmitter ramp-up and power stabilization;

b) synchronization and ambiguity resolution;

c) reserved symbol;

d) transmission length; and

e) header FEC.

Note.— Immediately after these segments follows an AVLC frame with the format as contained in the data link service description in the Manual on VDL Mode 2 Technical Specifications.

6.4.3.1.1.1 *Transmitter ramp-up and power stabilization.* The purpose of the first segment of the training sequence, called the ramp-up, is to provide for transmitter power stabilization and receiver AGC settling, and it shall immediately precede the first symbol of the unique word. The duration of the ramp-up shall be five symbol periods. The time reference point (t), for the following specification is the centre of the first unique word symbol, a point that occurs half a symbol period after the end of the ramp-up. Conversely stated, the beginning of the ramp-up starts at t = –5.5 symbol periods. The transmitted power shall be less than –40 dBc prior to time t = –5.5 symbol periods. The ramp-up shall provide that at time t = –3.0 symbol periods the transmitted power is 90 per cent of the manufacturer's stated output power or greater (see Figure 6-1*). Regardless of the method used to implement (or truncate) the raised cosine filter, the output of the transmitter between times t = –3.0 and t = –0.5 will appear as if '000' symbols were transmitted during the ramp-up period.

Note. 1.— For Mode 3, the timing reference point is the same as the "power reference point".

Note 2.— It is desirable to maximize the time allowed for the AGC settling time. Efforts should be made to have power above 90 per cent of nominal output power at t – 3.5 symbol periods.

6.4.3.1.1.2 *Synchronization and ambiguity resolution.* The second segment of the training sequence shall consist of the unique word:

000 010 011 110 000 001 101 110 001 100 011
111 101 111 100 010

and shall be transmitted from left to right.

6.4.3.1.1.3 *Reserved symbol.* The third segment of the training sequence shall consist of the single symbol representing 000.

Note.— This field is reserved for future definition.

6.4.3.1.1.4 *Transmission length.* To allow the receiver to determine the length of the final Reed-Solomon block, the transmitter shall send a 17-bit word, from least significant bit (lsb) to most significant bit (msb), indicating the total number of data bits that follow the header FEC.

Note.— The length does not include those bits transmitted for: the Reed Solomon FEC, extra bits padded to ensure that the interleaver generates an integral number of 8-bit words, or the extra bits padded to ensure that the data encoder generates an integral number of 3-bit symbols.

6.4.3.1.1.5 *Header FEC.* To correct bit errors in the header, a (25, 20) block code shall be computed over the reserved symbol and the transmission length segments. The block code shall be transmitted as the fifth segment. The encoder shall accept the header in the bit sequence that is being transmitted. The five parity bits to be transmitted shall be generated using the following equation:

$$[P_1, \ldots, P_5] = [R_1, \ldots, R_3, TL_1, \ldots, TL_{17}]\, H^T$$

where:

P is the parity symbol (P_1 shall be transmitted first);

R is the reserved symbol;

TL is the transmission Length symbol;

^{T} is the matrix transpose function; and

H is the parity matrix defined below:

$$H = \begin{bmatrix} 0\,0 & 0\,0\,0\,0\,0\,0\,1\,1\,1\,1\,1\,1\,1\,1\,1\,1\,1 \\ 0\,0 & 1\,1\,1\,1\,1\,1\,0\,0\,0\,0\,1\,1\,1\,1\,1\,1\,1 \\ 1\,1 & 0\,0\,0\,1\,1\,1\,0\,0\,1\,1\,0\,0\,0\,0\,1\,1\,1 \\ 1\,1 & 0\,1\,1\,0\,1\,1\,0\,1\,0\,1\,0\,0\,1\,1\,0\,0\,1\,1 \\ 0\,1 & 1\,0\,1\,0\,0\,1\,1\,1\,1\,0\,0\,1\,0\,1\,0\,1\,0\,1 \end{bmatrix}$$

6.4.3.1.1.6 *Bit transmission order.* The five parity bits of the resultant vector product shall be transmitted from the left bit first.

6.4.3.1.2 *Forward error correction.* In order to improve the effective channel throughput by reducing the number of required retransmissions, FEC shall be applied after the training sequence, regardless of frame boundaries.

6.4.3.1.2.1 *FEC calculation.* The FEC coding shall be accomplished by means of a systematic fixed-length Reed-Solomon (RS)(255,249) 2^8-ary code.

Note 1.— This code is capable of correcting up to three octets for data blocks of 249 octets (1992 bits). Longer transmissions must be divided up into 1992 bit transmissions and shorter transmissions must be extended by virtual fill with trailing zeros. Six RS-check octets are appended for a total block of 255 octets.

The field defining the primitive polynomial of the code shall be as follows:

$$p(x) = (x^8 + x^7 + x^2 + x + 1)$$

The generator polynomial shall be as follows:

$$\prod_{i=120}^{125} (x - \alpha^i)$$

where:

α is a primitive element of GF(256);
GF(256) is a Galois field (GF) of size 256.

Note 2.— The Reed-Solomon codes are described in the Recommendation for Space Data System Standards Telemetry Channel Coding, by the Consultative Committee for Space Data Systems (see the Appendix).

* All figures are located at the end of this chapter.

6.4.3.1.2.2 *Block lengths.* The six RS-check octets shall be calculated on blocks of 249 octets. Longer transmissions shall be split into blocks of 249 octets, per 6.4.3.1.3. Blocks of shorter length shall be extended to 249 octets by a virtual fill of trailing zeros. The virtual fill shall not be transmitted. Blocks shall be coded according to 6.4.3.1.2.3 through 6.4.3.1.2.3.3.

6.4.3.1.2.3 *No error correction.* For blocks with 2 or fewer non-fill octets, no error correction shall be used.

6.4.3.1.2.3.1 *Single-byte error correction.* For blocks with 3 to 30 non-fill octets, all six RS-check octets shall be generated, but only the first two shall be transmitted. The last four RS-check octets shall be treated as erasures at the decoder.

6.4.3.1.2.3.2 *Two-byte error correction.* For blocks with 31 to 67 non-fill octets, all six RS-check octets shall be generated, but only the first four shall be transmitted. The last two RS-check octets shall be treated as erasures at the decoder.

6.4.3.1.2.3.3 *Three-byte error correction.* For blocks with 68 or more non-fill octets, all six RS-check octets shall be generated and transmitted.

6.4.3.1.3 *Interleaving.* To improve the performance of the FEC, an octet-based table-driven interleaver shall be used. The interleaver shall create a table having 255 octets per row and c rows, where

$$c = \frac{\textit{transmission length (bits)}}{1992\ \textit{(bits)}}$$

where:

a) the transmission length is as defined in 6.4.3.1.1.5; and

b) c = the smallest integer greater than or equal to the value of the fraction.

After extending the data to an even multiple of 1992 bits, the interleaver shall write the transmission stream into the first 249 octets of each row by taking each consecutive group of eight bits and storing them from the first column to the 249th. The first bit in each group of eight bits shall be stored in the eighth bit position; the first group of 1992 bits shall be stored in the first row, the second group of 1992 bits in the second row, etc. After the FEC is computed on each row, the FEC data (or erasures) shall be stored in columns 250 through 255. The interleaver shall then pass the data to the scrambler by reading out column by column, skipping any octet which contains erasures or all fill bits. All of the bits in an octet shall be transmitted from bit 8 to bit 1.

On reception, the de-interleaver shall calculate the number of rows and size of the last (potentially partial) row from the length field in the header. It shall only pass valid data bytes to the higher layer.

6.4.3.1.4 *Bit scrambling.* To aid clock recovery and to stabilize the shape of the transmitted spectrum, bit scrambling shall be applied. The pseudo noise (PN) sequence shall be a 15-stage generator (see Figure 6-2) with the characteristic polynomial:

$$X^{15} + X + 1$$

The PN-sequence shall start after the frame synchronization pattern with the initial value 1101 0010 1011 001 with the left-most bit in the first stage of the register as per Figure 6-2. After processing each bit, the register shall be shifted one bit to the right. For possible encryption in the future this initial value shall be programmed. The sequence shall be added (modulo 2) to the data at the transmit side (scrambling) and to the scrambled data at the receive side (descrambling) per Table 6-3.

Note.— The concept of a PN scrambler is explained in ITU-R Recommendation S.446-4, Annex I, Section 4.3.1, Method 1 (see the Appendix to this Chapter).

6.4.3.2 MODE 2 CHANNEL SENSING

6.4.3.2.1 *Channel busy to idle detection.* When a station receives on-channel power of at least –87 dBm for at least 5 milliseconds, then:

a) with a likelihood of 0.9, it shall continue to consider the channel occupied if the signal level is attenuated to below –92 dBm for less than 1 millisecond; and

b) with a likelihood of 0.9, it shall consider the channel unoccupied if the signal level is attenuated to below –92 dBm for at least 1.5 milliseconds.

Note.— The maximum link throughput available to all users is highly sensitive to the RF channel sense delay (from the time when the channel actually changes state until a station detects and acts on that change) and RF channel seizure delay (from the time when a station decides to transmit until the transmitter is sufficiently ramped up to lock out other stations). Accordingly, it is imperative that all efforts are made to reduce those times as the state-of-the-art advances.

6.4.3.2.2 *Channel idle to busy detection.* With a likelihood of at least 0.9, a station shall consider the channel occupied within 1 millisecond after on-channel power rises to at least –90 dBm.

6.4.3.2.3 **Recommendation.—** *The detection of an occupied channel should occur within 0.5 milliseconds.*

Note.— A higher probability of false alarm is acceptable on the idle to busy detection than the busy to idle detection because of the effects of the two different errors.

6.4.3.3 MODE 2 RECEIVER/TRANSMITTER INTERACTION

6.4.3.3.1 *Receiver to transmitter turnaround time.* A station shall transmit the training sequence such that the centre of the first symbol of the unique word will be transmitted within 1.25 milliseconds after the result of an access attempt is successful (see Figure 6-3). The total frequency change during the transmission of the unique word shall be less than 10 Hz. After transmission of the unique word, the phase acceleration shall be less than 500 Hz per second.

6.4.3.3.2 *Transmitter to receiver turnaround time.* The transmitter power shall be –20 dBc within 2.5 symbol periods of the middle of the final symbol of the burst. The transmitter power leakage when the transmitter is in the "off" state shall be less than –83 dBm. A station shall be capable of receiving and demodulating with nominal performance, an incoming signal within 1.5 milliseconds after transmission of the final information symbol.

Note.— Reference DO-160D section 21, category H for antenna radiated signals.

6.4.3.4 MODE 2 PHYSICAL LAYER SYSTEM PARAMETERS

6.4.3.4.1 The physical layer shall implement the system parameters as defined in Table 6-4.

6.4.3.4.1.1 *Parameter P1 (minimum transmission length).* Parameter P1 defines the minimum transmission length that a receiver shall be capable of demodulating without degradation of BER.

6.4.4 Mode 3 specific physical layer

Note.— The Mode 3 specific physical layer specification includes a description of Mode 3 management (M) burst and handoff check message (H) burst uplink, M burst downlink, voice/data (V/D) burst, and bit scrambling.

6.4.4.1 *Management (M) burst and handoff check message (H) burst uplink.* The M uplink burst (as contained in the Manual on VDL Mode 3 Technical Specifications) shall consist of three segments, the training sequence followed by the system data and the transmitter ramp down. The H uplink burst (as contained in the Manual on VDL Mode 3 Technical Specifications) shall consist of three segments, the training sequence followed by the handoff check message and the transmitter ramp down.

6.4.4.1.1 *Training sequence.* Uplink M burst and H burst training sequences shall consist of two components as follows:

a) transmitter ramp up and power stabilization; and

b) synchronization and ambiguity resolution.

6.4.4.1.1.1 *Transmitter ramp-up and power stabilization.* This shall be as defined in Section 6.4.3.1.1.1.

6.4.4.1.1.2 *Synchronization and ambiguity resolution.* The second component of the training sequence shall consist of the synchronization sequence, known as S_2*, as follows:

000 001 101 100 110 010 111 100 010 011 101 000
111 000 011 001

and shall be transmitted from left to right.

Note.— The sequence S_2 is very closely related to the sequence S_2 (Section 6.4.4.3.1.2). The 15 phase changes between the 16 symbols of S_2* are each exactly 180° out of phase from the 15 phase changes associated with S_2. This relationship can be used to simplify the process of simultaneously searching for both sequences.*

6.4.4.1.2 *System data and handoff check message.* The non-3T configuration (as contained in the Manual on VDL Mode 3 Technical Specifications) system data shall consist of 32 transmitted symbols. The 96 transmitted bits shall include 48 bits of information and 48 parity bits, generated as 4 Golay (24, 12) code words. The 3T configuration as contained in the Manual on VDL Mode 3 Technical Specifications shall consist of 128 transmitted symbols. The 384 transmitted bits shall include 192 bits of information and 192 parity bits, generated as 16 Golay (24, 12) code words. The 3T configuration handoff check message shall consist of 40 transmitted symbols. The 120 transmitted bits shall include 60 bits of information and 60 parity bits, generated as 5 Golay (24,12) code words.

The specific definition of the Golay encoder shall be as follows:

If the 12 bit input bit sequence is written as a row vector **x**, then the 24 bit output sequence can be written as the row vector **y**, where **y** = **x G**, and the matrix **G** shall be given by

$$\mathbf{G} = \begin{matrix}
1&1&0&1&0&1&1&1&0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0\\
0&1&1&1&1&1&0&0&1&0&0&1&0&1&0&0&0&0&0&0&0&0&0&0\\
1&1&1&0&1&0&0&1&0&1&0&1&0&0&1&0&0&0&0&0&0&0&0&0\\
0&1&1&0&0&0&1&1&1&0&1&1&0&0&0&1&0&0&0&0&0&0&0&0\\
1&1&1&0&0&1&1&0&1&1&0&0&0&0&0&0&1&0&0&0&0&0&0&0\\
1&0&1&1&0&0&1&1&0&1&1&0&0&0&0&0&0&1&0&0&0&0&0&0\\
1&0&0&1&1&0&0&1&1&0&1&1&0&0&0&0&0&0&1&0&0&0&0&0\\
0&1&0&1&1&0&1&1&1&1&0&0&0&0&0&0&0&0&0&1&0&0&0&0\\
0&0&1&0&1&1&0&1&1&1&1&0&0&0&0&0&0&0&0&0&1&0&0&0\\
0&0&0&1&0&1&1&0&1&1&1&1&0&0&0&0&0&0&0&0&0&1&0&0\\
1&1&0&1&1&1&0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0&1&0\\
1&0&1&0&1&1&1&0&0&0&1&1&0&0&0&0&0&0&0&0&0&0&0&1
\end{matrix}$$

Note.— The extended Golay code allows for the correction of any error pattern with 3 or fewer bit errors and the detection of any 4-bit error pattern.

6.4.4.1.3 *Transmitter ramp-down.* The transmitter power shall be –20 dBc within 2.5 symbol periods of the middle of the final symbol of the burst. The transmitter power leakage when the transmitter is in the "off" state shall be less than –83 dBm.

Note.— Reference RTCA/DO-160D section 21, category H for antenna radiated signals.

6.4.4.2 *Management (M) burst downlink.* The M downlink burst (as contained in the Manual on VDL Mode 3 Technical Specifications) shall consist of three segments, the training sequence followed by the system data and the transmitter ramp down.

6.4.4.2.1 *Training sequence.* The M downlink burst training sequence shall consist of two components as follows:

a) transmitter ramp up and power stabilization; and

b) synchronization and ambiguity resolution.

6.4.4.2.1.1 *Transmitter ramp-up and power stabilization.* This shall be as defined in Section 6.4.4.1.1.1.

6.4.4.2.1.2 *Synchronization and ambiguity resolution.* Three separate synchronization sequences shall be used for this burst type. The standard sequence, known as S_1, shall be as follows:

000 111 001 001 010 110 000 011 100 110 011 111
010 101 100 101

and shall be transmitted from left to right. The special sequence used to identify poll responses shall be as defined in Section 6.4.4.1.1.2.

The special sequence used to identify net entry requests (S_1*) shall use the following sequence:

000 001 111 111 100 000 110 101 010 000 101 001
100 011 010 011

and shall be transmitted from left to right.

Note.— The sequence S_1 is very closely related to the sequence S_1. The 15 phase changes between the 16 symbols of S_1* are each exactly 180° out of phase from the 15 phase changes associated with S_1. This relationship can be used to simplify the process of simultaneously searching for both sequences.*

6.4.4.2.2 *System data.* The system data segment shall consist of 16 transmitted symbols. The 48 transmitted bits shall be encoded as 24 bits of system data and 24 bits of parity bits generated as two consecutive (24, 12) Golay code words. The encoding of the (24, 12) Golay code words should be as defined in Section 6.4.4.1.2.

6.4.4.2.3 *Transmitter ramp-down.* This shall be as defined in Section 6.4.4.1.3.

6.4.4.3 *Voice or data (V/D) burst.* The V/D burst (as contained in the Manual on VDL Mode 3 Technical Specifications) shall consist of four segments: the training sequence followed by the header, the user information segment and the transmitter ramp down. The same V/D burst format shall be used for both uplink and downlink.

6.4.4.3.1 *Training sequence.* V/D burst training sequence shall consist of two components as follows:

a) transmitter ramp-up and power stabilization; and

b) synchronization and ambiguity resolution.

6.4.4.3.1.1 *Transmitter ramp-up and power stabilization.* This shall be as specified in Section 6.4.4.1.1.1.

6.4.4.3.1.2 *Synchronization and ambiguity resolution.* The second component of the training sequence shall consist of the synchronization sequence, known as S_2, as follows:

000 111 011 010 000 100 001 010 100 101 011 110
001 110 101 111

and shall be transmitted from left to right.

6.4.4.3.2 *Header.* The header segment shall consist of 8 transmitted symbols. The 24 transmitted bits shall be encoded as 12 bits of header information and 12 parity bits, generated as a single (24, 12) Golay code word. The encoding of the (24, 12) Golay code word shall be as defined in Section 6.4.4.1.2.

6.4.4.3.3 *User information.* The user information segment shall consist of 192 3-bit symbols. When transmitting voice, FEC shall be applied to the analysis output of the vocoder specified in Section 6.8. The vocoder shall provide satisfactory performance in a BER environment of 10^{-3} (with a design goal of 10^{-2}). The overall bit rate of the vocoder *including FEC* is 4 800 bits/s (except when in the truncated mode in which the bit rate is 4 000 bits/s).

6.4.4.3.3.1 When transmitting user data, the 576 bits shall be encoded as a single Reed-Solomon (72, 62) 2^8–ary code word. For user data input to the Reed-Solomon encoder of length less than 496 bits, input data shall be padded with zeroes at the end to a full length of 496 bits. The field defining the primitive polynomial of the code shall be as described in Section 6.4.3.1.2.1. The generator polynomial shall be as follows:

$$\prod_{i=120}^{129} (x - \alpha^i)$$

Note.— The Reed-Solomon (72, 62) code is capable of correcting up to five 2^8-ary (code word) symbol errors in the received word.

6.4.4.3.4 *Transmitter ramp-down.* This shall be as defined in Section 6.4.4.1.3.

6.4.4.4 *Interleaving.* There shall be no interleaving in Mode 3 operation.

6.4.4.5 *Bit scrambling.* Under Mode 3 operation, bit scrambling, as specified in Section 6.4.3.1.4 shall be performed on each burst, starting after the training sequence. The scrambling sequence shall be reinitialized on each burst effectively providing a constant overlay for each of the Mode 3 fixed length bursts.

6.4.4.6 *Receiver/transmitter interaction.* The switching times in this subsection will be defined as the time between the middle of the last information symbol of one burst and the middle of the first symbol of the synchronization sequence of the subsequent burst.

Note.— This nominal time will be shortened by considerations such as the finite width of each symbol due to Nyquist filtering and the ramp up and power stabilization sequence. Such alternative definitions could yield switching times up to 8 symbol periods shorter.

6.4.4.6.1 *Receiver to transmitter switching time.* An aircraft radio shall be capable of switching from reception to transmission within 17 symbol periods. This time can be relaxed to 33 symbol periods for aircraft radios which do not implement functions requiring discrete addressing.

Note 1.— The shortest R/T switching time for an aircraft radio occurs when the reception of an uplink M channel beacon is followed by a V/D transmission in the same slot. In certain instances where aircraft radios do not implement functions requiring discrete addressing, the R/T switching time can be increased since the last two Golay words of the uplink M channel beacon need not be read.

Note 2.— The minimum turnaround time assumes that in configurations 3V1D, 2V1D, and 3T (as contained in Section 5.5.2.4 of the Manual on VDL Mode 3 Technical Specifications), the aircraft radios will be provided with software that will prevent them from transmitting a downlink M channel message in a slot following the reception of a voice message from another aircraft with a long time delay.

6.4.4.6.2 *Transmitter to receiver switching time.* An aircraft radio shall be capable of switching from transmission to reception within 32 symbol periods.

Note.— The worst case T/R switching time for an aircraft radio occurs when it transmits a downlink M channel message and receives a V/D message in the same slot.

6.4.4.7 *Fringe coverage indication.*

6.4.4.7.1 **Recommendation.**— *Indication of near edge-of-coverage should be provided to the VDL Mode 3 aircraft.*

6.5 LINK LAYER PROTOCOLS AND SERVICES

6.5.1 General information

6.5.1.1 *Functionality.* The VDL link layer shall provide the following sublayer functions:

a) media access control (MAC) sublayer, which requires the use of the carrier sense multiple access (CSMA) algorithm for Mode 2 or TDMA for Mode 3;

b) a data link service (DLS) sublayer:

   1) for Mode 2, the DLS sublayer provides connection-oriented point-to-point links using data link entities (DLE) and connectionless broadcast link over the MAC sublayer; and

   2) for Mode 3, the DLS sublayer provides acknowledged connectionless point-to-point and point-to-multipoint links over a MAC sublayer that guarantees sequencing; and

c) a VDL management entity (VME), which establishes and maintains DLEs between the aircraft and the ground-based systems using link management entities (LME).

6.5.1.2 SERVICE

6.5.1.2.1 *Connection-oriented.* The VDL Mode 2 link layer shall provide a reliable point-to-point service using a connection-oriented DLS sublayer.

6.5.1.2.2 *Connectionless.* The VDL Mode 2 and 3 link layers shall provide an unacknowledged broadcast service using a connectionless DLS sublayer.

6.5.1.2.3 *Acknowledged connectionless.* The VDL Mode 3 link layer shall provide an acknowledged point-to-point service using a connectionless DLS sublayer that relies upon the MAC sublayer to guarantee sequencing.

6.5.2 MAC sublayer

6.5.2.1 The MAC sublayer shall provide for the transparent acquisition of the shared communications path. It makes invisible to the DLS sublayer the way in which supporting communications resources are utilized to achieve this.

Note.— Specific MAC services and procedures for VDL Modes 2 and 3 are contained in the Manuals on VDL Mode 2 and VDL Mode 3 Technical Specifications.

6.5.3 Data link service sublayer

6.5.3.1 For Mode 2, the DLS shall support bit-oriented simplex air-ground communications using the aviation VHF link control (AVLC) protocol.

Note.— Specific data link services, parameters and protocol definitions for VDL Mode 2 are contained in the Manual on VDL Mode 2 Technical Specifications.

6.5.3.2 For Mode 3, the DLS shall support bit-oriented, priority based, simplex air-ground communications using the acknowledged connectionless data link (A-CLDL) protocol.

Note.— Specific data link services, parameter and protocol definitions for VDL Mode 3 are contained in the Manual on VDL Mode 3 Technical Specifications.

6.5.4 VDL management entity

6.5.4.1 *Services.* The VME shall provide link establishment, maintenance and disconnection services as well as support parameter modification. Specific VME services, parameter formats and procedures for Modes 2 and 3 are contained in the Manuals on VDL Mode 2 and Mode 3 Technical Specifications.

6.6 SUBNETWORK LAYER PROTOCOLS AND SERVICES

6.6.1 Architecture for Mode 2

6.6.1.1 The subnetwork layer protocol used across the VHF air-ground subnetwork for VDL Mode 2 is referred to formally as a subnetwork access protocol (SNAcP) and shall conform to ISO 8208, except as contained in the Manual on VDL Mode 2 Technical Specifications. The SNAcP is contained within the Manual on VDL Mode 2 Technical Specifications as the subnetwork protocol. If there are any differences between the Manual on VDL Mode 2 Technical Specifications and the cited specifications, the Manual on VDL Mode 2 Technical Specifications shall have precedence. On the air-ground interface, the aircraft subnetwork entity shall act as a DTE and the ground subnetwork entity shall act as a DCE.

Note.— Specific subnetwork layer protocol access points, services, packet formats, parameters and procedures for VDL Mode 2 are contained in the Manual on VDL Mode 2 Technical Specifications.

6.6.2 Architecture for Mode 3

6.6.2.1 The subnetwork layer used across the VHF air-ground subnetwork for VDL Mode 3 provides the flexibility to simultaneously support multiple subnetwork protocols. The currently defined options are to support ISO 8473 connectionless network protocol and to support ISO 8208, both as contained in the Manual on VDL Mode 3 Technical Specifications. The Manual on VDL Mode 3 Technical Specifications shall have precedence with respect to any differences with the cited specifications. For the ISO 8208 interface, both the air and ground subnetwork entities shall act as DCEs.

Note.— Specific subnetwork layer protocol access points, services, packet formats, parameters and procedures for VDL Mode 3 are contained in the Manual on VDL Mode 3 Technical Specifications.

6.7 THE VDL MOBILE SUBNETWORK DEPENDENT CONVERGENCE FUNCTION (SNDCF)

6.7.1 VDL Mode 2 SNDCF

6.7.1.1 *Introduction.* The VDL Mode 2 mobile SNDCF shall be the standard mobile SNDCF.

6.7.1.2 *New function.* The VDL Mode 2 mobile SNDCF shall support maintaining context (e.g. compression tables) across subnetwork calls. The SNDCF shall use the same context (e.g. compression tables) across all SVCs negotiated to a DTE, when negotiated with the same parameters. The SNDCF shall support at least 2 SVCs sharing a context.

Note 1.— Because handoffs can be expected to reorder packets, certain compression algorithms do not lend themselves to use over VDL Mode 2. Further, implementors of dictionary-based compression algorithms must be sensitive to the problem of updates arriving on either the old or newly established call.

Note 2.— The encoding of the Call User Data field is described in Doc 9705 except with modifications as contained in the Manual on VDL Mode 2 Technical Specifications.

6.7.2 VDL Mode 3 SNDCF

6.7.2.1 The VDL Mode 3 shall support one or more of the defined SNDCFs. The first is the standard ISO 8208 SNDCF as defined in Doc 9705. This is a connection-oriented SNDCF. The second type of SNDCF supported by VDL Mode 3 is denoted frame-based SNDCF. The details of this connection-less oriented SNDCF are contained in the Manual on VDL Mode 3 Technical Specifications, including network layer interface, support for broadcast and unicast network packets, and ATN router support.

Note.— The framed-based SNDCF is termed such because it uses the VDL Mode 3 frames without the need for an additional protocol (viz. ISO 8208 SNDCF) to transfer network packets. The frame-based SNDCF achieves independence from the network protocol by identifying the payload of each frame. Upon receipt of a frame, the payload is examined and control is passed to the protocol identified.

6.8 VOICE UNIT FOR MODE 3

6.8.1 Services

6.8.1.1 The voice unit shall provide for a simplex, "push-to-talk" audio and signalling interface between the user and the VDL. Two separate mutually exclusive voice circuit types shall be supported:

a) Dedicated circuits: This shall provide service to a specific user group on an exclusive basis with no sharing of the circuit with other users outside the group. Access shall be based on a "listen-before-push-to-talk" discipline.

b) Demand assigned circuits: This shall provide voice circuit access which is arbitrated by the ground station in response to an access request received from the aircraft station. This type of operation shall allow dynamic sharing of the channel resource increasing trunking efficiency.

6.8.1.2 *Priority access*. The voice unit operation shall support a priority override access for authorized ground users.

6.8.1.3 *Message source identification*. The voice unit operation shall support notification to the user of the source of a received message (i.e. whether the message originated from an air or ground station).

6.8.1.4 *Coded squelch*. The voice unit shall support a coded squelch operation that offers some degree of rejection of undesired co-channel voice messages based on the burst time of arrival.

6.8.2 Speech encoding, parameters and procedures

6.8.2.1 The VDL Mode 3 shall use the advanced multiband excitation (AMBE) 4.8 kbits/s encoding/decoding algorithm, version number AMBE-ATC-10, developed by Digital Voice Systems, Incorporated (DVSI) for voice communications.

Note 1.— Information on technical characteristics of the 4.8 kbits/s AMBE algorithm is contained in AMBE-ATC-10 Low Level Description, obtainable from DVSI.

Note 2.— The 4.8 kbits/s AMBE encoding/decoding technology described in the document is subject to DVSI patent rights and copyrights. Manufacturers must enter into a license agreement with DVSI prior to obtaining a detailed description of the algorithm before incorporation in equipment operating in the VDL Mode 3 service. By letter to ICAO dated 29 October 1999, DVSI confirmed its commitment to license the technology for the manufacture and sale of aeronautical equipment under reasonable terms and conditions, negotiated on a non-discriminatory basis.

6.8.2.2 Speech encoding definition, voice unit parameters, and procedure descriptions for VDL Mode 3 Voice Unit operation are contained in the Manual on VDL Mode 3 Technical Specifications.

6.9 VDL MODE 4

6.9.1 A Mode 4 station shall conform to the requirements defined in sections 6.1.2.3, 6.1.4.2, 6.2.1.1, 6.2.3.1, 6.2.4, 6.3.1, 6.3.3.1, 6.3.4, 6.3.5.1, 6.3.5.2, 6.3.5.3, 6.3.5.4.1 and 6.9.

6.9.2 VDL Mode 4 radio channels

6.9.2.1 VDL MODE 4 STATION FREQUENCY RANGE

6.9.2.1.1 *Transmitter/receiver tuning range*. A VDL Mode 4 transmitter/receiver shall be capable of tuning to any of the 25 kHz channels from 117.975 MHz through 137 MHz. The transmitter shall have a means for the tuning range to be restricted to a narrower range.

Note.— Operational conditions or certain applications may require the equipment to be operated in a narrower frequency range.

6.9.2.1.2 **Recommendation.—** *A VDL Mode 4 transmitter/receiver should be capable of tuning to any of the 25 kHz channels from 108 to 117.975 MHz.*

Note.— The band 108–117.975 MHz may be utilized in accordance with the relevant provisions of the ITU Radio Regulations.

6.9.2.1.3 *Simultaneous reception.* A VDL Mode 4 station shall be capable of receiving two channels simultaneously.

6.9.2.1.4 **Recommendation.—** *A VDL Mode 4 station should be capable of receiving additional channels simultaneously as required by operational services.*

6.9.2.2 GLOBAL SIGNALLING CHANNELS

6.9.2.2.1 VDL Mode 4 stations shall use two assigned frequencies as global signalling channels (GSC), to support user communications and link management functions.

Note.— Additional channels may be defined in a local domain and notified to mobile users by broadcast from ground stations on the GSCs defined above.

6.9.3 System capabilities

6.9.3.1 *ATN compatibility.* The VDL Mode 4 system shall support ATN-compliant subnetwork services for surveillance applications.

6.9.3.2 *Data transparency.* The VDL Mode 4 system shall provide code-independent, byte-independent transfer of data.

6.9.3.3 *Broadcast.* The VDL Mode 4 system shall provide link layer broadcast services.

6.9.3.4 *Point-to-point.* The VDL Mode 4 system shall provide link layer point-to-point services.

6.9.3.5 *Air-air communications.* The VDL Mode 4 system shall provide air-air communications, without ground support, as well as air-ground communications.

6.9.3.6 *Connection management.* When supporting air-ground operations, the VDL Mode 4 system shall establish and maintain a reliable communications path between the aircraft and the ground system while allowing, but not requiring, manual intervention.

6.9.3.7 *Ground network transition.* A mobile VDL Mode 4 DLS station shall transition from one ground VDL Mode 4 DLS station to another as required.

6.9.3.8 *Derived time capability.* VDL Mode 4 shall provide the capability for deriving time from time-of-arrival measurements of received VDL Mode 4 transmissions whenever externally derived estimates of time are unavailable.

6.9.3.9 *Simplex operations.* Mobile and ground VDL Mode 4 stations shall access the physical medium operating in simplex mode.

6.9.4 Coordination of channel utilization

6.9.4.1 On a regional basis, transmissions shall be scheduled relative to UTC, to ensure efficient use of shared channels and to avoid unintentional slot re-use.

6.9.5 Physical layer protocols and services

Note.— Unless otherwise stated, the requirements defined in this section apply to both mobile and ground stations.

6.9.5.1 FUNCTIONS

6.9.5.1.1 TRANSMITTED POWER

6.9.5.1.1.1 *Airborne installation.* The effective radiated power shall be such as to provide a field strength of at least 35 microvolts per metre (minus 114.5 dBW/m^2) on the basis of free space propagation, at ranges and altitudes appropriate to the conditions pertaining to the areas over which the aircraft is operated.

6.9.5.1.1.2 *Ground installation.*

Recommendation.— *The effective radiated power should be such as to provide a field strength of at least 75 microvolts per metre (minus 109 dBW/m^2) within the defined operational coverage of the facility, on the basis of free-space propagation.*

6.9.5.1.2 TRANSMITTER AND RECEIVER FREQUENCY CONTROL

6.9.5.1.2.1 The VDL Mode 4 physical layer shall set the transmitter or receiver frequency as commanded by the link management entity (LME). Channel selection time shall be less than 13 ms after the receipt of a command from a VSS user.

6.9.5.1.3 DATA RECEPTION BY RECEIVER

6.9.5.1.3.1 The receiver shall decode input signals and forward them to the higher layers for processing.

6.9.5.1.4 DATA TRANSMISSION BY TRANSMITTER

6.9.5.1.4.1 *Data encoding and transmission.* The physical layer shall encode the data received from the data link layer and transmit it over the RF channel. RF transmission shall take place only when permitted by the MAC.

6.9.5.1.4.2 *Order of transmission.* The transmission shall consist of the following stages in the following order:

a) transmitter power stabilization;

b) bit synchronization;

c) ambiguity resolution and data transmission; and

d) transmitter decay.

Note.— The definitions of the stages are given in Sections 6.9.5.2.3.1 to 6.9.5.2.3.4.

6.9.5.1.4.3 *Automatic transmitter shutdown.* A VDL Mode 4 station shall automatically shut-down power to any final stage amplifier in the event that output power from that amplifier exceeds –30 dBm for more than 1 second. Reset to an operational mode for the affected amplifier shall require a manual operation.

Note.— This is intended to protect the shared channel resource against so-called "stuck transmitters".

6.9.5.1.5 NOTIFICATION SERVICES

6.9.5.1.5.1 *Signal quality.* The operational parameters of the equipment shall be monitored at the physical layer. Signal quality analysis shall be performed in the demodulator process and in the receive process.

Note.— Processes that may be evaluated in the demodulator include bit error rate (BER), signal to noise ratio (SNR), and timing jitter. Processes that may be evaluated in the receiver include received signal level and group delay.

6.9.5.1.5.2 *Arrival time.* The arrival time of each received transmission shall be measured with a two-sigma error of 5 microseconds.

6.9.5.1.5.3 **Recommendation.—** *The receiver should be capable of measuring the arrival time within a two-sigma error of 1 microsecond.*

6.9.5.2 PROTOCOL DEFINITION FOR GFSK

6.9.5.2.1 *Modulation scheme.* The modulation scheme shall be GFSK. The first bit transmitted (in the training sequence) shall be a high tone and the transmitted tone shall be toggled before transmitting a 0 (i.e. non-return to zero inverted encoding).

6.9.5.2.2 *Modulation rate.* Binary ones and binary zeros shall be generated with a modulation index of 0.25 ± 0.03 and a BT product of 0.28 ± 0.03, producing data transmission at a bit rate of 19 200 bits/s ± 50 ppm.

6.9.5.2.3 STAGES OF TRANSMISSION

6.9.5.2.3.1 *Transmitter power stabilization.* The first segment of the training sequence is the transmitter power stabilization, which shall have a duration of 16 symbol periods. The transmitter power level shall be no less than 90 per cent of the steady state power level at the end of the transmitter power stabilization segment.

6.9.5.2.3.2 *Bit synchronization.* The second segment of the training sequence shall be the 24-bit binary sequence 0101 0101 0101 0101 0101 0101, transmitted from left to right immediately before the start of the data segment.

6.9.5.2.3.3 *Ambiguity resolution and data transmission.* The transmission of the first bit of data shall start 40 bit intervals (approximately 2083.3 microseconds) ± 1 microsecond after the nominal start of transmission.

Note 1.— This is referenced to emissions at the output of the antenna.

Note 2.— Ambiguity resolution is performed by the link layer.

6.9.5.2.3.4 *Transmitter decay.* The transmitted power level shall decay at least by 20 dB within 300 microseconds after completing a transmission. The transmitter power level shall be less than -90 dBm within 832 microseconds after completing a transmission.

6.9.5.3 CHANNEL SENSING

6.9.5.3.1 *Estimation of noise floor.* A VDL Mode 4 station shall estimate the noise floor based on power measurements of the channel whenever a valid training sequence has not been detected.

6.9.5.3.2 The algorithm used to estimate the noise floor shall be such that the estimated noise floor shall be lower than the maximum power value measured on the channel over the last minute when the channel is regarded as idle.

Note.— The VDL Mode 4 receiver uses an energy sensing algorithm as one of the means to determine the state of the channel (idle or busy). One algorithm that can be used to estimate the noise floor is described in the Manual on VDL Mode 4 Technical Specifications.

6.9.5.3.3 *Channel idle to busy detection.* A VDL Mode 4 station shall employ the following means to determine the channel idle to busy transition at the physical layer.

6.9.5.3.3.1 *Detection of a training sequence.* The channel shall be declared busy if a VDL Mode 4 station detects a valid training sequence followed by a frame flag.

6.9.5.3.3.2 *Measurement of channel power.* Regardless of the ability of the demodulator to detect a valid training sequence, a VDL Mode 4 station shall consider the channel busy with at least a 95 per cent probability within 1 ms after on-channel power rises to the equivalent of at least four times the estimated noise floor for at least 0.5 milliseconds.

6.9.5.3.4 *Channel busy to idle detection*

6.9.5.3.4.1 A VDL Mode 4 station shall employ the following means to determine the channel busy to idle transition.

6.9.5.3.4.2 *Measurement of transmission length.* When the training sequence has been detected, the channel busy state shall be held for a period of time at least equal to 5 milliseconds, and subsequently allowed to transition to the idle state based on measurement of channel power.

6.9.5.3.4.3 *Measurement of channel power.* When not otherwise held in the channel busy state, a VDL Mode 4 station shall consider the channel idle with at least a 95 per cent probability if on-channel power falls below the equivalent of twice the estimated noise floor for at least 0.9 milliseconds.

6.9.5.4 RECEIVER/TRANSMITTER INTERACTION

6.9.5.4.1 *Receiver to transmitter turnaround time.* A VDL Mode 4 station shall be capable of beginning the transmission of the transmitter power stabilization sequence within 16 microseconds after terminating the receiver function.

6.9.5.4.2 *Frequency change during transmission.* The phase acceleration of the carrier from the start of the synchronization sequence to the data end flag shall be less than 300 Hz per second.

6.9.5.4.3 *Transmitter to receiver turnaround time.* A VDL Mode 4 station shall be capable of receiving and demodulating with nominal performance an incoming signal within 1 ms after completing a transmission.

Note.— Nominal performance is defined as a bit error rate (BER) of 10^{-4}.

6.9.5.5 PHYSICAL LAYER SYSTEM PARAMETERS

6.9.5.5.1 *Parameter P1 (minimum transmission length)*

6.9.5.5.1.1 A receiver shall be capable of demodulating a transmission of minimum length P1 without degradation of BER.

6.9.5.5.1.2 The value of P1 shall be 19 200 bits.

6.9.5.5.2 *Parameter P2 (nominal co-channel interference performance)*

6.9.5.5.2.1 The parameter P2 shall be the nominal co-channel interference at which a receiver shall be capable of demodulating without degradation in BER.

6.9.5.5.2.2 The value of P2 shall be 12 dB.

6.9.5.6 FM BROADCAST INTERFERENCE IMMUNITY PERFORMANCE FOR VDL MODE 4 RECEIVING SYSTEMS

6.9.5.6.1 A VDL Mode 4 station shall conform to the requirements defined in section 6.3.5.4 when operating in the band 117.975–137 MHz.

6.9.5.6.2 A VDL Mode 4 station shall conform to the requirements defined below when operating in the band 108–117.975 MHz.

6.9.5.6.2.1 The VDL Mode 4 receiving system shall meet the requirements specified in 6.3.5.1 in the presence of two-signal, third-order intermodulation products caused by VHF FM broadcast signals having levels in accordance with the following:

$$2N_1 + N_2 + 72 \leq 0$$

for VHF FM sound broadcasting signals in the range 107.7–108.0 MHz

and

$$2N_1 + N_2 + 3\left\{24 - 20 \ \log \ \frac{\Delta f}{0.4}\right\} \leq 0$$

for VHF FM sound broadcasting signals below 107.7 MHz,

where the frequencies of the two VHF FM sound broadcasting signals produce, within the receiver, a two-signal, third-order intermodulation product on the desired VDL Mode 4 frequency.

N_1 and N_2 are the levels (dBm) of the two VHF FM sound broadcasting signals at the VDL Mode 4 receiver input. Neither level shall exceed the desensitization criteria set forth in 6.9.5.6.2.2.

$\Delta f = 108.1 - f_1$, where f_1 is the frequency of N_1, the VHF FM sound broadcasting signal closer to 108.1 MHz.

Note.— The FM intermodulation immunity requirements are not applied to a VDL Mode 4 channel operating below 108.1 MHz, and hence frequencies below 108.1 MHz are not intended for general assignments.

6.9.5.6.2.2 The VDL Mode 4 receiving system shall not be desensitized in the presence of VHF FM broadcast signals having levels in accordance with Tables 6-5 and 6-6.

6.9.6 Link layer

Note.— Details on link layer functions are contained in the Manual on VDL Mode 4 Technical Specifications.

6.9.7 Subnetwork layer and SNDCF

Note.— Details on subnetwork layer functions and SNDCF are contained in the Manual on VDL Mode 4 Technical Specifications.

6.9.8 ADS-B applications

Note.— Details on ADS-B application functions are contained in the Manual on VDL Mode 4 Technical Specifications.

TABLES FOR CHAPTER 6

Table 6-1. Modes 2 and 3 data encoding

X_k	Y_k	Z_k	$\Delta\phi_k$
0	0	0	0 π / 4
0	0	1	1 π / 4
0	1	1	2 π / 4
0	1	0	3 π / 4
1	1	0	4 π / 4
1	1	1	5 π / 4
1	0	1	6 π / 4
1	0	0	7 π / 4

Table 6-2. Modes 2 and 3 modulation stability

VDL Mode	Aircraft Modulation Stability	Ground Modulation Stability
Mode 2	± 0.0050 per cent	± 0.0050 per cent
Mode 3	± 0.0005 per cent	± 0.0002 per cent

Table 6-3. Scrambler functions

Function	Data in	Data out
scrambling	clean data	scrambled data
descrambling	scrambled data	clean data

Table 6-4. Physical services system parameters

Symbol	Parameter name	Mode 2 value
P1	Minimum transmission length	131071 bits

Table 6-5. VDL Mode 4 operating on frequencies between 108.0–111.975 MHz

Frequency (MHz)	Maximum level of unwanted signal at receiver input (dBm)
88–102	+15
104	+10
106	+5
107.9	–10

Table 6-6. VDL Mode 4 operating on frequencies between 112.0–117.975 MHz

Frequency (MHz)	Maximum level of unwanted signal at receiver input (dBm)
88–104	+15
106	+10
107	+5
107.9	0

Note.— The relationship is linear between adjacent points designated by the above frequencies.

FIGURES FOR CHAPTER 6

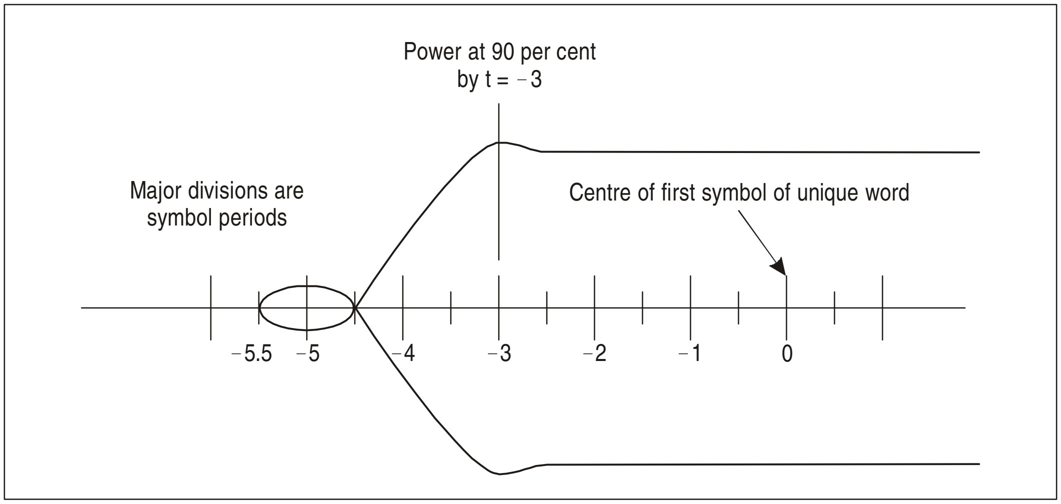

Figure 6-1. Transmitter Power Stabilization

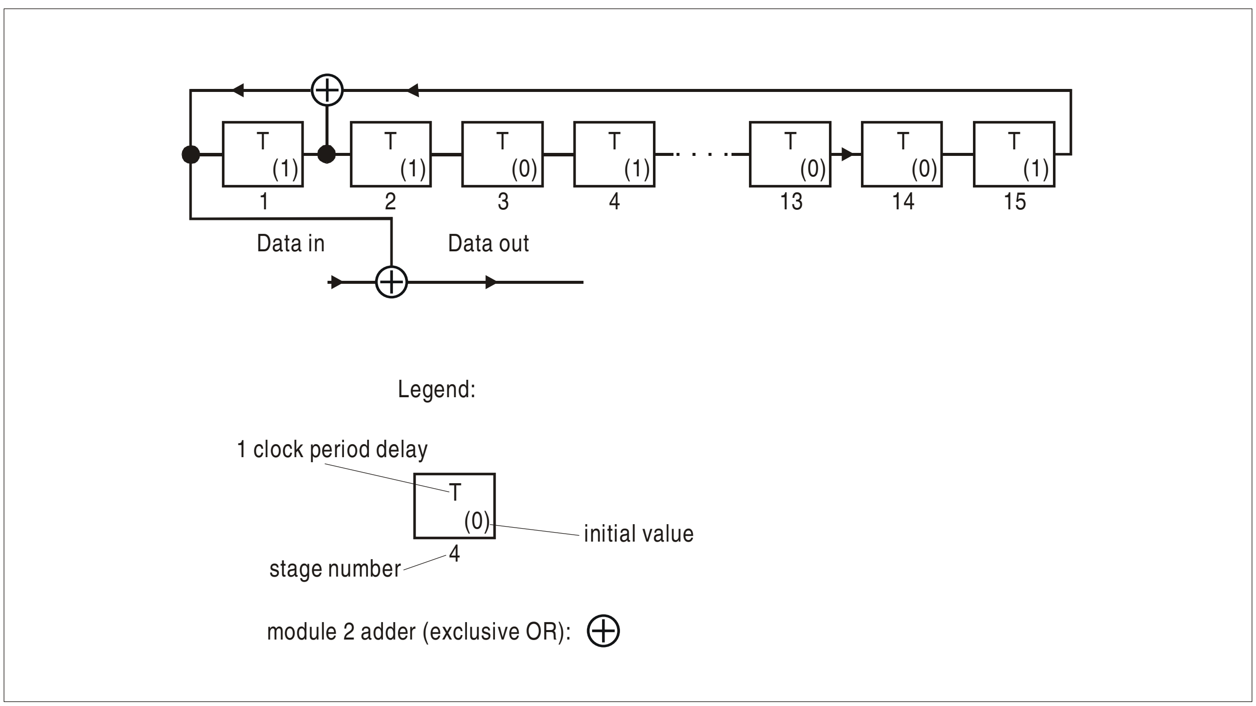

Figure 6-2. PN-generator for bit scrambling sequence

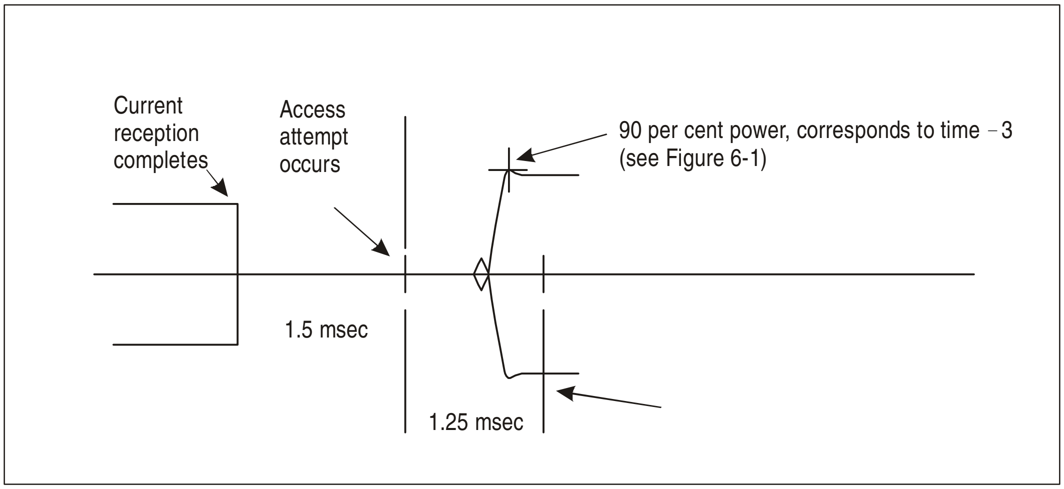

Figure 6-3. Receive to Transmit Turnaround Time

Appendix to Chapter 6

REFERENCES

1. REFERENCES

References to Standards from the International Organization for Standardization (ISO) are as specified (including date published) below. These ISO Standards shall apply to the extent specified in the SARPs.

2. NORMATIVE REFERENCES

These SARPs reference the following ISO documents:

ISO	*Title*	*Date published*
646	*Information technology — ISO 7-bit coded character set for information interchange*	12/91
3309	*HDLC Procedures — Frame Structure, Version 3*	12/93
4335	*HDLC Elements of Procedures*, Version 3	12/93
7498	*OSI Basic Reference Model, Version 1*	11/94
7809	*HDLC Procedures — Consolidation of Classes of Procedures, Version 1*	12/93
8208	*Information Processing Systems — Data Communications — X.25 Packet Level Protocol for Data Terminal Equipment*	3/90 2nd ed.
8885	*HDLC Procedures — General Purpose XID Frame Information Field Content and Format*, Version [1]	12/93
8886.3	*OSI Data Link Service Definition*, Version 3	6/92
10039	*Local Area Networks — MAC Service Definition*, Version 1	6/91

3. BACKGROUND REFERENCES

The following documents are listed as reference material.

Originator	*Title*	*Date published*
ITU-R	Recommendation S.446.4, Annex I	
CCSDS	*Telemetry Channel Coding, Recommendation for Space Data System Standards*, Consultative Committee for Space Date Systems, CCSDS 101.0-B-3, Blue Book	5/92

CHAPTER 7. SUBNETWORK INTERCONNECTION

[to be developed]

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CHAPTER 8. AFTN NETWORK

8.1 DEFINITIONS

Data signalling rate. Data signalling rate refers to the passage of information per unit of time, and is expressed in bits/second. Data signalling rate is given by the formula:

$$\sum_{i=1}^{i=m} \frac{1}{T_i} \log_2 n_i$$

where m is the number of parallel channels, T_i is the minimum interval for the ith channel expressed in seconds, n_i is the number of significant conditions of the modulation in the ith channel.

Note 1.—

a) For a single channel (serial transmission) it reduces to (1/T)$\log_2$n; *with a two-condition modulation* (n = 2), *it is* 1/T.

b) For a parallel transmission with equal minimum intervals and equal number of significant conditions on each channel, it is m(1/T)$\log_2$n (m(1/T) *in case of a two-condition modulation).*

Note 2.— In the above definition, the term "parallel channels" is interpreted to mean: channels, each of which carries an integral part of an information unit, e.g. the parallel transmission of bits forming a character. In the case of a circuit comprising a number of channels, each of which carries information "independently", with the sole purpose of increasing the traffic handling capacity, these channels are not to be regarded as parallel channels in the context of this definition.

Degree of standardized test distortion. The degree of distortion of the restitution measured during a specific period of time when the modulation is perfect and corresponds to a specific text.

Effective margin. That margin of an individual apparatus which could be measured under actual operating conditions.

Low modulation rates. Modulation rates up to and including 300 bauds.

Margin. The maximum degree of distortion of the circuit at the end of which the apparatus is situated which is compatible with the correct translation of all the signals which it may possibly receive.

Medium modulation rates. Modulation rates above 300 and up to and including 3 000 bauds.

Modulation rate. The reciprocal of the unit interval measured in seconds. This rate is expressed in bauds.

Note.— Telegraph signals are characterized by intervals of time of duration equal to or longer than the shortest or unit interval. The modulation rate (formerly telegraph speed) is therefore expressed as the inverse of the value of this unit interval. If, for example, the unit interval is 20 milliseconds, the modulation rate is 50 bauds.

Synchronous operation. Operation in which the time interval between code units is a constant.

8.2 TECHNICAL PROVISIONS RELATING TO TELETYPEWRITER APPARATUS AND CIRCUITS USED IN THE AFTN

8.2.1 In international teletypewriter circuits of the AFTN, using a 5-unit code, the International Telegraph Alphabet No. 2 (see Table 8-1) shall be used only to the extent prescribed in 4.1.2 of Volume II.

8.2.2 **Recommendation.—** *The modulation rate should be determined by bilateral or multilateral agreement between administrations concerned, taking into account primarily traffic volume.*

8.2.3 **Recommendation.—** *The nominal duration of the transmitting cycle should be at least 7.4 units (preferably 7.5), the stop element lasting for at least 1.4 units (preferably 1.5).*

8.2.3.1 **Recommendation.—** *The receiver should be able to translate correctly in service the signals coming from a transmitter with a nominal transmitting cycle of 7 units.*

8.2.4 **Recommendation.—** *Apparatus in service should be maintained and adjusted in such a manner that its net effective margin is never less than 35 per cent.*

8.2.5 **Recommendation.—** *The number of characters which the textual line of the page-printing apparatus may contain should be fixed at 69.*

Table 8-1. International Telegraph Alphabets No. 2 and No. 3

Number of signal	*Letter case*	*Figure case*	*Impulses 5-unit code*		
			Start	*12345*	*Stop*
				International Code No. 2	
1	A	—	A	ZZAAA	Z
2	B	?	A	ZAAZZ	Z
3	C	:	A	AZZZA	Z
4	D	Note 1	A	ZAAZA	Z
5	E	3	A	ZAAAA	Z
6	F		A	ZAZZA	Z
7	G		A	AZAZZ	Z
8	H		A	AAZAZ	Z
9	I	8	A	AZZAA	Z
10	J	Attention signal	A	ZZAZA	Z
11	K	(	A	ZZZZA	Z
12	L	)	A	AZAAZ	Z
13	M	.	A	AAZZZ	Z
14	N	,	A	AAZZA	Z
15	O	9	A	AAAZZ	Z
16	P	0	A	AZZAZ	Z
17	Q	1	A	ZZZAZ	Z
18	R	4	A	AZAZA	Z
19	S	'	A	ZAZAA	Z
20	T	5	A	AAAAZ	Z
21	U	7	A	ZZZAA	Z
22	V	=	A	AZZZZ	Z
23	W	2	A	ZZAAZ	Z
24	X	/	A	ZAZZZ	Z
25	Y	6	A	ZAZAZ	Z
26	Z	+	A	ZAAAZ	Z
27	carriage return		A	AAAZA	Z
28	line feed		A	AZAAA	Z
29	letters		A	ZZZZZ	Z
30	figures		A	ZZAZZ	Z
31	space		A	AAZAA	Z
32	unperforated tape		A	AAAAA	Z
33	signal repetition				
34	signal α				
35	signal β				

Sign	*Closed circuit*	*Double current*
A	No current	Negative current
Z	Positive current	Positive current

Note 1. Used for answer-back facility.

8.2.6 **Recommendation.—** *In start-stop apparatus fitted with automatic time delay switches, the disconnection of the power supply to the motor should not take place before the lapse of at least 45 seconds after the reception of the last signal.*

8.2.7 **Recommendation.—** *Arrangements should be made to avoid the mutilation of signals transmitted at the head of a message and received on start-stop reperforating apparatus.*

8.2.7.1 **Recommendation.—** *If the reperforating apparatus is provided with local means for feeding the paper, not more than one mutilated signal should be tolerated.*

8.2.8 **Recommendation.—** *Complete circuits should be so engineered and maintained that their degree of standardized test distortion does not exceed 28 per cent on the standardized text:*

THE QUICK BROWN FOX JUMPS
OVER THE LAZY DOG

or

VOYEZ LE BRICK GEANT QUE
JEXAMINE PRES DU WHARF

8.2.9 **Recommendation.—** *The degree of isochronous distortion on the standardized text of each of the parts of a complete circuit should be as low as possible, and in any case should not exceed 10 per cent.*

8.2.10 **Recommendation.—** *The over-all distortion in transmitting equipment used on teletypewriter channels should not exceed 5 per cent.*

8.2.11 **Recommendation.—** *AFTN circuits should be equipped with a system of continuous check of channel condition. Additionally, controlled circuit protocols should be applied.*

8.3 TERMINAL EQUIPMENT ASSOCIATED WITH AERONAUTICAL RADIOTELETYPEWRITER CHANNELS OPERATING IN THE BAND 2.5 – 30 MHZ

8.3.1 Selection of type of modulation and code

8.3.1.1 **Recommendation.—** *Frequency shift modulation (F1B) should be employed in radioteletypewriter systems used in the aeronautical fixed service (AFS), except where the characteristics of the independent sideband (ISB) method of operation are of advantage.*

Note.— F1B type of modulation is accomplished by shifting a radio frequency carrier between two frequencies representing "position A" (start signal polarity) and "position Z" (stop signal polarity) of the start-stop 5-unit telegraphic code.

8.3.2 System characteristics

8.3.2.1 **Recommendation.—** *The characteristics of signals from radioteletypewriter transmitters utilizing F1B modulation should be as follows:*

a) Frequency shift: *the lowest possible value.*

b) Frequency shift tolerance: *within plus or minus 3 per cent of the nominal value of the frequency shift.*

c) Polarity: single channel circuits: *the higher frequency corresponds to "position A" (start signal polarity).*

8.3.2.2 **Recommendation.—** *The variation of the mean between the radio frequencies representing respectively "position A" and "position Z" should not exceed 100 Hz during any two-hour period.*

8.3.2.3 **Recommendation.—** *The over-all distortion of the teletypewriter signal, as monitored at the output of the radio transmitter or in its immediate vicinity, should not exceed 10 per cent.*

Note.— Such distortion means the displacement in time of the transitions between elements from their proper positions, expressed as a percentage of unit element time.

8.3.2.4 **Recommendation.—** *Radioteletypewriter receivers concerned with F1B modulation should be capable of operating satisfactorily on signals having the characteristics set out in 8.3.2.1 and 8.3.2.2 above.*

8.3.2.5 **Recommendation.—** *The characteristics of multichannel transmission of teletypewriter signals over a radio circuit should be established by agreement between the Administrations concerned.*

8.4 CHARACTERISTICS OF INTERREGIONAL AFS CIRCUITS

8.4.1 **Recommendation.—** *Interregional AFS circuits being implemented or upgraded should employ high quality telecommunications service. Modulation rate should take into account traffic volumes expected under both normal and alternate route conditions.*

8.5 TECHNICAL PROVISIONS RELATING TO ATS MESSAGE TRANSMISSION

8.5.1 *Interconnection by direct or omnibus channels — low modulation rates — 5-unit code.*

Note.— See 8.6 below for medium modulation rates.

8.5.1.1 **Recommendation.—** *AFTN techniques (cf. 8.2 above) should be used.*

8.6 TECHNICAL PROVISIONS RELATING TO INTERNATIONAL GROUND-GROUND DATA INTERCHANGE AT MEDIUM AND HIGHER SIGNALLING RATES

Note.— Throughout this section in the context of coded character sets, the term "unit" means the unit of selective information, and is essentially equivalent to the term "bit".

8.6.1 General

8.6.1.1 **Recommendation.—** *In international data interchange of characters, a 7-unit coded character set providing a repertoire of 128 characters and designated as International Alphabet No. 5 (IA-5) should be used. Compatibility with the 5-unit coded character set of International Telegraph Alphabet No. 2 (ITA-2) should be ensured where applicable.*

8.6.1.2 When the provisions of 8.6.1.1 above are applied, International Alphabet No. 5 (IA-5) contained in Table 8-2 shall be used.

8.6.1.2.1 The serial transmission of units comprising an individual character of IA-5 shall be with the low order unit (b_1) transmitted first.

8.6.1.2.2 **Recommendation.—** *When IA-5 is used, each character should include an additional unit for parity in the eighth level position.*

8.6.1.2.3 When the provisions of 8.6.1.2.2 above are applied, the sense of the character parity bit shall produce even parity in links which operate on the start-stop principle, and odd parity in links using end-to-end synchronous operations.

8.6.1.2.4 Character-for-character conversion shall be as listed in Tables 8-3 and 8-4 for all characters which are authorized in the AFTN format for transmission on the AFS in both IA-5 and ITA-2.

8.6.1.2.5 Characters which appear in only one code set, or which are not authorized for transmission on the AFS shall be as depicted in the code conversion tables.

8.6.2 Data transmission characteristics

8.6.2.1 **Recommendation.—** *The data signalling rate should be chosen from among the following:*

600 bits/s	*4 800 bits/s*
1 200 bits/s	*9 600 bits/s*
2 400 bits/s	

8.6.2.2 **Recommendation.—** *The type of transmission for each data signalling rate should be chosen as follows:*

Data signalling rate	Type of transmission
600 bits/s	*Synchronous or asynchronous serial transmission*
1 200 bits/s	*Synchronous or asynchronous serial transmission*
2 400 bits/s	*Synchronous serial transmission*
4 800 bits/s	*Synchronous serial transmission*
9 600 bits/s	*Synchronous serial transmission*

8.6.2.3 **Recommendation.—** *The type of modulation for each data signalling rate should be chosen as follows:*

Data signalling rate	Type of modulation
600 bits/s	*Frequency*
1 200 bits/s	*Frequency*
2 400 bits/s	*Phase*
4 800 bits/s	*Phase*
9 600 bits/s	*Phase-amplitude*

Note.— This recommendation does not necessarily apply to ground-ground extensions of air-ground links used exclusively for the transfer of air-ground data, inasmuch as such circuits may be considered as part of the air-ground link.

8.6.2.4 CHARACTER STRUCTURE ON DATA LINKS

8.6.2.4.1 Character parity shall not be used for error checking on CIDIN links. Parity appended to IA-5 coded characters per 8.6.1.2.2 above, prior to entry to the CIDIN shall be ignored. For messages exiting the CIDIN, parity shall be generated in accordance with 8.6.1.2.3 above.

Table 8-2. International Alphabet No. 5 (IA-5)
(international reference version)

				b_7	0	0	0	0	1	1	1	1
				b_6	0	0	1	1	0	0	1	1
				b_5	0	1	0	1	0	1	0	1
b_4	b_3	b_2	b_1		0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	TC_7 (DLE)	SP	0	@	P	`	p
0	0	0	1	1	TC_1 (SOH)	DC_1	!	1	A	Q	a	q
0	0	1	0	2	TC_2 (STX)	DC_2	" ④	2	B	R	b	r
0	0	1	1	3	TC_3 (ETX)	DC_3	#	3	C	S	c	s
0	1	0	0	4	TC_4 (EOT)	DC_4	¤ ②	4	D	T	d	t
0	1	0	1	5	TC_5 (ENQ)	TC_8 (NAK)	%	5	E	U	e	u
0	1	1	0	6	TC_6 (ACK)	TC_9 (SYN)	&	6	F	V	f	v
0	1	1	1	7	BEL	TC_{10} (ETB)	' ④	7	G	W	g	w
1	0	0	0	8	FE_0 (BS)	CAN	(	8	H	X	h	x
1	0	0	1	9	FE_1 (HT)	EM	)	9	I	Y	i	y
1	0	1	0	10	FE_2 ① (LF)	SUB	*	:	J	Z	j	z
1	0	1	1	11	FE_3 (VT)	ESC	+	;	K	[	k	{
1	1	0	0	12	FE_4 (FF)	IS_4 (FS)	, ④	<	L	\	l	|
1	1	0	1	13	FE_5 ① (CR)	IS_3 (GS)	–	=	M	]	m	}
1	1	1	0	14	SO	IS_2 (RS)	.	>	N	^ ④	n	‾ ③
1	1	1	1	15	SI	IS_1 (US)	/	?	O	_	o	DEL

NOTES

Note 1.— The format effectors are intended for equipment in which horizontal and vertical movements are effected separately. If equipment requires the action of CARRIAGE RETURN to be combined with a vertical movement, the format effector for that vertical movement may be used to effect the combined movement. Use of FE 2 for a combined CR and LF operation is not allowed for international transmission on AFS networks.

Note 2.— The symbol ¤ does not designate the currency of a specific country.

Note 3.— Position 7/14 is used for graphic character ‾ (OVERLINE), the graphical representation of which may vary according to national use to represent (TILDE) or another diacritical sign provided that there is no risk of confusion with another graphic character included in the table.

Note 4.— The graphic characters in position 2/2, 2/7, 2/12 and 5/14 have respectively the significance of QUOTATION MARK, APOSTROPHE, COMMA and UPWARD ARROW HEAD; however, these characters take on the significance of the diacritical signs DIAERESIS, ACUTE ACCENT, CEDILLA and CIRCUMFLEX ACCENT when they are preceded or followed by the BACKSPACE character (0/8).

Note 5.— When graphical representation of the control characters of IA-5 is required, it is permissible to use the symbols specified in International Organization for Standardization (ISO) Standard 2047-1975.

Table 8-2 (cont.)

CONTROL CHARACTERS

Abbreviation	*Meaning*	*Position in the code table*
ACK	Acknowledge	0/6
BEL	Bell	0/7
BS	Backspace	0/8
CAN	Cancel	1/8
CR	Carriage return*	0/13
DC	Device control	—
DEL	Delete	7/15
DLE	Data link escape	1/0
EM	End of medium	1/9
ENQ	Enquiry	0/5
EOT	End of transmission	0/4
ESC	Escape	1/11
ETB	End of transmission block	1/7
ETX	End of text	0/3
FE	Format effector	—
FF	Form feed	0/12
FS	File separator	1/12
GS	Group separator	1/13
HT	Horizontal tabulation	0/9
IS	Information separator	—
LF	Line feed*	0/10
NAK	Negative acknowledge	1/5
NUL	Null	0/0
RS	Record separator	1/14
SI	Shift-in	0/15
SO	Shift-out	0/14
SOH	Start of heading	0/1
SP	Space	2/0
STX	Start of text	0/2
SUB	Substitute character	1/10
SYN	Synchronous idle	1/6
TC	Transmission control	—
US	Unit separator	1/15
VT	Vertical tabulation	0/11

* See Note 1.

GRAPHIC CHARACTERS

Graphic	*Note*	*Name*	*Position in the code table*
(space)		Space (*see* 7.2)	2/0
!		Exclamation mark	2/1
"	4	Quotation mark, Diaeresis	2/2
#		Number sign	2/3
¤	2	Currency sign	2/4
%		Percent sign	2/5
&		Ampersand	2/6
'	4	Apostrophe, Acute accent	2/7
(		Left parenthesis	2/8
)		Right parenthesis	2/9
*		Asterisk	2/10
+		Plus sign	2/11
,	4	Comma, Cedilla	2/12
—		Hyphen, Minus sign	2/13
.		Full stop (period)	2/14
/		Solidus	2/15
:		Colon	3/10
;		Semi-colon	3/11
<		Less-than sign	3/12
=		Equal sign	3/13
>		Greater-than sign	3/14
?		Question mark	3/15
@		Commercial 'at'	4/0
[		Left square bracket	5/11
\		Reverse solidus	5/12
]		Right square bracket	5/13
^	4	Upward arrow head, Circumflex accent	5/14
_		Underline	5/15
`		Grave accent	6/0
{		Left curly bracket	7/11
|		Vertical line	7/12
}		Right curly bracket	7/13
‾	3	Overline, Tilde	7/14

DIACRITICAL SIGNS

In the character set, some printing symbols may be designed to permit their use for the composition of accented letters when necessary for general interchange of information. A sequence of three characters, comprising a letter, BACKSPACE and one of these symbols, is needed for this composition, and the symbol is then regarded as a diacritical sign. It should be noted that these symbols take on their diacritical significance only when they are preceded or followed by the BACKSPACE character; for example, the symbol corresponding to the code combination 2/7 (') normally has the significance of APOSTROPHE, but becomes the diacritical sign ACUTE ACCENT when it precedes or follows the BACKSPACE character.

NAMES, MEANINGS AND FONTS OF GRAPHIC CHARACTERS

At least one name is assigned to denote each of the graphic characters. These names are intended to reflect their customary meanings and are not intended to define or restrict the meanings of graphic characters. No particular style or font design is specified for the graphic characters.

UNIQUENESS OF CHARACTER ALLOCATION

A character allocated to a position in the table may not be placed elsewhere in the table.

Table 8-2 (cont.)

FUNCTIONAL CHARACTERISTICS RELATED TO CONTROL CHARACTERS

Some definitions given below are stated in general terms and more explicit definitions of use may be needed for specific implementation of the code table on recording media or on transmission channels. These more explicit definitions and the use of these characters are the subject of ISO publications.

General designations of control characters

The general designation of control characters involves a specific class name followed by a subscript number.

They are defined as follows:

TC — *Transmission control characters* — Control characters intended to control or facilitate transmission of information over telecommunication networks.

The use of the TC characters on the general telecommunication networks is the subject of ISO publications.

The transmission control characters are:
ACK, DLE, ENQ, EOT, ETB, ETX, NAK, SOH, STX and SYN.

FE — *Format effectors* — Control characters mainly intended for the control of the layout and positioning of information on printing and /or display devices. In the definitions of specific format effectors, any reference to printing devices should be interpreted as including display devices. The definitions of format effectors use the following concept:

a) a page is composed of a number of lines of characters;

b) the characters forming a line occupy a number of positions called character positions;

c) the active position is that character position in which the character about to be processed would appear if it were to be printed. The active position normally advances one character position at a time.

The format effector characters are:
BS, CR, FF, HT, LF and VT (see also Note 1 to Table 8-2).

DC — *Device control characters* — Control characters for the control of a local or remote ancillary device (or devices) connected to a data processing and/or telecommunication system. These control characters are not intended to control telecommunication systems; this should be achieved by the use of TCs.

Certain preferred uses of the individual DCs are given below under *Specific control characters*.

IS — *Information separators* — Control characters that are used to separate and qualify data logically. There are four such characters. They may be used either in hierarchical order or non-hierarchically; in the latter case their specific meanings depend on their applications.

When they are used hierarchically, the ascending order is:
US, RS, GS, FS.

In this case data normally delimited by a particular separator cannot be split by a higher order separator but will be considered as delimited by any higher order separator.

Specific control characters

Individual members of the classes of controls are sometimes referred to by their abbreviated class name and a subscript number (e.g. TC_5) and sometimes by a specific name indicative of their use (e.g. ENQ).

Different but related meanings may be associated with some of the control characters but in an interchange of data this normally requires agreement between the sender and the recipient.

ACK — *Acknowledge* — A transmission control character transmitted by a receiver as an affirmative response to the sender.

BEL — *Bell* — A control character that is used when there is a need to call for attention; it may control alarm or attention devices.

BS — *Backspace* — A format effector which moves the active position one character position backwards on the same line.

CAN — *Cancel* — A character, or the first character of a sequence, indicating that the data preceding it are in error. As a result these data are to be ignored. The specific meaning of this character must be defined for each application and/or between sender and recipient.

CR — *Carriage return* — A format effector which moves the active position to the first character position on the same line.

Device controls

DC_1 — A device control character which is primarily intended for turning on or starting an ancillary device. If it is not required for this purpose, it may be used to restore a device to the basic mode of operation (*see also* DC_2 and DC_3), or for any other device control function not provided by other DCs.

DC_2 — A device control character which is primarily intended for turning on or starting an ancillary device. If it is not required for this purpose, it may be used to set a device to a special mode of operation (in which case DC_1 is used to restore the device to the basic mode), or for any other device control function not provided by other DCs.

DC_3 — A device control character which is primarily intended for turning off or stopping an ancillary device. This function may be a secondary level stop, e.g. wait, pause, stand-by or halt (in which case DC_1 is used to restore normal operation). If it is not required for this purpose, it may be used for any other device control function not provided by other DCs.

DC_4 — A device control character which is primarily intended for turning off, stopping or interrupting an ancillary device. If it is not required for this purpose, it may be used for any other device control function not provided by other DCs.

Examples of use of the device controls

1) One switching			
		on — DC_2	off — DC_4
2) Two independent switchings			
	First one	on — DC_2	off — DC_4
	Second one	on — DC_1	off — DC_3
3) Two dependent switchings			
	General	on — DC_2	off — DC_4
	Particular	on — DC_1	off — DC_3
4) Input and output switching			
	Output	on — DC_2	off — DC_4
	Input	on — DC_1	off — DC_3

DEL — *Delete* — A character used primarily to erase or obliterate an erroneous or unwanted character in punched tape. DEL characters may also serve to accomplish media-fill or time-fill. They may be inserted into or removed from a stream of data without affecting the information content of that stream, but then the addition or removal of these characters may affect the information layout and/or the control of equipment.

Table 8-2 (cont.)

DLE — *Data link escape* — A transmission control character which will change the meaning of a limited number of contiguously following characters. It is used exclusively to provide supplementary data transmission control functions. Only graphic characters and transmission control characters can be used in DLE sequences.

EM — *End of medium* — A control character that may be used to identify the physical end of a medium, or the end of the used portion of a medium, or the end of the wanted portion of data recorded on a medium. The position of this character does not necessarily correspond to the physical end of the medium.

ENQ — *Enquiry* — A transmission control character used as a request for a response from a remote station — the response may include station identification and/or station status. When a "Who are you?" function is required on the general switched transmission network, the first use of ENQ after the connection is established shall have the meaning "Who are you?" (station identification). Subsequent use of ENQ may, or may not, include the function "Who are you?", as determined by agreement.

EOT — *End of transmission* — A transmission control character used to indicate the conclusion of the transmission of one or more texts.

ESC — *Escape* — A control character which is used to provide an additional control function. It alters the meaning of a limited number of contiguously following bit combinations which constitute the escape sequence.

Escape sequences are used to obtain additional control functions which may provide among other things graphic sets outside the standard set. Such control functions must not be used as additional transmission controls.

The use of the character ESC and of the escape sequences in conjunction with code extension techniques is the subject of an ISO Standard.

ETB — *End of transmission block* — A transmission control character used to indicate the end of a transmission block of data where data are divided into such blocks for transmission purposes.

ETX — *End of text* — A transmission control character which terminates a text.

FF — *Form feed* — A format effector which advances the active position to the same character position on a pre-determined line of the next form or page.

HT — *Horizontal tabulation* — A format effector which advances the active position to the next pre-determined character position on the same line.

Information separators

IS_1 (US) — A control character used to separate and qualify data logically; its specific meaning has to be defined for each application. If this character is used in hierarchical order as specified in the general definition of IS, it delimits a data item called a UNIT.

IS_2 (RS) — A control character used to separate and qualify data logically; its specific meaning has to be defined for each application. If this character is used in hierarchical order as specified in the general definition of IS, it delimits a data item called a RECORD.

IS_3 (GS) — A control character used to separate and qualify data logically; its specific meaning has to be defined for each application. If this character is used in hierarchical order as specified in the general definition of IS, it delimits a data item called a GROUP.

IS_4 (FS) — A control character used to separate and qualify data logically; its specific meaning has to be defined for each application. If this character is used in hierarchical order as specified in the general definition of IS, it delimits a data item called a FILE.

LF — *Line feed* — A format effector which advances the active position to the same character position of the next line.

NAK — *Negative acknowledge* — A transmission control character transmitted by a receiver as a negative response to the sender.

NUL — *Null* — A control character used to accomplish media-fill or time-fill. NUL characters may be inserted into or removed from a stream of data without affecting the information content of that stream, but then the addition or removal of these characters may affect the information layout and/or the control of equipment.

SI — *Shift-in* — A control character which is used in conjunction with SHIFT-OUT and ESCAPE to extend the graphic character set of the code. It may reinstate the standard meanings of the bit combinations which follow it. The effect of this character when using code extension techniques is described in an ISO Standard.

SO — *Shift-out* — A control character which is used in conjunction with SHIFT-IN and ESCAPE to extend the graphic character set of the code. It may alter the meaning of the bit combinations of columns 2 to 7 which follow it until a SHIFT-IN character is reached. However, the characters SPACE (2/0) and DELETE (7/15) are unaffected by SHIFT-OUT. The effect of this character when using code extension techniques is described in an ISO Standard.

SOH — *Start of heading* — A transmission control character used as the first character of a heading of an information message.

SP — *Space* — A character which advances the active position one character position on the same line. This character is also regarded as a non-printing graphic.

STX — *Start of text* — A transmission control character which precedes a text and which is used to terminate a heading.

SUB — *Substitute character* — A control character used in the place of a character that has been found to be invalid or in error. SUB is intended to be introduced by automatic means.

SYN — *Synchronous idle* — A transmission control character used by a synchronous transmission system in the absence of any other character (idle condition) to provide a signal from which synchronism may be achieved or retained between data-terminal equipment.

VT — *Vertical tabulation* — A format effector which advances the active position to the same character position on the next pre-determined line.

Table 8-3. Conversion from the International Telegraph Alphabet No. 2 (ITA-2) to the International Alphabet No. 5 (IA-5)

ITA-2 letter case of signal No.		*IA-5 column/row*		*ITA-2 figure case of signal No.*		*IA-5 column/row*	
1	A	4/1	A	1	–	2/13	–
2	B	4/2	B	2	?	3/15	?
3	C	4/3	C	3	:	3/10	:
4	D	4/4	D	4		3/15	?
5	E	4/5	E	5	3	3/3	3
6	F	4/6	F	6		3/15	?
7	G	4/7	G	7		3/15	?
8	H	4/8	H	8		3/15	?
9	I	4/9	I	9	8	3/8	8
10	J	4/10	J	10	Attention signal *(Note 3)*	0/7	Bel
11	K	4/11	K	11	(	2/8	(
12	L	4/12	L	12	)	2/9	)
13	M	4/13	M	13	.	2/14	.
14	N	4/14	N	14	,	2/12	,
15	O	4/15	O	15	9	3/9	9
16	P	5/0	P	16	0	3/0	0
17	Q	5/1	Q	17	1	3/1	1
18	R	5/2	R	18	4	3/4	4
19	S	5/3	S	19	'	2/7	'
20	T	5/4	T	20	5	3/5	5
21	U	5/5	U	21	7	3/7	7
22	V	5/6	V	22	=	3/13	=
23	W	5/7	W	23	2	3/2	2
24	X	5/8	X	24	/	2/15	/
25	Y	5/9	Y	25	6	3/6	6
26	Z	5/10	Z	26	+	2/11	+
27	CR	0/13	CR	27	CR	0/13	CR
28	LF	0/10	LF	28	LF	0/10	LF
29	LTRS	*		29	LTRS	*	
30	FIGS	*		30	FIGS	*	
31	SP	2/0	SP	31	SP	2/0	SP
32		*		32		*	

* *No conversion shall be made for these positions and the signal/character shall be removed from the data.*

Note 1.— The end-of-message signal NNNN (in letter and figure case) shall convert to ETX (0/3).

Note 2.— The start-of-message signal ZCZC (in letter and figure case) shall convert to SOH (0/1).

Note 3.— Figures case of Signal No. 10 shall only be converted upon detection of the AFTN priority alarm which shall convert to five occurrences of BEL (0/7).

Note 4.— When converting from ITA-2, a STX (0/2) character shall be inserted once at the beginning of the next line following detection of CR LF or LF CR at the end of the Origin Line.

Note 5.— The sequence of seven signal 28 (LF) shall convert to one VT (0/11) character.

Table 8-4. Conversion from the International Telegraph Alphabet No. 5 (IA-5) to the International Alphabet No. 2 (ITA-2)

Row \ Col.	0	1	2	3	4	5	6	7
0	*	*	31FL	16F	2F	16L	2F	16L
1	Note 5	*	2F	17F	1L	17L	1L	17L
2	*	*	2F	23F	2L	18L	2L	18L
3	Note 1	*	2F	5F	3L	19L	3L	19L
4	*	*	2F	18F	4L	20L	4L	20L
5	*	*	2F	20F	5L	21L	5L	21L
6	*	*	2F	25F	6L	22L	6L	22L
7	Note 2	*	19F	21F	7L	23L	7L	23L
8	*	*	11F	9F	8L	24L	8L	24L
9	*	*	12F	15F	9L	25L	9L	25L
10	28FL	*	2F	3F	10L	26L	10L	26L
11	Note 3	*	26F	2F	11L	2F	11L	2F
12	*	*	14F	2F	12L	2F	12L	2F
13	27FL	*	1F	22F	13L	2F	13L	2F
14	*	*	13F	2F	14L	2F	14L	2F
15	*	*	24F	2F	15L	2F	15L	*

* *No conversion shall be madė for these positions and the signal/character shall be removed from the data.*

Example: *To find the ITA-2 signal to which the charater 3/6 of IA-5 is to be converted, look at column 3, row 6.*

25F means figure case of signal No. 25

(L = letter case, FL = either case designation).

Note 1.— The character 0/3 (ETX) shall convert to the ITA-2 sequence signals 14L, 14L, 14L, 14L (NNNN).

Note 2.— The signal 0/7 (BEL) shall only be converted when a sequence of 5 occurrences is detected, which shall convert to the ITA-2 sequence signals 30, 10F, 10F, 10F, 10F, 10F, 29.

Note 3.— The character sequence CR CR LF VT (0/11) ETX (0/3) shall convert to the ITA-2 sequence signals 29, 27, 27, 28, 28, 28, 28, 28, 28, 28, 28, 14L, 14L, 14L, 14L.

Note 4.— To prevent redundant generation of figure and letter characters in ITA-2 when converting from IA-5, no case designation shall be assigned to ITA-2 non-printing functions (signals No. 27, 28, 29, 30, 31).

Note 5.— The character 0/1 (SOH) shall convert to the ITA-2 sequence signals 26L, 3L, 26L, 3L (ZCZC).

8.6.2.4.2 Characters of less than eight bits in length shall be padded out to eight bits in length before transmission over any octet based or bit-oriented communications network. The padding bits shall occupy the higher order end of the octet, i.e. bit 8, bit 7 as required, and shall have the binary values 0.

8.6.2.5 When exchanging data over CIDIN links using bit-oriented procedures, the entry centre address, exit centre addresses and destination addresses in the Transport and CIDIN Packet Headers shall be in the IA-5 character set contained in Table 8-2.

8.6.2.6 **Recommendation.—** *When transmitting messages in AFTN format over CIDIN links using bit-oriented procedures, the messages should be in the IA-5 character set contained in Table 8-2.*

8.6.3 Ground-ground character-oriented data link control procedures

Note.— The provisions of this section pertain to ground-ground data interchange applications using IA-5 prescribed by 8.6.1 above and which employ the ten transmission control characters (SOH, STX, ETX, EOT, ENQ, ACK, DLE, NAK, SYN, and ETB) for data link control, over synchronous or asynchronous transmission facilities.

8.6.3.1 *Descriptions.* The following descriptions shall apply to data link applications contained in this section:

a) A master station is that station which has control of the data link at a given instant.

b) A slave station is one that has been selected to receive a transmission from the master station.

c) A control station is the single station on a multipoint link that is permitted to assume master status and deliver messages to one or more individually selected (non-control) tributary stations, or it is permitted to assign temporary master status to any of the other tributary stations.

8.6.3.2 MESSAGE COMPOSITION

a) A transmission shall consist of characters from IA-5 transmitted in accordance with 8.6.1.2.2 above and shall be either an information message or a supervisory sequence.

b) An information message used for the exchange of data shall take one of the following forms:

```
1)  S            E B
    T ---TEXT--- T C
    X            X C

2)  S            E B
    T ---TEXT--- T C
    X            B C

3)  S               S            E B
    O ---HEADING--- T ---TEXT--- T C
    H               X            X C

4)  S               S            E B
    O ---HEADING--- T ---TEXT--- T C
    H               X            B C

5)  S               E B
    O ---HEADING--- T C
    H               B C
```

```
        B
Note 1.— C is a block check character (BCC).
        C
```

Note 2.— In formats 2), 4), and 5) above which end with ETB, some continuation is required.

c) A supervisory sequence shall be composed of either a single transmission control character (EOT, ENQ, ACK, or NAK) or a single transmission control (ENQ) preceded by a prefix of up to 15 non-control characters, or the character DLE used in conjunction with other graphic and control characters to provide additional communication control functions.

8.6.3.3 Three system categories are specified in terms of their respective circuit characteristics, terminal configurations, and message transfer procedures as follows:

System category A: two-way alternate, multipoint allowing either centralized or non-centralized operation and single or multiple message-oriented information transfers without replies (but with delivery verification).

System category B: two-way simultaneous, point-to-point employing message associated blocking and modulo 8 numbering of blocks and acknowledgements.

System category C: two-way alternate, multipoint allowing only centralized (computer-to-terminal) operation, single or multiple message transfers with replies.

8.6.3.3.1 In addition to the characteristics prescribed in the paragraphs that follow for both system categories A and B, other parameters that shall be accounted for in order to ensure viable, operationally reliable communications include:

a) the number of SYN characters required to establish and maintain synchronization;

Note.— Normally the transmitting station sends three contiguous SYN characters and the receiving station detects at least two before any action is taken.

b) the values of system time-outs for such functions as "idle line" and "no response" as well as the number of automatic retries that are to be attempted before manual intervention is signalled;

c) the composition of prefixes within a 15 character maximum.

Note.— By agreement between the administrations concerned, it is permissible for supervisory signals to contain a station identification prefix using characters selected from columns 4 through 7 of IA-5.

8.6.3.3.2 **Recommendation.—** *For multipoint implementations designed to permit only centralized (computer-to-terminal) operations, the provisions of 8.6.3.7 should be employed.*

8.6.3.4 BLOCK CHECK CHARACTER

8.6.3.4.1 Both system category A and B shall utilize a block check character to determine the validity of a transmission.

8.6.3.4.2 The block check character shall be composed of 7 bits plus a parity bit.

8.6.3.4.3 Each of the first 7 bits of the block check character shall be the modulo 2 binary sum of every element in the same bit 1 to bit 7 column of the successive characters of the transmitted block.

8.6.3.4.4 The longitudinal parity of each column of the block, including the block check character, shall be even.

8.6.3.4.5 The sense of the parity bit of the block check character shall be the same as for the information characters (see 8.6.1.2.3 above).

8.6.3.4.6 *SUMMATION*

8.6.3.4.6.1 The summation to obtain the block check character shall be started by the first appearance of either SOH (start of heading) or STX (start of text).

8.6.3.4.6.2 The starting character shall not be included in the summation.

8.6.3.4.6.3 If an STX character appears after the summation has been started by SOH, then the STX character shall be included in the summation as if it were a text character.

8.6.3.4.6.4 With the exception of SYN (synchronous idle), all the characters which are transmitted after the start of the block check summation shall be included in the summation, including the ETB (end of transmission/block) or ETX (end of text) control character which signals that the following character is the block check character.

8.6.3.4.7 No character, SYN or otherwise, shall be inserted between the ETB or ETX character and the block check character.

8.6.3.5 *Description of system category A.* System category A is one in which a number of stations are connected by a multipoint link and one station is permanently designated as the control station which monitors the link at all times to ensure orderly operation.

8.6.3.5.1 *LINK ESTABLISHMENT PROCEDURE*

8.6.3.5.1.1 To establish the link for transmission, the control station shall either:

a) poll one of the tributary stations to assign it master status; or

b) assume master status and select one or more tributary (slave) stations to receive a transmission.

8.6.3.5.1.2 Polling shall be accomplished by the control station sending a polling supervisory sequence consisting of a prefix identifying a single tributary station and ending in ENQ.

8.6.3.5.1.3 A tributary station detecting its assigned polling supervisory sequence shall assume master status and respond in one of two ways:

a) if the station has a message to send, it shall initiate a selection supervisory sequence as described in 8.6.3.5.1.5 below;

b) if the station has no message to send, it shall send EOT, and master status shall revert to the control station.

8.6.3.5.1.4 If the control station detects an invalid or no response resulting from a poll, it shall terminate by sending EOT prior to resuming polling or selection.

8.6.3.5.1.5 Selection shall be accomplished by the designated master station sending a selection supervisory sequence consisting of a prefix identifying a single station and ending in ENQ.

8.6.3.5.1.6 A station detecting its assigned selection supervisory sequence shall assume slave status and send one of two replies:

a) if the station is ready to receive, it shall send a prefix followed by ACK. Upon detecting this reply, the master station shall either select another station or proceed with message transfer;

b) if the station is not ready to receive, it shall send a prefix followed by NAK and thereby relinquish slave status. If the master station receives NAK, or no reply, it shall either select another or the same tributary station or terminate;

c) it shall be permissible for N retries ($N \geq 0$) to be made to select a station for which NAK, an invalid reply, or no response has been received.

8.6.3.5.1.7 If one or more stations have been selected and have properly responded with ACK, the master station shall proceed with message transfer.

8.6.3.5.2 *MESSAGE TRANSFER PROCEDURE*

8.6.3.5.2.1 The master station shall send a message or series of messages, with or without headings to the selected slave station(s).

8.6.3.5.2.2 The transmission of a message shall:

a) begin with:

— SOH if the message has a heading,
— STX if the message has no heading;

b) be continuous, ending with ETX, immediately followed by a block check character (BCC).

8.6.3.5.2.3 After transmitting one or more messages, the master station shall verify successful delivery at each selected slave station.

8.6.3.5.3 *DELIVERY VERIFICATION PROCEDURE*

8.6.3.5.3.1 The master station shall send a delivery verification supervisory sequence consisting of a prefix identifying a single slave station and ending in ENQ.

8.6.3.5.3.2 A slave station detecting its assigned delivery verification supervisory sequence shall send one of two replies:

a) if the slave station properly received all of the transmission, it shall send an optional prefix followed by ACK;

b) if the slave station did not receive all of the transmission properly, it shall send an optional prefix followed by NAK.

8.6.3.5.3.3 If the master station receives no reply or an invalid reply, it shall request a reply from the same or another slave station until all selected stations have been properly accounted for.

8.6.3.5.3.4 If the master station receives a negative reply (NAK) or, after $N \geq 0$ repeat attempts, no reply, it shall repeat that transmission to the appropriate slave stations at a later opportunity.

8.6.3.5.3.5 After all messages have been sent and delivery verified, the master station shall proceed with link termination.

8.6.3.5.4 *LINK TERMINATION PROCEDURE*

8.6.3.5.4.1 The terminate function, negating the master or slave status of all stations and returning master status to the control station, shall be accomplished by the master station transmitting EOT.

8.6.3.6 *Description of system category B.* System category B is one in which two stations are on a point-to-point, full-duplex link and each station has the capability to maintain concurrent master and slave status, i.e. master status on its transmit side and slave status on its receive side and both stations can transmit simultaneously.

8.6.3.6.1 *LINK ESTABLISHMENT PROCEDURE*

8.6.3.6.1.1 To establish the link for message transfers (from the calling to the called station), the calling station shall request the identity of the called station by sending an identification supervisory sequence consisting of a DLE character followed by a colon character, an optional prefix, and ENQ.

8.6.3.6.1.2 The called station, upon detecting ENQ, shall send one of two replies:

a) if ready to receive, it shall send a sequence consisting of a DLE followed by a colon, a prefix which includes its identity and ended by ACK0 (see 8.6.3.6.2.5 below). This establishes the link for message transfers from the calling to the called station;

b) if not ready to receive, it shall send the above sequence with the ACK0 replaced by NAK.

8.6.3.6.1.3 Establishment of the link for message transfers in the opposite direction can be initiated at any time following circuit connection in a similar manner to that described above.

8.6.3.6.2 *MESSAGE TRANSFER PROCEDURE*

8.6.3.6.2.1 System category B message transfer provides for message associated blocking with longitudinal checking and modulo 8 numbered acknowledgements.

8.6.3.6.2.2 It is permissible for a transmission block to be a complete message or a portion of a message. The sending station shall initiate the transmission with SOTB N followed by:

a) SOH if it is the beginning of a message that contains a heading;

b) STX if it is the beginning of a message that has no heading;

c) SOH if it is an intermediate block that continues a heading;

d) STX if it is an intermediate block that continues a text.

Note.— SOTB N is the two-character transmission control sequence DLE = (characters 1/0, and 3/13) followed by the block number, N, where N is one of the IA-5 characters 0, 1 ... 7 (characters 3/0, 3/1 ... 3/7).

8.6.3.6.2.3 A block which ends at an intermediate point within a message shall be ended with ETB; a block which ends at the end of a message shall be ended with ETX.

8.6.3.6.2.4 It shall be permissible for each station to initiate and continue to send messages to the other concurrently according to the following sequence.

a) It shall be permissible for the sending station (master side) to send blocks, containing messages or parts of messages, continuously to the receiving station (slave side) without waiting for a reply.

b) It shall be permissible for replies, in the form of slave responses, to be transmitted by the receiving station while the sending station is sending subsequent blocks.

   Note.— By use of modulo 8 numbering of blocks and replies, it shall be permissible for the sending station to send as many as seven blocks ahead of the received replies before being required to stop transmission until six or less blocks are outstanding.

c) If a negative reply is received, the sending station (master side) shall start retransmission with the block following the last block for which the proper affirmative acknowledgement was received.

8.6.3.6.2.5 Slave responses shall be according to one of the following:

a) if a transmission block is received without error and the station is ready to receive another block, it shall send DLE, a colon, an optional prefix, and the appropriate acknowledgement ACKN (referring to the received block beginning with SOTB N, e.g. ACK0, transmitted as DLE0 is used as the affirmative reply to the block numbered SOTB0; DLE1 for SOTB1, etc.);

b) if a transmission block is not acceptable, the receiving station shall send DLE, a colon, an optional prefix, and NAK.

8.6.3.6.2.6 **Recommendation.—** *Slave responses should be interleaved between message blocks and transmitted at the earliest possible time.*

8.6.3.6.3 *LINK TERMINATION PROCEDURE*

8.6.3.6.3.1 If the link has been established for message transfers in either or both directions, the sending of EOT by a station shall signal the end of message transfers in that direction. To resume message transfers after sending EOT, the link shall be re-established in that direction.

8.6.3.6.3.2 EOT shall only be transmitted by a station after all outstanding slave responses have been received or otherwise accounted for.

8.6.3.6.4 *CIRCUIT DISCONNECTION*

8.6.3.6.4.1 On switched connections, the data links in both directions shall be terminated before the connection is cleared. In addition, the station initiating clearing of the connection shall first announce its intention to do so by transmitting the two-character sequence DLE EOT, followed by any other signals required to clear the connection.

8.6.3.7 *Description of system category C (centralized).* System category C (centralized) is one (like system category A) in which a number of stations are connected by a multipoint link and one station is designated as the control station but (unlike system category A) provides only for centralized (computer-to-terminal) operations where message interchange (with replies) shall be constrained to occur only between the control and a selected tributary station.

8.6.3.7.1 *LINK ESTABLISHMENT PROCEDURE*

8.6.3.7.1.1 To establish the link for transmission the control station shall either:

a) poll one of the tributary stations to assign it master status; or

b) assume master status and select a tributary station to assume slave status and receive a transmission according to either of two prescribed selection procedures:

   1) selection with response (see 8.6.3.7.1.5 below); or

2) fast select (see 8.6.3.7.1.7 below).

8.6.3.7.1.2 Polling is accomplished by the control station sending a polling supervisory sequence consisting of a prefix identifying a single tributary station and ending in ENQ.

8.6.3.7.1.3 A tributary station detecting its assigned polling supervisory sequence shall assume master status and respond in one of two ways:

a) if the station has a message to send, it shall initiate message transfer. The control station assumes slave status;

b) if the station has no message to send, it shall send EOT and master status shall revert to the control station.

8.6.3.7.1.4 If the control station detects an invalid or no response resulting from a poll, it shall terminate by sending EOT prior to resuming polling or selection.

8.6.3.7.1.5 Selection with response is accomplished by the control station assuming master status and sending a selection supervisory sequence consisting of a prefix identifying a single tributary station and ending in ENQ.

8.6.3.7.1.6 A tributary station detecting its assigned selection supervisory sequence shall assume slave status and send one of two replies:

a) if the station is ready to receive, it shall send an optional prefix followed by ACK. Upon detecting this reply, the master station shall proceed with message transfer;

b) if the station is not ready to receive, it shall send an optional prefix followed by NAK. Upon detecting NAK, it shall be permissible for the master station to again attempt selecting the same tributary station or initiate termination by sending EOT.

Note.— If the control station receives an invalid or no reply, it is permitted to attempt again to select the same tributary or after N retries (N ≥ 0) either to exit to a recovery procedure or to initiate termination by sending EOT.

8.6.3.7.1.7 Fast select is accomplished by the control station assuming master status and sending a selection supervisory sequence, and without ending this transmission with ENQ or waiting for the selected tributary to respond, proceeding directly to message transfer.

8.6.3.7.2 *MESSAGE TRANSFER PROCEDURE*

8.6.3.7.2.1 The station with master status shall send a single message to the station with slave status and wait for a reply.

8.6.3.7.2.2 The message transmission shall:

a) begin with:

— SOH if the message has a heading,

— STX if the message has no heading;

and

b) be continuous, ending with ETX, immediately followed by BCC.

8.6.3.7.2.3 The slave station, upon detecting ETX followed by BCC, shall send one of two replies:

a) if the messages were accepted and the slave station is ready to receive another message, it shall send an optional prefix followed by ACK. Upon detecting ACK, the master station shall be permitted either to transmit the next message or initiate termination;

b) if the message was not accepted and the slave station is ready to receive another message, it shall send an optional prefix followed by NAK. Upon detecting NAK, the master station may either transmit another message or initiate termination. Following the NAK reply, the next message transmitted need not be a retransmission of the message that was not accepted.

8.6.3.7.2.4 If the master station receives an invalid or no reply to a message, it shall be permitted to send a delivery verification supervisory sequence consisting of an optional prefix followed by ENQ. Upon receipt of a delivery verification supervisory sequence, the slave station repeats its last reply.

8.6.3.7.2.5 *N* retries ($N \geq 0$) may be made by the master station in order to get a valid slave reply. If a valid reply is not received after *N* retries, the master station exits to a recovery procedure.

8.6.3.7.3 *LINK TERMINATION PROCEDURE*

8.6.3.7.3.1 The station with master status shall transmit EOT to indicate that it has no more messages to transmit. EOT shall negate the master/slave status of both stations and return master status to the control station.

8.6.4 Ground-ground bit-oriented data link control procedures

Note.— The provisions of this section pertain to ground-ground data interchange applications using bit-oriented data link control procedures enabling transparent, synchronous *transmission that is independent of any encoding; data link control functions are accomplished by interpreting designated bit positions in the transmission envelope of a frame.*

8.6.4.1 The following descriptions shall apply to data link applications contained in this section:

a) Bit-oriented data link control procedures enable transparent transmission that is independent of any encoding.

b) A data link is the logical association of two interconnected stations, including the communication control capability of the interconnected stations.

c) A station is a configuration of logical elements, from or to which messages are transmitted on a data link, including those elements which control the message flow on the link via communication control procedures.

d) A combined station sends and receives both commands and responses and is responsible for control of the data link.

e) Data communication control procedures are the means used to control and protect the orderly interchange of information between stations on a data link.

f) A component is defined as a number of bits in a prescribed order within a sequence for the control and supervision of the data link.

g) An octet is a group of 8 consecutive bits.

h) A sequence is one or more components in prescribed order comprising an integral number of octets.

i) A field is a series of a specified number of bits or specified maximum number of bits which performs the functions of data link or communications control or constitutes data to be transferred.

j) A frame is a unit of data to be transferred over the data link, comprising one or more fields in a prescribed order.

k) A common ICAO data interchange network (CIDIN) switching centre is that part of an automatic AFTN switching centre which provides for the entry, relay, and exit centre functions using the bit-oriented link and CIDIN network procedures specified in this section and includes the appropriate interface(s) with other parts of the AFTN and with other networks.

8.6.4.2 BIT-ORIENTED DATA LINK CONTROL PROCEDURES FOR POINT-TO-POINT, GROUND-GROUND DATA INTERCHANGE APPLICATIONS EMPLOYING SYNCHRONOUS TRANSMISSION FACILITIES

Note.— The following link level procedures are the same as the LAPB link level procedures described in ITU CCITT Recommendation X.25, Section 2, Yellow Book (1981 version). Later versions of Recommendation X.25 will be reviewed as they are released to ascertain whether or not they should be adopted.

8.6.4.2.1 *Frame format.* Frames shall contain not less than 32 bits, excluding the opening and closing flags, and shall conform to the following format:

FLAG	ADDRESS	CONTROL	INFORMATION	FCS	FLAG
F	A	C	I		F

8.6.4.2.1.1 A frame shall consist of an opening flag (F), an address field (A), a control field (C), an optional information field (I), a frame check sequence (FCS), and a closing flag sequence (F), and shall be transmitted in that order.

Note.— In relation to CIDIN, the opening flag, the fields A and C, the FCS and the closing flag form together the Data Link Control Field (DLCF). The field I is denoted as the Link Data Field (LDF).

8.6.4.2.1.1.1 The flag (F) shall be the 8-bit sequence 01111110 which delimits the beginning and ending of each frame. It shall be permissible for the closing flag of a frame to also serve as the opening flag of the next frame.

8.6.4.2.1.1.2 The address (A) field shall consist of one octet, excluding 0 bits added to achieve transparent transmission, which shall contain the link address of the combined station.

8.6.4.2.1.1.3 The control (C) field shall consist of one octet, excluding 0 bits added to achieve transparent transmission, and shall contain the commands, responses, and frame sequence number components for the control of the data link.

8.6.4.2.1.1.4 The information (I) field shall contain digital data which may be presented in any code or sequence but shall not exceed a maximum of 259 octets, excluding 0 bits added to achieve transparent transmission. The I field shall always be a multiple of 8 bits in length.

8.6.4.2.1.1.5 The frame check sequence (FCS) shall consist of two octets, excluding 0 bits added to achieve transparent transmission, and shall contain the error detecting bits.

8.6.4.2.2 A frame check sequence (FCS) shall be included in each frame for the purpose of error checking.

8.6.4.2.2.1 The error checking algorithm shall be a cyclic redundancy check (CRC).

8.6.4.2.2.2 The CRC polynominal ($P(x)$) shall be

$$x^{16} + x^{12} + x^5 + 1.$$

8.6.4.2.2.3 The FCS shall be a 16-bit sequence. This FCS shall be the ones' complement of the remainder, $R(x)$, obtained from the modulo 2 division of

$$x^{16}[G(x)] + x^K(x^{15} + x^{14} + x^{13} + ... + x^2 + x^1 + 1)$$

by the CRC polynomial, $P(x)$.

$G(x)$ shall be the contents of the frame existing between, but including neither, the final bit of the opening flag nor the first bit of the FCS, excluding bits inserted for transparent transmission.

K shall be the length of $G(x)$ (number of bits).

8.6.4.2.2.4 The generation and checking of the FCS accumulation shall be as follows:

a) the transmitting station shall initiate the FCS accumulation with the first (least significant) bit of the address (A) field and shall include all bits up to and including the last bit preceding the FCS sequence, but shall exclude all 0 bits (if any) inserted to achieve transparent transmission;

b) upon completion of the accumulation the FCS shall be transmitted, starting with bit *b*1 (highest order coefficient) and proceeding in sequence to bit b16 (lowest order coefficient) as shown below;

First bit transmitted ↓

b16	b15	b14	-------	b3	b2	b1
x^0	x^1	x^2	-------	x^{13}	x^{14}	x^{15}

c) the receiving station shall carry out the cyclic redundancy check (CRC) on the content of the frame commencing with the first bit received following the opening flag, and shall include all bits up to and including the last bit preceding the closing flag, but shall exclude all 0 bits (if any) deleted according to the rules for achievement of transparency;

d) upon completion of the FCS accumulation, the receiving station shall examine the remainder. In the absence of transmission error, the remainder shall be 1111000010111000 (x^0 through x^{15}, respectively).

8.6.4.2.3 *Achievement of transparency.* The frame format contents (A, C, link data field, and FCS) shall be capable of containing any bit configuration.

8.6.4.2.3.1 The following rules shall apply to all frame contents, except flag sequences:

a) the transmitting station shall examine the frame contents before transmission, and shall insert a single 0 bit immediately following each sequence of 5 consecutive 1 bits;

b) the receiving station shall examine the received frame contents for patterns consisting of 5 consecutive 1 bits immediately followed by one (or more) 0 bit(s) and shall remove the 0 bit which directly follows 5 consecutive 1 bits.

8.6.4.2.4 *Special transmission sequences and related link states.* In addition to employing the prescribed repertoire of commands and responses to manage the interchange of data and control information, stations shall use the following conventions to signal the indicated conditions:

a) *Abort* is the procedure by which a station in the process of sending a frame ends the frame in an unusual manner such that the receiving station shall ignore the frame. The conventions for aborting a frame shall be:

   1) transmitting at least seven, but less than fifteen, one bits (with no inserted zeros);

   2) receiving seven one bits.

b) *Active link state.* A link is in an active state when a station is transmitting a frame, an abort sequence, or interframe time fill. When the link is in the active state, the right of the transmitting station to continue transmission shall be reserved.

c) *Interframe time fill.* Interframe time fill shall be accomplished by transmitting continuous flags between frames. There is no provision for time fill within a frame.

d) *Idle link state.* A link is in an idle state when a continuous one condition is detected that persists for 15 bit times, or longer. Idle link time fill shall be a continuous one condition on the link.

e) *Invalid frame.* An invalid frame is one that is not properly bounded by two flags or one which is shorter than 32 bits between flags.

Table 8-5. Control field formats

Control field format for	Control field bits							
	1	2	3	4	5	6	7	8
Information transfer (I frame)	0		*N(S)*		*P*		*N(R)*	
Supervisory commands/responses (S frame)	1	0	*S*	*S*	*P/F*		*N(R)*	
Unnumbered commands/responses	1	1	*M*	*M*	*P/F*	*M*	*M*	*M*

where:

N(S) = send sequence count (bit 2 = low order bit)
N(R) = receive sequence count (bit 6 = low order bit)
S = supervisory function bits
M = modifier function bits
P = poll bit (in commands)
F = final bit (in responses)

8.6.4.2.5 *MODES*

8.6.4.2.5.1 *Operational mode.* The operational mode shall be the asynchronous balanced mode (ABM).

8.6.4.2.5.1.1 It shall be permissible for a combined station in ABM to transmit without invitation from the associated station.

8.6.4.2.5.1.2 A combined station in ABM shall be permitted to transmit any command or response type frame except DM.

8.6.4.2.5.2 *Non-operational mode.* The non-operational mode shall be the asynchronous disconnected mode (ADM) in which a combined station is logically disconnected from the data link.

8.6.4.2.5.2.1 It shall be permissible for a combined station in ADM to transmit without invitation from the associated station.

8.6.4.2.5.2.2 A combined station in ADM shall transmit only SABM, DISC, UA and DM frames. (See 8.6.4.2.7 below for a description of the commands and responses to which these frame types refer.)

8.6.4.2.5.2.3 A combined station in ADM shall transmit a DM when a DISC is received, and shall discard all other received command frames except SABM. If a discarded command frame has the P bit set to "1", the combined station shall transmit a DM with the F bit set to "1".

8.6.4.2.6 *Control field functions and parameters.* Control fields contain a command or a response and sequence numbers where applicable. Three types of control fields shall be used to perform:

a) numbered information transfer (I-frames);

b) numbered supervisory functions (S-frames); and

c) unnumbered control functions (U-frames).

The control field formats shall be as shown in Table 8-5. The functional frame designation associated with each type control field as well as the control field parameters employed in performing these functions shall be described in the following paragraphs.

8.6.4.2.6.1 The I-frame type is used to perform information transfers. Except for some special cases it is the only format which shall be permitted to contain an information field.

8.6.4.2.6.2 The S-frame type is used for supervisory commands and responses that perform link supervisory control functions such as acknowledge information frames, request transmission or retransmission of information frames, and to request a temporary suspension of transmission of I-frames. No information field shall be contained in the S-frame.

8.6.4.2.6.3 The U-frame type is used for unnumbered commands and responses that provide additional link control functions. One of the U-frame responses, the frame reject (FRMR) response, shall contain an information field; all other frames of the U-frame type shall not contain an information field.

8.6.4.2.6.4 The station parameters associated with the three control field types shall be as follows:

a) *Modulus.* Each I-frame shall be sequentially numbered with a send sequence count, N(S), having value 0 through modulus minus one (where modulus is the modulus of the sequence numbers). The modulus shall be 8. The maximum number of sequentially numbered I-frames that a station shall have outstanding (i.e. unacknowledged) at any given time shall never exceed one less than the modulus of the sequence numbers. This restriction on the number of outstanding frames is to prevent any ambiguity in the association of transmission frames with sequence numbers during normal operation and/or error recovery.

b) The send state variable $V(S)$ shall denote the sequence number of the next in-sequence I-frame to be transmitted.

   1) The send state variable shall take on the value 0 through modulus minus one (modulus is the modulus of the sequence numbering and the numbers cycle through the entire range).

   2) The value of $V(S)$ shall be incremented by one with each successive in-sequence I-frame transmission, but shall not exceed the value of $N(R)$ contained in the last received frame by more than the maximum permissible number of outstanding I-frames (k). See i) below for the definition of k.

c) Prior to transmission of an in-sequence I-frame, the value of $N(S)$ shall be updated to equal the value of $V(S)$.

d) The receive state variable $V(R)$ shall denote the sequence number of the next in-sequence I-frame to be received.

   1) $V(R)$ shall take on the values 0 through modulus minus one.

   2) The value of $V(R)$ shall be incremented by one after the receipt of an error-free, in-sequence I-frame whose send sequence number $N(S)$, equals $V(R)$.

e) All I-frames and S-frames shall contain $N(R)$, the expected sequence number of the next received frame. Prior to transmission of either an I or an S type frame, the value of $N(R)$ shall be updated to equal the current value of the receive state variable. $N(R)$ indicates that the station transmitting the $N(R)$ has correctly received all I-frames numbered up to and including $N(R) - 1$.

f) Each station shall maintain an independent send state variable, $V(S)$, and receive state variable, $V(R)$, on the I-frames it sends and receives. That is, each combined station shall maintain a $V(S)$ count on the I-frames it transmits and a $V(R)$ count on the I-frames it has correctly received from the remote combined station.

g) The poll (P/F) bit shall be used by a combined station to solicit (poll) a response or sequence of responses from the remote combined station.

h) The final (P/F) bit shall be used by the remote combined station to indicate the response frame transmitted as the result of a soliciting (poll) command.

i) The maximum number (k) of sequentially numbered I-frames that a station may have outstanding (i.e. unacknowledged) at any given time is a station parameter which shall never exceed the modulus.

Note.— k is determined by station buffering limitations and should be the subject of bilateral agreement at the time of circuit establishment.

8.6.4.2.7 *Commands and responses.* It shall be permissible for a combined station to generate either commands or responses. A command shall contain the remote station address while a response shall contain the sending station address. The mnemonics associated with all of the commands and responses prescribed for each of the three frame types (I, S, and U) and the corresponding encoding of the control field are as shown in Table 8-6.

8.6.4.2.7.1 The I-frame command provides the means for transmitting sequentially numbered frames, each of which shall be permitted to contain an information field.

8.6.4.2.7.2 The S-frame commands and responses shall be used to perform numbered supervisory functions (such as acknowledgement, polling, temporary suspension of information transfer, or error recovery).

8.6.4.2.7.2.1 The receive ready command or response (RR) shall be used by a station to:

a) indicate that it is ready to receive an I-frame;

b) acknowledge previously received I-frames numbered up to and including $N(R) - 1$;

c) clear a busy condition that was initiated by the transmission of RNR.

Note.— It is permissible for a combined station to use the RR command to solicit a response from the remote combined station with the poll bit set to "1".

8.6.4.2.7.2.2 It shall be permissible to issue a reject command or response (REJ) to request retransmission of frames starting with the I-frame numbered $N(R)$ where:

a) I-frames numbered $N(R) - 1$ and below are acknowledged;

Table 8-6. Commands and responses

Type	*Commands*		*Responses*		*C field encoding* 1	2	3	4	5	6	7	8
Information transfer	I	(information)			0		*N(S)*		*P*		*N(R)*	
Supervisory	RR	(receive ready)	RR	(receive ready)	1	0	0	0	*P/F*		*N(R)*	
	RNR	(receive not ready)	RNR	(receive not ready)	1	0	1	0	*P/F*		*N(R)*	
	REJ	(reject)	REJ	(reject)	1	0	0	1	*P/F*		*N(R)*	
Unnumbered			DM	(disconnected mode)	1	1	1	1	*P/F*	0	0	0
	SABM	(set asynchronous balanced mode)			1	1	1	1	*P*	1	0	0
	DISC	(disconnect)			1	1	0	0	*P*	0	1	0
			UA	(unnumbered acknowledgement)	1	1	0	0	*F*	1	1	0
			FRMR	(frame reject)	1	1	1	0	*F*	0	0	1

b) additional I-frames pending initial transmission are to be transmitted following the retransmitted I-frame(s);

c) only one REJ exception condition, from one given station to another station, shall be established at any given time: another REJ shall not be issued until the first REJ exception condition has been cleared;

d) the REJ exception condition is cleared (reset) upon the receipt of an I-frame with an *N*(*S*) count equal to the *N*(*R*) of the REJ command/response.

8.6.4.2.7.2.3 The receive not ready command or response (RNR) shall be used to indicate a busy condition, i.e. temporary inability to accept additional incoming I-frames, where:

a) frames numbered up to and including *N*(*R*) – 1 are acknowledged;

b) frame *N*(*R*) and any subsequent I-frames received, if any, are not acknowledged (the acceptance status of these frames shall be indicated in subsequent exchanges);

c) the clearing of a busy condition shall be indicated by the transmission of an RR, REJ, SABM, or UA with or without the P/F bit set to "1".

8.6.4.2.7.2.3.1 **Recommendation.—**

a) A station receiving an RNR frame when in the process of transmitting should stop transmitting I-frames at the earliest possible time.

b) Any REJ command or response which was received prior to the RNR should be actioned before the termination of transmission.

c) It should be permissible for a combined station to use the RNR command with the poll bit set to "1" to obtain a supervisory frame with the final bit set to "1" from the remote combined station.

8.6.4.2.7.2.4 It shall be permissible for the selective reject command or response (SREJ) to be used to request retransmission of the single I-frame numbered *N*(*R*) where:

a) frames numbered up to *N*(*R*) – 1 are acknowledged; frame *N*(*R*) is not accepted; the only I-frames accepted are those received correctly and in sequence following the I-frame requested; the specific I-frame to be retransmitted is indicated by the *N*(*R*) in the SREJ command/response;

b) the SREJ exception condition is cleared (reset) upon receipt of an I-frame with an *N*(*S*) count equal to the *N*(*R*) of the SREJ;

c) after a station transmits a SREJ it is not permitted to transmit SREJ or REJ for an additional sequence error until the first SREJ error condition has been cleared;

d) I-frames that have been permitted to be transmitted following the I-frame indicated by the SREJ are not retransmitted as the result of receiving a SREJ; and

e) it is permissible for additional I-frames pending initial transmission to be transmitted following the retransmission of the specific I-frame requested by the SREJ.

8.6.4.2.7.3 The U-frame commands and responses shall be used to extend the number of link control functions. Transmitted U-frames do not increment the sequence counts at either the transmitting or receiving station.

a) The U-frame mode-setting commands (SABM, and DISC) shall be used to place the addressed station in the appropriate response mode (ABM or ADM) where:

   1) upon acceptance of the command, the station send and receive state variables, $V(S)$ and $V(R)$, are set to zero;

   2) the addressed station confirms acceptance at the earliest possible time by transmission of a single unnumbered acknowledgement, UA;

   3) previously transmitted frames that are unacknowledged when the command is actioned remain unacknowledged;

   4) the DISC command is used to perform a logical disconnect, i.e. to inform the addressed combined station that the transmitting combined station is suspending operation. No information field shall be permitted with the DISC command.

b) The unnumbered acknowledge response (UA) shall be used by a combined station to acknowledge the receipt and acceptance of an unnumbered command. Received unnumbered commands are not actioned until the UA response is transmitted. No information field shall be permitted with the UA response.

c) The frame reject response (FRMR), employing the information field described below, shall be used by a combined station in the operational mode (ABM) to report that one of the following conditions resulted from the receipt of a frame without an FCS error:

   1) a command/response that is invalid or not implemented;

   2) a frame with an information field that exceeds the size of the buffer available;

   3) a frame having an invalid $N(R)$ count.

   Note.— An invalid N(R) is a count which points to an I-frame which has previously been transmitted and acknowledged or to an I-frame which has not been transmitted and is not the next sequential I-frame pending transmission.

d) The disconnected mode response (DM) shall be used to report a non-operational status where the station is logically disconnected from the link. No information field shall be permitted with the DM response.

Note.— The DM response shall be sent to request the remote combined station to issue a mode-setting command or, if sent in response to the reception of a mode-setting command, to inform the remote combined station that the transmitting station is still in ADM and cannot action the mode-setting command.

8.6.4.3 Exception condition reporting and recovery. This section specifies the procedures that shall be employed to effect recovery following the detection or occurrence of an exception condition at the link level. Exception conditions described are those situations that may occur as the result of transmission errors, station malfunction, or operational situations.

8.6.4.3.1 *Busy condition.* A busy condition occurs when a station temporarily cannot receive or continue to receive I-frames due to internal constraints, e.g. due to buffering limitations. The busy condition shall be reported to the remote combined station by the transmission of an RNR frame with the $N(R)$ number of the next I-frame that is expected. It shall be permissible for traffic pending transmission at the busy station to be transmitted prior to or following the RNR.

Note.— The continued existence of a busy condition must be reported by retransmission of RNR at each P/F frame exchange.

8.6.4.3.1.1 Upon receipt of an RNR, a combined station in ABM shall cease transmitting I-frames at the earliest possible time by completing or aborting the frame in process. The combined station receiving an RNR shall perform a time-out operation before resuming asynchronous transmission of I-frames unless the busy condition is reported as cleared by the remote combined station. If the RNR was received as a command with the P bit set to "1", the receiving station shall respond with an S-frame with the F bit set to "1".

8.6.4.3.1.2 The busy condition shall be cleared at the station which transmitted the RNR when the internal constraint ceases. Clearance of the busy condition shall be reported to the remote station by transmission of an RR, REJ, SABM, or UA frame (with or without the P/F bit set to "1").

FRMR INFORMATION FIELD BITS FOR BASIC (SABM) OPERATION

First bit transmitted

1 8	9	10 12	13	14 16	17	18	19	20	21 24
rejected basic control field	0	*V(S)*	*v*	*V(R)*	*w*	*x*	*y*	*z*	set to zero

where:

rejected basic control field is the control field of the received frame which caused the frame reject;

V(S) is the current value of the send state variable at the remote combined station reporting the error condition (bit 10 = low order bit);

V(R) is the current value of the receive state variable at the remote combined station reporting the error condition (bit 14 = low order bit);

v set to "1" indicates that the received frame which caused rejection was a response;

w set to "1" indicates that the control field received and returned in bits 1 through 8 are invalid or not implemented;

x set to "1" indicates that the control field received and returned in bits 1 through 8 was considered invalid because the frame contained an information field which is not permitted with this command. Bit *w* must be set to "1" in conjunction with this bit;

y set to "1" indicates that the information field received exceeded the maximum information field length which can be accommodated by the station reporting the error condition. This bit is mutually exclusive with bits *w* and *x* above;

z set to "1" indicates that the control field received and returned in bits 1 through 8 contained an invalid *N(R)* count. This bit is mutually exclusive with bit *w*.

8.6.4.3.2 *N(S) sequence error.* An *N(S)* sequence exception shall be established in the receiving station when an I-frame that is received error free (no FCS error) contains an *N(S)* sequence number that is not equal to the receive variable *V(R)* at the receiving station. The receiving station shall not acknowledge (shall not increment its receive variable *V(R)*) the frame causing the sequence error, or any I-frames which may follow, until an I-frame with the correct *N(S)* number is received. A station that receives one or more I-frames having sequence errors, but which are otherwise error free, shall accept the control information contained in the *N(R)* field and the P/F bit to perform link control functions, e.g. to receive acknowledgement of previously transmitted I-frames (via the *N(R)*), to cause the station to respond (P bit set to "1").

8.6.4.3.2.1 The means specified in 8.6.4.3.2.1.1 and 8.6.4.3.2.1.2 below shall be available for initiating the retransmission of lost or errored I-frames following the occurrence of a sequence error.

8.6.4.3.2.1.1 Where the REJ command/response is used to initiate an exception recovery following the detection of a sequence error, only one "sent REJ" exception condition, from one station to another station, shall be established at a time. A "sent REJ" exception shall be cleared when the requested I-frame is received. A station receiving REJ shall initiate sequential (re)transmission of I-frames starting with the I-frame indicated by the *N(R)* contained in the REJ frame.

8.6.4.3.2.1.2 In the event a receiving station, due to a transmission error, does not receive (or receives and discards) a single I-frame or the last I-frame(s) in a sequence of I-frames, it shall not detect an out-of-sequence exception and, therefore, shall not transmit REJ. The station which transmitted the unacknowledged I-frame(s) shall, following the completion of a system-specified time-out period, take appropriate recovery action to determine the sequence number at which retransmission must begin.

8.6.4.3.2.1.3 **Recommendation.—** *A combined station which has timed out waiting for a response should not retransmit all unacknowledged frames immediately. The station may enquire about status with a supervisory frame.*

Note 1.— If a station does retransmit all unacknowledged I-frames after a time-out, it must be prepared to receive a subsequent REJ frame with an N(R) *greater than its send variable* V(S).

Note 2.— Since contention may occur in the case of two-way alternate communications in ABM or ADM, the time-out interval employed by one combined station must be greater than that employed by the other combined station so as to permit contention to be resolved.

8.6.4.3.3 *FCS error.* Any frame with an FCS error shall not be accepted by the receiving station and will be discarded. No action shall be taken by the receiving station as the result of that frame.

8.6.4.3.4 *Frame reject exception condition.* A frame reject exception condition shall be established upon the receipt of an error-free frame which contains an invalid or unimplemented control field, an invalid *N(R),* or an information field which has exceeded the maximum established storage capability. If a frame reject exception condition occurs in a combined station, the station shall either:

a) take recovery action without reporting the condition to the remote combined station; or

b) report the condition to the remote combined station with a FRMR response. The remote station will then be expected to take recovery action; if, after waiting an appropriate time, no recovery action appears to have been taken, the combined station reporting the frame reject exception condition may take recovery action.

Recovery action for balanced operation includes the transmission of an implemented mode-setting command. Higher level functions may also be involved in the recovery.

8.6.4.3.5 *Mode-setting contention.* A mode-setting contention situation exists when a combined station issues a mode-setting command and, before receiving an appropriate response (UA or DM), receives a mode-setting command from the remote combined station. Contention situations shall be resolved in the following manner:

a) when the send and receive mode-setting commands are the same, each combined station shall send a UA response at the earliest respond opportunity. Each combined station shall either enter the indicated mode immediately or defer entering the indicated mode until receiving a UA response. In the latter case, if the UA response is not received:

   1) the mode may be entered when the response timer expires; or

   2) the mode-setting command may be reissued;

b) when the mode-setting commands are different, each combined station shall enter ADM and issue a DM response at the earliest respond opportunity. In the case of DISC contention with a different mode-setting command, no further action is required.

8.6.4.3.6 *Time-out functions.* Time-out functions shall be used to detect that a required or expected acknowledging action or response to a previously transmitted frame has not been received. Expiration of the time-out function shall initiate appropriate action, e.g. error recovery or reissuance of the P bit. The duration of the following time-out functions is system dependent and subject to bilateral agreement:

a) combined stations shall provide a time-out function to determine that a response frame with F bit set to "1" to a command frame with the P bit set to "1" has not been received. The time-out function shall automatically cease upon receipt of a valid frame with the F bit set to "1";

b) a combined station which has no P bit outstanding, and which has transmitted one or more frames for which responses are anticipated shall start a time-out function to detect the no-response condition. The time-out function shall cease when an I- or S-frame is received with the *N(R)* higher than the last received *N(R)* (actually acknowledging one or more I-frames).

8.6.5 Common ICAO data interchange network (CIDIN)

8.6.5.1 INTRODUCTION

Note 1.— The common ICAO data interchange network (CIDIN) is an element of the aeronautical fixed service (AFS) which uses bit-oriented procedures, store and forward techniques and packet switching techniques based on CCITT Recommendation X.25 to carry messages of specific applications of the AFS such as AFTN and operational meteorological information (OPMET).

Note 2.— The CIDIN provides a reliable common network service for the conveyance of application messages in binary or text form to air traffic service providers and aircraft operating agencies.

8.6.5.1.1 CIDIN entry and exit centres or stations shall be used to connect application entities to the CIDIN.

Note.— The interfacing between CIDIN and application entities is a matter for local implementation.

8.6.5.1.2 CIDIN relay centres shall be used to forward packets between CIDIN entry and exit centres or stations which are not directly connected.

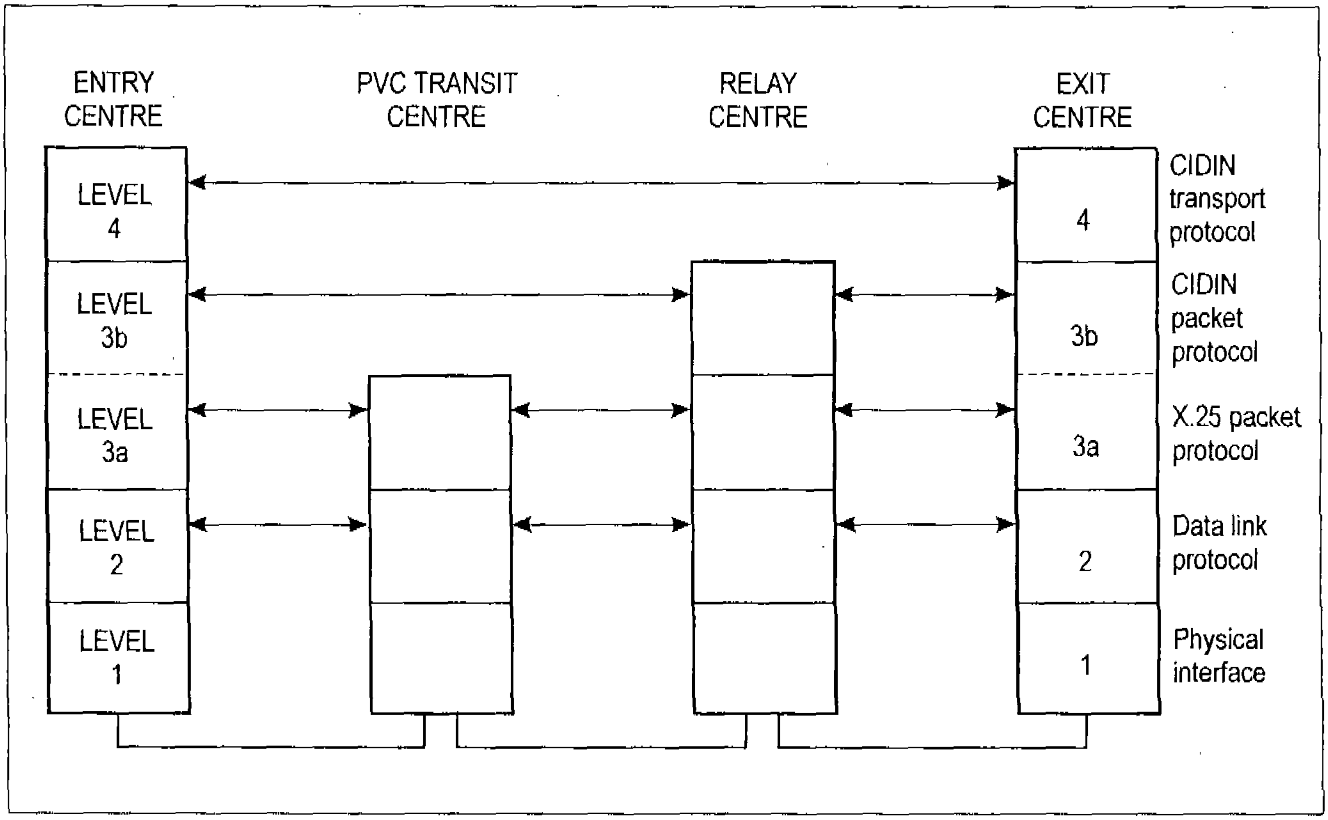

Figure 8-1. CIDIN Protocol Levels

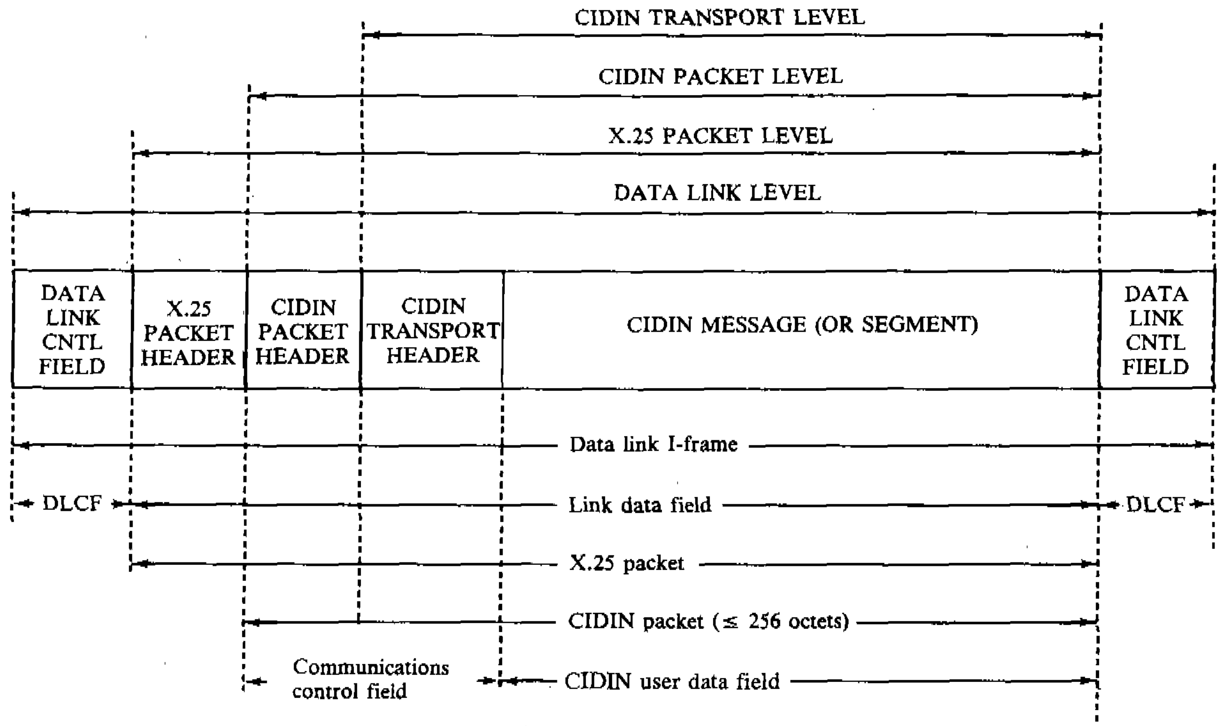

Figure 8-2. CIDIN Terminology

8.6.5.2 GENERAL

8.6.5.2.1 There shall be four protocol levels defined to control the transfer of messages between CIDIN switching centres:

— the data link protocol level

— the X.25 packet protocol level

— the CIDIN packet protocol level

— the CIDIN transport protocol level

Note 1.— The relationship of the terms used is shown in Figures 8-1 and 8-2.

Note 2.— The details of CIDIN communication procedures and system specifications, as implemented in Europe, are shown in the EUR CIDIN Manual *(EUR Doc 005).*

8.6.5.2.2 *THE DATA LINK PROTOCOL LEVEL*

8.6.5.2.2.1 X.25 packets to be transferred between two CIDIN switching centres or a CIDIN switching centre and a packet switched data network, shall be formatted into data link frames.

8.6.5.2.2.2 Each data link frame shall consist of a data link control field (DLCF), possibly followed by a link data field, and shall be terminated by a frame check sequence and flag (being the second part of the DLCF). If a link data field is present, the frame shall be denoted as an information frame.

8.6.5.2.2.3 X.25 packets shall be transmitted within the link data field of information frames. Only one packet shall be contained in the link data field.

8.6.5.2.3 *THE X.25 PACKET PROTOCOL LEVEL*

8.6.5.2.3.1 Each CIDIN packet to be transferred on CIDIN circuits between CIDIN switching centres shall be formatted into one X.25 packet. When a packet switched data network is used, it shall be permissible to format the CIDIN packet into more than one X.25 packet.

8.6.5.2.3.2 The integrity of each CIDIN packet shall be preserved by the X.25 packet protocol by mapping each CIDIN packet onto one complete X.25 packet sequence, as defined in CCITT Recommendation X.25.

8.6.5.2.3.3 Each X.25 packet shall consist of an X.25 packet header, possibly followed by a user data field (UDF).

8.6.5.2.3.4 The X.25 packet protocol is based on the application of virtual circuit procedures. A virtual circuit shall be defined as a logical path between two CIDIN switching centres. If a packet switched data network is used to interconnect two CIDIN switching centres, the procedure shall provide full compatibility with the procedures to be followed for virtual circuits according to CCITT Recommendation X.25.

8.6.5.2.4 *THE CIDIN PACKET PROTOCOL LEVEL*

8.6.5.2.4.1 Each transport header and the associated segment shall be preceded by a CIDIN packet header. No further segmentation of the CIDIN message shall be used between transport protocol level and CIDIN packet protocol level. Both headers, therefore, shall be used in combination. Together they shall be referred to as the communications control field (CCF). Together with the message segment they form CIDIN packets that shall be transmitted from entry centre to exit centre(s), when necessary through one or more relay centres, as an entity.

8.6.5.2.4.2 CIDIN packets of one CIDIN message shall be relayed independently via predetermined routes through the network thus allowing alternative routing on a CIDIN packet basis as necessary.

8.6.5.2.4.3 The CIDIN packet header shall contain information to enable relay centres to handle CIDIN packets in the order of priority, to transmit the CIDIN packets on the proper outgoing circuit(s) and to duplicate or multiplicate CIDIN packets when required for multiple dissemination purposes. The information shall be sufficient to apply address stripping on the exit addresses as well as on the addressee indicators of messages in AFTN format.

8.6.5.2.5 *THE TRANSPORT PROTOCOL LEVEL*

8.6.5.2.5.1 Information exchanged over the CIDIN shall be transmitted as CIDIN messages.

8.6.5.2.5.2 The length of a CIDIN message shall be defined by the CIDIN packet sequence number (CPSN). The maximum permissible length is 2^{15} packets which in effect results in no practical limitation.

8.6.5.2.5.3 If the length of a CIDIN message and its transport and packet headers (as defined below) exceeds 256 octets, the message shall be divided into segments and placed in the CIDIN user data field of CIDIN packets. Each segment shall be preceded by a transport header containing information to enable the re-assembly of the CIDIN message at the exit centre(s) from individually received segments and to determine further handling of the received complete CIDIN message.

8.6.5.2.5.4 All segments of one CIDIN message shall be provided with the same message identification information in the transport header. Only the CPSN and final CIDIN packet (FCP) indicator shall be different.

8.6.5.2.5.5 Recovery of messages shall be performed at the transport level.

AS A RESULT OF AMENDMENT NO. 76
PAGES 310 TO 328 HAVE BEEN REMOVED

CHAPTER 9. AIRCRAFT ADDRESSING SYSTEM

9.1 The aircraft address shall be one of 16 777 214 twenty-four-bit aircraft addresses allocated by ICAO to the State of Registry or common mark registering authority and assigned as prescribed in the Appendix to this Chapter.

APPENDIX TO CHAPTER 9. A WORLD-WIDE SCHEME FOR THE ALLOCATION, ASSIGNMENT AND APPLICATION OF AIRCRAFT ADDRESSES

1. General

1.1 Global communications, navigation and surveillance systems shall use an individual aircraft address composed of 24 bits. At any one time, no address shall be assigned to more than one aircraft. The assignment of aircraft addresses requires a comprehensive scheme providing for a balanced and expandable distribution of aircraft addresses applicable world-wide.

2. Description of the scheme

2.1 Table 9-1 provides for blocks of consecutive addresses available to States for assignment to aircraft. Each block is defined by a fixed pattern of the first 4, 6, 9, 12 or 14 bits of the 24-bit address. Thus, blocks of different sizes (1 048 576, 262 144, 32 768, 4 096 and 1 024 consecutive addresses respectively) are made available.

3. Management of the scheme

3.1 The International Civil Aviation Organization (ICAO) shall administer the scheme so that appropriate international distribution of aircraft addresses can be maintained.

4. Allocation of aircraft addresses

4.1 Blocks of aircraft addresses shall be allocated by ICAO to the State of Registry or common mark registering authority. Address allocations to States shall be as shown in Table 9-1.

4.2 A State of Registry or common mark registering authority shall notify ICAO when allocation to that State of an additional block of addresses is required for assignment to aircraft.

4.3 In the future management of the scheme, advantage shall be taken of the blocks of aircraft addresses not yet allocated. These spare blocks shall be distributed on the basis of the relevant ICAO region:

Addresses starting with bit combination 00100: AFI region

Addresses starting with bit combination 00101: SAM region

Addresses starting with bit combination 0101: EUR and NAT regions

Addresses starting with bit combination 01100: MID region

Addresses starting with bit combination 01101: ASIA region

Addresses starting with bit combination 1001: NAM and PAC regions

Addresses starting with bit combination 111011: CAR region

In addition, aircraft addresses starting with bit combinations 1011, 1101 and 1111 have been reserved for future use.

4.4 Any future requirement for additional aircraft addresses shall be accommodated through co-ordination between ICAO and the States of Registry or common mark registering authority concerned. A request for additional aircraft addresses shall only be made by a registering authority when at least 75 per cent of the number of addresses already allocated to that registering authority have been assigned to aircraft.

4.5 ICAO shall allocate blocks of aircraft addresses to non-Contracting States upon request.

5. Assignment of aircraft addresses

5.1 When required for use by suitably equipped aircraft entered on a national or international register, individual aircraft addresses within each block shall be assigned to aircraft by the State of Registry or common mark registering authority.

5.2 Aircraft addresses shall be assigned to aircraft in accordance with the following principles:

a) at any one time, no address shall be assigned to more than one aircraft;

b) only one address shall be assigned to an aircraft, irrespective of the composition of equipment on board;

c) the address shall not be changed except under exceptional circumstances and shall not be changed during flight;

d) when an aircraft changes its State of Registry, the previously assigned address shall be relinquished and a new address shall be assigned by the new registering authority;

e) the address shall serve only a technical role for addressing and identification of aircraft and shall not be used to convey any specific information; and

f) the addresses composed of 24 ZEROs or 24 ONEs shall not be assigned to aircraft.

6. Application of aircraft addresses

6.1 The aircraft addresses shall be used in applications which require the routing of information to or from individual suitably equipped aircraft.

Note 1.— Examples of such applications are the aeronautical telecommunication network (ATN), SSR Mode S and airborne collision avoidance system (ACAS).

Note 2.— This Standard does not preclude assigning the aircraft addresses for special applications associated with the general applications defined therein. Examples of such special applications are the utilization of the 24-bit address in a pseudo-aeronautical earth station to monitor the aeronautical mobile-satellite service ground earth station and in the fixed Mode S transponders (reporting the on-the-ground status as specified in Annex 10, Volume IV, 3.1.2.6.10.1.2) to monitor the Mode S ground station operation. Address assignments for special applications are to be carried out in conformance with the procedure established by the State to manage the 24-bit address assignments to aircraft.

6.2 An address consisting of 24 ZEROs shall not be used for any application.

7. Administration of the temporary aircraft address assignments

7.1 Temporary addresses shall be assigned to aircraft in exceptional circumstances, such as when operators have been unable to obtain an address from their individual States of Registry or Common Mark Registering Authority in a timely manner. ICAO shall assign temporary addresses from the block ICAO[1] shown in Table 9-1.

7.2 When requesting a temporary address, the aircraft operator shall supply to ICAO: aircraft identification, type and make of aircraft, name and address of the operator, and an explanation of the reason for the request.

7.2.1 Upon issuance of the temporary address to the aircraft operators, ICAO shall inform the State of Registry of the issuance of the temporary address, reason and duration.

7.3 The aircraft operator shall:

a) inform the State of Registry of the temporary assignment and reiterate the request for a permanent address; and

b) inform the airframe manufacturer.

7.4 When the permanent aircraft address is obtained from the State of Registry, the operator shall:

a) inform ICAO without delay;

b) relinquish his/her temporary address; and

c) arrange for encoding of the valid unique address within 180 calendar days.

7.5 If a permanent address is not obtained within one year, the aircraft operator shall re-apply for a new temporary aircraft address. Under no circumstances shall a temporary aircraft address be used by the aircraft operator for over one year.

Table 9-1. Allocation of aircraft addresses to States

Note.— The left-hand column of the 24-bit address patterns represents the most significant bit (MSB) of the address.

	Number of addresses in block					*Allocation of blocks of addresses (a dash represents a bit value equal to 0 or 1)*
	1 024	*4 096*	*32 768*	*262 144*	*1 048 576*	
Afghanistan		*				0 1 1 1 0 0 0 0 0 0 0 0 – – – – – – – – – – – –
Albania	*					0 1 0 1 0 0 0 0 0 0 0 1 0 0 – – – – – – – – – –
Algeria			*			0 0 0 0 1 0 1 0 0 – – – – – – – – – – – – – – –
Angola		*				0 0 0 0 1 0 0 1 0 0 0 0 – – – – – – – – – – – –
Antigua and Barbuda	*					0 0 0 0 1 1 0 0 1 0 1 0 0 0 – – – – – – – – – –
Argentina				*		1 1 1 0 0 0 – – – – – – – – – – – – – – – – – –
Armenia	*					0 1 1 0 0 0 0 0 0 0 0 0 0 0 – – – – – – – – – –
Australia				*		0 1 1 1 1 1 – – – – – – – – – – – – – – – – – –
Austria			*			0 1 0 0 0 1 0 0 0 – – – – – – – – – – – – – – –
Azerbaijan	*					0 1 1 0 0 0 0 0 0 0 0 0 1 0 – – – – – – – – – –
Bahamas		*				0 0 0 0 1 0 1 0 1 0 0 0 – – – – – – – – – – – –
Bahrain		*				1 0 0 0 1 0 0 1 0 1 0 0 – – – – – – – – – – – –
Bangladesh		*				0 1 1 1 0 0 0 0 0 0 1 0 – – – – – – – – – – – –
Barbados	*					0 0 0 0 1 0 1 0 1 0 1 0 0 0 – – – – – – – – – –
Belarus	*					0 1 0 1 0 0 0 1 0 0 0 0 0 0 – – – – – – – – – –
Belgium			*			0 1 0 0 0 1 0 0 1 – – – – – – – – – – – – – – –
Belize	*					0 0 0 0 1 0 1 0 1 0 1 1 0 0 – – – – – – – – – –
Benin	*					0 0 0 0 1 0 0 1 0 1 0 0 0 0 – – – – – – – – – –
Bhutan	*					0 1 1 0 1 0 0 0 0 0 0 0 0 0 – – – – – – – – – –
Bolivia		*				1 1 1 0 1 0 0 1 0 1 0 0 – – – – – – – – – – – –
Bosnia and Herzegovina	*					0 1 0 1 0 0 0 1 0 0 1 1 0 0 – – – – – – – – – –
Botswana	*					0 0 0 0 0 0 1 1 0 0 0 0 0 0 – – – – – – – – – –
Brazil				*		1 1 1 0 0 1 – – – – – – – – – – – – – – – – – –
Brunei Darussalam	*					1 0 0 0 1 0 0 1 0 1 0 1 0 0 – – – – – – – – – –
Bulgaria			*			0 1 0 0 0 1 0 1 0 – – – – – – – – – – – – – – –
Burkina Faso		*				0 0 0 0 1 0 0 1 1 1 0 0 – – – – – – – – – – – –
Burundi		*				0 0 0 0 0 0 1 1 0 0 1 0 – – – – – – – – – – – –
Cambodia		*				0 1 1 1 0 0 0 0 1 1 1 0 – – – – – – – – – – – –
Cameroon		*				0 0 0 0 0 0 1 1 0 1 0 0 – – – – – – – – – – – –
Canada				*		1 1 0 0 0 0 – – – – – – – – – – – – – – – – – –
Cape Verde	*					0 0 0 0 1 0 0 1 0 1 1 0 0 0 – – – – – – – – – –
Central African Republic		*				0 0 0 0 0 1 1 0 1 1 0 0 – – – – – – – – – – – –
Chad		*				0 0 0 0 1 0 0 0 0 1 0 0 – – – – – – – – – – – –
Chile		*				1 1 1 0 1 0 0 0 0 0 0 0 – – – – – – – – – – – –
China				*		0 1 1 1 1 0 – – – – – – – – – – – – – – – – – –
Colombia		*				0 0 0 0 1 0 1 0 1 1 0 0 – – – – – – – – – – – –
Comoros	*					0 0 0 0 0 0 1 1 0 1 0 1 0 0 – – – – – – – – – –
Congo		*				0 0 0 0 0 0 1 1 0 1 1 0 – – – – – – – – – – – –
Cook Islands	*					1 0 0 1 0 0 0 0 0 0 0 1 0 0 – – – – – – – – – –

	Number of addresses in block					*Allocation of blocks of addresses (a dash represents a bit value equal to 0 or 1)*
	1 024	*4 096*	*32 768*	*262 144*	*1 048 576*	
Costa Rica		*				0 0 0 0 1 0 1 0 1 1 1 0 – – – – – – – – – – – –
Côte d'Ivoire		*				0 0 0 0 0 0 1 1 1 0 0 0 – – – – – – – – – – – –
Croatia	*					0 1 0 1 0 0 0 0 0 0 0 1 1 1 – – – – – – – – – –
Cuba		*				0 0 0 0 1 0 1 1 0 0 0 0 – – – – – – – – – – – –
Cyprus	*					0 1 0 0 1 1 0 0 1 0 0 0 0 0 – – – – – – – – – –
Czech Republic			*			0 1 0 0 1 0 0 1 1 – – – – – – – – – – – – – – –
Democratic People's Republic of Korea			*			0 1 1 1 0 0 1 0 0 – – – – – – – – – – – – – – –
Democratic Republic of the Congo		*				0 0 0 0 1 0 0 0 1 1 0 0 – – – – – – – – – – – –
Denmark			*			0 1 0 0 0 1 0 1 1 – – – – – – – – – – – – – – –
Djibouti	*					0 0 0 0 1 0 0 1 1 0 0 0 0 0 – – – – – – – – – –
Dominican Republic		*				0 0 0 0 1 1 0 0 0 1 0 0 – – – – – – – – – – – –
Ecuador		*				1 1 1 0 1 0 0 0 0 1 0 0 – – – – – – – – – – – –
Egypt			*			0 0 0 0 0 0 0 1 0 – – – – – – – – – – – – – – –
El Salvador		*				0 0 0 0 1 0 1 1 0 0 1 0 – – – – – – – – – – – –
Equatorial Guinea		*				0 0 0 0 0 1 0 0 0 0 1 0 – – – – – – – – – – – –
Eritrea	*					0 0 1 0 0 0 0 0 0 0 1 0 0 0 – – – – – – – – – –
Estonia	*					0 1 0 1 0 0 0 1 0 0 0 1 0 0 – – – – – – – – – –
Ethiopia		*				0 0 0 0 0 1 0 0 0 0 0 0 – – – – – – – – – – – –
Fiji		*				1 1 0 0 1 0 0 0 1 0 0 0 – – – – – – – – – – – –
Finland			*			0 1 0 0 0 1 1 0 0 – – – – – – – – – – – – – – –
France				*		0 0 1 1 1 0 – – – – – – – – – – – – – – – – – –
Gabon		*				0 0 0 0 0 0 1 1 1 1 1 0 – – – – – – – – – – – –
Gambia		*				0 0 0 0 1 0 0 1 1 0 1 0 – – – – – – – – – – – –
Georgia	*					0 1 0 1 0 0 0 1 0 1 0 0 0 0 – – – – – – – – – –
Germany				*		0 0 1 1 1 1 – – – – – – – – – – – – – – – – – –
Ghana		*				0 0 0 0 0 1 0 0 0 1 0 0 – – – – – – – – – – – –
Greece			*			0 1 0 0 0 1 1 0 1 – – – – – – – – – – – – – – –
Grenada	*					0 0 0 0 1 1 0 0 1 1 0 0 0 0 – – – – – – – – – –
Guatemala		*				0 0 0 0 1 0 1 1 0 1 0 0 – – – – – – – – – – – –
Guinea		*				0 0 0 0 0 1 0 0 0 1 1 0 – – – – – – – – – – – –
Guinea-Bissau	*					0 0 0 0 0 1 0 0 1 0 0 0 0 0 – – – – – – – – – –
Guyana		*				0 0 0 0 1 0 1 1 0 1 1 0 – – – – – – – – – – – –
Haiti		*				0 0 0 0 1 0 1 1 1 0 0 0 – – – – – – – – – – – –
Honduras		*				0 0 0 0 1 0 1 1 1 0 1 0 – – – – – – – – – – – –
Hungary			*			0 1 0 0 0 1 1 1 0 – – – – – – – – – – – – – – –
Iceland		*				0 1 0 0 1 1 0 0 1 1 0 0 – – – – – – – – – – – –
India				*		1 0 0 0 0 0 – – – – – – – – – – – – – – – – – –
Indonesia			*			1 0 0 0 1 0 1 0 0 – – – – – – – – – – – – – – –
Iran, Islamic Republic of			*			0 1 1 1 0 0 1 1 0 – – – – – – – – – – – – – – –
Iraq			*			0 1 1 1 0 0 1 0 1 – – – – – – – – – – – – – – –

	Number of addresses in block					*Allocation of blocks of addresses (a dash represents a bit value equal to 0 or 1)*
	1 024	*4 096*	*32 768*	*262 144*	*1 048 576*	
Ireland		*				0 1 0 0 1 1 0 0 1 0 1 0 – – – – – – – – – – – –
Israel			*			0 1 1 1 0 0 1 1 1 – – – – – – – – – – – – – – –
Italy				*		0 0 1 1 0 0 – – – – – – – – – – – – – – – – – –
Jamaica		*				0 0 0 0 1 0 1 1 1 1 1 0 – – – – – – – – – – – –
Japan				*		1 0 0 0 0 1 – – – – – – – – – – – – – – – – – –
Jordan			*			0 1 1 1 0 1 0 0 0 – – – – – – – – – – – – – – –
Kazakhstan	*					0 1 1 0 1 0 0 0 0 0 1 1 0 0 – – – – – – – – – –
Kenya		*				0 0 0 0 0 1 0 0 1 1 0 0 – – – – – – – – – – – –
Kiribati	*					1 1 0 0 1 0 0 0 1 1 1 0 0 0 – – – – – – – – – –
Kuwait		*				0 1 1 1 0 0 0 0 0 1 1 0 – – – – – – – – – – – –
Kyrgyzstan	*					0 1 1 0 0 0 0 0 0 0 0 1 0 0 – – – – – – – – – –
Lao People's Democratic Republic		*				0 1 1 1 0 0 0 0 1 0 0 0 – – – – – – – – – – – –
Latvia	*					0 1 0 1 0 0 0 0 0 0 1 0 1 1 – – – – – – – – – –
Lebanon			*			0 1 1 1 0 1 0 0 1 – – – – – – – – – – – – – – –
Lesotho	*					0 0 0 0 0 1 0 0 1 0 1 0 0 0 – – – – – – – – – –
Liberia		*				0 0 0 0 0 1 0 1 0 0 0 0 – – – – – – – – – – – –
Libyan Arab Jamahiriya			*			0 0 0 0 0 0 0 1 1 – – – – – – – – – – – – – – –
Lithuania	*					0 1 0 1 0 0 0 0 0 0 1 1 1 1 – – – – – – – – – –
Luxembourg	*					0 1 0 0 1 1 0 1 0 0 0 0 0 0 – – – – – – – – – –
Madagascar		*				0 0 0 0 0 1 0 1 0 1 0 0 – – – – – – – – – – – –
Malawi		*				0 0 0 0 0 1 0 1 1 0 0 0 – – – – – – – – – – – –
Malaysia			*			0 1 1 1 0 1 0 1 0 – – – – – – – – – – – – – – –
Maldives	*					0 0 0 0 0 1 0 1 1 0 1 0 0 0 – – – – – – – – – –
Mali		*				0 0 0 0 0 1 0 1 1 1 0 0 – – – – – – – – – – – –
Malta	*					0 1 0 0 1 1 0 1 0 0 1 0 0 0 – – – – – – – – – –
Marshall Islands	*					1 0 0 1 0 0 0 0 0 0 0 0 0 0 – – – – – – – – – –
Mauritania	*					0 0 0 0 0 1 0 1 1 1 1 0 0 0 – – – – – – – – – –
Mauritius	*					0 0 0 0 0 1 1 0 0 0 0 0 0 0 – – – – – – – – – –
Mexico			*			0 0 0 0 1 1 0 1 0 – – – – – – – – – – – – – – –
Micronesia, Federated States of	*					0 1 1 0 1 0 0 0 0 0 0 1 0 0 – – – – – – – – – –
Monaco	*					0 1 0 0 1 1 0 1 0 1 0 0 0 0 – – – – – – – – – –
Mongolia	*					0 1 1 0 1 0 0 0 0 0 1 0 0 0 – – – – – – – – – –
Morocco			*			0 0 0 0 0 0 1 0 0 – – – – – – – – – – – – – – –
Mozambique		*				0 0 0 0 0 0 0 0 0 1 1 0 – – – – – – – – – – – –
Myanmar		*				0 1 1 1 0 0 0 0 0 1 0 0 – – – – – – – – – – – –
Namibia	*					0 0 1 0 0 0 0 0 0 0 0 1 0 0 – – – – – – – – – –
Nauru	*					1 1 0 0 1 0 0 0 1 0 1 0 0 0 – – – – – – – – – –
Nepal		*				0 1 1 1 0 0 0 0 1 0 1 0 – – – – – – – – – – – –
Netherlands, Kingdom of the			*			0 1 0 0 1 0 0 0 0 – – – – – – – – – – – – – – –
New Zealand			*			1 1 0 0 1 0 0 0 0 – – – – – – – – – – – – – – –

	Number of addresses in block					*Allocation of blocks of addresses (a dash represents a bit value equal to 0 or 1)*
	1 024	*4 096*	*32 768*	*262 144*	*1 048 576*	
Nicaragua		*				0 0 0 0 1 1 0 0 0 0 0 0 – – – – – – – – – – – –
Niger		*				0 0 0 0 0 1 1 0 0 0 1 0 – – – – – – – – – – – –
Nigeria		*				0 0 0 0 0 1 1 0 0 1 0 0 – – – – – – – – – – – –
Norway			*			0 1 0 0 0 1 1 1 1 – – – – – – – – – – – – – – –
Oman	*					0 1 1 1 0 0 0 0 1 1 0 0 0 0 – – – – – – – – – –
Pakistan			*			0 1 1 1 0 1 1 0 0 – – – – – – – – – – – – – – –
Palau	*					0 1 1 0 1 0 0 0 0 1 0 0 0 0 – – – – – – – – – –
Panama		*				0 0 0 0 1 1 0 0 0 0 1 0 – – – – – – – – – – – –
Papua New Guinea		*				1 0 0 0 1 0 0 1 1 0 0 0 – – – – – – – – – – – –
Paraguay		*				1 1 1 0 1 0 0 0 1 0 0 0 – – – – – – – – – – – –
Peru		*				1 1 1 0 1 0 0 0 1 1 0 0 – – – – – – – – – – – –
Philippines			*			0 1 1 1 0 1 0 1 1 – – – – – – – – – – – – – – –
Poland			*			0 1 0 0 1 0 0 0 1 – – – – – – – – – – – – – – –
Portugal			*			0 1 0 0 1 0 0 1 0 – – – – – – – – – – – – – – –
Qatar	*					0 0 0 0 0 1 1 0 1 0 1 0 0 0 – – – – – – – – – –
Republic of Korea			*			0 1 1 1 0 0 0 1 1 – – – – – – – – – – – – – – –
Republic of Moldova	*					0 1 0 1 0 0 0 0 0 1 0 0 1 1 – – – – – – – – – –
Romania			*			0 1 0 0 1 0 1 0 0 – – – – – – – – – – – – – – –
Russian Federation					*	0 0 0 1 – – – – – – – – – – – – – – – – – – – –
Rwanda		*				0 0 0 0 0 1 1 0 1 1 1 0 – – – – – – – – – – – –
Saint Lucia	*					1 1 0 0 1 0 0 0 1 1 0 0 0 0 – – – – – – – – – –
Saint Vincent and the Grenadines	*					0 0 0 0 1 0 1 1 1 1 0 0 0 0 – – – – – – – – – –
Samoa	*					1 0 0 1 0 0 0 0 0 0 1 0 0 0 – – – – – – – – – –
San Marino	*					0 1 0 1 0 0 0 0 0 0 0 0 0 0 – – – – – – – – – –
Sao Tome and Principe	*					0 0 0 0 1 0 0 1 1 1 1 0 0 0 – – – – – – – – – –
Saudi Arabia			*			0 1 1 1 0 0 0 1 0 – – – – – – – – – – – – – – –
Senegal		*				0 0 0 0 0 1 1 1 0 0 0 0 – – – – – – – – – – – –
Seychelles	*					0 0 0 0 0 1 1 1 0 1 0 0 0 0 – – – – – – – – – –
Sierra Leone	*					0 0 0 0 0 1 1 1 0 1 1 0 0 0 – – – – – – – – – –
Singapore			*			0 1 1 1 0 1 1 0 1 – – – – – – – – – – – – – – –
Slovakia	*					0 1 0 1 0 0 0 0 0 1 0 1 1 1 – – – – – – – – – –
Slovenia	*					0 1 0 1 0 0 0 0 0 1 1 0 1 1 – – – – – – – – – –
Solomon Islands	*					1 0 0 0 1 0 0 1 0 1 1 1 0 0 – – – – – – – – – –
Somalia		*				0 0 0 0 0 1 1 1 1 0 0 0 – – – – – – – – – – – –
South Africa			*			0 0 0 0 0 0 0 0 1 – – – – – – – – – – – – – – –
Spain				*		0 0 1 1 0 1 – – – – – – – – – – – – – – – – – –
Sri Lanka			*			0 1 1 1 0 1 1 1 0 – – – – – – – – – – – – – – –
Sudan		*				0 0 0 0 0 1 1 1 1 1 0 0 – – – – – – – – – – – –
Suriname		*				0 0 0 0 1 1 0 0 1 0 0 0 – – – – – – – – – – – –
Swaziland	*					0 0 0 0 0 1 1 1 1 0 1 0 0 0 – – – – – – – – – –
Sweden			*			0 1 0 0 1 0 1 0 1 – – – – – – – – – – – – – – –

	Number of addresses in block					*Allocation of blocks of addresses (a dash represents a bit value equal to 0 or 1)*
	1 024	*4 096*	*32 768*	*262 144*	*1 048 576*	
Switzerland			*			0 1 0 0 1 0 1 1 0 – – – – – – – – – – – – – – –
Syrian Arab Republic			*			0 1 1 1 0 1 1 1 1 – – – – – – – – – – – – – – –
Tajikistan	*					0 1 0 1 0 0 0 1 0 1 0 1 0 0 – – – – – – – – – –
Thailand			*			1 0 0 0 1 0 0 0 0 – – – – – – – – – – – – – – –
The former Yugoslav Republic of Macedonia	*					0 1 0 1 0 0 0 1 0 0 1 0 0 0 – – – – – – – – – –
Togo		*				0 0 0 0 1 0 0 0 1 0 0 0 – – – – – – – – – – – –
Tonga	*					1 1 0 0 1 0 0 0 1 1 0 1 0 0 – – – – – – – – – –
Trinidad and Tobago		*				0 0 0 0 1 1 0 0 0 1 1 0 – – – – – – – – – – – –
Tunisia			*			0 0 0 0 0 0 1 0 1 – – – – – – – – – – – – – – –
Turkey			*			0 1 0 0 1 0 1 1 1 – – – – – – – – – – – – – – –
Turkmenistan	*					0 1 1 0 0 0 0 0 0 0 0 1 1 0 – – – – – – – – – –
Uganda		*				0 0 0 0 0 1 1 0 1 0 0 0 – – – – – – – – – – – –
Ukraine			*			0 1 0 1 0 0 0 0 1 – – – – – – – – – – – – – – –
United Arab Emirates		*				1 0 0 0 1 0 0 1 0 1 1 0 – – – – – – – – – – – –
United Kingdom				*		0 1 0 0 0 0 – – – – – – – – – – – – – – – – – –
United Republic of Tanzania		*				0 0 0 0 1 0 0 0 0 0 0 0 – – – – – – – – – – – –
United States					*	1 0 1 0 –
Uruguay		*				1 1 1 0 1 0 0 1 0 0 0 0 – – – – – – – – – – – –
Uzbekistan	*					0 1 0 1 0 0 0 0 0 1 1 1 1 1 – – – – – – – – – –
Vanuatu	*					1 1 0 0 1 0 0 1 0 0 0 0 0 0 – – – – – – – – – –
Venezuela			*			0 0 0 0 1 1 0 1 1 – – – – – – – – – – – – – – –
Viet Nam			*			1 0 0 0 1 0 0 0 1 – – – – – – – – – – – – – – –
Yemen		*				1 0 0 0 1 0 0 1 0 0 0 0 – – – – – – – – – – – –
Yugoslavia			*			0 1 0 0 1 1 0 0 0 – – – – – – – – – – – – – – –
Zambia		*				0 0 0 0 1 0 0 0 1 0 1 0 – – – – – – – – – – – –
Zimbabwe	*					0 0 0 0 0 0 0 0 0 1 0 0 0 0 – – – – – – – – – –
Other allocations						
ICAO[1]			*			1 1 1 1 0 0 0 0 0 – – – – – – – – – – – – – – –
ICAO[2]	*					1 0 0 0 1 0 0 1 1 0 0 1 0 0 – – – – – – – – – –
ICAO[2]	*					1 1 1 1 0 0 0 0 1 0 0 1 0 0 – – – – – – – – – –

1. ICAO administers this block for assigning temporary aircraft addresses as described in section 7.

2. Block allocated for special use in the interest of flight safety.

CHAPTER 10. POINT-TO-MULTIPOINT COMMUNICATIONS

10.1 SERVICE VIA SATELLITE FOR THE DISSEMINATION OF AERONAUTICAL INFORMATION

10.1.1 Point-to-multipoint telecommunication service via satellite to support the dissemination of aeronautical information shall be based on full-time, non pre-emptible, protected services as defined in the relevant CCITT Recommendations.

10.2 SERVICE VIA SATELLITE FOR THE DISSEMINATION OF WAFS PRODUCTS

10.2.1 **Recommendation.—** *System characteristics should include the following:*

a) frequency — C-band, earth-to-satellite, 6 GHz band, satellite-to-earth, 4 GHz band;

b) capacity with effective signalling rate of not less than 9 600 bits/s;

c) bit error rates — better than 1 in 10^7;

d) forward error correction; and

e) availability 99.95 per cent.

CHAPTER 11. HF DATA LINK

11.1 DEFINITIONS AND SYSTEM CAPABILITIES

Note.— The following Standards and Recommended Practices are specific to the high frequency data link (HFDL) and are in addition to the requirements specified in the ITU Radio Regulations (Appendix 27). The HFDL is a constituent mobile subnetwork of the aeronautical telecommunication network (ATN), operating in the aeronautical mobile (R) high frequency bands. In addition, the HFDL may provide non-ATN functions, such as direct link service (DLS). The HFDL system must enable aircraft to exchange data with ground-based users.

11.1.1 Definitions

Coded chip. A "1" or "0" output of the rate ½ or ¼ convolutional code encoder.

Designated operational coverage (DOC) area. The area in which a particular service is provided and in which the service is afforded frequency protection.

Note.— This area may, after proper co-ordination to ensure frequency protection, extend to areas outside the allotment areas contained in Appendix S27 to the Radio Regulations.

Direct link service (DLS). A data communications service which makes no attempt to automatically correct errors, detected or undetected, at the link layer of the air-ground communications path. (Error control may be effected by end-user systems.)

High frequency network protocol data unit (HFNPDU). User data packet.

Link protocol data unit (LPDU). Data unit which encapsulates a segment of an HFNPDU.

Media access protocol data unit (MPDU). Data unit which encapsulates one or more LPDUs.

M-ary phase shift keying (M-PSK) modulation. A digital phase modulation that causes the phase of the carrier waveform to take on one of a set of M values.

M-PSK symbol. One of the M possible phase shifts of the M-PSK modulated carrier representing a group of $\log_2$ M coded chips.

Peak envelope power (PEP). The peak power of the modulated signal supplied by the transmitter to the antenna transmission line.

Physical layer protocol data unit (PPDU). Data unit passed to the physical layer for transmission, or decoded by the physical layer after reception.

Quality of service (QOS). The information relating to data transfer characteristics used by various communications protocols to achieve various levels of performance for network users.

Reliable link service (RLS). A data communications service provided by the subnetwork which automatically provides for error control over its link through error detection and requested retransmission of signal units found to be in error.

Squitter protocol data unit (SPDU). Data packet which is broadcast every 32 seconds by an HFDL ground station on each of its operating frequencies, and which contains link management information.

11.2 HF DATA LINK SYSTEM

11.2.1 System architecture

The HFDL system shall consist of one or more ground and aircraft station sub-systems, which implement the HFDL protocol (see 11.3). The HFDL system shall also include a ground management sub-system (see 11.4).

11.2.1.1 AIRCRAFT AND GROUND STATION SUB-SYSTEMS

The HFDL aircraft station sub-system and the HFDL ground station sub-system shall include the following functions:

a) HF transmission and reception;

b) data modulation and demodulation; and

c) HFDL protocol implementation and frequency selection.

11.2.2 Operational coverage

Frequency assignments for HFDL shall be protected throughout their designated operational coverage (DOC) area.

Note 1.— Designated operational coverage (DOC) areas may be different from current MWARAs or RDARAs as defined in Appendix 27 to the ITU Radio Regulations.

Note 2.— Additional co-ordination with ITU is required in cases where DOC areas are not in conformity with the allotment areas specified in the ITU Radio Regulations.

11.2.3 Requirements for carriage of HFDL equipment

Requirements for mandatory carriage of HFDL equipment shall be made on the basis of regional air navigation agreements that specify the airspace of operation and the implementation time-scale.

11.2.3.1 NOTICE

The agreement above shall provide advance notice of at least two years for the mandatory carriage of airborne systems.

11.2.4 Ground station networking

11.2.4.1 **Recommendation.—** *HFDL ground station sub-systems should interconnect through a common ground management sub-system.*

Note.— This provides a distributed subnetwork, with a subnetwork point of attachment (SNPA), depending on the method of implementation, which allows for the maintenance of virtual circuit connections as aircraft stations transition between designated operational coverage areas. The distribution may be multi-regional or world-wide.

11.2.5 Ground station synchronization

Synchronization of HFDL ground station sub-systems shall be to within ±25 ms of UTC. For any station not operating within ±25 ms of UTC, appropriate notification shall be made to all aircraft and ground station sub-systems to allow for continued system operation.

11.2.6 Quality of service

11.2.6.1 RESIDUAL PACKET ERROR RATE

The undetected error rate for a network user packet which contains between 1 and 128 octets of user data shall be equal to or less than 1 in 10^6.

11.2.6.2 SPEED OF SERVICE

Transit and transfer delays for network user packets (128 octets) with priorities defined in Part I, Chapter 4, Table 4-26 for message priorities 7 through 14, shall not exceed the values of Table 11-1.

Table 11-1. Transfer delays

	Direction	*Priority*	*Delay*
Transit delay	To-aircraft	7 through 14	45 s
	From-aircraft	7 through 14	60 s
Transfer delay (95 percentile)	To-aircraft	11 through 14	90 s
		7 through 10	120 s
	From-aircraft	11 through 14	150 s
		7 through 10	250 s

11.3 HF DATA LINK PROTOCOL

The HFDL protocol shall consist of a physical layer, a link layer, and a subnetwork layer, as specified below.

Note.— The HFDL protocol is a layered protocol and is compatible with the open systems interconnection (OSI) reference model. It permits the HFDL to function as an aeronautical telecommunication network (ATN)-compatible subnetwork. The details of the protocol are described in the Manual on HF Data Link *(Doc 9741).*

11.3.1 Physical layer RF characteristics

The aircraft and ground stations shall access the physical medium operating in simplex mode.

11.3.1.1 FREQUENCY BANDS

HFDL installations shall be capable of operating at any single sideband (SSB) carrier (reference) frequency available to the aeronautical mobile (R) service in the band 2.8 to 22 MHz, and in compliance with the relevant provisions of the Radio Regulations.

11.3.1.2 CHANNELS

Channel utilization shall be in conformity with the table of carrier (reference) frequencies of Appendix 27 to the ITU Radio Regulations.

11.3.1.3 TUNING

The equipment shall be capable of operating on integral multiples of 1 kHz.

11.3.1.4 SIDEBAND

The sideband used for transmission shall be on the higher side of its carrier (reference) frequency.

11.3.1.5 MODULATION

HFDL shall employ M-ary phase shift keying (M-PSK) to modulate the radio frequency carrier at the assigned frequency. The symbol rate shall be 1 800 symbols per second ±10 parts per million (i.e. 0.018 symbols per second). The value of M and the information data rate shall be as specified in Table 11-2.

Table 11-2. Value of M and information data rate

M	*Information data rate (bits per second)*
2	300 or 600
4	1 200
8	1 800

Note.— When M equals the value 2, the data rate may be 300 or 600 bits per second as determined by the channel coding rate. The value of M may change from one data transmission to another depending on the data rate selected. The channel coding rate is described in the Manual on HF Data Link *(Doc 9741).*

11.3.1.5.1 *M-PSK CARRIER*

The M-PSK carrier expressed mathematically shall be defined as:

$s(t) = A\Sigma(p(t-kT)\cos[2\pi f_0 t + \varphi(k)]),\ k = 0, 1 \ldots, N-1$

where:

N	=	number of M-PSK symbols in transmitted physical layer protocol data unit (PPDU)
s(t)	=	analog waveform or signal at time t
A	=	peak amplitude
f_0	=	SSB carrier (reference) + 1 440 Hz
T	=	M-PSK symbol period (1/1 800 s)
φ(k)	=	phase of kth M-PSK symbol
p(t-kT)	=	pulse shape of kth M-PSK symbol at time t.

Note.— The number of M-PSK symbols sent, N, defines the length (duration = NT seconds) of the PPDU. These parameters are defined in the Manual on HF Data Link *(Doc 9741).*

11.3.1.5.2 *PULSE SHAPE*

The pulse shape, p(t), shall determine the spectral distribution of the transmitted signal. The Fourier transform of the pulse shape, P(f), shall be defined by:

$P(f) = 1,\quad \text{if } 0 < |f| < (1 - b)/2T$

$P(f) = \cos\{\pi(2|f|T - 1 + b)/4b\},\quad \text{if } (1 - b)/2T < |f| < (1 + b)/2T$

$P(f) = 0,\quad \text{if } |f| > (1 + b)/2T$

where the spectral roll-off parameter, b = 0.31, has been chosen so that the –20 dB points of the signal are at SSB carrier (reference) + 290 Hz and SSB carrier (reference) + 2 590 Hz and the peak-to-average power ratio of the waveform is less than 5 dB.

11.3.1.6 TRANSMITTER STABILITY

The basic frequency stability of the transmitting function shall be better than:

a) ±20 Hz for HFDL aircraft station sub-systems; and

b) ±10 Hz for HFDL ground station sub-systems.

11.3.1.7 RECEIVER STABILITY

The basic frequency stability of the receiving function shall be such that, with the transmitting function stability specified in 11.3.1.6, the over-all frequency difference between ground and airborne functions achieved in service does not exceed 70 Hz.

11.3.1.8 PROTECTION

A 15 dB desired to undesired (D/U) signal ratio shall apply for the protection of co-channel assignments for HFDL as follows:

a) data versus data;

b) data versus voice; and

c) voice versus data.

11.3.1.9 CLASS OF EMISSION

The class of emission shall be 2K80J2DEN.

11.3.1.10 ASSIGNED FREQUENCY

The HFDL assigned frequency shall be 1 400 Hz higher than the SSB carrier (reference) frequency.

Note.— By convention, the HFDL assigned frequency is offset from the SSB carrier (reference) frequency by 1 400 Hz. The HFDL M-PSK carrier of the digital modulation is offset from the SSB carrier (reference) frequency by 1 440 Hz. The digital modulation is fully contained within the same overall channel bandwidth as the voice signal and complies with the provisions of Appendix 27 to the ITU Radio Regulations.

11.3.1.11 EMISSION LIMITS

For HFDL aircraft and ground station transmitters, the peak envelope power (P_p) of any emission on any discrete frequency shall be less than the peak envelope power (P_p) of the transmitter in accordance with the following (see Figure 11-1):

a) on any frequency between 1.5 kHz and 4.5 kHz lower than the HFDL assigned frequency, and on any frequency between 1.5 kHz and 4.5 kHz higher than the HFDL assigned frequency: at least 30 dB;

b) on any frequency between 4.5 kHz and 7.5 kHz lower than the HFDL assigned frequency, and on any frequency between 4.5 kHz and 7.5 kHz higher than the HFDL assigned frequency: at least 38 dB; and

c) on any frequency lower than 7.5 kHz below the HFDL assigned frequency and on any frequency higher than 7.5 kHz above the HFDL assigned frequency:

1) HFDL aircraft station transmitters: 43 dB;

2) HFDL ground station transmitters up to and including 50 W:

[43 + 10 $\log_{10} P_p$(W)] dB; and

3) HFDL ground station transmitters more than 50 W: 60 dB.

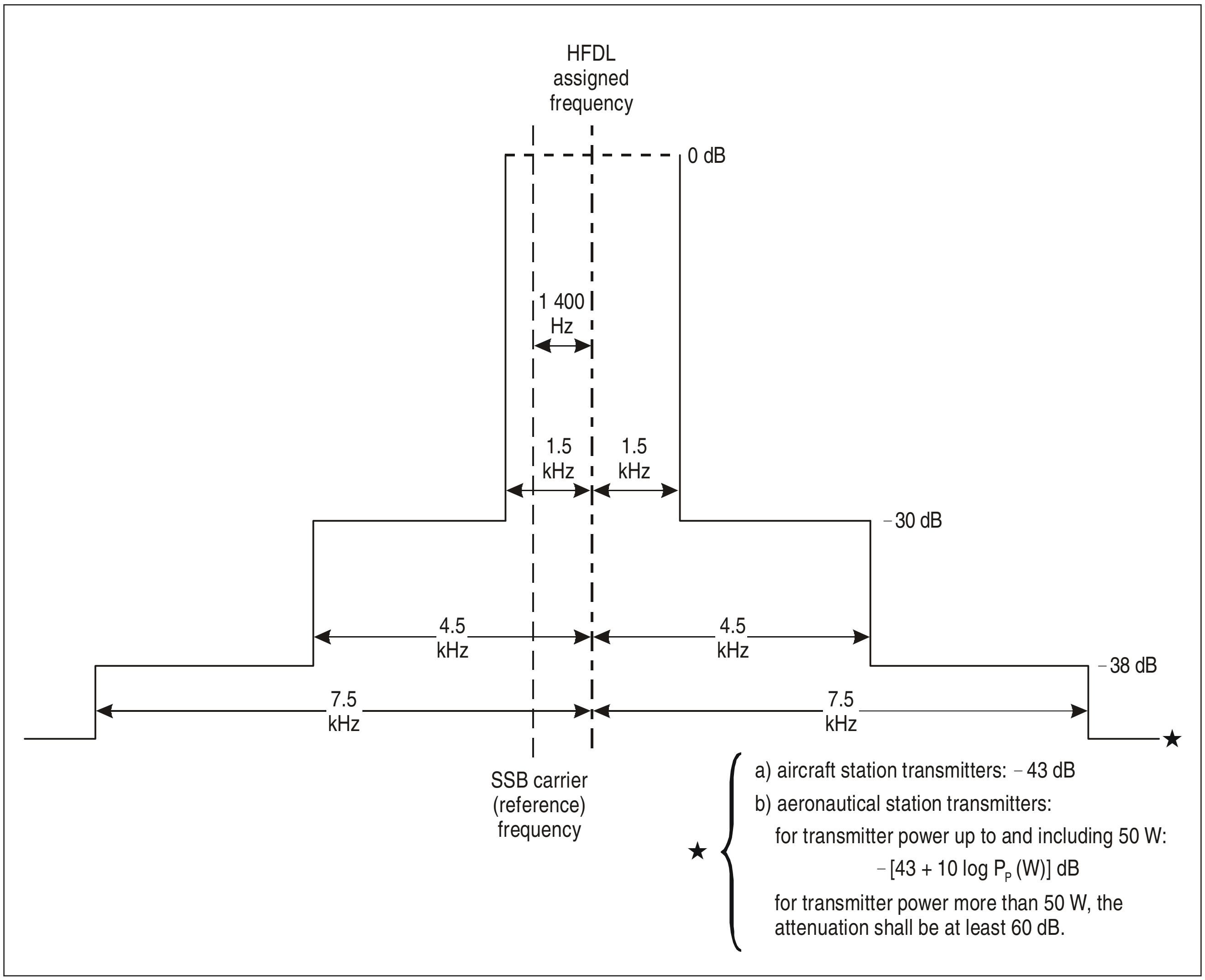

Figure 11-1. Required spectrum limits (in terms of peak power) for HFDL aircraft and ground station transmitters

11.3.1.12 POWER

11.3.1.12.1 *Ground station installations*. The peak envelope power (P_p) supplied to the antenna transmission line shall not exceed a maximum value of 6 kW as provided for in Appendix 27 of the Radio Regulations.

11.3.1.12.2 *Aircraft station installations*. The peak envelope power supplied to the antenna transmission line shall not exceed 400 W, except as provided for in Appendix 27/62 of the Radio Regulations.

11.3.1.13 UNDESIRED SIGNAL REJECTION

For HFDL aircraft and ground station receivers, undesired input signals shall be attenuated in accordance with the following:

a) on any frequency between f_c and (f_c – 300 Hz), or between (f_c + 2 900 Hz) and (f_c + 3 300 Hz): at least 35 dB below the peak of the desired signal level; and

b) on any frequency below (f_c – 300 Hz), or above (f_c + 3 300 Hz): at least 60 dB below the peak of the desired signal level,

where f_c is the carrier (reference) frequency.

11.3.1.14 RECEIVER RESPONSE TO TRANSIENTS

Recommendation.— *The receiving function should recover from an instantaneous increase in RF power at the antenna terminal of 60 dB within 10 milliseconds. The receiving function should recover from an instantaneous decrease in RF power at the antenna terminal of 60 dB within 25 milliseconds.*

11.3.2 Physical layer functions

11.3.2.1 FUNCTIONS

The functions provided by the physical layer shall include the following:

a) transmitter and receiver control;

b) transmission of data; and

c) reception of data.

11.3.2.2 TRANSMITTER AND RECEIVER CONTROL

The HFDL physical layer shall implement the transmitter/receiver switching and frequency tuning as commanded by the link layer. The physical layer shall perform transmitter keying on demand from the link layer to transmit a packet.

11.3.2.2.1 *TRANSMITTER TO RECEIVER TURNAROUND TIME*

The transmitted power level shall decay at least by 10 dB within 100 milliseconds after completing a transmission. An HFDL station sub-system shall be capable of receiving and demodulating, with nominal performance, an incoming signal within 200 milliseconds of the start of the subsequent receive slot.

11.3.2.2.2 *RECEIVER TO TRANSMITTER TURNAROUND TIME*

An HFDL station sub-system shall provide nominal output power within plus or minus 1 dB to the antenna transmission line within 200 milliseconds of the start of the transmit slot.

11.3.2.3 TRANSMISSION OF DATA

Transmission of data shall be accomplished using a time division multiple access (TDMA) technique. The HFDL data link ground station sub-systems shall maintain TDMA frame and slot synchronization for the HFDL system. To ensure that slot synchronization is maintained, each HF data link modulator shall begin outputting a pre-key segment at the beginning of a time slot plus or minus 10 milliseconds.

11.3.2.3.1 *TDMA STRUCTURE*

Each TDMA frame shall be 32 seconds. Each TDMA frame shall be divided into thirteen equal duration slots as follows:

a) the first slot of each TDMA frame shall be reserved for use by the HFDL ground station sub-system to broadcast link management data in SPDU packets; and

b) the remaining slots shall be designated either as uplink slots, downlink slots reserved for specific HFDL aircraft station sub-systems, or as downlink random access slots for use by all HFDL aircraft station sub-systems on a contention basis. These TDMA slots shall be assigned on a dynamic basis using a combination of reservation, polling and random access assignments.

11.3.2.3.2 *BROADCAST*

The HFDL ground station sub-system shall broadcast a squitter protocol data unit (SPDU) every 32 seconds on each of its operating frequencies.

Note.— Details on the TDMA frame and slot structures, pre-key segment, data structures, including the SPDU, are contained in the Manual on HF Data Link *(Doc 9741).*

11.3.2.4 RECEPTION OF DATA

11.3.2.4.1 *FREQUENCY SEARCH*

Each HFDL aircraft station shall automatically search the assigned frequencies until it detects an operating frequency.

11.3.2.4.2 *RECEPTION OF PPDUS*

The HF data link receiver shall provide the means to detect, synchronize, demodulate and decode PPDUs modulated according to the waveform defined in 11.3.1.5, subject to the following distortion:

a) the 1 440 Hz audio carrier offset by plus or minus 70 Hz;

b) discrete and/or diffuse multipath distortion with up to 5 ms multipath spread;

c) multipath amplitude fading with up to 2 Hz two-sided RMS Doppler spread and Rayleigh statistics; and

d) additive Gaussian and broadband impulsive noise with varying amplitude and random arrival times.

Note.— Reference CCIR Report 549-2.

11.3.2.4.3 *DECODING OF PPDUS*

Upon receipt of the preamble segment the receiver shall:

a) detect the beginning of a burst of data;

b) measure and correct the frequency offset between the transmitter and receiver due to Doppler shift and transmitter/receiver frequency offsets;

c) determine the data rate and interleaver settings to use during data demodulation;

d) achieve M-PSK symbol synchronization; and

e) train the equalizer.

11.3.2.4.4 *SYNCHRONIZATION*

Each HFDL aircraft station sub-system shall synchronize its slot timing to that of its corresponding ground station with respect to the reception time of the last received SPDU.

11.3.2.4.5 *SPECIFIED PACKET ERROR RATE PERFORMANCE*

The number of HFDL media access protocol data units (MPDUs) received with one or more bit errors shall not exceed 5 per cent of the total number of MPDUs received, when using a 1.8 second interleaver and under the signal-in-space conditions shown in Table 11-3.

Recommendation.— *The number of HFDL MPDUs received with one or more bit errors should not exceed 5 per cent of the total number of MPDUs received, when using a 1.8 second interleaver under the conditions shown in Table 11-3a.*

11.3.3 Link layer

Note.— Details on link layer functions are contained in the Manual on HF Data Link *(Doc 9741).*

The link layer shall provide control functions for the physical layer, link management and data service protocols.

11.3.3.1 CONTROL FUNCTIONS

The link layer shall pass commands for frequency tuning, transmitter keying and transmitter/receiver switching to the physical layer.

11.3.3.2 LINK MANAGEMENT

The link layer shall manage TDMA slot assignments, log-on and log-off procedures, ground station and aircraft station TDMA synchronization, and other functions necessary, taking into account message priority, for the establishment and maintenance of communications.

11.3.3.3 DATA SERVICE PROTOCOLS

The link layer shall support a reliable link service (RLS) protocol and a direct link service (DLS) protocol.

11.3.3.3.1 *RLS*

The RLS protocol shall be used to exchange acknowledged user data packets between aircraft and ground peer link layers.

11.3.3.3.2 *DLS*

The DLS protocol shall be used to broadcast unsegmented uplink high frequency network protocol data units (HFNPDUs) and other HFNPDUs not requiring automatic retransmission by the link layer.

11.3.4 Subnetwork layer

Note.— Details on subnetwork layer protocols and services are contained in the Manual on HF Data Link *(Doc 9741).*

11.3.4.1 PACKET DATA

The HFDL subnetwork layer in the HFDL aircraft station sub-system and HFDL ground station sub-system shall provide connection-oriented packet data service by establishing subnetwork connections between subnetwork service users.

11.3.4.2 CONNECTIVITY NOTIFICATION SERVICE

The HFDL subnetwork layer in the HFDL aircraft station sub-system shall provide the additional connectivity notification service by sending connectivity notification event messages to the attached ATN router.

11.3.4.2.1 *CONNECTIVITY NOTIFICATION EVENT MESSAGES*

The connectivity notification service shall send connectivity notification event messages to the attached ATN router through the subnetwork access function.

11.3.4.3 HFDL SUBNETWORK LAYER FUNCTIONS

The HFDL subnetwork layer in both the HFDL aircraft station sub-system and HFDL ground station sub-system shall include the following three functions:

a) HFDL subnetwork dependent (HFSND) function;

b) subnetwork access function; and

c) interworking function.

11.3.4.3.1 *HFSND FUNCTION*

The HFSND function shall perform the HFSND protocol between each pair of HFDL aircraft station sub-systems and HFDL ground station sub-systems by exchanging HFNPDUs. It shall perform the HFSND protocol aircraft function in the HFDL aircraft station sub-system and the HFSND protocol ground function in the HFDL ground station sub-system.

11.3.4.3.2 *SUBNETWORK ACCESS FUNCTION*

The subnetwork access function shall perform the ISO 8208 protocol between the HFDL aircraft station sub-system or HFDL ground station sub-system and the attached routers by exchanging ISO 8208 packets. It shall perform the ISO 8208 DCE function in the HFDL aircraft station sub-system and the HFDL ground station sub-system.

11.3.4.3.3 *INTERWORKING FUNCTION*

The interworking function shall provide the necessary harmonization functions between the HFSND, the subnetwork access and the connectivity notification functions.

11.4 GROUND MANAGEMENT SUB-SYSTEM

Note.— Details on the ground management sub-system functions and interfaces are contained in the Manual on HF Data Link *(Doc 9741).*

11.4.1 Management functions

The ground management sub-system shall perform the functions necessary to establish and maintain communications channels between the HFDL ground and aircraft station sub-systems.

11.4.2 Management/control information exchange

The ground management sub-system shall interface with the ground station sub-system in order to exchange control information required for frequency management, system table management, log status management, channel management, and quality of service (QOS) data collection.

Table 11-3. HF signal-in-space conditions

Data rate (bits per second)	*Number of channel paths*	*Multipath spread (milliseconds)*	*Fading bandwidth (Hz) per CCIR Report 549-2*	*Frequency offset (Hz)*	*Signal to noise ratio (dB) in a 3 kHz bandwidth*	*MPDU size (octets)*
1 200	1 fixed	–	–	40	4	256
1 800	2 fading	2	1	40	16	400
1 200	2 fading	2	1	40	11.5	256
600	2 fading	2	1	40	8	128
300	2 fading	2	1	40	5	64

Table 11-3a. HF signal-in-space conditions

Data rate (bits per second)	*Number of channel paths*	*Multipath spread (milliseconds)*	*Fading bandwidth (Hz) per CCIR Report 549-2*	*Frequency offset (Hz)*	*Signal to noise ratio (dB) in a 3 kHz bandwidth*	*MPDU size (octets)*
1 200	2 fading	4	1	40	13	256
1 200	2 fading	2	2	40	11.5	256

11.3.2.4 RECEPTION OF DATA

11.3.2.4.1 *FREQUENCY SEARCH*

Each HFDL aircraft station shall automatically search the assigned frequencies until it detects an operating frequency.

11.3.2.4.2 *RECEPTION OF PPDUS*

The HF data link receiver shall provide the means to detect, synchronize, demodulate and decode PPDUs modulated according to the waveform defined in 11.3.1.5, subject to the following distortion:

a) the 1 440 Hz audio carrier offset by plus or minus 70 Hz;

b) discrete and/or diffuse multipath distortion with up to 5 ms multipath spread;

c) multipath amplitude fading with up to 2 Hz two-sided RMS Doppler spread and Rayleigh statistics; and

d) additive Gaussian and broadband impulsive noise with varying amplitude and random arrival times.

Note.— Reference CCIR Report 549-2.

11.3.2.4.3 *DECODING OF PPDUS*

Upon receipt of the preamble segment the receiver shall:

a) detect the beginning of a burst of data;

b) measure and correct the frequency offset between the transmitter and receiver due to Doppler shift and transmitter/receiver frequency offsets;

c) determine the data rate and interleaver settings to use during data demodulation;

d) achieve M-PSK symbol synchronization; and

e) train the equalizer.

11.3.2.4.4 *SYNCHRONIZATION*

Each HFDL aircraft station sub-system shall synchronize its slot timing to that of its corresponding ground station with respect to the reception time of the last received SPDU.

11.3.2.4.5 *SPECIFIED PACKET ERROR RATE PERFORMANCE*

The number of HFDL media access protocol data units (MPDUs) received with one or more bit errors shall not exceed 5 per cent of the total number of MPDUs received, when using a 1.8 second interleaver and under the signal-in-space conditions shown in Table 11-3.

Recommendation.— *The number of HFDL MPDUs received with one or more bit errors should not exceed 5 per cent of the total number of MPDUs received, when using a 1.8 second interleaver under the conditions shown in Table 11-3a.*

11.3.3 Link layer

Note.— Details on link layer functions are contained in the Manual on HF Data Link *(Doc 9741).*

The link layer shall provide control functions for the physical layer, link management and data service protocols.

11.3.3.1 CONTROL FUNCTIONS

The link layer shall pass commands for frequency tuning, transmitter keying and transmitter/receiver switching to the physical layer.

11.3.3.2 LINK MANAGEMENT

The link layer shall manage TDMA slot assignments, log-on and log-off procedures, ground station and aircraft station TDMA synchronization, and other functions necessary, taking into account message priority, for the establishment and maintenance of communications.

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11.3.4.3.3 *INTERWORKING FUNCTION*

The interworking function shall provide the necessary harmonization functions between the HFSND, the subnetwork access and the connectivity notification functions.

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1 200	2 fading	2	1	40	11.5	256
600	2 fading	2	1	40	8	128
300	2 fading	2	1	40	5	64

Table 11-3a. HF signal-in-space conditions

Data rate (bits per second)	*Number of channel paths*	*Multipath spread (milliseconds)*	*Fading bandwidth (Hz) per CCIR Report 549-2*	*Frequency offset (Hz)*	*Signal to noise ratio (dB) in a 3 kHz bandwidth*	*MPDU size (octets)*
1 200	2 fading	4	1	40	13	256
1 200	2 fading	2	2	40	11.5	256

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

PART II — VOICE COMMUNICATION SYSTEMS

CHAPTER 1. DEFINITIONS

Note.— Material on secondary power supply and guidance material concerning reliability and availability for communication systems is contained in Annex 10, Volume I, 2.9 and Volume I, Attachment F, respectively.

CHAPTER 2. AERONAUTICAL MOBILE SERVICE

2.1 AIR-GROUND VHF COMMUNICATION SYSTEM CHARACTERISTICS

Note.— In the following text the channel spacing for 8.33 kHz channel assignments is defined as 25 kHz divided by 3 which is 8.3333 ... kHz.

2.1.1 The characteristics of the air-ground VHF communication system used in the International Aeronautical Mobile Service shall be in conformity with the following specifications:

2.1.1.1 Radiotelephone emissions shall be double sideband (DSB) amplitude modulated (AM) carriers. The designation of emission is A3E, as specified in the ITU Radio Regulations.

2.1.1.2 Spurious emissions shall be kept at the lowest value which the state of technique and the nature of the service permit.

Note.— Appendix S3 to the ITU Radio Regulations specifies the levels of spurious emissions to which transmitters must conform.

2.1.1.3 The radio frequencies used shall be selected from the radio frequencies in the band 117.975 – 137 MHz. The separation between assignable frequencies (channel spacing) and frequency tolerances applicable to elements of the system shall be as specified in Volume V.

Note.— The band 117.975 – 132 MHz was allocated to the Aeronautical Mobile (R) Service in the ITU Radio Regulations (1947). By subsequent revisions at ITU World Administrative Radio Conferences the bands 132 – 136 MHz and 136 – 137 MHz were added under conditions which differ for ITU Regions, or for specified countries or combinations of countries (see RRs S5.203, S5.203A and S5.203B for additional allocations in the band 136 – 137 MHz, and S5.201 for the band 132 – 136 MHz).

2.1.1.4 The design polarization of emissions shall be vertical.

2.2 SYSTEM CHARACTERISTICS OF THE GROUND INSTALLATION

2.2.1 Transmitting function

2.2.1.1 *Frequency stability.* The radio frequency of operation shall not vary more than plus or minus 0.005 per cent from the assigned frequency. Where 25 kHz channel spacing is introduced in accordance with Volume V, the radio frequency of operation shall not vary more than plus or minus 0.002 per cent from the assigned frequency. Where 8.33 kHz channel spacing is introduced in accordance with Volume V, the radio frequency of operation shall not vary more than plus or minus 0.0001 per cent from the assigned frequency.

Note.— The above tolerances will not be suitable for offset carrier systems.

2.2.1.1.1 Offset carrier systems in 25 kHz, 50 kHz and 100 kHz channel spaced environments. The stability of individual carriers of an offset carrier system shall be such as to prevent first-order heterodyne frequencies of less than 4 kHz and, additionally, the maximum frequency excursion of the outer carrier frequencies from the assigned carrier frequency shall not exceed 8 kHz. Offset carrier systems shall not be used on 8.33 kHz spaced channels.

Note.— Examples of the required stability of the individual carriers of offset carrier systems may be found at Attachment A to Part II.

2.2.1.2 POWER

Recommendation.— *On a high percentage of occasions, the effective radiated power should be such as to provide a field strength of a least 75 microvolts per metre (minus 109 dBW/m^2) within the defined operational coverage of the facility, on the basis of free space propagation.*

2.2.1.3 *Modulation.* A peak modulation factor of at least 0.85 shall be achievable.

2.2.1.4 **Recommendation.—** *Means should be provided to maintain the average modulation factor at the highest practicable value without overmodulation.*

2.2.2 Receiving function

2.2.2.1 *Frequency stability.* Where 8.33 kHz channel spacing is introduced in accordance with Volume V, the radio frequency of operation shall not vary more than plus or minus 0.0001 per cent from the assigned frequency.

2.2.2.2 *Sensitivity.* After due allowance has been made for feeder loss and antenna polar diagram variation, the sensitivity of the receiving function shall be such as to provide on a high percentage of occasions an audio output signal with a wanted/unwanted ratio of 15 dB, with a 50 per cent amplitude modulated (A3E) radio signal having a field strength of 20 microvolts per metre (minus 120 dBW/m^2) or more.

2.2.2.3 *Effective acceptance bandwidth.* When tuned to a channel having a width of 25 kHz, 50 kHz or 100 kHz, the receiving system shall provide an adequate and intelligible audio output when the signal specified at 2.2.2.2 above has a carrier frequency within plus or minus 0.005 per cent of the assigned frequency. When tuned to a channel having a width of 8.33 kHz, the receiving system shall provide an adequate and intelligible audio output when the signal specified at 2.2.2.2 above has a carrier frequency within plus or minus 0.0005 per cent of the assigned frequency. Further information on the effective acceptance bandwidth is contained in Attachment A to Part II.

Note.— The effective acceptance bandwidth includes Doppler shift.

2.2.2.4 *Adjacent channel rejection.* The receiving system shall ensure an effective rejection of 60 dB or more at the next assignable channel.

Note.— The next assignable frequency will normally be plus or minus 50 kHz. Where this channel spacing will not suffice, the next assignable frequency will be plus or minus 25 kHz, or plus or minus 8.33 kHz, implemented in accordance with the provisions of Volume V. It is recognized that in certain areas of the world receivers designed for 25 kHz, 50 kHz or 100 kHz channel spacing may continue to be used.

2.3 SYSTEM CHARACTERISTICS OF THE AIRBORNE INSTALLATION

2.3.1 Transmitting function

2.3.1.1 *Frequency stability.* The radio frequency of operation shall not vary more than plus or minus 0.005 per cent from the assigned frequency. Where 25 kHz channel spacing is introduced, the radio frequency of operation shall not vary more than plus or minus 0.003 per cent from the assigned frequency. Where 8.33 kHz channel spacing is introduced, the radio frequency of operation shall not vary more than plus or minus 0.0005 per cent from the assigned frequency.

2.3.1.2 *Power.* On a high percentage of occasions, the effective radiated power shall be such as to provide a field strength of at least 20 microvolts per metre (minus 120 dBW/m^2) on the basis of free space propagation, at ranges and altitudes appropriate to the operational conditions pertaining to the areas over which the aircraft is operated.

2.3.1.3 *Adjacent channel power.* The amount of power from a 8.33 kHz airborne transmitter under all operating conditions when measured over a 7 kHz channel bandwidth centred on the first 8.33 kHz adjacent channel shall not exceed –45 dB below the transmitter carrier power. The above adjacent channel power shall take into account the typical voice spectrum.

Note.— The voice spectrum is assumed to be a constant level between 300 and 800 Hz and attenuated by 10 dB per octave above 800 Hz.

2.3.1.4 *Modulation.* A peak modulation factor of at least 0.85 shall be achievable.

2.3.1.5 **Recommendation.—** *Means should be provided to maintain the average modulation factor at the highest practicable value without overmodulation.*

2.3.2 Receiving function

2.3.2.1 *Frequency stability.* Where 8.33 kHz channel spacing is introduced in accordance with Volume V, the radio frequency of operation shall not vary more than plus or minus 0.0005 per cent from the assigned frequency.

2.3.2.2 SENSITIVITY

2.3.2.2.1 **Recommendation.—** *After due allowance has been made for aircraft feeder mismatch, attenuation loss and antenna polar diagram variation, the sensitivity of the receiving function should be such as to provide on a high percentage of occasions an audio output signal with a wanted/unwanted ratio of 15 dB, with a 50 per cent amplitude modulated (A3E) radio signal having a field strength of 75 microvolts per metre (minus 109 dBW/m^2).*

Note.— For planning extended range VHF facilities, an airborne receiving function sensitivity of 30 microvolts per metre may be assumed.

2.3.2.3 *Effective acceptance bandwidth for 100 kHz, 50 kHz and 25 kHz channel spacing receiving installations.* When tuned to a channel designated in Volume V as having a width of 25 kHz, 50 kHz or 100 kHz, the receiving function shall ensure an effective acceptance bandwidth as follows:

a) in areas where offset carrier systems are employed, the receiving function shall provide an adequate audio output when the signal specified at 2.3.2.2 above has a carrier frequency within 8 kHz of the assigned frequency;

b) in areas where offset carrier systems are not employed, the receiving function shall provide an adequate audio output when the signal specified at 2.3.2.2 above has a carrier frequency of plus or minus 0.005 per cent of the assigned frequency.

2.3.2.4 *Effective acceptance bandwidth for 8.33 kHz channel spacing receiving installations.* When tuned to a channel designated in Volume V, as having a width of 8.33 kHz, the receiving function shall provide an adequate audio output when the signal specified at 2.3.2.2 above has a carrier frequency within plus or minus 0.0005 per cent of the assigned frequency. Further information on the effective acceptance bandwidth is contained in Attachment A to Part II.

Note.— The effective acceptance bandwidth includes Doppler shift.

2.3.2.5 *Adjacent channel rejection.* The receiving function shall ensure an effective adjacent channel rejection as follows:

a) *8.33 kHz channels:* 60 dB or more at plus or minus 8.33 kHz with respect to the assigned frequency, and 40 dB or more at plus or minus 6.5 kHz;

Note.— The receiver local oscillator phase noise should be sufficiently low to avoid any degradation of the receiver capability to reject off carrier signals. A phase noise level better than minus 99 dBc/Hz 8.33 kHz away from the carrier is necessary to comply with 45 dB adjacent channel rejection under all operating conditions.

b) *25 kHz channel spacing environment:* 50 dB or more at plus or minus 25 kHz with respect to the assigned frequency and 40 dB or more at plus or minus 17 kHz;

c) *50 kHz channel spacing environment:* 50 dB or more at plus or minus 50 kHz with respect to the assigned frequency and 40 dB or more at plus or minus 35 kHz;

d) *100 kHz channel spacing environment:* 50 dB or more at plus or minus 100 kHz with respect to the assigned frequency.

2.3.2.6 **Recommendation.—** *Whenever practicable, the receiving system should ensure an effective adjacent channel rejection characteristic of 60 dB or more at plus or minus 25 kHz, 50 kHz and 100 kHz from the assigned frequency for receiving systems intended to operate in channel spacing environments of 25 kHz, 50 kHz and 100 kHz respectively.*

Note.— Frequency planning is normally based on an assumption of 60 dB effective adjacent channel rejection at plus or minus 25 kHz, 50 kHz or 100 kHz from the assigned frequency as appropriate to the channel spacing environment.

2.3.2.7 **Recommendation.—** *In the case of receivers complying with 2.3.2.3 above used in areas where offset carrier systems are in force, the characteristics of the receiver should be such that:*

a) the audio frequency response precludes harmful levels of audio heterodynes resulting from the reception of two or more offset carrier frequencies;

b) the receiver muting circuits, if provided, operate satisfactorily in the presence of audio heterodynes resulting from the reception of two or more offset carrier frequencies.

2.3.2.8 *VDL — INTERFERENCE IMMUNITY PERFORMANCE*

2.3.2.8.1 For equipment intended to be used in independent operations of services applying DSB-AM and VDL technology on board the same aircraft, the receiving function shall provide an adequate and intelligible audio output with a desired signal field strength of not more than 150 microvolts per metre (minus 102 dBW/m^2) and with an undesired VDL signal field strength of at least 50 dB above the desired field strength on any assignable channel 100 kHz or more away from the assigned channel of the desired signal.

Note.— This level of VDL interference immunity performance provides a receiver performance consistent with the influence of the VDL RF spectrum mask as specified in Volume III, Part I, 6.3.4 with an effective transmitter/receiver isolation of 68 dB. Better transmitter and receiver performance could result in less isolation required.

2.3.2.8.2 After 1 January 2002, the receiving function of all new installations intended to be used in independent operations of services applying DSB-AM and VDL technology on board the same aircraft shall meet the provisions of 2.3.2.8.1.

2.3.2.8.3 After 1 January 2005, the receiving function of all installations intended to be used in independent operations of services applying DSB-AM and VDL technology on board the same aircraft shall meet the provisions of 2.3.2.8.1, subject to the conditions of 2.3.2.8.4.

2.3.2.8.4 Requirements for mandatory compliance of the provisions of 2.3.2.8.3 shall be made on the basis of regional air navigation agreements which specify the airspace of operation and the implementation timescales.

2.3.2.8.4.1 The agreement indicated in 2.3.2.8.4 shall provide at least two years' notice of mandatory compliance of airborne systems.

2.3.3 Interference immunity performance

2.3.3.1 After 1 January 1998, the VHF communications receiving system shall provide satisfactory performance in the presence of two signal, third-order intermodulation products caused by VHF FM broadcast signals having levels at the receiver input of minus 5 dBm.

2.3.3.2 After 1 January 1998, the VHF communications receiving system shall not be desensitized in the presence of VHF FM broadcast signals having levels at the receiver input of minus 5 dBm.

Note.— Guidance material on immunity criteria to be used for the performance quoted in 2.3.3.1 and 2.3.3.2 above is contained in Attachment A to Part II, 1.3.

2.3.3.3 After 1 January 1995, all new installations of airborne VHF communications receiving systems shall meet the provisions of 2.3.3.1 and 2.3.3.2 above.

2.3.3.4 **Recommendation.—** *Airborne VHF communications receiving systems meeting the immunity performance Standards of 2.3.3.1 and 2.3.3.2 above should be placed into operation at the earliest possible date.*

2.4 SINGLE SIDEBAND (SSB) HF COMMUNICATION SYSTEM CHARACTERISTICS FOR USE IN THE AERONAUTICAL MOBILE SERVICE

2.4.1 The characteristics of the air-ground HF SSB system, where used in the Aeronautical Mobile Service, shall be in conformity with the following specifications.

2.4.1.1 Frequency range

2.4.1.1.1 HF SSB installations shall be capable of operation at any SSB carrier (reference) frequency available to the Aeronautical Mobile (R) Service in the band 2.8 MHz to 22 MHz and necessary to meet the approved assignment plan for the region(s) in which the system is intended to operate, and in compliance with the relevant provisions of the Radio Regulations.

Note 1.— See Introduction to Volume V, Chapter 3, and Figures 2-1 and 2-2.

Note 2.— The ITU World Administrative Radio Conference, Aeronautical Mobile (R) Service, Geneva, 1978, established a new Allotment Plan (Appendix 27, Aer to the Radio Regulations) based on single sideband replacing the earlier double sideband Allotment Plan. The World Radiocommunication Conference 1995 redesignated it as Appendix S.27. Minor editorial changes were made at the World Radiocommunication Conference 1997.

2.4.1.1.2 The equipment shall be capable of operating on integral multiples of 1 kHz.

2.4.1.2 Sideband selection

2.4.1.2.1 The sideband transmitted shall be that on the higher frequency side of its carrier (reference) frequency.

2.4.1.3 Carrier (reference) frequency

2.4.1.3.1 Channel utilization shall be in conformity with the table of carrier (reference) frequencies at 27/16 and the Allotment Plan at 27/186 to 27/207 inclusive (or frequencies established on the basis of 27/21, as may be appropriate) of Appendix S27.

Note.— It is intended that only the carrier (reference) frequency be promulgated in Regional Plans and Aeronautical Publications.

2.4.1.4 Classes of emission and carrier suppression

2.4.1.4.1 The system shall utilize the suppressed carrier class of emission J3E (also J7B and J9B as applicable). When SELCAL is employed as specified in Chapter 3 of Part II, the installation shall utilize class H2B emission.

2.4.1.4.2 By 1 February 1982 aeronautical stations and aircraft stations shall have introduced the appropriate class(es) of emission prescribed in 2.4.1.4.1 above. Effective this date the use of class A3E emission shall be discontinued except as provided in 2.4.1.4.4 below.

2.4.1.4.3 Until 1 February 1982 aeronautical stations and aircraft stations equipped for single sideband operations shall also be equipped to transmit class H3E emission where required to be compatible with reception by double sideband equipment. Effective this date the use of class H3E emission shall be discontinued except as provided in 2.4.1.4.4 below.

2.4.1.4.4 **Recommendation.—** *For stations directly involved in co-ordinated search and rescue operations using the frequencies 3 023 kHz and 5 680 kHz, the class of emission J3E should be used; however, since maritime mobile and land mobile services may be involved, A3E and H3E classes of emission may be used.*

2.4.1.4.5 After 1 April 1981 no new DSB equipment shall be installed.

2.4.1.4.6 Aircraft station transmitters shall be capable of at least 26 dB carrier suppression with respect to peak envelope power (P_p) for classes of emission J3E, J7B or J9B.

2.4.1.4.7 Aeronautical station transmitters shall be capable of 40 dB carrier suppression with respect to peak envelope power (P_p) for classes of emission J3E, J7B or J9B.

2.4.1.5 AUDIO FREQUENCY BANDWIDTH

2.4.1.5.1 For radiotelephone emissions the audio frequencies shall be limited to between 300 and 2 700 Hz and the occupied bandwidth of other authorized emissions shall not exceed the upper limit of J3E emissions. In specifying these limits, however, no restriction in their extension shall be implied in so far as emissions other than J3E are concerned, provided that the limits of unwanted emissions are met (see 2.4.1.7 below).

Note.— For aircraft and aeronautical station transmitter types first installed before 1 February 1983 the audio frequencies will be limited to 3 000 Hz.

2.4.1.5.2 For other authorized classes of emission the modulation frequencies shall be such that the required spectrum limits of 2.4.1.7 below will be met.

2.4.1.6 FREQUENCY TOLERANCE

2.4.1.6.1 The basic frequency stability of the transmitting function for classes of emission J3E, J7B or J9B shall be such that the difference between the actual carrier of the transmission and the carrier (reference) frequency shall not exceed:

— 20 Hz for airborne installations;

— 10 Hz for ground installations.

2.4.1.6.2 The basic frequency stability of the receiving function shall be such that, with the transmitting function stabilities specified in 2.4.1.6.1 above, the over-all frequency difference between ground and airborne functions achieved in service and including Doppler shift, does not exceed 45 Hz. However, a greater frequency difference shall be permitted in the case of supersonic aircraft.

2.4.1.7 SPECTRUM LIMITS

2.4.1.7.1 For aircraft station transmitter types and for aeronautical station transmitters first installed before 1 February 1983 and using single sideband classes of emission H2B, H3E, J3E, J7B or J9B the mean power of any emission on any discrete frequency shall be less than the mean power (P_m) of the transmitter in accordance with the following:

— on any frequency removed by 2 kHz or more up to 6 kHz from the assigned frequency: at least 25 dB;

— on any frequency removed by 6 kHz or more up to 10 kHz from the assigned frequency: at least 35 dB;

— on any frequency removed from the assigned frequency by 10 kHz or more:

a) aircraft station transmitters: 40 dB;

b) aeronautical station transmitters:

$$[43 + 10 \log_{10} P_m \, (W)] \, dB$$

2.4.1.7.2 For aircraft station transmitters first installed after 1 February 1983 and for aeronautical station transmitters in use as of 1 February 1983 and using single sideband classes of emission H2B, H3E, J3E, J7B or J9B, the peak envelope power (P_p) of any emission on any discrete frequency shall be less than the peak envelope power (P_p) of the transmitter in accordance with the following:

— on any frequency removed by 1.5 kHz or more up to 4.5 kHz from the assigned frequency: at least 30 dB;

— on any frequency removed by 4.5 kHz or more up to 7.5 kHz from the assigned frequency: at least 38 dB;

— on any frequency removed from the assigned frequency by 7.5 kHz or more:

a) aircraft station transmitters: 43 dB;

b) aeronautical station transmitters: for transmitter power up to and including 50 W:

$$[43 + 10 \log_{10} P_p \, (W)] \, dB$$

For transmitter power more than 50 W: 60 dB.

Note.— See Figures 2-1 and 2-2.

2.4.1.8 POWER

2.4.1.8.1 *Aeronautical station installations.* Except as permitted by the relevant provisions of Appendix S27 to the ITU Radio Regulations, the peak envelope power (P_p) supplied to the antenna transmission line for H2B, H3E, J3E, J7B or J9B classes of emissions shall not exceed a maximum value of 6 kW.

2.4.1.8.2 *Aircraft station installations.* The peak envelope power supplied to the antenna transmission line for H2B, H3E, J3E, J7B or J9B classes of emission shall not exceed 400 W except as provided for in Appendix S27 of the ITU Radio Regulations as follows:

S27/68 It is recognized that the power employed by aircraft transmitters may, in practice, exceed the limits specified in No. 27/60. However, the use of such increased power (which normally should not exceed 600 $W\ P_p$) shall not cause harmful interference to stations using frequencies in accordance with the technical principles on which the Allotment Plan is based.

S27/60 Unless otherwise specified in Part II of this Appendix, the peak envelope powers supplied to the antenna transmission line shall not exceed the maximum values indicated in the table below; the corresponding peak effective radiated powers being assumed to be equal to two-thirds of these values:

Class of emission	*Stations*	*Max. peak envelope power (P_p)*
H2B, J3E, J7B, J9B, A3E*, H3E* (100% modulation)	Aeronautical stations Aircraft stations	6 kW 400 W
Other emission such as A1A, F1B	Aeronautical stations Aircraft stations	1.5 kW 100 W

* A3E and H3E to be used only on 3 023 kHz and 5 680 kHz.

2.4.1.9 *Method of operation.* Single channel simplex shall be employed.

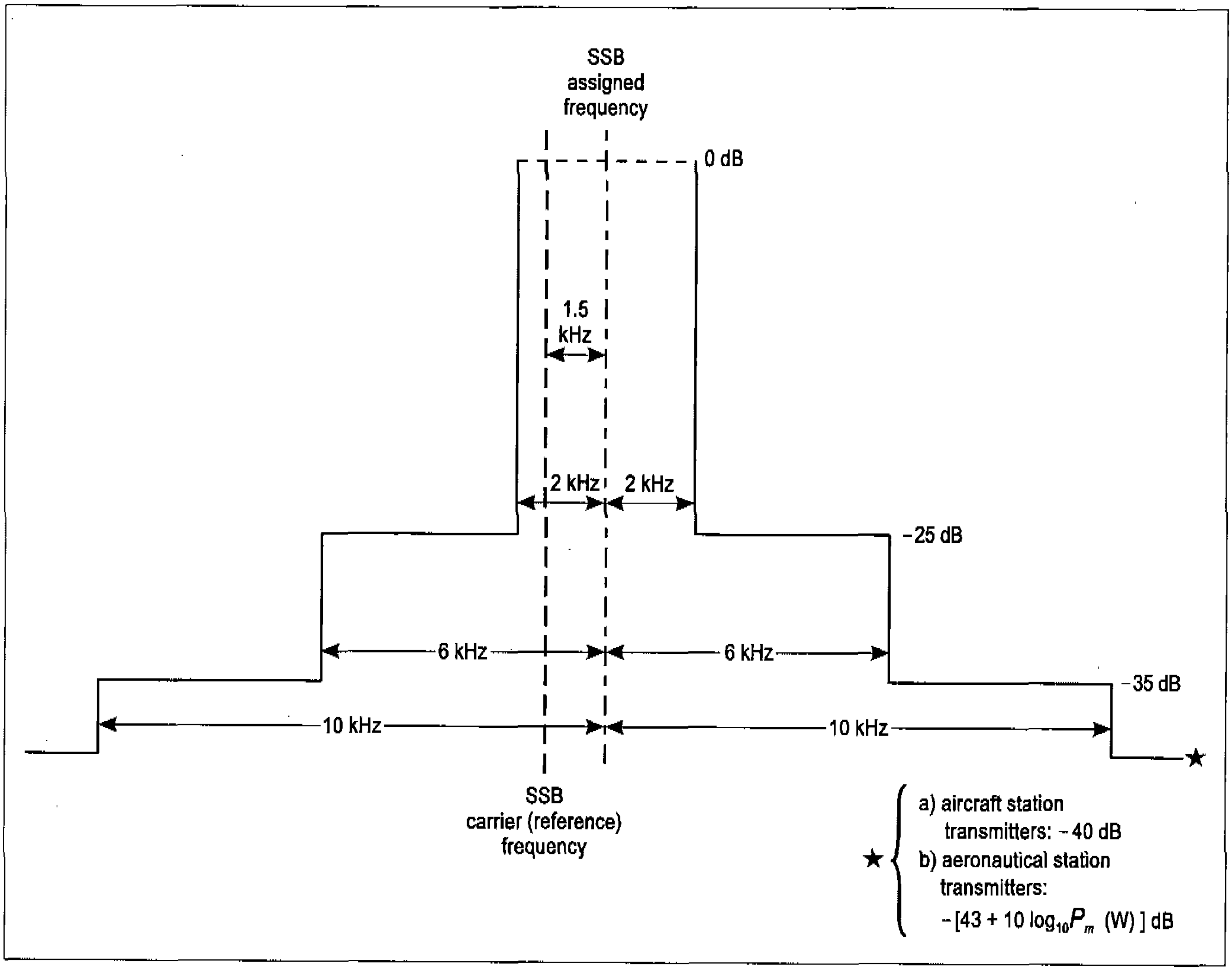

Figure 2-1. Required spectrum limits (in terms of mean power) for aircraft station transmitter types and for aeronautical station transmitters first installed before 1 February 1983

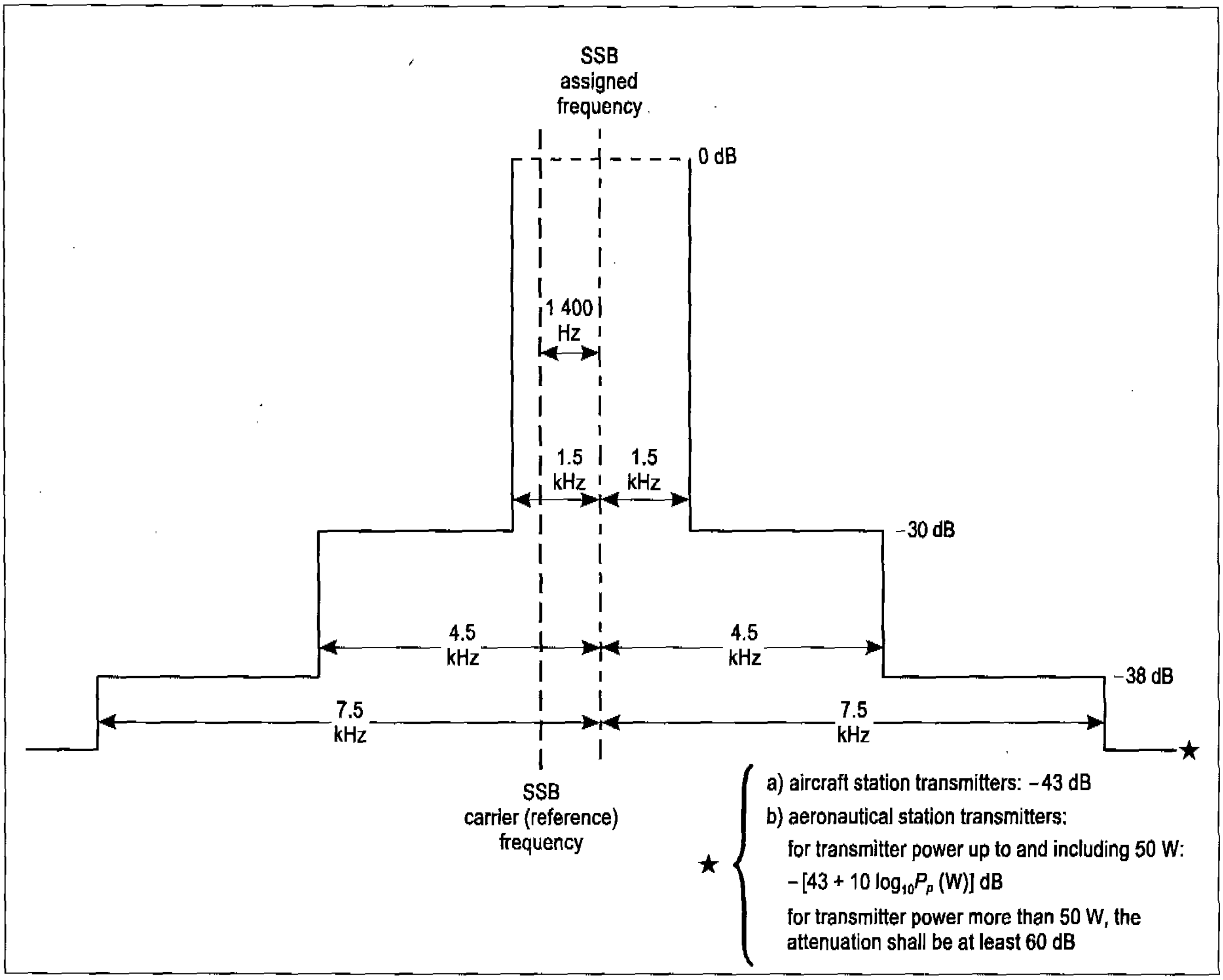

Figure 2-2. Required spectrum limits (in terms of peak power) for aircraft station transmitters first installed after 1 February 1983 and aeronautical station transmitters in use after 1 February 1983

CHAPTER 3. SELCAL SYSTEM

3.1 **Recommendation.—** *Where a SELCAL system is installed, the following system characteristics should be applied:*

a) Transmitted code. *Each transmitted code should be made up of two consecutive tone pulses, with each pulse containing two simultaneously transmitted tones. The pulses should be of 1.0 plus or minus 0.25 seconds duration, separated by an interval of 0.2 plus or minus 0.1 second.*

b) Stability. *The frequency of transmitted tones should be held to plus or minus 0.15 per cent tolerance to ensure proper operation of the airborne decoder.*

c) Distortion. *The over-all audio distortion present on the transmitted RF signal should not exceed 15 per cent.*

d) Per cent modulation. *The RF signal transmitted by the ground radio station should contain, within 3 dB, equal amounts of the two modulating tones. The combination of tones should result in a modulation envelope having a nominal modulation percentage as high as possible and in no case less than 60 per cent.*

e) Transmitted tones. *Tone codes should be made up of various combinations of the tones listed in the following table and designated by colour and letter as indicated:*

Designation	*Frequency (Hz)*
Red A	*312.6*
Red B	*346.7*
Red C	*384.6*
Red D	*426.6*
Red E	*473.2*
Red F	*524.8*
Red G	*582.1*
Red H	*645.7*
Red J	*716.1*
Red K	*794.3*
Red L	*881.0*
Red M	*977.2*
Red P	*1 083.9*
Red Q	*1 202.3*
Red R	*1 333.5*
Red S	*1 479.1*

Note 1.— It should be noted that the tones are spaced by Log^{-1} *0.045 to avoid the possibility of harmonic combinations.*

Note 2.— In accordance with the application principles developed by the Sixth Session of the Communications Division, the only codes at present used internationally are selected from the red group.

Note 3.— Guidance material on the use of SELCAL systems is contained in Attachment A to Part II.

Note 4.— The tones Red P, Red Q, Red R, and Red S are applicable after 1 September 1985, in accordance with 3.2 below.

3.2 As from 1 September 1985, aeronautical stations which are required to communicate with SELCAL-equipped aircraft shall have SELCAL encoders in accordance with the red group in the table of tone frequencies of 3.1 above. After 1 September 1985, SELCAL codes using the tones Red P, Red Q, Red R, and Red S may be assigned.

CHAPTER 4. AERONAUTICAL SPEECH CIRCUITS

4.1 TECHNICAL PROVISIONS RELATING TO INTERNATIONAL AERONAUTICAL SPEECH CIRCUIT SWITCHING AND SIGNALLING FOR GROUND-GROUND APPLICATIONS

Note.— Guidance material on the implementation of aeronautical speech circuit switching and signalling for ground-ground applications is contained in the Manual on Air Traffic Services (ATS) Ground-Ground Voice Switching and Signalling *(Doc 9804). The material includes explanation of terms, perfor-mance parameters, guidance on basic call types and additional functions, references to appropriate ISO/IEC international standards and ITU-T recommendations, guidance on the use of signalling systems, details of the recommended numbering scheme and guidance on migration to future schemes.*

4.1.1 The use of circuit switching and signalling to provide speech circuits to interconnect ATS units not interconnected by dedicated circuits shall be by agreement between the Administrations concerned.

4.1.2 The application of aeronautical speech circuit switching and signalling shall be made on the basis of regional air navigation agreements.

4.1.3 **Recommendation.—** *The ATC communication requirements defined in Annex 11, Section 6.2 should be met by implementation of one or more of the following basic three call types:*

a) instantaneous access;

b) direct access; and

c) indirect access.

4.1.4 **Recommendation.—** *In addition to the ability to make basic telephone calls, the following functions should be provided in order to meet the requirements set out in Annex 11:*

a) means of indicating the calling/called party identity;

b) means of initiating urgent/priority calls; and

c) conference capabilities.

4.1.5 **Recommendation.—** *The characteristics of the circuits used in aeronautical speech circuit switching and signalling should conform to appropriate ISO/IEC inter-national standards and ITU-T recommendations.*

4.1.6 **Recommendation.—** *Digital signalling systems should be used wherever their use can be justified in terms of any of the following:*

a) improved quality of service;

b) improved user facilities; or

c) reduced costs where quality of service is maintained.

4.1.7 **Recommendation.—** *The characteristics of supervisory tones to be used (such as ringing, busy, number unobtainable) should conform to appropriate ITU-T recommendations.*

4.1.8 **Recommendation.—** *To take advantage of the benefits of interconnecting regional and national aeronautical speech networks, the international aeronautical telephone network numbering scheme should be used.*

CHAPTER 5. EMERGENCY LOCATOR TRANSMITTER (ELT) FOR SEARCH AND RESCUE

5.1 GENERAL

5.1.1 Until 1 January 2005, emergency locator transmitters shall operate either on both 406 MHz and 121.5 MHz or on 121.5 MHz.

Note.— From 1 January 2000, ELTs operating on 121.5 MHz will be required to meet the improved technical characteristics contained in 5.2.1.8.

5.1.2 All installations of emergency locator transmitters operating on 406 MHz shall meet the provisions of 5.3.

5.1.3 All installations of emergency locator transmitters operating on 121.5 MHz shall meet the provisions of 5.2.

5.1.4 From 1 January 2005, emergency locator transmitters shall operate on 406 MHz and 121.5 MHz simultaneously.

5.1.5 All emergency locator transmitters installed on or after 1 January 2002 shall operate simultaneously on 406 MHz and 121.5 MHz.

5.1.6 The technical characteristics for the 406 MHz component of an integrated ELT shall be in accordance with 5.3.

5.1.7 The technical characteristics for the 121.5 MHz component of an integrated ELT shall be in accordance with 5.2.

5.1.8 States shall make arrangements for a 406 MHz ELT register. Register information regarding the ELT shall be immediately available to search and rescue authorities. States shall ensure that the register is updated whenever necessary.

5.1.9 ELT register information shall include the following:

a) transmitter identification (expressed in the form of an alphanumerical code of 15 hexadecimal characters);

b) transmitter manufacturer, model and, when available, manufacturer's serial number;

c) COSPAS-SARSAT* type approval number;

d) name, address (postal and e-mail) and emergency telephone number of the owner and operator;

e) name, address (postal and e-mail) and telephone number of other emergency contacts (two, if possible) to whom the owner or the operator is known;

f) aircraft manufacturer and type; and

g) colour of the aircraft.

Note 1.— Various coding protocols are available to States. Depending on the protocol adopted, States may, at their discretion, include one of the following as supplementary identification information to be registered:

a) aircraft operating agency designator and operator's serial number; or

b) 24-bit aircraft address; or

c) aircraft nationality and registration marks.

The aircraft operating agency designator is allocated to the operator by ICAO through the State administration, and the operator's serial number is allocated by the operator from the block 0001 to 4096.

Note 2.— At their discretion, depending on arrangements in place, States may include other relevant information to be registered such as the last date of register, battery expiry date and place of ELT in the aircraft (e.g. "primary ELT" or "life-raft No. 1").

5.2 SPECIFICATION FOR THE 121.5 MHZ COMPONENT OF EMERGENCY LOCATOR TRANSMITTER (ELT) FOR SEARCH AND RESCUE

Note 1.— Information on technical characteristics and operational performance of 121.5 MHz ELTs is contained in RTCA Document DO-183 and European Organization for Civil Aviation Equipment (EUROCAE) Document ED.62.

* COSPAS = Space system for search of vessels in distress;
SARSAT = Search and rescue satellite-aided tracking.

Note 2.— Technical characteristics of emergency locator transmitters operating on 121.5 MHz are contained in ITU-R Recommendation M.690-1. The ITU designation for an ELT is Emergency Position — Indicating Radio Beacon (EPIRB).

5.2.1 Technical characteristics

5.2.1.1 Emergency locator transmitters (ELT) shall operate on 121.5 MHz. The frequency tolerance shall not exceed plus or minus 0.005 per cent.

5.2.1.2 The emission from an ELT under normal conditions and attitudes of the antenna shall be vertically polarized and essentially omnidirectional in the horizontal plane.

5.2.1.3 Over a period of 48 hours of continuous operation, at an operating temperature of minus 20°C, the peak effective radiated power (PERP) shall at no time be less than 50 mW.

5.2.1.4 The type of emission shall be A3X. Any other type of modulation that meets the requirements of 5.2.1.5, 5.2.1.6 and 5.2.1.7 below may be used provided that it will not prejudice precise location of the beacon by homing equipment.

Note.— Some ELTs are equipped with an optional voice capability (A3E) in addition to the A3X emission.

5.2.1.5 The carrier shall be amplitude modulated at a modulation factor of at least 0.85.

5.2.1.6 The modulation applied to the carrier shall have a minimum duty cycle of 33 per cent.

5.2.1.7 The emission shall have a distinctive audio characteristic achieved by amplitude modulating the carrier with an audio frequency sweeping downward over a range of not less than 700 Hz within the range 1 600 Hz to 300 Hz and with a sweep repetition rate of between 2 Hz and 4 Hz.

5.2.1.8 After 1 January 2000, the emission shall include a clearly defined carrier frequency distinct from the modulation sideband components; in particular, at least 30 per cent of the power shall be contained at all times within plus or minus 30 Hz of the carrier frequency on 121.5 MHz.

5.3 SPECIFICATION FOR THE 406 MHZ COMPONENT OF EMERGENCY LOCATOR TRANSMITTER (ELT) FOR SEARCH AND RESCUE

5.3.1 Technical characteristics

Note 1.— Transmission characteristics for 406 MHz emergency locator transmitters are contained in ITU-R M.633.

Note 2.— Information on technical characteristics and operational performance of 406 MHz ELTs is contained in RTCA Document DO-204 and European Organization for Civil Aviation Equipment (EUROCAE) Document ED-62.

5.3.1.1 Emergency locator transmitters shall operate on one of the frequency channels assigned for use in the frequency band 406.0 to 406.1 MHz.

Note.— The COSPAS-SARSAT 406 MHz channel assignment plan is contained in COSPAS-SARSAT Document C/S T.012.

5.3.1.2 The period between transmissions shall be 50 seconds plus or minus 5 per cent.

5.3.1.3 Over a period of 24 hours of continuous operation at an operating temperature of –20°C, the transmitter power output shall be within the limits of 5 W plus or minus 2 dB.

5.3.1.4 The 406 MHz ELT shall be capable of transmitting a digital message.

5.3.2 Transmitter identification coding

5.3.2.1 Emergency locator transmitters operating on 406 MHz shall be assigned a unique coding for identification of the transmitter or aircraft on which it is carried.

5.3.2.2 The emergency locator transmitter shall be coded in accordance with either the aviation user protocol or one of the serialized user protocols described in Appendix 1 to this chapter, and shall be registered with the appropriate authority.

APPENDIX 1 TO CHAPTER 5. EMERGENCY LOCATOR TRANSMITTER CODING

(see Chapter 5, 5.3.2)

Note.— A detailed description of beacon coding is contained in ITU-R Recommendation M.633-1. The following information is specific to emergency locator transmitters used in aviation.

1. GENERAL

1.1 The emergency locator transmitter (ELT) operating on 406 MHz has the capacity to transmit a programmed digital message which contains information related to the ELT and/or the aircraft on which it is carried.

1.2 The ELT shall be uniquely coded in accordance with 1.3 below and be registered with the appropriate authority.

1.3 The ELT digital message shall contain either the transmitter serial number or one of the following information elements:

a) aircraft operating agency designator and a serial number from 0001 to 4096;

b) 24-bit aircraft address;

c) aircraft nationality and registration marks.

1.4 All ELTs shall be designed for co-operation with the COSPAS-SARSAT* system and be type approved.

Note.— Transmission characteristics of the ELT signal can be confirmed by making use of the COSPAS-SARSAT Type Approval Standard (C-S T.007).

2. ELT CODING

2.1 The ELT digital message contains information relating to the message format, coding protocol, country code and identification data consisting of one of the information elements listed in 1.3 above.

2.2 For ELTs with no navigation data provided, the short message format described in ITU-R Recommendation M.633-1 shall be used, making use of bits 1 through 112.

2.3 Protected data field

2.3.1 The protected data field consisting of bits 25 through 85 shall be protected by an error correcting code, and shall be the portion of the message which shall be unique in every distress ELT.

2.3.2 A message format flag indicated by bit 25 shall be set to "0" to indicate the short message format or set to "1" to indicate the long format for ELTs capable of providing location data.

2.3.3 A protocol flag shall be indicated by bit 26 and shall be set to "1".

2.3.4 A country code, which indicates the State where additional data are available on the aircraft on which the ELT is carried, shall be contained in bits 27 through 36 which designate a three-digit decimal country code number expressed in binary notation.

Note.— Country codes are based on the International Telecommunication Union (ITU) country codes shown in Table 4 of Part I, Volume I of the ITU List of Call Signs and Numerical Identities.

2.3.5 Bits 37 through 39 shall designate one of the user protocols where values "001" and "011" are used for aviation as shown in the examples contained in this Appendix.

2.3.6 The ELT digital message shall contain either the transmitter serial number or an identification of the aircraft or operator in bits 40 through 83 as shown below. This information shall be encoded in binary notation with the least significant bit on the right, or using the modified Baudot code shown in Table 5-1.

2.3.7 In the serialized user protocol (designated by bits 37 through 39 being "011") bits 40 through 42 shall indicate type of beacon where:

— "000" indicates ELT serial number is encoded in bits 44 through 63;

— "001" indicates aircraft operator and a serial number are encoded in bits 44 through 61 and 62 through 73, respectively;

* COSPAS = Space system for search of vessels in distress;
SARSAT = Search and rescue satellite-aided tracking.

— "011" indicates the 24-bit aircraft address is encoded in bits 44 through 67 and each additional ELT on the same aircraft is numbered in bits 68 through 73.

Note.— States will ensure that each beacon, coded with the country code of the State, is uniquely coded and registered in a data base. Unique coding of serialized coded beacons can be facilitated by including the COSPAS-SARSAT Type Approval Certificate Number which is a unique number assigned by COSPAS-SARSAT for each approved ELT model, as part of the ELT message.

2.3.8 In the aviation user protocol (designated by bits 37 through 39 being "001"), the aircraft nationality and registration marking shall be encoded in bits 40 through 81, using the modified Baudot code shown in Table 5-1 to encode seven alpha-numeric characters. This data shall be right justified with the modified Baudot space ("100100") being used where no character exists.

2.3.9 Bits 84 and 85 shall indicate any homing transmitter that may be integrated in the ELT.

Table 5-1. Modified Baudot Code

Letter	*Code* *MSB LSB*	*Figure*	*Code* *MSB LSB*
A	111000	(-)*	011000
B	110011		
C	101110		
D	110010		
E	110000	3	010000
F	110110		
G	101011		
H	100101		
I	101100		
J	111010	8	001100
K	111110		
L	101001		
M	100111		
N	100110		
O	100011	9	000011
P	101101	0	001101
Q	111101	1	011101
R	101010	4	001010
S	110100		
T	100001	5	000001
U	111100	7	011100
V	101111		
W	111001	2	011001
X	110111	/	010111
Y	110101	6	010101
Z	110001		
( )**	100100		

MSB = most significant bit
LSB = least significant bit
* = hyphen
** = space

EXAMPLES OF CODING

ELT serial number

25		27 36	37			40				44 63	64 73	74 83		85
F	1	COUNTRY	0	1	1	T	T	T	C	SERIAL NUMBER DATA (20 BITS)	SEE NOTE 1	SEE NOTE 2	A	A

Aircraft address

25		27 36	37			40				44 67	68 73	74 83		85
F	1	COUNTRY	0	1	1	T	T	T	C	AIRCRAFT ADDRESS (24 BITS)	SEE NOTE 3	SEE NOTE 2	A	A

Aircraft operator designator and serial number

25		27 36	37			40				44 61	62 73	74 83		85
F	1	COUNTRY	0	1	1	T	T	T	C	OPERATOR 3-LETTER DESIGNATOR	SERIAL NUMBER 1-4096	SEE NOTE 2	A	A

Aircraft registration marking

25		27 36	37			40 81		83		85
F	1	COUNTRY	0	0	1	AIRCRAFT REGISTRATION MARKING (UP TO 7 ALPHANUMERIC CHARACTERS) (42 BITS)	0	0	A	A

T = Beacon type TTT = 000 indicates ELT serial number is encoded;
= 001 indicates operating agency and serial number are encoded;
= 011 indicates 24-bit aircraft address is encoded.

C = Certificate flag bit: 1 = to indicate that COSPAS-SARSAT Type Approval Certificate number is encoded in bits 74 through 83 and
0 = otherwise

F = Format flag: 0 = Short Message
1 = Long Message

A = Auxiliary radio-locating device: 00 = no auxiliary radio-locating device
01 = 121.5 MHz
11 = other auxiliary radio-locating device

Note 1.— 10 bits, all 0s or National use.

Note 2.— COSPAS-SARSAT Type Approval Certificate number in binary notation with the least significant bit on the right, or National use.

Note 3.— Serial number, in binary notation with the least significant bit on the right, of additional ELTs carried in the same aircraft or default to 0s when only one ELT is carried.

Attachment A to Part I

GUIDANCE MATERIAL FOR AERONAUTICAL MOBILE-SATELLITE SERVICE

1. INTRODUCTION

Note.— The aeronautical mobile-satellite service (AMSS) Standards and Recommended Practices (SARPs) referred to are contained in Annex 10, Volume III, Part I, Chapter 4.

1.1 Overview

1.1.1 The major elements of the aeronautical mobile-satellite service (AMSS) are the space segment (the satellites and their controlling earth stations); the ground earth stations (GESs) that provide interfaces between the satellite and fixed terrestrial voice and data networks; and the aircraft earth stations (AESs) that comprise the avionics and antenna systems on-board the aircraft.

Note.— Several operators of AMS(R)S may operate independent but compatible satellite networks. The different operators should co-operate in order for AESs to move seamlessly among the different networks.

1.1.2 The system architecture is capable of meeting a range of communication requirements which may include ATS, AOC, AAC and APC. The same system architecture is used for various service levels, from the basic low data-rate service to a multi-channel high data-rate service.

1.1.3 The level of capability of an AMSS system can be chosen to suit the performance required by the application.

Note 1.— The performance of a service will be set by the lowest level of capability available in the chain of GES, space segment and AES.

Note 2.— While a low level of capability service will have lower capital costs, it may have higher satellite user charges for the same data flow.

1.1.4 The capabilities are summarized in Table A-1* of this guidance material.

1.1.5 The examples of performance given in this section are to give a quick look at the over-all system performance. If exact figures are required, the relevant paragraphs of Annex 10, Volume III, Part I, Chapter 4 should be studied.

System capabilities: Annex 10, Volume III, Part I, Chapter 4, 4.1.3

Packet data performance: Annex 10, Volume III, Part I, Chapter 4, 4.7.2

1.1.6 CIRCUIT MODE VOICE PERFORMANCE

Assuming that the AES is logged on to a GES, the AMSS will typically take the following times to set up a call:

from-aircraft:

— Use of abbreviated access request SU: 10 to 14 seconds (average)

— Use of general access request SU: less than 17 seconds (average)

to-aircraft: 9 to 11 seconds (average).

Note.— The call set-up time may be affected by the performance of the associated terrestrial network.

1.2 Levels of capability

1.2.1 The various levels of capability for the aircraft earth station (AES) and ground earth station (GES) defined in Annex 10, Volume III, Part I, Chapter 4, 4.1.3 allow various capabilities to exist which have different performance characteristics. A Level 1 capability is the minimum capability required for aeronautical mobile-satellite (route) service (AMS(R)S) providing basic packet data communications. A Level 3 is required as a minimum when, in addition to packet communications, circuit voice communications are required. All levels of capability require that the AES be under positive control either by receiving a P channel signal or through the C channel sub-band. Only one of the channel rates indicated below is required to operate at any given time.

1.2.2 The Level 1 capability provides for basic packet data communications by requiring an AES to receive and process a P channel signal operating at channel rates of 0.6 and 1.2 kbits/s. It also requires the capability for an AES to transmit on an R channel or on a T channel at these channel

* All tables are located at the end of this attachment.

rates. Both R and T channel capabilities are required. The channel rate used will depend on the link quality determined by the GES measurement of bit error rate (BER) or the estimate of that BER. Major factors that determine the channel rate are the antenna gain of the satellite and AES, and the RF power output of the satellite and AES. Level 1 requires one transmit channel (for R or T channel) and one receive channel (for P channel).

1.2.3 The Level 2 capability provides for channel rates of 0.6 and 10.5 kbits/s for the P channel; and 0.6 and 10.5 kbits/s for the R channel and the T channel. The major factor determining when to use these channel rates is the AES antenna gain, which must be at least 12 dBic when working with a "global" beam satellite. This capability provides greater data communications throughput, faster message delivery and may decrease operational cost. Level 2 requires one transmit channel and one receive channel as in Level 1.

1.2.4 The Level 3 capability adds to Level 2 packet data communications a circuit capability for voice or communications using a transmit and a receive C channel. These C channels are capable of operating at channel rates of 10.5 or 21.0 kbits/s to support 9.6 kbits/s vocoders for voice communications. The C channel can also provide circuit-mode data communications but this is not considered part of the safety services. The C channel rate used depends on the use of 1/2 rate forward error correction (FEC) coding (1/2 rate coding requires 21.0 kbits/s). Provision has been made to allow use of lower vocoder rates that could operate at channel rates of 5.25 or 6.0 kbits/s. Level 3 requires one transmit channel (R, T or C channel) and two receive channels (P channel and C channel). Simultaneous operation of two-way packet and circuit communications is not possible, but near-simultaneous operation is possible by switching between transmit channel types.

1.2.5 Level 4 capability adds to Level 3 capability additional transmit channel capability to provide simultaneous operation of two-way packet and circuit communications. Level 4 capability requires two or more transmit channels (R or T, and C channel) and two or more receive channels (P channel and C channel), power control for each channel carrier and a linear power amplifier. Channel rates are the same as Level 3. Both R and T channel capabilities are required on a transmit channel but not simultaneously.

1.2.6 The AMS(R)S is the first aeronautical safety communications service which integrates both voice and data, as well as non-safety services. This integration of services must respect message priority. Pre-emption of one data message by another data message of higher priority is handled easily within the system without loss of information. Pre-emption of a voice call by a higher priority data call, or vice versa, will not normally be necessary in an AES which has two transmitters. However, in a Level 3 AES which has only one transmitter such a pre-emption may occasionally be necessary.

1.2.7 Although a Level 4 AES is not required to provide simultaneous packet data communications with more than one GES, such a capability is not precluded.

2. BROADBAND RF CHARACTERISTICS

2.1 Use of AMS(R)S bands

2.1.1 *Message categories.* The transmission sequence at any aircraft earth station (AES) or ground earth station (GES) will be ordered in accordance with a given priority scheme. At the subnetwork interface to the AMSS, the priority scheme for packet data is as described in Annex 10, Volume III, Part I, Chapter 4, Table 4-26. Within the AMSS, this external priority scheme is augmented with internal priorities assigned to various signalling and voice-related functions. At the link layer this augmented priority scheme is referred to as the Q-precedence number and the resulting internal priority scheme is given in Table A-3 of this guidance material. This "Q-precedence" number list conforms to Annex 10 priorities, which in turn are derived from Article S44 of the ITU Radio Regulations. The single Q-precedence list includes both voice and data traffic, and also includes the signalling necessary to integrate voice and data. The Q-precedence numbers associated with the signalling were chosen to optimize the over-all system performance and integrity.

2.1.2 *Receive frequency band.* For historical reasons, most AESs may be capable of receiving more than the required band of 1 544 to 1 555 MHz but not the full band suggested by the recommendations. Typically, they cover the frequency band 1 530 to 1 559 MHz, and may not cover 1 525 to 1 530 MHz.

2.2 Frequency accuracy and compensation

2.2.1 *Frequency accuracy.* The Standard contained in Annex 10, Volume III, Part I, Chapter 4, 4.2.2 reflects a requirement on the signal received by the GES. There are several contributors to the frequency error observed at the GES. These include frequency errors due to the satellite oscillator, due to relative motion between the aircraft and spacecraft, due to the local oscillator of the GES (for a closed loop compensation system) and the local oscillator of the AES. Efforts are made to reduce the error caused by the first two as described below. This Standard characterizes that portion of the frequency error which is due to the AES and the aircraft motion relative to the satellite. Consequently, the proper frame of reference for measuring the transmit frequency is the satellite. A practical test of this requirement would use the AES frame of reference, and the corresponding value in the satellite frame of reference would be calculated based on the aircraft position and velocity, and the satellite position.

2.2.2 *Frequency compensation by the GES.* To reduce the error due to the spacecraft oscillators, the GES should listen to an L-band pilot frequency transmitted (at C-band) by a designated GES and correct its transmission frequency to minimize the frequency error at L-band. In the from-aircraft direction a designated GES transmits an L-band pilot frequency which all GESs listen to at C-band and adjust their receiver local oscillators accordingly. This approach may not be possible in the case of satellite spot beams where the GES is not within the footprint of the spot beam of interest.

2.2.3 *Doppler shift compensation by the AES.* There are at least two methods of implementing Doppler-shift compensation. One approach is to use aircraft navigational aids to estimate the velocity of the aircraft in the direction of the satellite and then, estimate the Doppler shift from this. A second approach is to estimate the Doppler shift by measuring the frequency offset of the received P channel or C channel. For this latter approach, the frequency of any transmission to that ground earth station is then the basic channel frequency offset by the receive frequency, offset with opposite sign and a scaling factor of approximately 1.07. This approximately corrects the component of the frequency error due to aircraft motion (Doppler shift) but does not correct errors in the AES local oscillator.

2.2.4 *Frequency error budget.* The frequency error budgets used in arriving at the accuracy requirements for the GES-AES link are presented in Tables A-4 and A-5 of this guidance material. Note that in Table A-4 the Doppler shift due to aircraft motion is not included, and in Table A-5 it is assumed to be compensated for.

2.3 Aircraft earth station antenna characteristics

2.3.1 *Antennas and level of capability.* The Standards contained in Annex 10, Volume III, Chapter 4 specify high, intermediate and low-gain antenna systems, but one should note that these are not linked directly to a level of capability of AES. A high-gain antenna, with the supporting avionics, will mean a Level 2, 3 or 4 AES installation; and a low- or intermediate-gain antenna, with the supporting avionics will always lead to at least a Level 1 AES installation. In the future, different system characteristics may be capable of providing a Level 2 or higher service. For example, the combination of satellite spot beam antennas and a low- or intermediate-gain aircraft antenna may be capable of providing a Level 2 or higher service. The level of service provided to an aircraft will depend not only on its capabilities but those of the service providers as well.

2.3.2 Higher-gain future satellites could serve AESs with lower G/T and EIRP, but may have an effect of potentially higher service costs and reduced system capacity. AES antennas with gain less than 12 dBic may be considered similar operationally to low-gain antennas because they have too broad a beam to discriminate against other satellite interference.

2.4 Receiver requirements

2.4.1 *Gain-to-noise temperature ratio.* The following factors influence the aircraft earth station receive system gain-to-noise temperature ratio (G/T):

a) climatic conditions;

b) antenna elevation angles to the satellite;

c) residual antenna pointing errors (including the effects of errors introduced by the antenna beam steering system);

d) the noise contribution of the receiver low noise amplifier at the operating temperature;

e) the transmitter power amplifier output level;

f) the attenuation and noise temperature contributions of a radome, where a radome is fitted; and

g) the RF environmental conditions in which the aircraft earth station is intended to operate.

2.4.2 *Typical link carrier to noise densities.* Tables A-6, A-7 and A-8 of this guidance material show typical carrier-to-noise spectral density ratios (C/N_0's) for the P, R, T and C channel services. In these tables modem implementation losses refer to losses in the practical implementation of a modem relative to ideal. This includes the effects due to non-ideal filtering, non-ideal synchronization in either time or frequency, non-ideal modulation, and non-linearities in the up- and down-converter chains. The analysis of the RF link is provided in the appendix to this guidance material.

2.4.3 *Receiver linearity.* There are multiple satellite systems being planned which have maximum L-band EIRP of 58 dBW at the centre of the antenna beam. Considering the worst case where the antenna beams of two such satellite systems overlap, the receiver must tolerate a total in-band power flux density of -100 dBW/m^2. This is derived from the combined two-satellite EIRP (62 dBW), minus a spreading loss of 162 dB.

2.4.4 *Receiver out-of-band performance.* Potential threats to receiver performance include terrestrial mobile communications systems and high-power sources, including television transmitters with EIRP in the megawatt range and surveillance radars which are naturally located at airports and may occur along the flight route.

2.4.4.1 Under radio environmental conditions where high-power, out-of-band signals may be near the flight path, the receiver's RF filter should protect against receiver saturation, which could reduce gain and degrade performance. Additionally, performance may be affected by such sources due to receiver image and spurious responses. As an example, a power flux density at the AES antenna of +3 dBW/m^2 could occur at a distance of a kilometre from a multi-megawatt transmitter such as permitted for television at frequencies from 470 to near 800 MHz. To protect from saturation, the RF filter would need a minimum of 75 dB rejection. Protection from degradation due to image and spurious responses is specific to the receiver design.

2.4.4.2 For a 5 000 kW peak power radar with a boresight gain of 34 dB, power levels can reach 100 dBW in the main beam. It has been calculated that, for an AES located 500 metres from an airport-located weather radar, the flux density could be as high as 30 dBW/m^2 below 1 459 MHz, and 38 dBW/m^2 from 1 675 to 18 000 MHz. It is not necessary to operate under these levels, but the equipment should survive without damage.

2.4.5 *Received phase noise.* The phase noise that the AES receiver must tolerate while operating within the AMSS SARPs is illustrated in Figure A-1* of this guidance material. This mask includes phase noise contributions of the transmitter and of the satellite. In practice, the receiver must be able to tolerate larger amounts of phase noise that are due to fading of the received signal.

2.5 Transmitter requirements

2.5.1 *EIRP limits.* An AES that is capable of an EIRP of 13.5 dBW should always be able to use the 0.6 kbit/s R and T channels when the satellite elevation angle exceeds 5 degrees. An AES that is capable of an EIRP of 25.5 dBW, and has the supporting avionics, will be capable of Level 2, 3 and 4 service grade portions of Levels 3 and 4. In practice, the transmitted power will usually be backed off from these settings, by an amount that depends on the system configuration.

2.5.1.1 The "maximum allowable operating EIRP" is based on a limit established from combined effects of HPA IM (active) and passive-component IM.

2.5.2 *EIRP control.* The requirement for control for the AES EIRP by the GES is for two reasons. The first reason is for dynamic power control of the C channel to optimize the system capacity. The second is to make optimal use of future spot beam satellite systems.

2.5.2.1 In initial AMSS operations using satellites with global beam coverage, an AES EIRP control range of 16 dB is required for both Class C (Levels 1-3) and Class A (Level 4 multi-channel) high-power amplifiers to cover selectable channel rates and variables in AES antenna gain. In C channel operation the AES EIRP is also frequently adjusted according to the GES-measured bit error rate. Therefore, for Level 4 AESs an additional 16 dB of control is presently required.

2.5.2.2 In future systems, AES transmission within an EIRP range satisfactory to satellite service operators may require a different control range. For example, the higher G/T of future spot beam satellites could require less AES EIRP, leading to a need for a larger control range. The range cannot be closely predetermined because spot beam size that affects satellite G/T is a future operator design choice.

2.5.3 *Out-of-band EIRP spectral density.* The out-of-band EIRP including discrete spurious, harmonics, intermodulation products and noise radiated by the AES should not cause harmful interference to other radio services. In particular, they should not interfere with other aeronautical communications/navigation radio services such as global positioning system (GPS) operating in the band 1 559 to 1 585 MHz, global orbiting navigation satellite system (GLONASS) operating in the band 1 598 to 1 610 MHz (1 597 to 1 605 MHz after the year 2005), the AMSS receive band 1 525 to 1 559 MHz, and the VHF band 108 to 137 MHz. Intermodulation product levels in the 1 598 to 1 610 MHz band should be checked when satellite navigation receiver operation in this band is planned on the same aircraft. Frequency management, additional filtering or increased antenna separation (for greater than 40 dB isolation) may be required aboard the same aircraft if interference potential to navigation equipment exists.

2.5.3.1 Table 4-3 contained in Annex 10, Volume III, Part I, Chapter 4, provides for a maximum EIRP density of –155 dBc/1 MHz in the 1 559 to 1 585 MHz band, which protects GPS receiver operation on the same aircraft as AMSS, and also GPS operation on nearby aircraft.

2.5.3.2 Table 4-3 contained in Annex 10, Volume III, Part I, Chapter 4, also indicates that the maximum EIRP spectral density shall be –143 dBc/1 MHz in the 1 585 to 1 605 MHz band and –117 dBc/1 MHz in the 1 605 to 1 610 MHz band. These limits will provide protection for GLONASS receiver operation on the same aircraft as AMSS assuming a minimum 40 dB antenna isolation and on nearby aircraft. The 40 dB isolation is measured from the AMSS antenna port to the GLONASS antenna port at the GLONASS frequencies, with the AMSS antenna steered for maximum coupling with the GLONASS antenna. This also holds for the GPS antenna.

2.5.4 *Intermodulation (IM) products.* Control of unwanted emissions from the AES is important to system operations in order to avoid blocking channels and reducing needed spectrum. Intermodulation occurs during multicarrier (Level 4) operation on predictable frequencies related to wanted signals due to component non-linearities. Potential sources are many, but can be controlled. Minimizing IM effects is accomplished both in AES design for linearity meeting the standards and in operation.

* All figures are located at the end of this attachment.

2.5.4.1 Intermodulation products (IM) that may be emitted by a Level 4 AES in multicarrier operation arise both from the high-power amplifier (HPA) and from other passive components that are subject to high AES RF power levels. Passive components causing IM may include connectors, particularly if they are subject to corrosion or looseness; and the diodes used in phased-array antennas. Depending on the choice of frequencies and levels in the GES, such IM can appear at frequencies and levels in the AES receiver that will degrade BER, disable reception, or affect reception of signals by other aircraft equipment.

2.5.4.2 AES-transmitted IM can block GES receivers. The HPA is a primary IM source because its linearity is limited by technology and heat dissipation.

2.5.4.3 Intersystem effects may arise from Level 4 AESs that may radiate IM. An AES operating with a global beam satellite must transmit higher EIRP than an AES operating with a more sensitive spot beam satellite. Therefore, this higher level of IM would be more readily received by the spot beam satellite for relay to its GES, where it could impair reception of that channel. Even if the two satellites are using separated portions of the frequency band and therefore cannot reuse the same assigned channel frequencies, the global beam AES transmitter's IM that is out of assigned channels could fall into the spot beam satellite's band. All GES frequency and EIRP level assignments should account for this possibility.

2.5.4.4 Frequency management techniques are used to eliminate 3rd and 5th order products below 1 610 MHz as described in 4.2.3.5.7. If GLONASS is to be installed on the same aircraft as AMSS, it may be necessary to employ frequency management techniques or other methods to ensure that AMSS 7th and higher order intermodulation products will not cause harmful interference to GLONASS operations.

2.5.5 *Frequency management.* Careful frequency management is needed because:

a) AMSS includes safety services;

b) there is concern about the availability of adequate AMSS spectrum, and adequate capacity for AMSS safety services; and

c) the difficulty in co-ordinating mobile satellite networks due to the poor discrimination characteristics of mobile station antennas.

Guidelines that should be considered when co-ordinating frequency plans to minimize intra and interservice interference include:

a) compliance with the relevant ITU Radio Regulations;

b) each provider should provide monitoring facilities to identify the actual usage of AMS(R)S and non-AMS(R)S communications;

c) in those AMSS systems with global and spot beams, operational measures to minimize the amount of global bandwidth used and to maximize the use of spot beams;

d) using the ITU-R Recommendations M.1089 and M.1233 technical co-ordination method, wherever possible;

e) efficient spectrum use including the following:

1) using other system providers' satellite transponder guard bands;

2) using frequency assignment by aircraft location;

3) taking advantage of improvements in aircraft earth station antenna sidelobe discrimination;

4) using offset and interleaved carriers;

5) using satellite spot/shaped beams;

6) reducing spacecraft antenna sidelobe levels;

7) increasing the resistance of systems to interference;

8) using earth station power control;

9) using satellite transponder adjustable gain setting;

10) using knowledge of operational schedules to take advantage of the difference in time zones;

11) appropriately grouping carriers;

12) repositioning satellites; and

13) taking advantage of high-gain AES antennas and the resulting ability to use lower carrier powers.

2.5.6 *Transmitted phase noise.* The phase noise mask that the AES transmitter must meet is illustrated in Figure A-2 of this guidance material. The purpose of this mask is to minimize the contribution of the AES transmitter phase noise to the degradation of GES performance.

2.6 Interference

2.6.1 *Intrasystem interference.* Intrasystem interference refers to interference among AMS(R)S services. Some examples would be co-channel, adjacent channel interference and intermodulation noise. Due to disparate satellite system designs, there is no single specification for intrasystem interference. Each satellite system operator must be able to show that intrasystem interference to AMS(R)S services, when combined with other noise sources in the link, does not degrade the achieved link C/N_0 below the required C/N_0 for a given performance.

2.6.2 *Intersystem interference.* Intersystem interference refers to interference to an AMS(R)S service from any other system, whether it is providing AMS(R)S services or otherwise. Required performance should be maintained at whatever level of interference is adopted as operable through co-ordination among the particular satellite system operators. As a minimum, the AMSS satellite system should provide adequate performance in the presence of single-entry interference resulting in a $\Delta T/T$ of 6 per cent, as adopted by WARC-ORB-88 as the threshold requiring co-ordination between satellite systems. A suggested criterion for aggregate interference due to all sources, including intrasystem interference, is a $\Delta T/T$ of 20 per cent.

3. RF CHANNEL CHARACTERISTICS

3.1 Modulation characteristics

3.1.1 *Modulation types.* Two modulation types are used in aeronautical mobile-satellite service (AMSS), each providing a system advantage. A form of binary phase shift keying (BPSK) is used for channel rates up to 2.4 kbits/s, providing more robustness against phase noise generated in frequency conversion processes in the aircraft earth station (AES), satellite, and ground earth station (GES). Above 2.4 kbits/s, phase noise effects on the demodulation process are diminished, and conservation of bandwidth at these higher channel rates becomes important. Therefore, a more bandwidth-efficient modulation type, quaternary phase shift keying (QPSK), is used.

3.1.2 *Aviation BPSK.* Aviation BPSK is a form of phase shift keyed modulation with shaped filters especially adapted to perform in an RF environment subject to fading. It has four possible phase states of which only two are permissible during any symbol period. The modulation technique maps binary "0"s into a phase shift of –90° and binary "1"s into +90°. This results in differential encoding of the transmitted data, and implies that during any symbol period two decisions separated by 180° are possible, and that these two decisions are rotated by 90° from the possible decisions in the previous symbol period. This modulation strategy is illustrated conceptually in Figures A-3 and A-4 of this guidance material. Consequently, A-BPSK is almost identical to minimum shift keying (MSK), except that the pulse shaping has a 40 per cent root raised cosine spectral shape, as opposed to sinusoidal weighting. The amplitude and phase masks which this pulse-shaping filter must satisfy are illustrated in Figures A-5 and A-7 of this guidance material. These correspond to the transmit filter requirements given in the definition of A-BPSK. Those requirements apply to the transmitted signal before it undergoes any non-linear amplification; their purpose is to limit and control the distortion and corresponding degradation in performance caused by nonlinear amplification. A-BPSK is a linear modulation with nearly constant envelope. Consequently, it may be transmitted through a "Class C" amplifier with little spectral spreading and performance degradation.

3.1.3 *Aviation QPSK.* Aviation QPSK is a form of offset QPSK modulation that is used for data rates above 2.4 kbits/s and is illustrated conceptually in Figures A-3 and A-4 of this guidance material. The A-QPSK data encoder is driven by a binary data sequence (a_i) at the bit rate 2/T. The "even" bits are switched onto the I line and the "odd" bits onto the Q line, generating two data streams at rate 1/T. The synchronous samplers S operate at rate 1/T and generate ideal positive and negative impulses depending on whether the data bits are "1" or "0". The pulse shaping filters in each channel have a 100 per cent root raised cosine spectral shape, except for the 8 400 bits/s C channel, which has a 60 per cent root raised cosine spectral shape. The outputs of the I and Q pulse shaping filters modulate the same carrier in quadrature and are combined linearly. The amplitude and phase masks that the 100 per cent raised cosine pulse shaping filter must satisfy are shown in Figures A-6 and A-7 of this guidance material, while those of the 60 per cent root raised cosine filter are shown in Figures A-23 and A-24. These correspond to the transmit filter requirements given in the definition of A-QPSK. Those requirements apply to the transmitted signal before it undergoes any non-linear amplification; their purpose is to limit and control the distortion and corresponding degradation in performance caused by non-linear amplification. There is no requirement for actual modulators to be implemented in this way, as long as the modulated RF signal is indistinguishable from one that was generated by an ideal modulator.

3.2 Bounds on radiated power spectral density

3.2.1 *Spectrum masks.* These spectrum masks allow for degradation from the ideal Nyquist model that could occur due to non-ideal system characteristics, e.g. saturation in the amplifier chain.

3.2.2 *From-aircraft.* The spectral mask that must be satisfied by any A-BPSK signal transmitted in the from-aircraft direction is shown in Figure A-8 of this guidance material. This mask is applicable for 100 per cent root raised cosine filtering. This was derived assuming a non-linear amplifier (Class C) is used on board the AES, but it is applicable to Class A linear amplifiers as well. The same spectral mask (Figure A-8) applies to A-QPSK. The spectral mask (Figure A-22) applies to A-QPSK with a 60 per cent root raised cosine filter.

3.2.3 *To-aircraft.* The spectral mask that must be met in the to-aircraft direction with A-BPSK is shown in Figure A-9 of this guidance material. This was derived assuming that all amplifiers in the to-aircraft transmission path are operating linearly. The corresponding spectral mask for A-QPSK is shown in Figure A-10 of this guidance material.

3.3 Demodulator performance

3.3.1 The performance specified in the Standards can be attained using coherent detection and a Viterbi decoder with 3-bit soft decisions. The R and T channel demodulators are allowed more E_b/N_0 to achieve the bit error rate of 10^{-5} because of the short bursty nature of communications over these channels. The theoretical performance of A-QPSK in additive white Gaussian noise is better than that of A-BPSK because the bits are not differentially encoded. However, for A-QPSK modulation, more margin is included (relative to theoretical) because of its poorer performance over fading channels.

3.3.2 The relative motion of the aircraft and the satellite means that any signal reflections from aircraft wings or tail, or the sea or ground below can result in time-varying multipath. This is in part due to the rather broad beamwidth of the AES antenna. The characteristics of this multipath depend on a number of characteristics including the aircraft velocity, the look-angle of the satellite with respect to the aircraft and the slope of the reflecting surface. The rate of these variations (Doppler bandwidth) increases with aircraft velocity and elevation angle to the satellite. However, the multipath intensity is inversely proportional to the aircraft velocity and the satellite elevation angle. Consequently, it is primarily below elevation angles of 20 degrees that multipath is a significant problem. At elevation angles of 5 to 20 degrees the Doppler bandwidth can vary from 20 to 100 Hz or more and the multipath power can be as much as –7 dB relative to the direct path signal.

3.4 Acquisition delay

This delay requirement is a high-level specification composed of a number of components due to various sub-systems including satellite acquisition, frequency and bit acquisition, and frame synchronization. The total delay of 16 seconds is the worst-case delay allowed. This is the time from when one first commands the AES to find the satellite until the time at which the AES can attempt to log-on. Once logged on, typical times for setting up a voice call or transmitting a packet data message will be much less than this.

4. CHANNEL FORMAT TYPES AND DATA RATES

4.1 General

4.1.1 *System timing.* All timing of the different transmission channels is derived from the P channel. If required, synchronization of the P channels of each ground earth station (GES) to universal co-ordinated time (UTC) is one way of ensuring a world-wide timing reference for all aircraft using aeronautical mobile-satellite service (AMSS). The synchronization of all P channels to UTC is currently not required because there has not been an application identified which would benefit significantly enough to warrant the increased cost.

4.1.2 *Channel spacings.* The channel spacings in Table A-9 of this guidance material make adequate provision for separation to reduce adjacent channel interference and to ensure correct channel tuning in the presence of Doppler shifts due to all causes. In the case of the channels at the lowest bit rate, the possible spacings for the to-aircraft direction (P channels) and from-aircraft directions (R and T channels) are different. This is due to the uncorrected Doppler shift on to-aircraft channels, and the use of automatic frequency control (AFC) to minimize Doppler shift in the from-aircraft direction. Note that the requirement on the aircraft earth station (AES) to be capable of tuning in steps of 2.5 kHz accommodates all the potential channel spacings listed below and allows the interleaving of channels between adjacent satellite spot beams.

4.1.3 *P channel synchronization/loss/degradation.* Actions by the AES management depend upon indications of the signal quality of the received P channel. These include an indicator of when the AES is synchronized to the P channel, and when it is degraded and/or lost. The AES must synchronize to a P channel before it can receive P channel signal units, or transmit over the R or T channel. A degraded/lost P channel indicates reduced operational performance and is usually an indication that a switching operation, for example, a satellite or spot beam handover, should be performed.

4.1.3.1 These indicators of signal quality generally are based on physical measurements exceeding a threshold. However, the measurements used and the threshold settings depend upon the AES implementation. P channel synchronization is declared whenever the P channel unique word is detected reliably. Synchronization is lost whenever the unique word is not detected reliably.

4.1.3.2 Either of two conditions will cause a declaration of degradation/loss of the P channel. The first condition corresponds to a "degraded" P channel and has two cases: 1) if the bit error rate rises above 10^{-4} in a three-minute averaging period; and 2) if synchronization is lost ten or more times during a three-minute period. This three-minute averaging period provides confidence that the degradation is not temporary, due, for example, to an aircraft manoeuvre. The second condition corresponds to a "lost" P channel, which is declared if synchronization is lost continuously for ten seconds. There is a single indicator for either of these conditions and, consequently, the action by the AES management for either event is the same.

4.2 P channel

4.2.1 *General.* At least one P channel is transmitted continuously by each GES that forms part of the AMSS service. Each AES must continuously monitor the P channel transmitted by the GES to which it is logged on. The P channel implements a time division multiplexing strategy to send small packets of information to the AESs that are monitoring it. The functional blocks at the GES end of each P channel are as follows:

a) data scrambler;

b) forward error correction (FEC) encoder;

c) interleaver;

d) timing mark inserter (unique word); and

e) modulator.

The functional blocks at the receive end of each P channel are complementary to those at the transmit end. The complete series of functional blocks from transmit end to receive end is shown in Figure A-11 of this guidance material.

4.2.2 FUNCTIONAL BLOCKS

4.2.2.1 *Data scrambler.* A data scrambler is a logical device which multiplies the data sequence by a known pseudo-random sequence. The data is unscrambled at the receiver by multiplying by the same sequence of random bits. This has no direct effect on the bit error rate performance on the link. However, it prevents the possibility of transmitting long sequences of 1's or 0's over the link. The latter could be detrimental to the performance of acquisition and tracking circuitry.

4.2.2.2 *Forward error correction coding.* Satellite communications are, in general, power-limited due to the limited resources at the satellite. One can reduce the amount of power required for communications by introducing forward error correction coding, which adds redundancy to the transmitted signal at the expense of requiring more bandwidth. At the receiver, a decoder uses the redundancy to correct those errors which normally occur when transmitting at a lower power.

4.2.2.3 *Interleaving.* Mobile communications are generally subject to fading due to reflections from nearby objects. The fading is correlated with time and when it occurs, can cause a sequence of correlated errors in the data detected at the receiver. These errors can be corrected by the forward error correction coding. However, most decoders work best with uncorrelated errors. The purpose of the (transmit) interleaver and its inverse, the (receive) de-interleaver, is to randomize the order of bits presented to the channel compared to those presented to the decoder, thus reducing any correlation between the errors which may be caused by the channel.

4.2.2.4 *Timing mark.* A unique word is inserted in each data stream, at periodic intervals, to provide timing information to the receiver. This timing information is needed in order to properly synchronize the de-scrambler, the decoder, and the de-interleaver with their counterparts on the transmit side. It also allows recovery of this synchronization if the signal happens to be lost momentarily.

4.2.3 *P channel frame duration.* The frame duration is either 500 milliseconds (channel rates of 2.4 kbits/s and higher) or a multiple of 500 milliseconds to provide simple derivation of a superframe used for R channel slotting and the reservation TDMA T channel. Scrambling and FEC coding of rate 1/2 is used on all P channels. The FEC encoder is not reset between frames, but starts a new frame in the state resulting from the previous frame. With the exception of the 0.6 kbits/s P channel, the duration of the interleaver is 500 milliseconds. For the 0.6 kbits/s, the interleaver is 384 bits corresponding to 2/3 second.

4.2.4 *P channel frame format.* All P channel frame formats include a 16-bit field (uncoded) as a format identifier and for derivation of the superframe that has a duration of 8 seconds. The format identifier is a 4-bit field and is always set to the value 0001 when the channel is a P channel. The remaining 12 bits of this field are used as a superframe counter. To achieve this, the field is subdivided into three 4-bit fields, of which the first is used to indicate the start of a new superframe, while the remaining two are used to indicate the frame number. It is advisable for AES implementations to make use of all 12 bits to achieve reliable superframe synchronization in the presence of bit errors.

4.2.5 For P channels of 4.8 and 10.5 kbits/s, a small number of "dummy" bits are included in the frame just after the framing bits. This matches the number of bits of the interleaver to the number of bits required to be transmitted on the channel.

4.2.6 To facilitate the re-synchronization of an AES transferring from one P channel to another on the same GES, all P channels transmitted by the same GES are synchronized.

4.3 R channel

4.3.1 *General.* All AESs will log on to AMSS using an R channel that has been designated for that purpose in the particular service area of the AES. For the duration of its log-on period an AES will be assigned one or more R channels (at the appropriate channel rates). Over these R channels, the AES can transmit signalling, short data packets, and requests for additional capacity on the T channel. The burst mode data channel characteristics for the R channel have been specified in the AMSS SARPs as has been the slot structure used for its slotted-ALOHA random access protocol. The functional blocks at the transmit (AES) end of each channel are as follows:

a) data scrambler;

b) FEC encoder;

c) interleaver;

d) preamble and unique word generator; and

e) modulator.

The functional blocks at the receive end of each R channel are complementary to those at the transmit end. The complete series of functional blocks form transmit end to receive end is shown in Figure A-12 of this guidance material.

4.3.2 *R channel transmit timing.* The R channel transmits in slots derived from the P channel superframe. The R channel slot length varies according to the channel bit rate. The start of any given R channel slot is referenced to the leading edge of the first bit in the P channel format identifier field. An R channel burst may begin at an integer number of slot durations after this time. For the R channel, the nominal starting instant of the first bit of the preamble is the beginning of the slot.

4.4 T channel

4.4.1 *General.* For the duration of its log-on period an AES will be assigned one or more T channel frequencies (at the appropriate channel rates). These channels are shared with a number of other AESs on a demand-assigned basis. That is, these channels are assigned on a conflict-free basis to individual AESs by the GES for short periods of time. The requests for T channel capacity can be made over the R channel, or over the T channel, if capacity has already been assigned. The burst mode data channel characteristics for the T channel have been specified in the SARPs, as has been the slot structure used for its reservation TDMA protocol. The functional blocks at the transmit (AES) end of each channel are as follows:

a) data scrambler;

b) FEC encoder;

c) interleaver;

d) preamble and unique word generator; and

e) modulator.

The functional blocks at the receive end of each T channel are complementary to those at the transmit end. The complete series of functional blocks form transmit end to receive end is shown in Figure A-12 of this guidance material.

4.4.2 *T channel format.* The T channel burst length can vary from 2 to 31 signal units. The number of columns used in the interleaver varies with the transmission bit rate and the burst length according to the AMSS SARPs. Each burst includes a special short signal unit, the burst identifier, which ensures that the originating AES and destination GES are always known. If a GES receives a burst in which the burst identifier is lost, absent or indicates a different GES, the GES would discard the burst.

4.4.3 *T channel transmit timing.* The T channel is also synchronized to the P channel superframe, but in this case the superframe is subdivided into 1 024 slots of approximately 7.8 milliseconds. The shortest guard time between the burst of two different AESs is under control of the receiving GES and is set to approximately 39 milliseconds (5 slots).

4.5 C channel

4.5.1 *General.* The C channel is a circuit-mode channel used for digital voice or data communications. A C channel can be requested by an AES over the R channel, and assigned by the GES over the P channel. The functional blocks at the transmit end of each C channel are as follows:

a) interfaces for primary (e.g. voice) and sub-band channel;

b) primary channel/sub-band channel data multiplexor;

c) data scrambler;

d) FEC encoder (unless it is not used);

e) interleaver (unless FEC is not used);

f) preamble and unique word generator; and

g) modulator.

The functional blocks at the receive end of each C channel are complementary to those at the transmit end. The complete series of functional blocks from transmit end to receive end is shown in Figure A-13 of this guidance material.

4.5.1.1 The C channel has been specified at a number of different channel rates: 5.25, 6.0, 8.4, 10.5 and 21.0 kbits/s. The underlying motivation is to allow the evolution of the system to lower channel rates as voice processing technology improves. Two of these channel rates, 5.25 and 10.5 kbits/s, do not include coding. Potential applications of these uncoded channels include transmitting 4.8 and 9.6 kbits/s vocoded speech in satellite systems that have limited spectrum but are not power limited. Alternative applications could include the use of vocoders that include their own coding, protecting the important bits more than the others; this could eliminate the need for coding in the channel modem.

4.5.2 *C channel frame.* The frame duration at all channel rates is 500 milliseconds. Carrier activation (burst mode) based on speech activity is used in the to-aircraft direction. At each activation, a preamble and unique word are transmitted to commence the burst, and from then on further unique words occur every 500 milliseconds. Thus the phasing of the unique word depends on the instant when activation commences. A postamble is sent when there is no voice content in the interleaver block.

4.5.3 *Voice activation.* In the to-aircraft direction, carrier activation is controlled by an electrical signal at the C channel interface. When the C channel is used for voice, this signal is controlled by the voice encoder. The voice encoder turns the signal on as soon as it detects voice, but applies a hangover time before turning the signal off to avoid excessive turn-offs between syllables. In addition, the forward carrier is activated by sub-band channel signalling as required.

4.5.3.1 The channel unit starts a new burst immediately after the "active" state is signalled. When the "not active" state is signalled, the channel unit continues transmission for a period and then drops the carrier. In the case of channels with FEC and an interleaver, the channel unit completes transmission of the current interleaver block, plus another complete interleaver block, which ends with a postamble to terminate the C channel carrier burst. In the case of channels with no FEC or interleaver, the channel unit continues transmission for 20 milliseconds. For both cases, during this period the required bits are taken from the primary channel interface as usual.

4.5.3.2 The same timing rules apply to the corresponding control signal from the sub-band signalling channel equipment.

4.5.3.3 In the from-aircraft direction, the carrier is transmitted continuously during the call regardless of speech activity. The start of the transmission is the same as for the forward direction, with a preamble and unique word transmitted at the beginning, followed by further unique words at 500 millisecond intervals.

4.5.4 *Data activation.* The capability to use the C channel for data other than vocoded speech is not required for safety applications. However, the C channel may be used for the transmission of data by non-safety services and some details of its operation are included here. In the to-aircraft direction the forward carrier is operated in burst mode for circuit-mode data transfer. Circuit 109 (CF) as defined in CCITT Recommendation V.24 (termed DCD in EIA RS-232C), from the GES voice band modem controls the activation interface of the C channel. The interface is initially activated when the call enters data mode, which is indicated by the circuit 109 transition to ON state. The interface normally remains activated until deactivation of data mode by the AES. If the circuit 109 changes to the OFF state indicating loss of received carrier from the far-end modem, the transmit circuit-mode interface unit finishes sending the contents of the plesiochronous buffer and then changes to "not active". The C channel activation interface is reactivated again when (if) the circuit 109 changes to the ON state.

4.5.5 *Interleaver size.* In any data transmission system where interleaving is required to randomize the errors, the interleaver size is always a trade-off between the delay incurred and its effectiveness at randomizing the errors. The interleaver blocksize for the 21 kbits/s C channel is 384 bits, which corresponds to 192 information bits. This 192 bits is the frame size (20 milliseconds) of most 9.6 kbits/s vocoders. This direct mapping between vocoder frames and interleaver buffers minimizes the delay caused by interleaving and its effect on voice communications. The resulting over-all transmission delay is around 30 milliseconds (rising to 50 milliseconds at the lowest channel rate). To match the number of interleaver bits to the required number of channel bits, a small number of "dummy" bits are included in the frame just after the framing bits.

4.5.5.1 The delay at the transmitter arising from the interleaver depends on the relationship between the voice frame and the interleaver size. The full de-interleaver delay of around 20 milliseconds will be experienced at the receiving end.

4.5.6 *Voice channel delay.* To maintain voice circuit quality, the CCITT recommends that the end-to-end delay should be limited to 440 milliseconds or less. Given that the nominal satellite delay is 270 milliseconds, the voice processing system delay should not exceed 65 milliseconds. This assumes that the terrestrial network is allotted 40 milliseconds of delay, and the modem and RF sub-systems are allotted 65 milliseconds of delay. It is to be noted that with current voice processing algorithms, the processing delay tends to increase as the vocoder rate decreases. Consequently, this end-to-end delay objective may be difficult to meet with low-rate vocoders, e.g. 2.4 and 4.8 kbits/s.

4.5.7 *Sub-band C channel.* The data transferred by the sub-band C channel includes control and signalling for the call set-up of the C channel, continuity checks, and power control. In each frame, the first 24 half-octets of the sub-band C channel are combined to form a standard length 96-bit signal unit. Successive groups of 24 half-octets are combined in the same way, if available. The 25th data field of the last voice/data block in the frame is discarded. When the C channel is activated, and there are no other signal units to be sent, fill-in signal units are sent.

5. LINK LAYER P CHANNEL AND R CHANNEL PROTOCOLS

5.1 General

The P and R channels are used for signalling and data communications in the to-aircraft and from-aircraft directions, respectively. Data transmission on the R channel is restricted to short messages (less than 33 octet link service data units (LSDUs)). This section of the guidance material describes issues related to the R and the P channel link layer protocols.

5.2 SU set generation

5.2.1 In both the aircraft earth station (AES) and the ground earth station (GES) link layers, an SU set cannot be generated from a received LIDU as described in Annex 10, Volume III, Part I, Chapter 4, 4.5.3.2.3 until a reference number is assigned to it, except for system table broadcast LIDUs and LIDUs received from the circuit-mode service entities to be transmitted, either on the R channel at the AES, or the P channel at the GES. System table broadcast LIDUs do not require reference numbers. Circuit-mode services LIDUs are assigned application reference numbers by the circuit-mode service entities at the AES and the GES, thus an SU set is generated upon receipt of the LIDU. For all LIDUs exchanged between the link layer, at the AES or the GES, and any of its service users, no formats have been specified in the SARPs. Such formats are implementation dependent.

5.2.2 When an LIDU received from the subnetwork layer is assigned a reference number, the LSDU of the LIDU is encoded in the data field of the ISU/SSU(s) of a P channel SU set or in the data field of the SUs of an R channel SU set. The number of SUs needed in the SU set depends on the LSDU length. Each SU, except the last one, will contain the maximum permitted number of user data octets. The number of user data octets in the last SU which belong to the set may have less than the maximum length. In a P channel SU set, the number of octets in the final SU (ISU or SSU) is encoded in the "No. of octets in the final SSU" field of the ISU. On the R channel, the number of octets in the last SU is encoded in the SU's "SU type" field (Annex 10, Volume III, Part I, Appendix 3 to Chapter 4, Item 67).

5.3 SUs transmission according to precedence

At the AES and the GES, in order to meet the SUs transmission requirements of Annex 10, Volume III, Part I, Chapter 4, 4.5.8.2.3, the R and P channel protocols may employ several first-in-first-out (FIFO) queues, one queue per valid Q number, to store the SUs prior to transmission. For the R channel, the SUs of an SU set would be queued according to the ascending order of their sequence indicators (Annex 10, Volume III, Part I, Appendix 3 to Chapter 4, Item 58). For the P channel, the SUs of an SU set would be queued with the ISU, or RTX SU for a retransmission set, first followed by the SSUs according to the descending order of the SSUs sequence numbers. At the instance of transmission, an SU would be selected from the highest priority queue with one or more SUs in it.

5.4 P channel protocol

5.4.1 The P channel link layer protocol is used in the to-aircraft direction for processing the transmission of: 1) the LIDUs received from the GES management, 2) the LIDUs received from the circuit-mode services with routing parameters indicating transmission on the P channel, and 3) all LIDUs received from the subnetwork layer. The P channel protocol reliable link service (RLS) is used for processing the transmission of the LIDUs received from the subnetwork layer only. The transmission of all other LIDUs is processed according to the P channel protocol direct link service (DLS). The P channel is also used for the transmission of the following link layer signalling SUs:

a) T channel reservation (RES) and reservation forthcoming (RFC) SUs associated with the T channel reservation protocol (Annex 10, Volume III, Part I, Chapter 4, 4.6);

b) T channel acknowledgement (TACK) SU; and

c) R channel acknowledgement (RACK) SU.

The above SUs are transmitted in accordance with the P channel protocol DLS service.

5.4.2 At a given time, the P channel protocol may be processing the transmission of several LSDUs (a reference number has been assigned and an SU set has been generated from each LIDU to transmit the LSDU). However, for RLS, at each Q number only one LSDU of the LSDUs destined to the same AES is permitted to be in process for transmission at one time. The other RLS LSDUs with the same Q number and destined to the same AES will be stored until the transmission of the current LSDU at that Q number is over, either successfully or unsuccessfully. Thus, at the AES, only one RLS SU set per Q number could be in the reassembly process at a given time and the AES will discard an incomplete RLS SU set if it starts receiving another RLS SU set with the same Q number and a different reference number. After either a successful or an unsuccessful transmission of an SU set, the GES link layer releases all link layer resources associated with that SU set, i.e. the assigned reference number, activated timers, memory allocation, etc.

5.4.3 For RLS, the P channel protocol implements a selective-repeat-ARQ scheme for error control. Accordingly, upon transmitting an SU set the GES expects to receive a P channel acknowledgement (PACK) SU from the AES. The PACK SU may indicate either complete or incomplete reception of the SU set using its acknowledgement control field. In the latter case, this field also indicates whether a complete or a partial retransmission of the SU set is required. For a partial retransmission request, this field, which is present in every PACK SU, further indicates the number of PACK SUs identifying the remainder of the missing SSUs of the SU set to follow; each PACK SU can identify, at most, three missing SSUs. A partial retransmission from the GES is assembled by the AES as any other SU set; however, a retransmission SU set is headed by an RTX SU rather than an ISU and the retransmitted SSUs' Sequence Numbers are as prescribed in Annex 10, Volume III, Part I, Appendix 3 to Chapter 4, Item 59. Failure to receive an acknowledgement from the AES would cause the GES to solicit such acknowledgement by sending a request for acknowledgement (RQA) SU to that AES. The AES keeps track of the status of the RLS SU set that the AES is currently processing at a given Q number in order to correctly respond to an RQA.

5.4.4 In an SU set, original or retransmitted, only the ISU, or the RTX SU, identifies the destination AES ID. In order to avoid erroneous processing due to the broadcast nature of the P channel, the AES discards an SSU if received without previously receiving the corresponding (same reference number and Q-number) ISU or RTX SU.

5.5 R channel protocol

5.5.1 The R channel link layer protocol is used in the from-aircraft direction for processing the transmission of: 1) the LIDUs received from the AES management, 2) the LIDUs received from the circuit-mode services with routing parameter indicating transmission on the R channel, and 3) some of the LIDUs carrying LSDUs of 33 or less octets received from the subnetwork layer. The R channel protocol reliable link service (RLS) is used for processing the transmission of the LIDUs received from the subnetwork layer only. The transmission of all other LIDUs is processed according to the R channel protocol direct link service (DLS).

5.5.2 The R channel is also used for the transmission of the following link layer signalling SUs:

a) P channel acknowledgements (PACKs);

b) T channel request for acknowledgement (RQA); and

c) T channel request for reservation (REQ).

The above SUs are transmitted in accordance with the R channel protocol DLS service.

5.5.3 At a given time, the R channel protocol at the AES may be processing the transmission of several LSDUs (reference number is assigned and an SU set is generated from each LIDU to transmit the LSDU). However, for RLS, at each Q number only one LSDU is permitted to be in process for transmission to the GES at one time. Other RLS LSDUs with the same Q number will be stored in the AES until the transmission of the current RLS LSDU at that Q number is over, either successfully or unsuccessfully. Thus, at the GES, only one RLS SU set per Q number per AES could be in the reassembly process at a given time and the GES will discard an incomplete RLS SU set if it starts receiving another RLS SU set with the same Q number from the same AES. After either a successful or an unsuccessful transmission of an SU set, the AES link layer releases all link layer resources associated with that SU set, i.e. the assigned reference number, activated timers, memory allocation, etc.

5.5.4 For RLS, the R channel protocol implements a selective-repeat-ARQ scheme for error control. Accordingly, upon transmitting an SU set, the AES expects to receive an R channel acknowledgement (RACK) SU from the GES. The RACK SU may indicate either complete or incomplete reception using its acknowledgement control field. In the latter case, the RACK SU also indicates the missing SUs of the SU set by identifying their sequence indicators. The AES transmits the indicated missing SUs without any alterations to their contents. The largest SU set on the R channel contains three SUs, thus, the GES may identify at the most two missing SUs in a RACK SU, one SU of the set must be correctly received at the GES in order to detect an attempt of an SU set transmission.

5.5.5 The R channel is a multiple access channel, therefore, the GES concurrently receives SUs from all AES assigned to one set of R channel frequencies. Each received SU contains the source AES ID. Thus, the received SUs are first sorted out according to their AES IDs and then independently processed. Annex 10, Volume III, Part I, 4.5.8.3 contains the R channel protocol requirements corresponding to the processing of SUs from a given AES.

6. LINK LAYER T CHANNEL AND SUB-BAND C CHANNEL PROTOCOLS

6.1 General

The link layer T channel protocols specified in Annex 10, Volume III, Part I, Chapter 4, 4.6 applies to link service data units (LSDUs) in the from-aircraft direction which cannot be transmitted via the R channel (e.g. because its length exceeds 33 octets). There are two T channel protocols: one for requesting the T channel capacity and the other for the transmission of SUs in assigned capacity. The link layer sub-band C channel protocol specified in Annex 10, Volume III, Part I, Chapter 4, 4.6 applies to the transmission of signalling SUs corresponding to the circuit-mode services in the to-aircraft and from-aircraft directions.

6.2 SU set generation

An SU set cannot be generated from the received LIDU as described in Annex 10, Volume III, Part I, Chapter 4, 4.6.4.2.1 until a reference number is assigned to it by the T channel reservation protocol. The LSDU (used data) is encoded in the user data field of the ISU/SSU of a T channel SU set. The number of SUs needed in the SU set depends on the LSDU length. Each SU, except the last one, will contain a maximum permitted number of user data octets. The number of user data octets of the last SU which belongs to the set may have less than the maximum length; unused octets are then padded with dummy bits. The number of octets in the final SSU is encoded in the "No. of octets in the final SSU" field of the ISU.

6.3 T channel transmission protocol

6.3.1 General

6.3.1.1 The T channel transmission protocol is used when there are LSDUs present for transmission on the T channel and the AES has received a requested T channel burst reservation. The T channel transmission protocol specifies reliable link service (RLS) for data transfer.

6.3.2 Aircraft earth station (AES)

6.3.2.1 The aircraft earth station (AES) is the transmitting end of the T channel transmission protocol. The oldest SU of the SUs with the highest Q number is transmitted first. If an SU set is waiting for transmission in an allocated burst reservation and a higher precedence SU set is submitted for transmission then the higher precedence SUs will displace the lower precedence SUs. Thus, a burst reservation may carry SUs corresponding to an LSDU other than the one which initiated the original request for reservation.

6.3.2.2 The AES, after transmitting the SU set to the ground earth station (GES), waits for T channel acknowledgement (TACK) SU(s) from the GES. The TACK SUs are received at the AES by the receiving end of the P channel protocol, which then passes them to the T channel transmission protocol. The AES may receive more than one TACK SU indicating the missing SUs of an SU set at the GES. Each TACK SU can identify up to three missing SUs. The receipt of a TACK SU of the TACK SU set identifying the missing SUs, initiates a timer tA5 in the AES and indicates the number of additional TACK SUs that are expected. If the timer tA5 expires before another TACK SU of the TACK SU set is received, the AES transmits the missing SUs identified in the so far received TACK SUs. If TACK SU(s) are received after the corresponding timer tA5 has expired and the AES has not yet transmitted the retransmission SU set identified in the received TACK SU(s), the AES discards the received TACK SU(s).

6.3.2.3 The AES computes the length of the expected reservation for retransmission based upon the number of missing SUs indicated in the received TACK SUs of the TACK SU set. This length is associated with the timer tA8 initiated by the T channel reservation protocol to supervise the receipt of reservation for retransmission. This length may be less than the length of the reservation actually assigned for retransmission by the GES if, for example, some TACK SUs of the TACK SU set are not received by the AES.

6.3.2.4 The AES saves a copy of an SU set for retransmission purposes. After passing the transmission status indication LIDU to the subnetwork layer indicating success or failure, the AES destroys the saved copy.

6.3.2.5 If after several retries, an expected reservation from the GES is not received, the AES discards at least the number of SUs for which the reservation was requested. The SUs discarded may not be those which initiated the original request for reservation because of the fact that the transmission of SUs is based upon the precedence described in Annex 10, Volume III, Part I, Chapter 4, 4.6.4.2.2, but will be of equal or lower precedence. If an ISU is among the SUs discarded at the AES, the complete SU set headed by the discarded ISU is discarded. This may result in discarding more SUs than required. If the SU discarded is a REQ SU, then the AES retransmits the REQ SU on either the T or R channel. If the SU discarded is a last SU of an SU set, then the AES starts a timer for the supervision of TACK SU(s) for that SU set.

6.3.3 Ground earth station (GES)

6.3.3.1 This is the receiving end of the T channel transmission protocol. The GES, upon receipt of an SU set, reassembles it into an LSDU. Before reassembling the SU set, the GES checks whether or not all the SUs of the SU set have been received. If the SU set is not complete after no more SUs of the SU set are expected (determined by the criterion specified in the AMSS SARPs), the GES requests for the retransmission of the missing SUs by transmitting appropriate number of TACK SUs, indicating error, on the P channel to the AES.

6.3.3.2 If while waiting for retransmissions from the AES, the GES receives an ISU with the same AES ID and Q number as the SU set awaiting completion and with a reference number belonging to a pair whose other member is the reference number of the SU set awaiting completion, the GES discards the SU set awaiting completion and proceeds with the new SU set. The receipt of the ISU with the parameters described above indicates that the AES has given up on the transmission of the previous SU set and has released the reference number, thus making available the other member of the pair for assignment.

6.3.3.3 The GES may receive an RQA SU from the AES in the following circumstances:

a) initial SU set loss (i.e. loss of at least the ISU): the RQA SU does not refer to an SU set which has been processed just before;

b) negative acknowledgement loss or retransmission loss: the RQA SU refers to an SU set under correction; and

c) positive acknowledgement loss: the RQA SU refers to an SU set which has been processed just before.

When the initial SU set has been lost, the GES determines the initial SU set length from the message length parameter in the RQA SU in order to reserve and send the correct T channel capacity along with the request for complete retransmission.

6.4 T channel reservation protocol

6.4.1 GENERAL

The T channel reservation protocol is used to request reservations for the transmission of data on the T channel.

6.4.2 AIRCRAFT EARTH STATION (AES)

6.4.2.1 The T channel reservation protocol in the AES assigns reference numbers to the LIDUs received from the subnetwork layer for transmission on the T channel. The reference numbers are assigned in such a way that no two consecutive LIDUs with the same Q number transmitted from an AES to a GES have the same reference number. The reference number assigned to an LSDU is used by the T channel reservation protocol in the request for reservation (REQ) SU and by all the associated signalling and by the T channel transmission protocol in the data SUs and by the associated acknowledgements and request for acknowledgement SUs.

6.4.2.2 The REQ SU is transmitted to the GES on the T channel or on the R channel. Every time the REQ SU is transmitted on the T channel, the requested length in the REQ SU is incremented by one in order to account for the T channel capacity used to transmit the REQ SU.

6.4.2.3 The timer tA8 in the AES is used to supervise the receipt of expected T channel reservation (RES) SUs associated with either previously received reservation forthcoming (RFC) SUs or received TACK SUs. Due to the priority scheme for the transmission of SU sets, resulting in higher priority SU sets potentially occupying reservation assignments for lower priority SU sets, there will be instances of time where multiple tA8 timers associated with the same SU set might have been initiated at the AES. Upon receipt of an awaited RES SU for that SU set, the AES must stop the corresponding tA8 timer (Annex 10, Volume III, Part I, Chapter 4, 4.6.5.2.6 and 4.6.5.2.7). However, since a one-to-one correspondence between a tA8 timer and a received RES SU is not guaranteed, a selection of a most suitable tA8 timer must be made. Such selection is implementation dependent. For instance, the selection could be made dependent on the time-out values of all outstanding tA8 timers, such that the tA8 timer with the shortest remaining time to time-out is selected regardless of the size of reservation in the received RES SU. In this case, care must be taken in the implementation to request reservations for any resulting deficit in the total size of outstanding reservations associated with an SU set at the AES when all tA8 timers have been stopped. Other criteria for the selection may be used; however, the constraint that at least the total size of all outstanding reservations associated with any given SU set must be received prior to releasing the reference number assigned to that SU set must always be observed.

6.4.2.4 Reservations may not be received in chronological order. The minimum inter-reservation gap between two reservations on two different T channels is made adequate to allow for frequency (T channel) switching at the AES. A reservation (RES) SU defines one or more burst allocations on one T channel. The starting frame number of the initial burst is encoded within the RES SU and is known as belonging to one of the sixteen frames following the reception of the RES SU (the time window). Thereafter, further reservations (if any) occur every 2BI frames until the number of reserved bursts is reached. BI is the encoding of the burst interval information element within the RES SU. The AES computes the starting frame for each reserved burst using both the starting frame number of the initial burst and the burst interval information. Once a reserved burst has elapsed, the AES deletes it from its time plan.

6.4.3 GROUND EARTH STATION (GES)

6.4.3.1 The GES assigns reservations in response to requests for reservations from its logged-on AESs. The GES also assigns reservations for retransmissions of missing SUs of an SU set transmitted by the AES. So, whenever the T channel transmission protocol at the GES transmits a TACK SU set comprised of one or more TACK SUs indicating errors, the T channel reservation protocol at the GES makes reservations for the retransmissions.

6.4.3.2 The GES assigns reservations to an AES for any one of the four T channels that may have been assigned to the AES at the time of log-on. The GES indicates the T channel on which the reservation has been made to the AES in the RES SU. A procedure to select a T channel, out of the possible four assigned to the AES at the time of log-on, is implementation dependent. The following methods may be utilized for selecting the T channel:

a) all T channels available to a particular AES are polled. Reservations are assigned to any T channel on which the minimum allowable reservation delay is achievable, or to the channel offering the shortest reservation delay if no T channel offers the minimum allowable reservation delay;

b) each T channel assigned to a particular AES is associated with one or more message precedence. A T channel is selected according to the precedence of the message identified in the REQ SU; and

c) reservations for all non-safety messages are made on a single T channel; reservations for all safety messages are made on a T channel which offers a shortest reservation delay.

6.4.3.3 The GES transmits the RES SU to the AES whenever the start of the reservation is within eight seconds of the current time. This is done to avoid any misinterpretation of the reservation start time at the AES. The reservation start time in the RES SU is specified in terms of start frame number within a superframe. The superframe number is not specified. So, if the RES SU is not received by the AES within the superframe which actually includes the start frame number, the AES will apply the information incorrectly to the superframe within which the RES SU is received by the AES. If the frames in this superframe have been assigned to another AES, then there could be a collision of the T channel transmissions from the two AESs. Because of the fact that the RES SU should be received by the AES within the correct superframe, the precedence of the RES SU is set to 15 in order to minimize the P channel queuing delays that otherwise can be experienced by the RES SU.

6.4.3.4 If the start of the burst reservation is outside the eight second time window from the time the reservation was made, the GES transmits a reservation forthcoming (RFC) SU to the AES in order to prevent a timeout resulting in another request for reservation. The RFC SU gives an upper limit for the delay to the start of burst reservation in entire number of super frames (8 seconds). The time-plan in the GES is limited in length. Whenever the GES is not capable to assign a reservation within its current time-plan, it sends an RFC SU with the delay to RES set equal to its maximum time-plan length and saves the request for later assignment. Subsequently, when the GES is capable of serving the request, the GES sends a further RFC SU giving the delay to reservation which is now known. The size of the GES time-plan is implementation dependent and has not been specified in the AMSS SARPs.

6.4.3.5 The TACK SUs transmission must always precede the associated T channel reservation. As the precedence level of an RES SU is higher than the one of the TACK SU, the GES must wait until all TACK SUs have been effectively transmitted before allocating a reservation for retransmission. The TACK SUs transmitted to the AES by the T channel transmission protocol in the GES includes an estimation for the delay before the RES SU will be sent to the AES by the GES; this estimation is a function of the T channel(s) loading. Subsequently, if the reservation cannot be assigned within the estimated delay specified in the TACK SU, the GES transmits an RFC SU with the actual delay or with the maximum delay value corresponding to its time-plan length if it has not been able to assign a reservation within its current time-plan. In the latter case, the GES will delay T channel burst assignment until capacity is available. The length of the reservation for retransmission is the number of missing SUs identified by the TACK SU set indicating missing SUs at the GES plus one.

6.4.3.6 The GES assigns reservations such that no two AESs use the same T channel for transmission at the same time. The length of a reservation is such that the AES is always capable to send at least one REQ SU in addition to the SUs for which the reservation is made. This prevents delaying either the transmission of an REQ SU when its precedence level is lower than the precedence level of the SUs awaiting transmission, or the transmission of the complete SU set when interrupted by a single REQ SU. Long LSDUs are assigned burst reservation in multiple bursts of equal length, each burst being separated from the precedent one by a fixed burst interval. The intervals between bursts can be assigned to AESs for transmission or retransmissions. The burst interval between two bursts and the burst length of each burst corresponding to the same LSDU are made such that the transfer delay for the entire LSDU meets the performance requirements specified in Annex 10, Volume III, Part I, Chapter 4, 4.7. Since the transmitter in the AES could be shared between the R and T channels and the T channel mode of the transmitter has higher priority than its R channel mode, the assignment of reservations on the T channel will affect the R channel transmissions. The reservations are assigned on the T channel in such a way that most of the time there is at least one R channel burst every eight seconds from each AES logged on to the GES assigning reservations. The burst length and burst interval are not specified in the AMSS SARPs; they are implementation dependent.

6.4.3.7 Typical values for the length of an individual burst are as follows:

a) 18 SUs for a T channel operating at 600 bits/s;

b) 17 SUs for a T channel operating at 1 200 bits/s;

c) 31 SUs for a T channel operating at 2 400 bits/s; and

d) 31 SUs for a T channel operating at 10 500 bits/s.

Typical values for the burst interval are as follows:

a) 16 frames for a T channel operating at 600 bits/s;

b) 8 frames for a T channel operating at 1 200 bits/s;

c) 4 frames for a T channel operating at 2 400 bits/s; and

d) 1 frame for a T channel operating at 10 500 bits/s.

6.4.3.8 The earliest starting time that a reservation can be made by the GES must be such that the AES can receive the reservation in time to transmit at the start of the assigned reservation. This time takes into account the processing time at both the GES and the AES as well as coding and decoding delays. The value for the earliest starting time is implementation dependent and is computed according to the formula given below:

Minimum delay to start of reservation = P channel unit delay + GES processing delay + P channel queuing delay + R-slot duration + 0.2 sec(*) + propagation delay + AES processing delay.

* 0.2 seconds is the R/T channel switching time.

A system implementor has obtained the typical values shown in Table A-10 for some of the components. A typical value for GES processing delay is in the order of 200 msec.

6.4.3.9 The GES, upon receipt of either a log-on to another GES or log-off information about an AES which was logged on to it, may discard the reservations assigned to the AES, making the slots available for assignment to its other logged on AESs.

6.5 Sub-band C channel to-aircraft and from-aircraft protocol

6.5.1 General

The sub-band C channel protocol defined in AMSS SARPs contained in Annex 10, Volume III, Part I, Chapter 4, 4.6 specifies direct link service (DLS) for signalling SUs. The sub-band C channel carries signalling for circuit-mode services to set-up, maintain or release the C channel.

7. SATELLITE SUBNETWORK LAYER

7.1 General provisions

7.1.1 Architecture

To facilitate the development of interoperability specifications, the subnetwork layer has been divided into functional areas. This functional division is not intended to preclude implementations that aggregate functions in other ways, so long as the airborne and ground implementations of the subnetwork layer each behaves (to an external observer) as if it conformed with the provisions of this section.

7.1.1.1 *SSND function*

Each SSNDPX function contains one or more SSNDPX entities. Each entity communicates with the peer SSNDPX entity using the SSNDP.

7.1.1.2 *SNAc function*

Each SNAc function contains one or more ISO 8208 DCE entities. Each ISO 8208 DCE entity communicates with the peer ISO 8208 data terminal equipment (DTE) entity in the attached aeronautical telecommunication network (ATN) router using the ISO 8208 protocol.

7.1.1.3 (Reserved)

7.1.1.4 *IW function*

Each IW function contains one IW entity. The IW function performs the necessary harmonization between the SSND and the SNAc functions. It forwards ISO 8208 packets between the ISO 8208 DCE and SSNDPX entities.

7.1.2 Background for the use of ISO 8208 and the associated subnetwork dependent protocol

In the satellite subnetwork, data may be received out-of-sequence or duplicated. The subnetwork dependent convergence function (SNDCF) in the ATN router which uses the services provided by the satellite subnetwork assumes an underlying connection-mode service which provides sequenced delivery of data. The SNDCF does not perform any error recovery function to handle data duplication and data received out-of-sequence. Therefore, it requires a reliable connection-mode service which is provided by the ISO 8208 and SSND protocols. Furthermore, for the satellite subnetwork, it is more efficient to use these connection-mode protocols. Finally, ISO 8208 is the most mature connection-mode protocol available.

7.1.3 Services

7.1.3.1 The packet data interface allows AMSS to function as the satellite subnetwork of the ATN. The satellite subnetwork transfers data packets from air to ground and from ground to air. Packet data transfers are provided in the form of connection-mode service, using ISO 8208 as a subnetwork access protocol (see Figure A-14 of this guidance material).

7.1.3.2 The subnetwork user must initiate the set-up of each connection by sending an ISO 8208 CALL REQUEST packet. In normal operation, this action results in the establishment of a switched virtual circuit (SVC) between the calling subnetwork user and the called subnetwork user. SVCs can be released by either subnetwork user (when the connection is no longer needed) or by the subnetwork (when the connection is no longer supportable).

7.1.3.3 One or more subnetwork users on an aircraft may be connected to one or more subnetwork users on the ground, but all ground users will normally interface via a single ground earth station (GES) at any given time. Handovers from one GES to another may result in the temporary interruption of service.

7.1.3.4 The originator of a CALL REQUEST packet will normally identify both the called and calling subnetwork user. The originator may also identify quality of service requirements by invoking the appropriate ISO 8208 facilities.

7.1.3.5 Implementations of a satellite subnetwork will normally contain elements that are not standardized by ICAO. One of these elements is a packet switch that interprets DTE addresses and delivers packets to the appropriate DTE. The AMSS SARPs permit (but do not require) the connection of multiple DTEs with an aircraft earth station (AES) or with a GES, or with both. AMSS SARPs also permit the use of any DTE address format, subject to the limitations of ISO 8208. Subnetwork users are responsible for co-ordinating the DTE address formats (and address compression schemes, if employed) between the air and the ground.

7.1.3.6 The satellite subnetwork provides connectivity notification event messages to the attached ATN routers. Since CN event messages are not transferred across the subnetwork, the standardization of formats and media for these messages are considered to be local matters.

7.1.4 ERROR HANDLING FOR COMMUNICATION FAILURES

If communication between an AES and a GES is abruptly terminated (e.g. due to a loss of physical connectivity), it is possible for the subnetwork layer to remain in its last state until connections are cleared by the user. The GES subnetwork layer is particularly susceptible, since it may not immediately be aware of the loss of communication. Users and/or implementors may use supplemental means to detect and correct such conditions.

7.2 Packet data performance

7.2.1 GENERAL

7.2.1.1 *The need for ICAO performance specifications*

7.2.1.1.1 AMSS minimum system performance standards apply over a geographic coverage area to be identified by each AMSS service provider. In general, the minimum system performance should be continuously available to each AES within the identified coverage area. However, AES antennas are not required to provide full coverage in all directions; multiple antennas and/or multiple satellites may be needed in order to achieve the minimum system performance.

7.2.1.1.2 AMSS minimum system performance standards do not represent the fundamental limits of system performance. Under favourable conditions, the achievable AMSS system performance may be significantly better than the minimum standards reflected in the AMSS SARPs. States are not precluded from seeking AMSS service arrangements that would provide system performance that exceeds the minimum requirements of the AMSS SARPs. However, such arrangements should take into consideration the minimum AES configurations and the minimum AES performance requirements of the AMSS SARPs.

7.2.1.2 *Physical layer*

The basic performance standard for the physical layer is the maximum bit error rate, which is specified as 10^{-3} for digital voice and 10^{-5} for packet data and associated signalling. These system specifications avert the need to specify detailed satellite link budgets, thus allowing the flexibility to implement a variety of satellite and GES architectures.

7.2.1.3 *Packet data subnetwork layer*

7.2.1.3.1 The specification of subnetwork service performance will allow flexibility in the design and operation of GESs while assuring a uniform minimum level of performance for the packet data user. In general, the subnetwork performance parameters are based on the definitions given in Section 10 of ISO 8348, "Information processing systems — Data communications — Network service definition" (1987), which are incorporated into the AMSS SARPs by reference. The mapping between packets and subnetwork service primitives is defined in ISO 8878, "Information processing systems — Data communications — Use of X.25 to provide the OSI connection mode network service".

7.2.1.3.2 The term "subnetwork service" in the context of packet data performance refers to the service provided by the subnetwork to the higher layer user. The term "service provider" in this same context refers to the protocols within the satellite subnetwork and to the net effect of their operation. These terms should not be confused with the services of the satellite communication provider or GES operator. Packet data service depends on all elements of the system: AES, satellite, GES, and the physical paths between them.

7.2.1.3.3 The values of the performance parameters in the AMSS SARPs are intended to permit economical and spectrum-efficient operation. They are calculated under nominal worst case conditions, including maximum physical bit error rate and peak busy hour traffic loading. Improved speed of service performance (relative to the specified values) may be achieved by increasing the number of physical channels used to serve a given traffic load, thus decreasing the traffic load per channel. Using this technique, cost of service may be expected to increase (and spectrum efficiency may be expected to decrease) as the speed of service is improved.

7.2.1.3.4 AMSS subnetwork performance does not include the effects of other links in the end-to-end data path. Subnetwork performance includes the effects of all operations beginning with the ISO 8208 DCE protocol at the sending end of the satellite subnetwork and terminating with the ISO 8208 DCE operations at the receiving end of the satellite subnetwork, including:

a) the satellite subnetwork interworking functions;

b) the satellite subnetwork dependent protocols;

c) the satellite data link layers; and

d) the satellite physical layers.

ISO 8208 operations associated with the DTE are not part of the satellite subnetwork, and are excluded from AMSS packet data performance specifications, as are data link layer and physical layer operations between the DCE and the DTE.

7.2.2 SPEED OF SERVICE

7.2.2.1 Speed of service is determined by a number of factors, including:

a) the system architecture;

b) the channel rate(s) in use;

c) the priority of the traffic for which speed of service is being measured;

d) the length of the messages for which speed of service is being measured, the traffic loading on the system; and

e) data processing delays.

Finally, the actual speed of service in the from-aircraft direction depends on the amount and type of traffic being transmitted from each aircraft, to the extent that packets may be delayed on the aircraft while other packets are being transmitted to the GES.

7.2.2.2 In accordance with current industry practice, speed of service is specified in terms of packets containing 128 octets of subnetwork user data.

7.2.2.3 There is no specification for the maximum amount of traffic to be handled on P or T channels. However, the speed of service performance standards are based on a maximum utilization of approximately 70 per cent (of theoretical capacity) for these channel types. Higher utilizations are permitted, provided that all of the applicable performance standards are met. For example, a GES that operates multiple T channels in an appropriate multiserver configuration may be able to achieve T channel utilization factors of 80 per cent or more within the constraints imposed by the speed of service requirements. P channels may be operated at utilization factors higher than 70 per cent if the total P channel utilization by traffic at and above the lowest priority associated with safety and regularity of flight does not exceed 70 per cent.

7.2.2.4 A GES that is intended to serve as a backup to a another GES should be appropriately sized to provide the required performance in the event of the failure of the primary GES.

7.2.2.5 The term "highest priority service" denotes priority 14 service, which is reserved for distress, urgency and certain infrequent network/system management messages. The term "lowest priority service" denotes the lowest priority used for safety and regularity of flight, under peak-hour traffic loading. Performance for priority levels not used for safety or regularity of flight is not specified.

7.2.2.6 *Transit delay and 95 per cent data transfer delay*

7.2.2.6.1 Transit delay is a standard speed of service performance measure for single DATA packets; transit delay is defined as an average value. Because the civil aviation community typically does not rely on average values for the most critical performance measures, the 95 per cent data transfer delay is also specified. Under actual operational conditions, the relationship between the average and 95 per cent delay values is not fixed, but may depend on the distribution of traffic. A typical statistical distribution of to-aircraft delays, under projected peak traffic loading and at the lowest P channel rate, is illustrated in Figure A-15 of this guidance material for the highest and lowest priority of data. A typical statistical distribution of from-aircraft delays under similar conditions is shown in Figure A-16 of this guidance material. From-aircraft delays are independent of priority unless two or more from-aircraft packets contend for resources within a particular AES. The extent to which such internal contention may occur within a particular AES will depend on the avionics architecture of the aircraft in which the AES is installed.

7.2.2.6.2 Transit delay and 95 per cent data transfer delay are specified on the basis of a standard reference DATA packet containing 128 octets of subnetwork user data. Actual delays for shorter packets may be reduced, but not necessarily in proportion to the packet length. The delay parameters associated with DATA packets shorter than 128 octets (of subnetwork user data) should not exceed the corresponding parameters for 128 octet DATA packets.

7.2.2.7 *Throughput*

Throughput is the standard speed of service performance parameter for the transfer of multiple DATA packets. In accordance with current industry practices, throughput is computed on the basis of standard reference DATA packets containing 128 octets of subnetwork user data. Throughput is computed for the transfer of multiple independent packets. Throughput performance for the transfer of M-bit sequences may be substantially higher. The subnetwork is expected to support the minimum throughput values shown in Table A-11.

7.2.2.8 *Connection establishment delay, connection release delay*

7.2.2.8.1 *Connection establishment delay.* The maximum connection establishment delay is based on a connection request of the lowest priority, containing a total of 15 octets of DTE address information and 42 octets of facility fields and optional data. The specified value for each channel rate applies to an equal mix of GES-originated requests and AES-originated requests. The maximum connection establishment delay is the standard speed of service specification for the connection establishment phase; it is not intended to limit in any way the future use of optional facilities, user data fields, or address fields.

7.2.2.8.2 *Connection release delay.* The maximum connection release delay is based on a disconnect request at the lowest priority, containing no user data, invoking no optional facilities and carrying no address information. The specified value for each channel rate applies to an equal mix of GES-originated requests and AES-originated requests, when the connection release is not delayed by the presence of packets in transit on the connection. The maximum connection release delay is the standard speed of service specification for the connection release phase; it is not intended to limit in any way the future use of optional facilities, user data fields, or address fields.

7.2.3 RELIABILITY OF SERVICE

7.2.3.1 Reliability of service is determined by the system architecture, by the physical layer bit error rate, and by the average rate of "collisions" on R channels. There is no specification on the rate of R channel collisions. However, the system performance specifications for both speed of service and reliability of service are based on an average R channel occupancy factor (i.e. the ratio of occupied R channel slots to the total number of R channel slots during a given interval) of approximately 0.15. Higher R channel occupancies are permitted, provided that all of the applicable performance standards are met.

7.2.3.2 The standard reliability of service parameter for the transfer of a single DATA packet is residual error probability, which is the probability that an attempt to transfer a single DATA packet is not entirely successful. It is based on a standard reference DATA packet containing 128 octets of subnetwork user data. The undetected error probability for AMSS packet data service is expected to be less than 3×10^{-7} for standard reference DATA packets containing 128 octets of subnetwork user data. The undetected error probability for shorter packets is reduced approximately in proportion to the packet length.

7.2.3.3 Other reliability of service parameters are resilience of the virtual circuit or logical channel with respect to reset and release, i.e. the probability that the subnetwork service provider invokes a reset or release over some period of time. Reset and release operations may result in the loss of user data, whether invoked by the subnetwork user or by the subnetwork service provider.

7.3 Satellite subnetwork dependent protocol services and operations

7.3.1 LOGICAL CHANNELS

The requirements for selecting logical channel numbers are intended to prevent call collisions.

7.3.2 CONNECTION ESTABLISHMENT

7.3.2.1 The following describes a normal connection establishment between two SNS users.

7.3.2.2 When a subnetwork connection is initiated by one of the SNS users, an ISO 8208 DCE entity in the satellite subnetwork receives an ISO 8208 CALL REQUEST packet from the ISO 8208 DTE. This packet is forwarded to the IWF. The IWF forwards this packet to the appropriate SSNDPX entity. This SSNDPX entity forwards this packet as a CONNECTION REQUEST SNPDU to the remote SSNDPX. When the remote SSNDPX receives this SNPDU, it forwards this to the IWF as an ISO 8208 INCOMING CALL packet. The IWF forwards this packet to the appropriate ISO 8208 DCE entity. The ISO 8208 DCE entity forwards this packet to the peer ISO 8208 DTE entity. The ISO 8208 DTE forwards this connection request to the receiving SNS user. After the receiving SNS user has accepted this connection request, the ISO 8208 DTE entity forwards an ISO 8208 CALL ACCEPTED packet to the peer ISO 8208 DCE entity. The ISO 8208 DCE entity forwards this packet to the IWF. The IWF forwards this packet to the appropriate SSNDPX entity. This SSNDPX entity forwards this packet as a CONNECTION CONFIRM SNPDU to the peer SSNDPX entity. When the remote SSNDPX entity receives this SNPDU, it forwards this as an ISO 8208 CALL CONNECTED packet to the IWF. The IWF forwards this packet to the appropriate ISO 8208 DCE entity. This ISO 8208 DCE entity forwards this packet to the peer ISO 8208 DTE entity. When the ISO 8208 DTE entity receives this packet, it informs the originating SNS user about the establishment of a connection to the remote SNS user.

7.3.2.3 A connection between two SNS users consists of a series of logical channels. Each logical channel is selected based on the established rule by the receiving entity. Therefore, these logical channels may not have the same number. Figure A-17 of this guidance material shows an example of connection establishment between three pairs of SNS users.

7.3.2.4 *Throughput negotiation*

Since the GES has the knowledge of available throughput based on the throughputs that have been assigned to the existing subnetwork connections (SNCs), it should assign the throughput classes for each direction of data transmission. The recommended actions by the GES are given in 7.3.6.1 and 7.3.7.1 of this guidance material.

7.3.3 CONNECTION RELEASE

7.3.3.1 *SSNDPX*

To avoid unnecessary releases at the SSNDPG caused by residual DATA/INTERRUPT SNPDUs from the SSNDPA, the SSNDPA waits until all DATA/INTERRUPT SNPDUs in transmission and pertaining to that connection have been transmitted before forwarding a CONNECTION RELEASED or a CONNECTION RELEASE COMPLETE SNPDU to the SSNDPG. The SSNDPA need not correlate the transmission status of each DATA/INTERRUPT SNPDU with transmission status indications from the data link layer. However, the SSNDPA waits until all outstanding DATA/INTERRUPT SNPDUs have been acknowledged by the link layer (success/fail LIDU) before sending a CONNECTION RELEASED or CONNECTION RELEASE COMPLETE SNPDU. Since to-aircraft SNPDUs are always delivered in proper sequence by the link layer, the SSNDPG may send a CONNECTION RELEASED or CONNECTION RELEASE COMPLETE SNPDU without waiting for acknowledgement of previously sent DATA/INTERRUPT SNPDUs.

7.3.4 DATA TRANSFER

7.3.4.1 *IWF*

The IWF should forward the DATA packets between the appropriate SSNDPX and ISO 8208 DCE entities and supply these entities with sufficient information to identify the appropriate logical channel.

7.3.4.2 *SSNDPG*

Since the DATA SNPDUs from the AES are sent through either the R or T channel, they may be received out-of-sequence at the GES. Therefore, the SSNDPG should have sufficient storage to reorder the out-of-sequence DATA SNPDUs before forwarding the data in these SNDPUs to the IWF.

7.3.4.3 *Flow control procedure*

7.3.4.3.1 Memory management mechanisms are implementation dependent. In order to minimize the possibility of memory overflow and the consequent loss of data, the satellite subnetwork layer provides flow control, which may be invoked by the AES, the GES, or the subnetwork user. The SSNDPX uses start-stop flow control, while the DCE uses ISO 8208 window flow control. ISO 8208 RECEIVE READY and RECEIVE NOT READY packets are produced locally; they are never transferred across the subnetwork. If the SSNDPX remains in the "flow control not ready" state for 60 seconds, the subnetwork initiates a reset of the connection, regardless of whether flow control was suspended by the subnetwork or by the subnetwork user. The timer (tN7) is associated with the receiving SSNDPX, i.e. the SSNDPX that originated the FLOW CONTROL SUSPEND SNPDU.

7.3.4.3.2 System designs should minimize the possibility that flow control will be invoked on priority 14 connections, e.g. by dynamic memory allocation or by providing additional fixed memory allocation for priority 14 connections. Dynamic memory allocation procedures, if used, should take connection priority into consideration.

7.3.4.3.3 *SSNDPX*

7.3.4.3.3.1 When the SSNDPX surpasses a storage threshold or receives a FLOW CONTROL (suspend) SNPDU from the remote SSNDPX, it should notify the IWF of this condition.

7.3.4.3.3.2 If the SSNDPX falls below a storage threshold or receives a FLOW CONTROL (resume) SNPDU from the remote SSNDPX after it has informed the IWF of the flow control suspend condition, it should notify the IWF of this condition.

7.3.4.3.3.3 When the SSNDPX surpasses a storage threshold or receives flow control suspend information from the IWF, it should forward a FLOW CONTROL (suspend) SNPDU to the remote SSNDPX when the next DATA SNPDU is received on that VC, providing the situation has not cleared by then.

7.3.4.3.3.4 If the SSNDPX falls below a storage threshold or receives flow control resume information from the IWF after forwarding a FLOW CONTROL (suspend) SNPDU to the remote SSNDPX, it should forward a FLOW CONTROL (resume) SNPDU to the remote SSNDPX.

7.3.4.3.4 *ISO 8208 DCE*

7.3.4.3.4.1 When the ISO 8208 DCE surpasses a storage threshold or receives flow control suspend information from the IWF, it should suspend the updating of the lower window edge of the local DTE or forward a RECEIVE NOT READY packet to the local DTE.

7.3.4.3.4.2 If the ISO 8208 DCE falls below a storage threshold or receives a flow control resume information from the IWF after it has suspended the updating of the lower window edge of the local DTE or forwarded a RECEIVE NOT READY packet to the local DTE, it should resume updating the lower window edge of the local DTE or forward a RECEIVE READY packet to the local DTE.

7.3.4.3.4.3 When the ISO 8208 DCE surpasses a storage threshold or receives a RECEIVE NOT READY packet from the local DTE, it should notify the IWF of this condition.

7.3.4.3.4.4 If the ISO 8208 DCE falls below a storage threshold or receives a RECEIVE READY packet from the local DTE after it has informed the IWF of the flow control suspend condition, it should notify the IWF of this condition.

7.3.4.4 *Data loss*

7.3.4.4.1 In a connection release or connection reset, DATA SNPDUs and ISO 8208 DATA packets on that connection may be lost. To guarantee end-to-end delivery of end-user data, a confirmed service such as the one provided by a transport protocol may be used.

7.3.4.4.2 System designs should minimize the possibility that flow control will be invoked on priority 14 connections, e.g. by dynamic memory allocation or by providing additional fixed memory allocation for priority 14 connections. Dynamic memory allocation procedures, if used, should take connection priority into consideration.

7.3.4.5 *Expedited data transfer*

7.3.4.5.1 It is expected that the ATN will not require expedited data transfer service. However, expedited data transfer service is supported in accordance with ISO 8208.

7.3.4.5.2 For each logical channel, the expedited data transfer allows an interrupt SNPDU packet to be sent in a given direction while data transfer in that direction is suspended. This is accomplished by sending the interrupt SNPDU or interrupt packet ahead of data SNPDUs or data packets that have been suspended.

7.3.4.6 *Connection reset*

7.3.4.6.1 SSNDPX. To avoid resets at the SSNDPG caused by residual DATA/INTERRUPT SNPDUs from the SSNDPA, the SSNDPA waits until all DATA/INTERRUPT SNPDUs in transmission and pertaining to that connection have been transmitted before forwarding RESET or RESET CONFIRM SNPDUs to the SSNDPG. The SSNDPA need not correlate the transmission status of each DATA/INTERRUPT SNPDU with transmission status indications from the data link layer. However, the SSNDPA waits until all outstanding DATA/INTERRUPT SNPDUs have been acknowledged by the link layer (success/fail LIDU) before sending a RESET SNPDU. Since to-aircraft SNPDUs are always delivered in proper sequence by the link layer, the SSNDPG may send a RESET SNPDU without waiting for acknowledgement of previously sent DATA/INTERRUPT SNPDUs.

7.3.5 SNPDU FORMATS

7.3.5.1 *Fast select facility*

The fast select facility with parameter set to "use not permitted" may be included in the CONNECTION REQUEST SNPDU to explicitly indicate that no user data may be transferred in the CONNECTION CONFIRM and CONNECTION RELEASED SNPDUs. If this facility is not included in the CONNECTION REQUEST SNPDU, then up to 128 octets of user data may be transferred in the CONNECTION CONFIRM and CONNECTION RELEASED SNPDUs.

7.3.6 PACKET TO SNPDU MAPPING RULES

7.3.6.1 *GES actions*

7.3.6.1.1 The selected throughput class in the CALL ACCEPTED packet should be transferred to the TCN value in the CONNECTION CONFIRM SNPDU.

7.3.6.1.2 If the throughput class in the CALL REQUEST packet is less than or equal to the calculated available value, then the throughput class should be transferred to the TCN value in the CONNECTION REQUEST SNPDU; otherwise, the calculated available throughput, rounded down to the nearest standard value, should be transferred to the TCN value.

7.3.7 SNPDU TO PACKET MAPPING RULES

7.3.7.1 *GES actions*

7.3.7.1.1 If the throughput class negotiation (TCN) value in the CONNECTION REQUEST SNPDU is less than or equal to the calculated available throughput value, the throughput class in the INCOMING CALL packet should be set equal to the TCN value; otherwise, the throughput class in the INCOMING CALL packet should be set equal to the calculated available throughput, rounded down to the nearest standard value.

7.3.7.1.2 The selected throughput class in the CALL CONNECTED packet should be transferred from the TCN value in the CONNECTION CONFIRM SNPDU.

7.4 ISO 8208 DCE protocol operations

7.4.1 CONFORMANCE REQUIREMENTS

The capabilities which the ISO 8208 DCE is not required to support include the following:

a) modulo 128 packet sequencing;

b) default window size of more than 2; and

c) either the use of the D-bit or the optional mechanism for negotiating use or non-use of the D-bit since these capabilities are not required by the subnetwork users.

Note.— The use of D-bit or the optional mechanism for negotiating use or non-use of the D-bit is strongly discouraged.

7.5 Management interface

7.5.1 AES MANAGEMENT INTERFACE

When an AES logs off or otherwise terminates communication with a GES, the SSNL clears all connections and SVCs associated with that GES. This may be done by sending CLEAR INDICATION packets to each ISO 8208 DCE logical channel associated with these connections and releasing the resources for the logical channels in the associated SSNDPA entity.

7.5.1.1 (Reserved)

7.5.2 GES MANAGEMENT INTERFACE

When an AES logs-off from a GES, the SSNL should clear the connections between the SNS user(s) and the logged-off AES. This may be done by sending CLEAR INDICATION packets to each ISO 8208 DCE logical channel associated with these connections and releasing resources for the logical channels in the associated SSNDPG entity.

8. CIRCUIT-MODE SERVICES

8.1 Circuit-mode voice signalling protocols

8.1.1 *General.* The circuit-mode logic processes defined in Annex 10, Volume III, Part I, Chapter 4, 4.8 represent the minimum set of protocol interactions necessary to ensure interoperability of aircraft earth stations (AESs) and ground earth stations (GESs) operating in the safety service. The protocol interactions necessary to support air and ground-originated calls arriving at the AES or GES are defined via separate signalling procedures in each.

8.1.2 *Logic for air-originations.* The AES and GES air-origination signalling procedures for the prevalent aeronautical mobile-satellite service (AMSS) and for the aeronautical mobile satellite (route) service (AMS(R)S) are the same. Provisions are made for an abbreviated call establishment procedure, specifically voice calls at the safety priorities (i.e. distress/urgency, flight safety and regularity/meteorological).

8.1.3 *Link layer services.* Circuit-mode services use the R, P, and C channel sub-band link layer protocols defined in Annex 10, Volume III, Part I, Chapter 4, 4.5 and 4.6 for all call signalling information exchanged between the AES and GES. This information is exchanged with the link layer via circuit-mode link interface data units (CM-LIDUs). Link layer services perform conversions between CM-LIDUs and the respective AMS(R)S circuit-mode signalling units (SUs). In all cases, only the direct link service (DLS) is used since circuit-mode services are responsible for recovering from missing SUs.

8.1.4 AIR-ORIGINATION PROCEDURES

8.1.4.1 *Aircraft earth station (AES) procedure*

8.1.4.1.1 *Call origination*

8.1.4.1.1.1 *General call establishment.* The AES commences an air-origination by transmitting to the GES an "access request" CM-LIDU. The AES then awaits receipt from the GES of a C channel assignment CM-LIDU for a period of tA50 seconds. This sequence is repeated four times before aborting the call attempt. Calls aborted by the AES in this manner must be re-attempted by the user.

8.1.4.1.1.2 *Abbreviated call establishment.* The AES commences an air-origination by transmitting to the GES a series of four, three, or two contiguous "access request" CM-LIDUs. The series length is determined by whether the call priority is distress/urgency, flight safety or regularity/meteorological, respectively. The purpose of the multiple transmissions is to mitigate the effects of an SU lost due to R channel collisions. The AES then awaits receipt from the GES of a C channel assignment CM-LIDU for a period of tA50 seconds. This sequence will be repeated four times before aborting the call attempt. Calls aborted by the AES in this manner must be re-attempted by the user.

8.1.4.1.2 At the instant at which the call origination begins, if sufficient AES resources for the call are not available due to blockage attributable to a lower priority call at the AES, the AES will defer pre-emption of these resources and proceed as per 8.1.4.1.1 until a C channel assignment is received from the GES. This will allow the AES to make a proper pre-emption decision based on the exact EIRP assignment from the GES. Upon receipt of the C channel assignment, all required AES C channel resources (i.e. channel unit and AES EIRP) are pre-empted from a lower priority call (if necessary) and allocated to the call. This is followed immediately by further signalling and continuity checks on the C channel sub-band while the GES is engaged in completing the call to the ground destination.

Note.— As a secondary benefit, by requiring that the AES defer pre-emption until a C channel assignment is received, the future development of an alternative procedure incorporating reuse of an existing C channel is facilitated.

8.1.4.1.3 *Address digits*

8.1.4.1.3.1 *General call establishment.* The "access request" CM-LIDU contains the first two digits of the AMS(R)S ground address. The remaining digits are provided on the C channel sub-band as "call information — service address" CM-LIDUs which serve as a basis for the C channel continuity check procedure.

8.1.4.1.3.2 *Abbreviated call establishment.* The "access request" CM-LIDU contains all digits of the fixed-length 10-digit AMS(R)S ground address. Providing this information concurrent with the access request allows the GES to begin forward completion of the call across the ground network while it proceeds simultaneously with C channel establishment. These address digits are repeated on the C channel sub-band as "call information — service address" CM-LIDUs which serve as a basis for the C channel continuity check procedure. However, their presence in these CM-LIDUs serves no purpose for the AMS(R)S air-origination procedure other than to allow the AES to interwork with a GES which supports prevalent non-safety AMSS circuit-mode procedures rather than the SARPs-specific air-origination procedure.

8.1.4.2 *Ground earth station (GES) procedure*

8.1.4.2.1 *Processing of call initiation*

8.1.4.2.1.1 *General call establishment.* Upon receipt of an "access request" CM-LIDU from an AES, the GES immediately allocates C channel resources and responds with a "C channel assignment" CM-LIDU. Simultaneously, the GES analyses the network-ID contained in the access request and awaits the completion of the receipt of the service address. Forward call set-up across the ground network is then completed.

8.1.4.2.1.2 *Abbreviated call establishment.* Upon receipt of an "access request" CM-LIDU from an AES, the GES immediately allocates C channel resources and responds with a "C channel assignment" CM-LIDU. Simultaneously, the GES analyses the network-ID contained in the access request and begins forward call completion across the selected ground network.

8.1.4.2.2 The GES circuit-mode procedure monitors the status of the from-aircraft C channel carrier throughout the call. Loss of carrier for more than tG13 seconds will result in termination of the call by the GES. When this happens, the GES will send six "call progress — channel release" CM-LIDUs during this phase so as to ensure that the AES's call state is cleared. If the AES carrier were to reappear (possibly indicative of anomalous propagation conditions non-conducive to call continuance) the GES will attempt to again clear the AES call by sending six additional "call progress — channel release" CM-LIDUs on the C channel sub-band and one on the P channel.

8.1.4.2.3 When the GES passes the forward call origination to the selected ground network, it must also convey the call priority and the AES and terminal IDs of the originator. This will ensure that the ground network can be sensitive to the call's priority during routing; and that the ground user is always advised of the identity of the originator so as to facilitate return calls to aircraft that a controller may not otherwise be aware of. In those cases where a call is blocked due to an engaged (busy) condition at the ground destination, the GES may, as an option: (1) interpret a specific backward signal from the ground network which indicates that the call attempt has been recorded at the ground destination, and then (2) forward a corresponding CM-LIDU to the AES. This is accomplished by a specific combination of cause codes in the "call progress — channel release" CM-LIDU and the BITE 16 telephony event at the interworking interfaces with the external aircraft and terrestrial networks. This will serve to alert an aircrew that a ground user has been alerted to the existence of the unsuccessful call attempt and has been provided the information necessary to initiate a return call at a later time.

8.1.5 GROUND-ORIGINATION PROCEDURES

8.1.5.1 *Ground earth station (GES) procedure*

8.1.5.1.1 Upon receipt of a call origination from a ground network, the GES commences a ground-origination by allocating GES resources to the call and then sending to the AES via the P channel a "call announcement" CM-LID followed by a "C channel assignment" CM-LID. The GES will then await receipt of the from-aircraft C channel carrier prior to conducting a continuity check on the C channel sub-band. The AES will initiate the continuity check by sending a "call progress — test" CM-LIDU to which the GES will respond with a "call progress — test" CM-LIDU every tG35 seconds until the call is either completed to the aircraft destination or terminated unsuccessfully (e.g. destination busy, call clearing, etc.). The AES will acknowledge receipt of a "call progress — test" CM-LIDU, thereby completing the continuity check, by sending either a positive "telephony acknowledge" CM-LIDU or a "call progress — connect" CM-LIDU. (The latter will have been sent in lieu of the former if the aircraft user answered the call immediately after the continuity check procedure.) The GES will react to either CM-LIDU by forwarding an "address complete" BITE to the ground network and, in the case of the latter CM-LIDU, an "answer" BITE as well. At this point the talk phase of the call may proceed.

8.1.5.1.2 The GES will monitor the status of the C channel for the duration of the call. If a "call progress — connect" CM-LIDU is received during this phase and subsequent to the completion of the continuity check phase, the GES will forward an "answer" BITE to the ground network and maintain the C channel. The GES monitors the status of the from-aircraft C channel carrier throughout the call. Loss of carrier for more than tG19 seconds will result in termination of the call by the GES. When this happens, the GES will send six "call progress — channel release" CM-LIDUs during this phase so as to ensure that the AES's call state is cleared. If the AES carrier were to reappear (possibly indicative of anomalous propagation conditions non-conducive to a usable call) the GES will attempt to again clear the AES call by sending twelve additional "call progress — channel release" CM-LIDUs on the C channel sub-band and one on the P channel.

8.1.5.1.3 If the GES receives a "call progress — channel release" CM-LIDU (indicating that the aircraft user has terminated the call) the GES will forward a "clear back" BITE to the ground network and terminate the call. Similarly, if the GES receives a "clear forward" FITE from the ground network (indicating that the ground user has terminated the call) the GES will send six "call progress — channel release" CM-LIDUs over the C channel sub-band and then monitor the AES to ensure that it has terminated its from-aircraft C channel carrier.

8.1.5.1.4 Events such as unsuccessful continuity checks and call clearing will result in the eventual termination of C channel transmissions from the AES. While these various termination events are progressing, the GES will monitor the from-aircraft carrier to ensure that the AES is performing similar call termination activities. If the from-aircraft carrier has not terminated within tG17 seconds after the transmission of an initial series of "call progress — channel release" CM-LIDUs, the GES will send twelve additional of these CM-LIDUs via the C channel sub-band and a thirteenth via the P channel. If these transmissions are not successful in causing the AES to terminate its C channel transmission within tG18 seconds after the last transmission, the GES will terminate all call activities unilaterally.

8.1.5.2 *Aircraft earth station (AES) procedure*

8.1.5.2.1 An incoming call to an AES is announced by the receipt of "call announcement" and "C channel assignment" CM-LIDUs. Since these are sent on the direct link service, circuit-mode services implements an error recovery procedure whereby the AES can infer that one of these CM-LIDUs is missing (e.g. due to bit errors on the P channel) and request that it be repeated by the GES. The AES initiates the request by transmitting an appropriately encoded "telephony acknowledge" CM-LIDU via the R channel. When an AES has received a "call announcement" CM-LIDU and its associated "C channel assignment" CM-LIDU it will initially verify that the called terminal is available and that adequate C channel resources (i.e. channel unit and AES EIRP) are either available or pre-emptable. If the foregoing requirements are not all met the AES will send an appropriately encoded "call progress — call attempt result" CM-LIDU via the R channel and then terminate all activities for the call. Otherwise, it will activate a C channel unit on the assigned C channel frequency pair and begin the C channel continuity check procedure by sending a "call progress — test" CM-LIDU via the C channel sub-band.

8.1.5.2.2 The AES will send an additional "call progress — test" CM-LIDU every tA26 seconds for tA41 seconds until an identical CM-LIDU is received from the GES. This constitutes a successful continuity check and will immediately cause the AES to: (1) enable the voice circuit between the aircraft voice channel and the C channel unit, (2) forward a "call origination" FITE to the aircraft destination, and (3) send a "telephony acknowledge" CM-LIDU via the C channel sub-band to the GES. The AES will then await tA42 seconds for the aircraft destination to answer the call. If the call is not answered within this time period the AES will clear the call toward the aircraft destination, send six "call progress — channel release" CM-LIDUs to the GES, and then terminate the call. Otherwise, if the aircraft destination answers within this time limit the AES will send a "call progress — connect" CM-LIDU to the GES and maintain the C channel during the talk phase of the call.

8.1.5.2.3 When the "call progress — connect" CM-LIDU is sent, the AES will initiate an error recovery procedure to ensure its receipt at the GES. (The talk phase progresses in the interim.) Timer tA26 is used to implement a transmission repeat cycle for this CM-LIDU which must result in receipt at the AES of a "telephony acknowledge" CM-LIDU within tA30 seconds of the original transmission. Failure to receive the acknowledgement within tA30 seconds will cause the AES to terminate the call.

8.2 Interworking of circuit-mode services with other voice networks

8.2.1 *AMS(R)S circuit-mode procedures.* A standardized set of circuit-mode procedures within the AES and GES implement the AMS(R)S circuit-mode protocols and provide specific interfaces with non-AMS(R)S telephony interworking procedures. The AMS(R)S circuit-mode procedures correspond to specific AES and GES circuit-mode processes and represent the highest level of functionality contained in the AMSS SARPs. The interworking procedures, although physically contained within the AES and GES equipment, represent the initial "layer" of functionality immediately adjacent to and external from the AMS(R)S circuit-mode procedures. The interworking procedures represent the functional area where specific conversions between the AMS(R)S circuit-mode procedures and user or service provider-specific signalling implementations are effected. The interworking protocol between the AMS(R)S circuit-mode procedures and the interworking procedures is defined using a standard set of interworking telephony events.

8.2.2 *Interworking with external telephony systems.* Interworking is the controlled transfer of signalling information across the interface between different signalling systems where the significance of the information is identical or where the significance is translated in a defined manner.

8.2.2.1 *Interworking protocol basis.* The interworking protocol is defined through the use of a set of forward and backward interworking telephone events (FITEs and BITEs). The interworking telephone events that are used herein to define the interworking protocol are a subset derived from the standardized definitions contained in CCITT Recommendation Q.608. Defining the interworking protocols on the basis of FITEs and BITEs is in conformance with standard telephony system practice. It should be noted that the use of FITEs and BITEs is merely a convenient nomenclature and in no way places dependencies on specific equipment implementations.

8.2.2.1.1 *FITE.* A FITE is an event where telephony signalling information is transferred in the forward direction from an incoming signalling system to an outgoing signalling system. The "forward" direction of a FITE is referenced to the fact that a FITE propagates in a direction that is away from the originating end of a call. Certain FITEs may also carry mandatory and optional information elements pertinent to the event (e.g. address digits).

8.2.2.1.2 *BITE.* A BITE is an event where telephony signalling information is transferred in the reverse direction from an outgoing signalling system to an incoming signalling system. The "backward" direction of a BITE is referenced to the fact that a BITE propagates in a direction that is toward the originating end of a call. Certain BITEs may also carry mandatory and optional information elements pertinent to the event (e.g. call attempt result information).

8.2.3 AES TELEPHONY INTERWORKING

8.2.3.1 *Relationship of AES signalling systems.* Figure A-18 of this guidance material depicts the relationship between the AES circuit-mode procedures, their respective interworking procedures, and aircraft-specific telephony signalling implementations. In particular, the referenced figure defines both the usage of "incoming" and "outgoing" procedures from the viewpoint of the originating call party and the external interface of the AES circuit-mode procedures.

8.2.3.2 *AES interworking telephony event definition.* The AES circuit-mode procedures interwork with aircraft telephony signalling systems via the forward and backward interworking telephony events defined in the Standards. The AES circuit-mode procedures must map specific interworking telephony events to specific protocol interactions in the AES circuit-mode logic procedures where interactions with an aircraft signalling system are required. This mapping must also include parameter mapping where indicated in the Standards.

8.2.3.3 *Aircraft telephony interworking.* An on-aircraft telephony network is not to be required to implement any type or manner of physical network implementation. Any particular implementation is at the option of the aircraft operator as long as that implementation is made to interwork with the AES circuit-mode procedure's interworking protocol.

Note 1.— An aircraft operator might choose to not implement a discrete aircraft telephony signalling network external to the AES equipments. At their option, a "call control agent" function could be integrated within the AES equipments in such a manner as to eliminate the need for a discrete aircraft signalling network.

Note 2.— In those cases where an AES is configured to sustain more than one simultaneous ATS call, the aircraft's called terminal addresses should be configured into one or more appropriate "hunt groups". This will reduce the incidence of ground-originated calls to a specific called terminal being blocked by an engaged condition when an equally appropriate called terminal is available.

8.2.4 GES TELEPHONY INTERWORKING

8.2.4.1 *Relationship of GES signalling systems.* Figure A-19 of this guidance material depicts the relationship between the GES circuit-mode procedures, their respective interworking procedures, and ground-specific telephony signalling implementations. In particular, the referenced figure defines both the usage of "incoming" and "outgoing" procedures from the viewpoint of the originating call party and the interworking interface of the GES circuit-mode procedures.

8.2.4.2 *GES interworking telephony event definition.* The GES circuit-mode procedures interwork with terrestrial network telephony signalling systems via the forward and backward interworking telephony events defined in the Standards. The GES circuit-mode procedures must map specific interworking telephony events to specific protocol interactions in the GES circuit-mode logic procedures where interactions with a terrestrial network signalling system are required. This mapping must also include parameter mapping where indicated in the Standards.

8.3 Implementing satellite voice in the ATS environment

8.3.1 *Overview.* The AMS(R)S voice service has basic operational attributes which fundamentally differ with prevalent very high frequency (VHF) and high frequency (HF) voice operations. This will require close attention to how satellite voice is implemented in a data link-oriented ATS environment. These differences include a statistical delay in speech channel establishment, a perceptible delay in speech propagation, circuit-switched operation, full-duplex operation, and the inability for aircraft to monitor communications between the ground and other aircraft. Additionally, the AMS(R)S voice service places functional requirements on terrestrial facilities which are external to the GES (e.g. terrestrial networks and ACF automation equipment) in order to maximize its utility.

8.3.2 *Channel establishment delay.* Upon call origination, each user must provide to its respective AES or GES the telephone number of the desired destination and then wait for the system to establish a speech channel. This is in sharp contrast with conventional radio operations where typically each user maintains a continuous listening watch on a radio channel. In addition, the channel establishment delay is statistical in nature and is dependent upon the over-all traffic load on the AMSS system.

8.3.3 *Call annunciation.* It is anticipated that aircraft operators will integrate the satellite voice equipment with other aircraft systems in a manner very similar to current VHF and HF radio equipment. This may lead to minor inconsistencies in how voice calls are managed on different aircraft. For instance, interwiring satellite voice equipment with existing aircraft audio control panels may lead to inherently half-duplex operation on certain aircraft even though all of the intervening speech channels are full-duplex. Incoming air-originated calls will, in many cases, be annunciated to the aircrew via a SELCAL chime or other audible indication, and will require a crew action to answer the call. This means that a ground user must await a positive answer indication (e.g. crew voice response) before speech can begin. Otherwise, there would be no assurance to the ground user that the call is audible to the crew. This particular aspect is quite important given the expectation that:

a) satellite voice calls will be very infrequent in a data link oriented environment; and

b) the inability of an aircrew to monitor satellite voice communications by other aircraft precludes positive, routine assurance that the proper aircraft audio panel selections have been made.

8.3.4 *Aircraft call management.* Aircraft flight management computer systems can be useful in managing routine aspects of voice call management for the aircrew. For instance, ground number directories and selection menus can be provided by these systems so that the need for an aircrew to enter discrete telephone numbers on a control/display device can be minimized. These systems could also correlate with directory information the associated data link end-system address information or the aircraft's position in order to recommend an appropriate ground address for use in an ATC call. However, it should be noted that the crew must be able to select or otherwise imply the appropriate priority of a call attempt prior to origination.

8.3.5 *Air-originated call information.* When the GES forwards an air-originated call to the terrestrial network, the call indication will include, in addition to the desired ground address, the call's priority, and the AES-ID and calling terminal-ID associated with the call. (Annex 10, Volume III, Part I, Appendix 5 to Chapter 4, Figure A5-28 refers). The call priority can be used by the terrestrial network to facilitate a potential pre-emption action within that network and to notify the ground destination of the call's priority in cases where the ground user might be servicing other calls. The AES and terminal ID information is provided so as to facilitate correlated routing (8.3.6) of the call (by an ACF or other facility) to the proper destination within that facility as determined by the facility's information concerning the aircraft.

8.3.6 *Correlated routing.* Call routing functions within a facility should be able to determine the proper internal destination to which a call should be routed based on the facility's current data pertaining to the aircraft. This requires that the facility correlate the originating aircraft's AES-ID (see 8.3.5) with information that it may have concerning the aircraft and then route the call to the relevant ground user. Consideration should be given to the establishment of a universal default agent code in the AMS(R)S ground numbering plan (e.g. "000") which would be known to all facilities to be an implied request by the aircrew to provide the correlation function. The remaining 999 code values in the agent code field would remain available for discrete ground user addresses within a facility.

8.3.7 *Facility incoming call management.* The ground user should have several options available for those instances when an air-originated call arrives while they are conducting a pre-existing call with another aircraft. A ground user should be able to combine any reasonable number of satellite voice calls in a conference so that the communications service can be managed in a manner similar to a VHF radio channel if the ground user so chooses. This can be implemented with a conventional telephony conference bridge situated between the ground user and the terrestrial voice network. In addition, the ground user should receive an immediate presentation of the call information listed in 8.3.5 for all arriving calls so as to facilitate a proper call handling decision. Examples of two possible operational modes are as follows:

a) *Barge-in.* All arriving calls for an individual destination are automatically answered by an automation function on behalf of the ground user; and are placed in a multi-way conference consisting of the ground user and any existing calls. This is intrinsically the simplest mode of operation in that it allows all users to immediately contend for the ground user's attention by listening for any active conversation just as in VHF radio. Barging in to an active conversation, however, would require that the caller tie up a C channel resource while waiting for the previous conversation to end.

b) *Serial access with priority override.* An arriving call for an individual destination is automatically answered by an automation function on behalf of the ground user. Any additional calls arriving at a priority equal to or lower than an existing call receive a "busy" indication and are cleared automatically. Any additional calls arriving at a priority higher than an existing call are answered automatically and conferenced with any call(s) that the ground user is currently conducting. This allows only higher priority calls to "barge-in" on existing calls. It also allows a calling aircrew (at the higher priority) to gain the ground user's attention verbally without needlessly terminating an existing lower priority call.

8.3.8 *Aircraft microphone push-to-talk operation.* The AMSS voice channel provides a bi-directional audio path which is inherently full-duplex. However, it is strongly recommended that conventional (i.e. VHF-like) half-duplex push-to-talk (PTT) operation be maintained in all aircraft installations — but only to the extent that the flight crew must actuate a PTT key in order to be heard by the ground user. In other words, to-aircraft audio should always be audible in headphones without muting when the PTT key is actuated. (Designers should still pay due attention to cockpit speaker muting when a microphone is keyed.) This will allow the crew to manage the satellite voice conversation in consideration of other concurrent flight deck activities. In addition, enforced PTT operation will help ensure that the potential future use of audio conferencing at a ground user workstation is not impaired by uncontrolled cockpit ambient noise (i.e. from "hot" microphones) in those instances where a controller has several satellite voice calls operating simultaneously.

8.3.8.1 Flight crews should be able to override enforced half-duplex operation so they can take advantage of the full-duplex voice channel when the operational situation warrants (e.g. in-flight medical emergencies).

8.4 Terrestrial voice network considerations

8.4.1 *Overview.* The AMSS SARPs provide for the implementation of a shared, common-user terrestrial voice switching network that interconnects each GES with one or more ground facilities expressly for aeronautical safety communications. This network can be composed of one or more subnetworks operating in tandem to provide the appearance of a single cohesive network service between GESs and external ground facilities (e.g. ACF, aircraft dispatch, etc.) This network should be separate and distinct from other networks which may be attached to a GES for non-safety purposes (e.g. the public switched telephone network).

8.4.2 *Access control.* For air-originated calls, access to the terrestrial safety network is achieved by the AES encoding the access request signalling with a network-ID value of "10". This value will indicate to the GES that the call shall be routed to the terrestrial safety network and that all specific signalling information must be included with the call indication. AES implementations should be subject to certification provisions that ensure that it will not be possible for non-safety users on an aircraft to gain access to the terrestrial safety network.

8.4.3 *Routing analysis.* For air-originated calls, the GES will not analyze the ground address information contained within an access request other than to interpret the network-ID value for selection of the proper terrestrial network (i.e. "10"). Upon receipt of the call indication from the GES, the terrestrial safety network must interpret the country and facility code fields contained in the call information and route the call to the proper facility as required. For ground-originated calls, the originating facility must provide the terrestrial safety network with the ID of the desired GES along with the other call information (i.e. AES-ID, terminal-ID, and call priority) when the call indication is conveyed to the network.

8.4.4 *Call routing functions.* Call routing functions external to the GES can be categorized as being either high-level routing between GESs and ground facilities, and low-level routing carried out within a facility.

8.4.4.1 *High-level routing.* For air-originated calls, high-level routing consists of the terrestrial safety network interpreting the country and facility codes which are contained in the ground address and routing the call to the network's terminus with the proper facility. For ground-originated calls, high-level routing consists of the terrestrial safety network interpreting the GES-ID which was received in the call information from the originating facility and routing the call to the network's terminus with the proper GES.

8.4.4.2 *Low-level routing.* When an air-originated call reaches the desired facility over the terrestrial safety network, a low-level routing function within the facility must interpret the agent code contained within the call information and then route the call to the indicated ground user. It should be noted that, if the agent code value indicates that the call must be correlated with other aircraft information at the facility, the low-level routing function must also interpret the AES-ID contained within the call information and then route the call within the facility based on the correlation results.

8.4.5 *Terrestrial network implementation alternative.* Particular switching network architectures are not mandated for the terrestrial safety network. For instance, individual agreements between AMSS service providers and either administrations or aircraft operators may provide for the integration into the GES equipments of some or all of the high-level routing functions. This would then require that the GES perform the routing tasks described in 8.4.4.1 and route calls to individual facilities via dedicated GES-to-facility trunk groups.

8.4.6 *Pre-emption.* The terrestrial safety network, and/or its individual tandem subnetworks are required to pre-empt and reallocate any resource assigned to an existing call when that call is blocking the completion of a higher-priority call attempt. The incidence of pre-empted calls can be minimized by reserving one or more channels within all voice trunk group for high priority calls (e.g. distress/urgency).

8.5 Implementing the group call/broadcast functions

8.5.1 *Overview.* Under certain conditions a ground user may desire to establish a ground-originated conference call (a group call) with several aircraft at once. Similarly, there may be occasions where there is a need to establish a one-way broadcast to a group of aircraft (a group broadcast). Although the group call and group broadcast functions are not explicitly provided for in the AMS(R)S system protocols, equivalent functions can be readily catered for by implementing several basic call origination functions in the facility automation system.

8.5.2 *Group call.* The group call function can be effected by requiring that the ground user (or an associated automation service) place independent calls to each aircraft designated by the user to be in the group call or "conference". Separate, parallel calls through the terrestrial network and AMSS satellite service would then be established for each aircraft in the conference. The use of individual voice calls for each aircraft in the group can be easily implemented and it also facilitates the centralized management of aircraft entry-to and exit-from the conference by the user. Except for the facility automation functions and the low-level voice switching equipment serving the ground user, no other intervening tandem network (terrestrial or AMSS) need do any specialized call processing in order to establish a group call.

8.5.2.1 The terrestrial network equipment immediately adjacent to the ground user should provide an audio conference function on behalf of the user whereby all aircraft in the conference can hear speech audio generated by other aircraft as well as the ground user. This will provide a passive means to serialize access to the ground user that is identical to that of VHF radio except for the satellite delay effects. Additionally, the facility automation function should also manage the "list" of aircraft in the group so that the ground user can be constantly aware of the presence — or absence — of each aircraft in the group call.

8.5.2.2 During group call origination, the individual aircraft speech channels in a group call cannot be expected to begin operation simultaneously. This is because: (1) the call announcement signalling arriving over the P channel will not reach all aircraft in the group call simultaneously, (2) C channel establishment delay after receipt of this signalling will vary, and (3) all aircrew in the group may not be able to answer the incoming call simultaneously due to primary attention to flight deck duties. This latter human factors issue has the potential to cause considerable confusion as various aircrew answer the call and enter the group conference, especially if the aircrew are not aware that an incoming call is a group call. The risk of this confusion can be mitigated if the aircrew can be advised that an incoming call is actually a group call so that they can remain quiet on the circuit until the ground user begins speaking. One way to accomplish this is for the facility automation function to transmit a repetitive audio alert tone sequence or recorded verbal advisory until all aircraft have answered the call and are ready to participate in the conference.

8.5.3 *Group broadcast.* The procedures for group broadcast can be identical to those of group call except that the conference function provided by the facility should not convey or relay any air-to-ground audio that might inadvertently arrive from aircraft in the broadcast group. As in the case of group call, human factors considerations may require that there be some way to indicate the arrival of a one-way group broadcast to the aircrew.

8.6 Implementing the call registration function

8.6.1 *General.* Under normal circumstances, an ATS specialist who has available an AMS(R)S voice communications service should be able to receive and maintain concurrent air-originated calls from a reasonable number of aircraft. (Paragraph 8.3 provides further guidance on how this may be implemented.) However, there may be operational situations where the ATS specialist wishes either to bar incoming calls or to service arriving calls one at a time — in other words return a "busy" indication to calling aircraft. In these instances, good operational practice should include both making an automatic record of the call attempt for the ATS specialist (call "registration") and advising the aircrew that their failed call attempt has been registered. This notification to the aircrew would carry an implied intent on the part of the ATS specialist to originate a subsequent reciprocal call to the originating aircraft at the first opportunity.

Note.— Paragraph 8.3.5 describes the air-originated call information elements that can be used by the terrestrial facilities to accomplish call registration. The GES and terrestrial network facilities are required to convey this information to the ground user facility.

8.6.2 *Signalling of the call registration event.* The AMSS SARPs require that a call attempt to a busy destination be deemed unsuccessful and that a "call unsuccessful — called party busy" event (BITE 16) then be generated by the end-user's network facilities. (Intervening telephony signalling systems, including those of the AMS(R)S subnetwork, convey this event to the aircrew.) The call registration event is considered a variation of the BITE 16 event and it is carried over the AMS(R)S subnetwork by a unique code value in the cause value parameter of the AMS(R)S "call progress — channel release" LIDU (Annex 10, Volume III, Part I, Appendix 5 to Chapter 4, Figures A5-7 and A5-34 refer). Both terrestrial network facilities and network-specific telephony interworking logic within the GES must support the conveyance of this backward signal to the GES's air-origination logic procedure if the recommended call registration facility is implemented.

8.7 Notes on the abbreviated air-origination procedures

8.7.1 *General.* The procedures defined in the AMSS SARPs for use in air-originated calls provide for a general call set-up and an abbreviated call set-up. The abbreviated procedures provide comparatively shorter and more consistent access delay performance.

8.7.2 ACCESS REQUEST PHASE

8.7.2.1 *Abbreviated access request SU.* An "abbreviated access request" SU is used in the AMS(R)S procedures as a means to deliver all call information (i.e. ground address and calling terminal-ID) to the GES concurrent with the R channel access request. This eliminates the need for the GES to await receipt of this information on the C channel sub-band as is the case for the general access request procedure.

8.7.2.2 *Series transmission of redundant access requests.* In order to mitigate the effects of R channel collisions on circuit-mode access delay performance, the AES will send a short series of identical abbreviated access request SUs upon both the initial access attempt and each of the four subsequent attempts (which are initiated by expiry of timer tA50) for a total of five attempts. The quantity of identical SUs in the series increases with increasing call priority. The probability of receiving at least one abbreviated access request SU at the GES upon each of the five attempts over an R channel loaded to 15 per cent is depicted in Table A-12 of this guidance material. (The table brackets the expected performance by depicting two cases where all conflicting R channel traffic from other AESs comprises either 1-SU bursts or 3-SU bursts.)

8.7.3 *Simultaneous set-up of circuit segments by the GES.* In addition to the enhanced delivery reliability for the abbreviated access request SU as described in 8.7.2.2, end-to-end access delay performance is further aided by the GES beginning forward completion of the call across the terrestrial network at the same instant at which the GES allocates C channel resources and begins C channel establishment in the backward direction. Immediate initiation of forward call completion is possible because the abbreviated access request SU contains **all** necessary call information as described in 8.7.2.1. By establishing both the satellite and terrestrial segments of the end-to-end call concurrently, the limiting factor in end-to-end access delay (after receipt of the abbreviated access request SU) is the longer of either the terrestrial network call completion delay **or** the C channel establishment delay — but not the sum total of both delays as would be typical of the general call origination procedure.

8.7.4 *AES interworking with non-compliant GES.* There may be certain AMS(R)S service areas where one or more GESs are not equipped to support the abbreviated air-origination procedure (e.g. prior to a mandatory ICAO implementation date). The abbreviated procedure as defined for the AES accommodates this by being inherently compatible with both equipped and non-equipped GESs (mode switching or crew intervention are not necessary). Specific attributes of the abbreviated air-origination procedure that allow an equipped AES to interwork with both types of GESs are as follows:

a) the format of the abbreviated access request SU is identical to that of the equivalent general access request SU except that the digit No. 2-9 and terminal ID fields are designated as reserved in the latter SU. This allows a non-equipped GES to interpret the call attempt as it would for a general call (i.e. the call information extracted from the SU is identical to that for a general call);

b) equipped and non-equipped GESs will discard any redundant copies of an access request SU. Therefore, receipt by the GES of multiple copies of the abbreviated access request SU will not result in call processing logic errors (multiple receipt may occur in the absence of R channel collisions or if timer tA50 has expired before the AES has received a C channel assignment SU); and

c) the C channel sub-band signalling and continuity test logic for equipped and non-equipped AESs and GESs is identical. Of particular note is the fact that an equipped AES will repeat the digit No. 2-9 and terminal ID fields (from the abbreviated access request SU) on the C channel sub-band in a manner identical to that of a non-equipped AES. This particular aspect of the AMS(R)S procedure is key to the ability for an equipped AES to interwork with any GES.

Note.— The end-to-end access delay performance through a non-equipped GES will not correspond to that realized when an equipped GES is in use.

8.8 Circuit-mode access delay performance

Note.— Except where noted, projections of end-to-end circuit-mode access delay performance are based on R and P channels operating at channel rates of 10 500 bits/s.

8.8.1 *Air-originated calls.* Paragraphs 8.7.2 and 8.7.3 describe the special attributes of the abbreviated air-origination procedure that result in enhanced access delay performance for the safety versus non-safety user. With respect to the concurrent set-up of both C channel and terrestrial network resources (8.7.3), the benefits of this improved procedure are most apparent when the access delay component that is incurred within the terrestrial network facilities is no greater than that which is incurred by C channel establishment. As a point of reference it should be noted that the GES will require a minimum of six seconds (latency) to establish a C channel — measured from the time at which the C channel assignment SU is enqueued for P channel service. This implies that to derive maximum benefit from the enhanced air-origination procedure, the terrestrial network facilities should impart no more than an equivalent delay component to the end-to-end access delay performance — including the time for the answer indication to flow in the backward direction.

8.8.1.1 *GES C channel demodulator acquisition delay.* Annex 10, Volume III, Part I, Chapter 4, 4.3.4.4 allows three seconds (99 per cent) for the GES C channel demodulator to recover the received carrier and achieve frame lock (this is included in the aforementioned six-second minimum for the GES to establish a C channel after it has received a request). The AMSS SARPs further recommends that implementors achieve shorter acquisition times. This delay has a direct effect on the minimum achievable end-to-end delay in those cases where the terrestrial network is able to provide an access delay component of less than six seconds (8.8.1).

8.8.1.2 *End-to-end access delay for air-originations.* If one can assume that the delay component which is attributable to the terrestrial network facilities can be constrained to be no greater than the component attributable to C channel establishment, then end-to-end access delay in the absence of any significant contending P channel traffic can be as short as eight seconds (95 per cent) for air-originations. If a GES is provisioned with C channel demodulators which exhibit acquisition performance akin to that of the AES's burst mode of operation, then a five second (95 per cent) end-to-end access delay figure is possible provided that the terrestrial network facilities can provide an equivalent improvement in performance.

8.8.2 *Ground-originated calls.* The AES and GES logic procedures for ground-originated AMS(R)S calls are essentially identical to those of the prevalent non-safety AMSS procedures. The expected access delay component that is attributable to the AMS(R)S subnetwork in the absence of any significant contending P channel traffic is projected to be six seconds (95 per cent). (Inclusive of three seconds for GES C channel demodulator acquisition overhead). A terrestrial network facility delay component of four to six seconds will result in an expected end-to-end access delay of 10 to 12 seconds (95 per cent). Improvements in either terrestrial network or GES demodulator overhead will yield an equivalent improvement in the end-to-end delay performance.

8.8.3 *Projections of AMS(R)S subnetwork call set-up delay.* The call processing delays in Annex 10, Volume III, Part I, Chapter 4, 4.8.4.1 specify only the components of AMS(R)S call set-up delay attributable to the performance of AES and GES equipment. These performance parameters, while not entirely deterministic in nature, are not likely to exhibit a significant statistical variance. This is because the parameters are specified as maximum internal processing delays exclusive of any transmission delays or queuing delays for link layer service such as that which might be experienced by a telephony signalling CM-LIDU awaiting P channel transmission. However, the over-all AMS(R)S subnetwork delay to establish an air or ground-originated call, which will be subject to the statistical performance of the link layer, is likely to be of interest to system planners. Based on simulation studies using a traffic model identical to that used to determine the packet-mode performance requirements in Annex 10, Volume III, Chapter 4, 4.7. AMS(R)S subnetwork call set-up delay performance for abbreviated air and ground-originated calls is projected to be as depicted in Table A-13 of this guidance material.

Note.— Each performance parameter is applicable to all AMS(R)S priorities except for those parameters expressed as a range of values for highest to lowest priority.

8.8.4 *PSTN end-to-end call set-up delay.* End-to-end call set-up delay may be excessive when the AMS(R)S subnetwork is interconnected with the PSTN unless a specific performance is specified for the PSTN.

8.9 Subjective voice quality evaluation

8.9.1 BT LABORATORIES 9.6 KBITS/S LPC CODEC

8.9.1.1 Vocoders employing the algorithm described in Appendix 7, among others, were evaluated by BT Research Laboratories (BTRL) and the U.K. CAA. The results of these evaluations were used in the selection of this algorithm from the three finalist contenders.

8.9.1.2 *Intelligibility.* The BTRL evaluation used the mean opinion score (MOS) assessment methodology. In the BTRL evaluation, an MOS of about 3.1 was obtained under conditions of optimized input and listen levels, no channel noise and no ambient aircraft noise. When a channel bit error rate (BER) of 0.001 or greater was introduced and aircraft ambient noise was added, the MOS ranking decreased.

8.9.1.3 The U.K. CAA evaluations used a specially constructed test environment in which the test subject, a controller, was placed in a simulated work situation. A "pseudo-pilot" read typical ATC messages to the controller and responded to the controller's queries and instructions. Varying levels of channel bit error rates were introduced. The qualitative conclusion was that the vocoder was acceptable for ATC purposes in low-density airspace, such as oceanic.

8.9.2 DVSI 4.8 KBITS/S AMBE CODEC

8.9.2.1 The acceptability of the DVSI codec as a suitable alternative was assessed based on comparative tests against the BTRL 9.6 kbits/s LPC codec. These comparative tests were carried out by Comsat Laboratories based on test requirements agreed at RTCA Special Committee 165 and had the objective of determining whether this codec had an equivalent or better performance than the BTRL codec. Diagnostic rhyme test (DRT) and MOS were used in this assessment.

8.9.2.2 The results of the comparative tests led to the conclusion that the DVSI codec was statistically equivalent to the BTRL codec under most conditions and that it was suitable for operations in the same environment, e.g. oceanic airspace.

Note.— Test results have also shown that the use of noise reduction or cancelling techniques for operation under high propeller background noise is recommended.

9. AIRCRAFT EARTH STATION (AES) MANAGEMENT

9.1 General

Annex 10, Volume III, Part I, Chapter 4, 4.9 defines the minimum set of requirements that the AES management must meet in order to ensure interoperability. This chapter of the guidance material describes issues related to the AES management SARPs.

9.2 AES management interfaces

The AES management is described in the AMSS SARPs as an entity which interfaces to other AES entities, such as the link and subnetwork layers. The interfaces are defined in terms of the information exchanged between the AES management and these other entities and are shown in Figure A-20 of this guidance material. No formats of the exchanged information are specified in the AMSS SARPs. Such formats are considered to be implementation dependent.

9.3 AES management functions

9.3.1 AES TABLE MANAGEMENT

9.3.1.1 Two sets of information are required to be maintained by the AES. These sets of information are given in the AMSS SARPs in the form of tables, namely the system table and the log-on confirm table. The specifics of storing this information in the AES are not regulated by the AMSS SARPs, they are implementation dependent.

9.3.1.2 The information listed under "system table" is provided by the GES. This information contains the necessary search frequencies to enable the AES to select a satellite, a beam, and a GES in order to carry out the log-on procedure. Thus, it is mandatory that this information be current in the AES prior to logging on. The currency of the system table information is maintained at the AES by monitoring the system table broadcast sequences transmitted by the GES as stated in Annex 10, Volume III, Part I, Chapter 4, 4.9.3.2.3.1.

9.3.2 AES LOG STATUS MANAGEMENT

9.3.2.1 *Satellite, beam and GES selections*

9.3.2.1.1 Depending on the geographical location of the aircraft, the AES may have more than one option for the selection of a satellite, beam, and GES combination. The AMSS SARPs provide the flexibility of allowing the AES management to select the most desirable combination at a given time. The only requirement imposed on the selection is the AES capability of receiving an adequate signal on the selected GES P_{smc} channel.

9.3.2.1.2 The information used by the AES management in making its selection is contained in the AES system table. A GES is uniquely identified by the frequency of its P_{smc} channel transmitted within a specific beam in the service area of a given satellite. A satellite is uniquely identified by one or more sets of satellite/beam-identifying P_{smc} channel frequencies. Each set contains at least two frequencies and is associated with the ID of the beam within which the associated P channels are transmitted. If the satellite identification is made via the global beam (beam ID=0), the AES management may further attempt to select a spot beam, if any exist. For a satellite service area with spot beam only, the satellite identification will be made via a spot beam, thus the satellite and the spot beam selections are made concurrently.

9.3.2.1.3 AESs commonly have a programmable owner preference table by which there may be preferential selection of certain systems, satellites, and/or GESs and communication requirements. There are several criteria by which preferential selection for log on can be made; e.g. service provider identity, cost, service options. If this capability were misused (e.g. to exclude particular systems, satellites or GESs), safety could be derogated due to restricted availability of alternate/diverse communication paths. If exclusion is permitted in an AES owner preference table, it should be verified that the safety communication availability requirements for that aircraft's installation are met.

9.3.2.2 *Log-on procedure*

9.3.2.2.1 *Log-on initiation.* As prescribed by the AES management AMSS SARPs, the log-on procedure could be initiated by the receipt of a log-on command. The log-on command could specify the GES and/or the satellite to be selected to log on. These AMSS SARPs specify neither the source nor the format of such command. The source could be external to the AES relaying the command to the AES management on a specific interface. The format is implementation dependent.

9.3.2.2.2 *Log-on rejection.* Several reasons have been identified for the GES rejection of an AES log-on request. A list of these reasons is given in Annex 10, Volume III, Appendix 3 to Chapter 4. No specific AES responses corresponding to the specified rejection reasons have been given in the AMSS SARPs. Such responses are implementation dependent. However, the AMSS SARPs further classify the rejection reasons into three categories: permanent unavailability, temporary unavailability, and invalid parameters. The response of the AES management to a rejection reason could be defined in accordance with the category of the rejection reason in the following manner:

permanent unavailability: cease further log-on attempts to the same GES;
temporary unavailability: reattempt log on to the same GES only after a suitable period of time, or after attempting to log on to other suitable GES;
invalid parameters: reattempt log on to the same GES, only with different parameters.

9.3.2.3 *Universal time broadcast*

Some applications on the aircraft may need to be synchronized with the counterpart applications on the ground. The AMSS SARPs contain recommendations for support of a time synchronization facility at the AES and the GES. Thus, for interoperability consideration, a universal time signal unit (Annex 10, Volume III, Part I, Appendix 2 to Chapter 4, Figure A2-35) containing the current time to the nearest second, synchronized to the UTC standard has been defined in the AMSS SARPs. Upon receipt of a universal time SU from the GES, the AES may provide the received time information to the appropriate applications on the aircraft. The method selected by the AES to provide this time information to an application is implementation dependent.

9.3.2.4 *User commands*

9.3.2.4.1 The AMSS SARPs specify the AES responses to a minimum set of commands intended to influence some of the AES operations. Such commands may be initiated either prior to (Annex 10, Volume III, Part I, Chapter 4, 4.9.3.3.3.1) or after (Annex 10, Volume III, Part I, Chapter 4, 4.9.3.3.4.2) the AES log-on. Neither the sources nor the formats of such commands are specified in the AMSS SARPs. Such sources may be internal or external to the AES and operating in accordance with some stimulus criteria to satisfy a particular user requirement, such as continuity of service. For example, a stimulus criterion to invoke a beam-to-beam handover could be based on the knowledge of the beam pattern of a given satellite and the position and heading of the aircraft. The formats of the handover commands are implementation dependent.

9.3.2.4.2 *Handover commands.* The handover commands specified in the AMSS SARPs are intended to enable the AES user to alter the AES log-on conditions in various ways, as deemed suitable by the user.

9.3.2.4.2.1 A GES-to-GES handover command could be issued by the AES user in order to:

a) renew the log-on to the same GES but through a different spot beam;

b) to switch the log-on to a different GES in the same satellite service area, either through the same or a different spot beam.

Such command may have to specify the GES ID and spot beam ID when those IDs are different than the current values. Circuit-mode calls in a Level-4 AES (multiple transmit and receive channel units) are not effected by the execution of this command. Level-3 AES operation is as specified in Annex 10, Volume III, Part I, Chapter 4, 4.9.3.3.4.2 b).

9.3.2.4.2.2 A satellite-to-satellite handover command could be issued by the AES user in order to switch the AES log-on to a new GES within the service area of another satellite. Any circuit-mode call established through the current satellite will have to be forcibly terminated after a fixed period of time prior to switching to the new satellite. In the AMSS SARPs, this period of time is set to 3 minutes. If the AES was unable to tune to any of the listed satellite/beam-identifying P_{smc} channels of the new satellite, the AES may revert back to the previous satellite or any other satellite in view.

9.3.2.5 *P channel loss/degradation*

9.3.2.5.1 P channel loss/degradation declaration is conveyed to the AES management in the form of an indication from the AES physical layer (P channel receiver). The criteria on which such declaration is based are given in 4.1.3 of Attachment A. If the P channel loss or degradation is caused by the aircraft flying out of the selected beam coverage, the P channel loss/degradation declaration will cause the AES management to search for a new GES, within the same or a different satellite service area, and log-on to it. However, the loss/degradation of the P channel would cause an undesirable discontinuity of both data and voice services. Therefore, the use of such practice is not advisable as a means to invoke an

AES handover. The handover commands described in Annex 10, Volume III, Part I, Chapter 4, 4.9.3.3.4.2 b) and c) provide a more controlled means to invoke AES handovers.

9.3.2.5.2 Because all R and T channel transmissions are synchronized to the framing format of the P channel, and in order to ensure positive control of the AES from the GES, such transmissions must cease with the loss of the P channel.

9.3.3 AES CHANNEL MANAGEMENT

9.3.3.1 *Voice-voice pre-emption*

9.3.3.1.1 Several circuit-mode calls could be contending for the limited resources in the AES. In such cases, the establishment and continuation of a circuit-mode call is regulated by the priority and pre-emption requirement of Annex 10, Volume III, Part I, Chapter 4, 4.8.3.2 according to the precedence of the Q number assigned to the C channels carrying the calls. The C channels Q number assignment for the various categories of voice transactions is given in Annex 10, Volume III, Part I, Chapter 4, Table 4-43.

9.3.3.1.2 Various requirements are included in the AMSS SARPs in order to enforce the priority and pre-emption statement of Annex 10, Volume III, Part I, Chapter 4, 4.8.3.2 in the AES. In this regard, the circuit-mode services will only request the assignment of a transmit/receive channel unit pair from the AES management if, and only if, there are either sufficient resources available or at least one of the circuit-mode calls in progress has at a Q number strictly lower than the Q number of the call being established. In the latter case, the AES management will make available the channel units being used by the call in progress to support the call being established.

9.3.3.2 *Level 3 AES voice/data arbitration*

In a Level 3 AES, a single transmit channel unit is shared among the R, T and C channels. The arbitration between the R channel and the T channel is resolved in the AMSS SARPs by considering that the T channel signal unit (SU) transmissions, regardless of the Q number of the SUs, have precedence over the SUs transmission on the R channel. However, a minimum number of "gaps" in the T channel slot reservations to a particular aircraft are required to ensure that the R channel transmission are not totally blocked (Annex 10, Volume III, Part I, Chapter 4, 4.6.5.3.3). Arbitration between the C channel and the R or T channels is accomplished according to the priorities of the transactions on these channels. The specific requirements for such arbitration are given in Annex 10, Volume III, Part I, Chapter 4, 4.9.3.4.1.4. It should be noted that the AMSS SARPs do not require that an established voice call be terminated if the transmission of a higher precedence data message is required; rather, such action is optional. An alternative scheme allowed by the AMSS SARPs would be to cease transmission on the C channel long enough to transmit any higher precedence signal units in the AES link layer and then reassign the transmit channel unit to the C channel.

10. GROUND EARTH STATION (GES) MANAGEMENT

10.1 General

10.1.1 Ground earth station (GES) management functions specified in Annex 10, Volume III, Part I, Chapter 4, 4.10 are mandatory for each GES implementation. The GES management includes functions to manage the AES log-on to a GES, to control the assignment of P, R and T channels for data and signalling transfer, to reassign new channels on detection of an excess loading on a channel, to assign C channel frequencies on-demand, to control the power of the assigned C channels, to update the system table and time information in the AES and to verify the operational status of its logged-on AESs.

10.2 GES management architecture

10.2.1 SATELLITE SERVICE AREA

A service area of a satellite is defined as the satellite coverage area within which a satellite provider provides services. Different satellites can have overlapping satellite service areas.

10.2.2 SATELLITE SYSTEM CONFIGURATIONS

The following are the three satellite system configurations:

a) *Satellite with global beam only.* In this configuration, there is only one beam per satellite. This beam is referred to as a global beam. In this configuration, two GESs may be required per satellite in a satellite service area to account for two satellite-identifying P_{smc} channels for satellite identification.

b) *Satellite with global beam and spot beams.* In this configuration, a satellite supports multiple beams with some beams enclosed within another beam. The beams enclosed within a beam are called spot beams and the enclosing beam is referred to as a global beam. In this configuration, two GESs may be required per satellite in a satellite service area to account for two satellite-identifying P_{smc} channels for satellite identification. The satellite-identifying P_{smc} channels for satellite identification in this configuration are transmitted in the global beam.

c) *Satellite with spot beams only.* In this configuration, the satellite supports spot beams only, with no global beam. In order that a satellite/beam-identifying P_{smc} channel is available throughout a satellite service area for satellite and beam identification, at least one P_{smc} channel frequencies must be transmitted in each spot beam in the satellite service area. A GES in a satellite service area can support more than one spot beam by transmitting and receiving a unique set of frequencies in each spot beam.

10.2.3 GES CAPABILITY

At a minimum, the GES should be capable of operating through a space segment with a Level 4 AES. This implies that the GES should support voice channels for ATC and AOC services and interface with public switched telephone network or leased circuits at the option of the GES operator. The GES should also have provision for the highest specified rate data channels and interface with private or public switched networks at the option of the GES operator. The number of AESs that a GES can support depends upon the channel loading and the channel frequencies allocated to a GES. The loading on the channel should be such that the packet-mode data transfer meets the performance requirements specified in Annex 10, Volume III, Part I, Chapter 4, 4.7.

10.2.4 GES-TO-GES COMMUNICATION

GES-to-GES communication link is used to transfer information regarding the status of logged-on AESs to other GESs within the same satellite service area. It is also to be used to transfer the C channel access requests and C channel call announcements/C channel assignments between the log-on GES and the GES handling the particular call.

10.3 GES management interfaces

10.3.1 GES management interfaces to other GES entities are defined in Annex 10, Volume III, Part I, Chapter 4, 4.10 in terms of the information exchanged over these interfaces. The format of the information exchanged is not specified; it is implementation dependent.

10.3.2 The GES management interfaces with the link layer to use its services to transfer the management LIDUs to its peer in the AES. The GES management interfaces with the subnetwork layer to inform the subnetwork layer about the AES connectivity. The GES management interfaces with the circuit-mode services to pass the C channel frequencies and channel units assigned to a circuit-mode call. The GES management interfaces with the physical layer to control the frequency and power of the transmitted and received channels and to pre-empt the channel units for higher precedence voice or data calls.

10.4 GES management functions

10.4.1 GES TABLE MANAGEMENT

10.4.1.1 The term "table" refers to the system information stored at a GES. The information stored at the log-on GES includes the status of logged-on AESs and the status of AESs logged on to other GESs within the same satellite service area. It also includes information about the satellite — its identifying frequencies, its location, the beams supported by the satellite, the GESs within the satellite service area and the frequencies and bit rates of the P_{smc}/R_{smc} channels supported by each GES within the satellite service area. The format and the storage capacity for the information is not specified in the AMSS SARPs; it is implementation dependent.

10.4.1.2 The AES system table specified in Annex 10, Volume III, Part I, Chapter 4, 4.10 can be used for any satellite configuration. The initial search data for a satellite service area served by a satellite with spot beams may include two or more satellite-identifying P_{smc} channel frequencies per satellite plus a spot beam map, indicating the geographical coverage of the spot beams of that satellite. The regional data of the AES system table for a satellite service area served by a satellite with a global beam will include the GES ID for each GES within the satellite service area and the P_{smc} and R_{smc} channel frequencies supported by each GES in the global beam as well as the services each GES supports in the global and spot beams.

10.4.1.3 *AES log-on status table*

The AES log-on status table maintained by a GES other than the log-on GES contains information about each AES logged-on to any GES within the same satellite service area. This information can be used by a GES for call routing purposes such as to reject a ground-initiated call request destined for an AES not logged-on to any GES in the satellite service area or to forward the call request to the GES to which the destined AES is logged-on.

10.4.1.4 Each GES also maintains an authorization table. This table contains the list of all aircraft addresses for those AESs whose operators have successfully completed the administrative requirements necessary to enable the AES to operate within an AMS(R)S system. These administrative steps include, but are not limited to: confirmation that the aircraft address is correct and issued by an appropriate body; AES equipment has successfully passed unit testing; and contact and billing details for the AES operator are correct.

10.4.2 GES LOG-ON STATUS MANAGEMENT

10.4.2.1 *GES handover functions*

10.4.2.1.1 A log-on GES, upon receipt of an AES log-on information from another GES in the satellite service area served by the same satellite as the one serving the log-on GES, suspends any data transaction in progress with the AES if this AES was previously logged on to it. The voice calls in progress via the previous log-on GES does not have to be cleared since the AES can establish calls via a GES other than its log-on GES. The previous log-on GES does not indicate the AES in its AES log-on status table as being its logged on AES; however, it still retains the required information about the AES.

10.4.2.1.2 If the log-on information about an AES is received from a GES in a different satellite service area, then the received GES suspends the data transaction and clears voice calls in progress with the AES if this AES was previously logged-on to it and then deletes the AES from its AES log-on status table completely. The old log-on GES then transmits log-off information to other GESs in its satellite service area.

10.4.2.2 *Log-on verification*

10.4.2.2.1 The AMSS SARPs on GES management specify two methods of verifying the operational status of an AES. The direct verification method is utilized by the GES if the log-on verification (LOV) bit in the log-on request LIDU is set to zero by the AES; otherwise, indirect verification method is used.

10.4.2.2.2 The purpose of log-on verification is to optimize the use of resources among AESs. If an AES is not active for a period of time specified in the AMSS SARPs (i.e. it is not transmitting data or does not have a voice call set up to the log-on GES or to any other GES in the same satellite service area), the log-on GES logs-off the AES if the AES does not respond to log-on interrogation (for direct log-on verification) or remains inactive for 12 hours (for indirect verification). The resources released can thus be made available to other AESs that are trying to log on but cannot succeed due to insufficient resources at the GES.

10.4.2.2.3 The reason for an AES logged on to a GES to be inactive is that the AES has either landed without logging off or has switched satellites. Under such conditions, it is appropriate for the log-on GES to log off the AES.

10.4.2.3 *Log-on prompt*

The log-on prompt facility at a GES is used to prompt an AES to log on when the GES link layer receives a signal unit (SU) from an AES on an R_d channel and the AES is not in its AES log-on status table. This situation can occur if the GES has not updated its AES log-on status table after the initial log-on. The GES transmits the log-on prompt LIDU to the AES on all P channel frequencies.

10.4.2.4 *Assignment of data channels*

The GES management assign data channels (P, R, and T channels) at the highest bit rate, which is provided at both the GES and the AES and is supported by the combination of a satellite in use and the level of the AES. The decision as to which channels and with what EIRP to assign, can be made by the GES management from the following information:

a) the satellite in use (its return link sensitivity); and

b) the level of AES.

The GES management can assign up to eight R channels and up to four T channels at the time of log-on.

10.4.3 GES CHANNEL MANAGEMENT

10.4.3.1 *C channel frequency management*

On the basis of known/planned/predicted traffic capacity requirements, the GES can be pre-assigned a number of SCPC frequencies for use as a forward and return C channels. The total number of frequencies assigned to GESs within the same satellite service area is normally less than the total capacity available for the satellite in operation. On demand, each GES assigns the frequencies for a circuit-mode call from its own pool. However, lack of channel frequency for a call at the GES results in the initiation of a channel frequency reassignment request to a central authority which initially made the pre-assignment. The central authority can then make an assignment of frequency to the GES utilizing the frequencies held in a common pool.

10.4.3.2 *C channel power management*

10.4.3.2.1 The GES calculates the initial EIRP of the C channel according to the value derived from the worst case link budget.

10.4.3.2.2 The GESs can be assigned power budgets consistent with performance requirements of the channels operating to the satellite. Once this power budget is fully utilized, the GES management rejects further channels/call requests until sufficient power has been released to be assigned to the new requests or until the log-on request LIDU indicates AES in distress. The C channel power can be controlled for example in accordance with the following power control decision table:

for the 21 000 bits/s, rate 1/2 FEC channel, if the average number of errors per 2 560 channel bits (before decoding) is:

greater than 172:	increase EIRP by 2 dB
between 119 and 172:	increase EIRP by 1 dB
between 76 and 119:	leave EIRP unchanged
between 44 and 76:	decrease EIRP by 1 dB
less than 44:	decrease EIRP by 2 dB.

Note.— These values correspond to the input bit error rates to a rate 1/2 Viterbi decoder as specified for the C channel that provide an output bit error rate of 10^{-3} (nominal) to 10^{-4} (1 dB above nominal), with a margin of 1.5 dB.

10.4.4 GES PRE-EMPTION MANAGEMENT

10.4.4.1 *Voice versus voice pre-emption*

The purpose of this capability at the GES is to make resources available for a higher precedence voice call if there are no additional resources available at the GES and lower precedence voice calls are being serviced. The GES management, upon receipt of a request from circuit-mode services for a channel unit for a voice call, checks if the precedence of the new request for voice call set-up is higher than any call already in progress. If the precedence of new call request is higher than any one call-in-progress, the GES management then ruthlessly pre-empts the lowest precedence call in progress to make resources available for the higher precedence call. If there are more than one call at the lowest precedence in progress at a given time then it is at the discretion of the GES operator to pre-empt a call. One option could be to pre-empt the call which has been in progress for the longest time.

10.4.4.2 *Data versus voice pre-emption*

The purpose of this capability at the GES is to make resources available to set up an additional P channel for higher precedence data traffic when there are no additional resources available at the GES to set up an additional P channel, and lower precedence voice calls are being serviced and transmission of additional data traffic on the already operational P channels would violate the data transfer delay requirements specified in Annex 10, Volume III, Part I, Chapter 4, 4.7. However, a higher precedence voice call does not pre-empt an operational P channel to make resources available for setting up a higher precedence voice call because doing so will be detrimental to data transmissions from the AES.

10.4.5 GES SYSTEM BROADCAST

10.4.5.1 *System table broadcast*

10.4.5.1.1 This facility at the GES allows the GES to update the system table information and spot beam map information stored in an AES. The system table and spot beam map updates are transmitted to AESs as complete or partial sequences.

10.4.5.1.2 The initial search data in the system table contains satellite-identifying P_{smc} channel frequencies for all satellites. Any changes to the system table are made centrally by the satellite system provider and are disseminated to all GESs within all the satellite service areas provided by the satellite system provider, as required. The revision number for a system table and spot beam map are unique to each satellite service area.

10.4.5.1.3 The complete sequence is transmitted by the designated GES on the satellite-identifying P_{smc} channel and it comprises all broadcast LIDUs headed by a broadcast index LIDU. The partial sequence comprises one or more broadcast LIDUs headed by a broadcast index LIDU. The partial sequence contains the most recent updates only. The broadcast index LIDU identifies the presence of individual LIDU series within both the complete and partial sequences. Each GES broadcasts a partial sequence on all its operational P channels. Each satellite service area has its own system table and spot beam map broadcast information.

10.4.5.1.4 The system table complete and partial sequence broadcast rates may be reduced due to high P channel loading. This may delay the initiation of the log-on procedure at the AES. It is recommended that the GES management monitor such broadcast rates and provide further P channel capacity to maintain these rates at acceptable levels.

10.4.5.1.5 The system table consists of :

a) system table broadcast index SU (Figure A2-30, Chapter 4, Annex 10, Volume III);

b) system table broadcast satellite/beam ID channel advice SU (Figure A2-32, Chapter 4, Annex 10, Volume III);

c) system table broadcast GES P/R channel advice SU (Figure A2-31, Chapter 4, Annex 10, Volume III);

d) system table broadcast GES beam support advice SU (Figures A2-34 and A2-61, Chapter 4, Annex 10, Volume III); and

e) system table broadcast data channel EIRP SU (Figure A2-62, Chapter 4, Annex 10, Volume III).

The system table broadcast data channel EIRP SU is used by the AES in accordance with 4.10.4.4.3.1.1 of Annex 10, Volume III.

10.4.5.1.6 Where a satellite supports spot beam service, a GES transmits the spot beam map series consisting of SUs as shown in Figure A-21 of this guidance material. This sequence is independent to the system table broadcast series and contains the definition of the spot beam coverage areas and the GES services supported in the spot beams. The AES, upon receiving the complete series, will then know what spot beam(s) it is currently in and the services that are available to it. The AES may use this information to determine which GES to log on to. The message types for the spot beam map series are:

18 spot beam map broadcast — complete sequence — initial SU
19 spot beam map broadcast — complete sequence — SSU
26 spot beam map broadcast partial sequence — initial SU
27 spot beam map broadcast partial sequence — SSU

10.5 Considerations for GES services

10.5.1 The AMSS system, which forms part of the ICAO communications, navigation, and surveillance/air traffic management (CNS/ATM) systems concept, provides communication services on a global basis. The AMSS system architecture consists of a number of satellites and a limited number of GESs. All States/administrations can have full access to the AMSS, but most of them will not need to have their own GES; rather they will connect to the network through service providers.

10.5.2 Although a small number of GESs are sufficient for AMSS in a given geographical area, some States or administrations may feel it is necessary to install and operate their own GES for reasons such as:

a) redundancy — reducing the impact of GES failure;

b) less dependency on other States (who operate GESs) and service providers; and

c) exerting authority and control in their airspace.

10.5.3 However, the proliferation of GESs can lead to problems such as:

a) increased demand for spectrum because of the inefficiencies introduced by dividing the available spectrum into small pieces;

b) degraded packet data performance as AESs are subjected to more log-on/log-off cycles as they transit between various flight information regions (FIRs) which operate their own GESs;

c) increased workload for the flight crew (or cost and complexity of the AES) as they transit between various FIRs which operate their own GESs.

10.5.4 Additional factors which affect the number of GESs are the following:

a) available satellite power will limit the number of *600 bit/s* P-channels, i.e. GESs, which can be supported per satellite; and

b) the cost of installing and operating a GES will not be economical for most administrations.

Given this, some States may be concerned about their dependency on other States or service providers, for GES services. This concern can be alleviated by several considerations:

a) For packet services, the ATN will allow States without GESs to choose between a number of different States or service providers to obtain GES services.

b) In States where the ATN is less developed, fixed satellite links between a GES and the air traffic control centre could provide an alternative to terrestrial links. This approach could be a source of both cost-competitiveness and redundancy. If designed properly, the extra delay introduced by a second satellite link will have a negligible effect on the packet data performance. A second satellite link may not be adequate for voice communications, at least not in a normal conversation mode. However, its effect on verbal exchanges typical of ATC applications has not been studied.

c) States should have adequate institutional arrangements with service providers based on ICAO guidelines for AMSS.

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TABLES FOR ATTACHMENT A

Table A-1. Typical implementation versus levels of capability

Levels of capability	Packet data service (kbits/s)	Circuit mode service (kbits/s)	Number of channels	AES antenna gain	Comments
1	0.6 1.2	Not available	1 transmit 1 receive	0 dB	
2	0.6 4.8 10.5	Not available	1 transmit 1 receive	12 dB or 6 dB (6 dB does not support 10.5 kbits/s data channels)	Higher speed for packet data
3	0.6 4.8 10.5	Voice 21.0 and/or 8.4	1 transmit 2 receive	12 dB or 6 dB (6 dB does not support 21.0 kbits/s voice or 10.5 kbits/s data channels)	Provides digitized voice and packet data, but not simultaneously
4	0.6 4.8 10.5	Voice 21.0 and/or 8.4	2 or more transmit 2 or more receive	12 dB or 6 dB (6 dB does not support 21.0 kbits/s voice or 10.5 kbits/s data channels)	Simultaneous two-way packet and voice. Needs linear amplifier and power control for each carrier

NOTES:

1. Circuit mode data services may be supported by some implementation, but these are not defined in the AMSS SARPs.
2. The 4.8 kbits/s channel applies only to the P channel.

Table A-2. Worst case data performance versus channel rate

Minimum channel rate in use by AES (bit/s)	Maximum connection establishment delay (95th percentile) (seconds)	Transit delay (average) (seconds)			Data transfer delay (95th percentile) (seconds)		
		To-aircraft		From-aircraft	To-aircraft		From-aircraft
		Highest priority	Lowest priority	Highest priority	Highest priority	Lowest priority	Highest priority
600	70	12	40	40	15	110	80
1 200	45	8	25	30	9	60	65
2 400	25	5	12	15	6	30	35
4 800	25	4	7	13	5	20	30
10 500	25	4	5	13	4	10	30

Residual error rate:
from-aircraft direction: 10^{-4} per SNSDU (maximum)
to-aircraft direction: 10^{-6} per SNSDU (maximum)

NOTES:

1. In any particular AES, lower priority from aircraft traffic may be subject to additional delay, depending on the amount and rate of from-aircraft traffic loading.
2. The values of the transfer delays are based on packet sizes of 128 octets.

Table A-3. Q-precedence structure for AMSS transmissions

AMSS Q-number	Function
15	Distress/urgency voice; signalling
14	Distress/urgency data messages
13	Reserved for signalling
12	Flight safety voice; signalling
11	Flight safety data messages; communications related to direction finding
10	Meteorological and flight regularity voice; signalling
9	Reserved for signalling
8	Meteorological data messages
7	Flight regularity data messages
6	Aeronautical Information Service Messages
5	Aeronautical administrative data messages, network/systems administrative data messages
4	Routine cockpit and cabin voice; signalling
3-0	Various AAC and APC categories; other

Table A-4. Frequency error budget for receiving the P channel

	Specification	Standard deviation
GES transmit reference error	±100 Hz	57.7 Hz
AFC pilot transmit error	±100 Hz	57.7 Hz
GES AFC error	±100 Hz	57.7 Hz
AES receive reference error	±155 Hz	89.5 Hz
Oscillator related errors at AES		
— standard deviation		134.2 Hz
— 99 per cent contour		±345.6 Hz

NOTES:

1. It is assumed that oscillator specifications define a uniform error distribution.
2. The contribution of a number of oscillators to the overall error is estimated using a root-sum-square calculation.

Table A-5. AES-to-GES frequency error budget with a P channel reference

	Specification (Hz)	Standard deviation (Hz)
AES receive reference error × 1.07[1]		107
AES transmit/receive reference error	(165 + 155) = 320	184.8
AES AFC error	100	57.5
AFC pilot transmit frequency error[2]	75	43.3
GES AFC error[2]	100	57.7
Frequency error at GES demodulator		
— standard deviation		232.6
— 99 per cent contour[3]		±600

1. This is the total of the first three contributors to frequency error for the P channel. The factor of 1.07 is the approximate ratio of the transmit and receive frequencies.
2. The combination of the GES AFC error and the AFC pilot transmit error produce the frequency error of the satellite translation oscillators on the return link.
3. This is the GES demodulator specification.

Table A-6. Typical C channel carrier-to-noise densities required

	To-aircraft link C channels (voice)		From-aircraft link C channels (voice)	
Elevation angle to the satellite (degrees)	5	20	5	20
Objective FEC decoder output BER	10^{-3}	10^{-3}	10^{-3}	10^{-3}
AES minimum antenna gain (dB)	12	12	12	12
Carrier/multipath ratio (dB)	10	12	10	12
Multipath fading bandwidth (Hz)	20 to 100	20 to 100	20 to 100	20 to 100
FEC coding rate	½	½	½	½
Modulation method	A-QPSK	A-QPSK	A-QPSK	A-QPSK
Theoretical required E_s/N_0 (dB)	1.2	0.6	1.2	0.6
Modem implementation loss (dB)	1.1	0.9	1.1	0.9
Imperfect interleaving loss (dB)	3.0	1.2	3.0	1.2
Adjacent channel interference loss (dB)	0.1	0.1	0.8	0.8
Modem E_o/N_0 (dB) required	5.4	2.8	6.1	3.5
REQUIRED C/N_0 (dBHz)				
21.0 kbits/s	48.6	46.0	49.3	46.7

Table A-7. Typical P channel carrier-to-noise densities required

	To-aircraft link P channels (low rate data)		To-aircraft link P channel (high rate data)	
Elevation angle to the satellite (degrees)	5	20	5	20
Objective FEC decoder output BER	10^{-5}	10^{-5}	10^{-5}	10^{-5}
AES minimum antenna gain (dB)	0	0	12	12
Carrier/multipath ratio (dB)	7	12	10	12
Multipath fading bandwidth (Hz)	20 to 100	20 to 100	20 to 100	20 to 100
FEC coding rate	½	½	½	½
Modulation method	A-BPSK	A-BPSK	A-QPSK	A-QPSK
Theoretical required E_s/N_0 (dB)	5.0	3.5	2.8	2.4
Modem implementation loss (dB)	1.2	1.1	1.5	1.1
Imperfect interleaving loss (dB)	1.0	0.5	1.0	0.5
Adjacent channel interference loss (dB)[1]	0.1	0.1	0.1	0.1
Modem E_s/N_0 (dB) required	7.3	5.2	5.4	4.1
REQUIRED C/N_0 (dBHz)				
0.6 kbits/s	35.0	32.9		
1.2 kbits/s	38.1	36.0		
2.4 kbits/s	41.1	39.0		
4.8 kbits/s			42.2	40.9
10.5 kbits/s			45.6	44.3

NOTES:

1. The adjacent channel interference loss is a function of channel spacing. The example losses are for channel rates of 2.4 and 10.5 kbits/s, for A-BPSK and A-QPSK, respectively. The losses should be no greater for the other channel rates because the channel spacing, relative to the channel rate, will be larger.
2. The low data rates (A-BPSK) can also be used with high gain antennas with potentially less C/N_0 required.

Table A-8. Typical R/T channel carrier to noise densities required

	From-aircraft link R/T channels (low rate data)		From-aircraft link R/T channel (high rate data)	
Elevation angle to the satellite (degrees)	5	20	5	20
Objective FEC decoder output BER	10^{-5}	10^{-5}	10^{-5}	10^{-5}
AES minimum antenna gain (dB)	0	0	12	12
Carrier/multipath ratio (dB)	7	12	10	12
Multipath fading bandwidth (Hz)	20 to 100	20 to 100	20 to 100	20 to 100
FEC coding rate	½	½	½	½
Modulation method	A-BPSK	A-BPSK	A-QPSK	A-QPSK
Theoretical required E_s/N_0 (dB)	5.0	3.5	2.8	2.4
Modem implementation loss (dB)	1.2	1.1	1.5	1.1
Imperfect interleaving loss (dB)[1]	1.2	0.6	1.0	0.5
Adjacent channel interference loss (dB)[2]	0.1	0.1	0.4	0.4
Modem E_s/N_0 (dB) required	7.5	5.3	5.7	4.4
REQUIRED C/N_0 (dBHz)				
0.6 kbits/s	35.0	32.9		
1.2 kbits/s	38.1	36.0		
2.4 kbits/s	41.3	39.1		
4.8 kbits/s			42.5	41.2
10.5 kbits/s			45.9	44.6

NOTES:

1. The interleaver loss is a function of channel rate, the example losses correspond to channel rates of 2.4 and 10.5 kbits/s for A-BPSK and A-QPSK, respectively.
2. The adjacent channel interference loss is a function of channel spacing, the example losses correspond to channel rates of 2.4 and 10.5 kbits/s for A-BPSK and A-QPSK, respectively. The losses should be no greater for the other channel rates because the channel spacing, relative to the channel rate, will be larger.
3. The low data rates (A-BPSK) can also be used with high gain antennas with potentially less C/N_0 required.

Table A-9. Channel spacings

Channel rate (kbits/s)	Channel spacing (kHz)	Modulation
21.0	17.5	A-QPSK
10.5	10.0/7.5[1]	A-QPSK
8.4	7.5	A-QPSK
6.0	5.0	A-QPSK
5.25	5.0	A-QPSK
4.8	5.0	A-QPSK
2.4	5.0	A-BPSK
1.2	5.0/2.5[2]	A-BPSK
0.6	5.0/2.5[2]	A-BPSK

NOTES:

1. Channel spacing for 10.5 kbits/s channels may be 10.0 or 7.5 kHz, according to the relative availability of power and bandwidth in the operating satellite.
2. Channel spacing of 5.0 kHz applies to the P channel and 2.5 kHz applies to the R and T channel.

Table A-10. Typical values for computing earliest starting time

P Channel bit rate bits/s	P Channel unit delay(s)	Queuing delay(s)	AES processing delay(s)
600	3.0	0.7	1.8
1200	2.0	0.5	1.2
≥1200	1.5	0.5	1.0

Table A-11. Minimum throughput values
(minimum achievable throughput on a subnetwork connection, bits/s, with 128-octet packets)

Minimum channel rate in use by AES (bits/s)	To-aircraft		From-aircraft	
	Highest priority service	Lowest priority service	Highest priority service	Lowest priority service
600	70	35	35	30
1 200	130	70	100	80
2 400	150	90	300	275
4 800	160	110	500	475
10 500	165	115	500	475

Table A-12. Probability of delivering at least one abbreviated access request SU (per cent)

Call priority (series length)	Conflicting traffic comprising 1-SU bursts	Conflicting traffic comprising 3-SU bursts
Distress/urgency (4)	99.99	97.9
Flight safety (3)	99.7	93.7
Regularity/meteorological (2)	97.5	89.2

Table A-13. Projected AMS(R)S subnetwork abbreviated call set-up delay performance, (seconds) (R and P channels operating at 600 and 10 500 bits/s)

		Average	95 percentile
AIR-ORIGINATIONS	**AMS(R)S subnetwork signalling transit delay** (Difference between the time at which an air-originated call request (incoming FITE 18) is received at the AES interworking interface and the time at which the GES forwards the resultant call indication (outgoing FITE 18) to the terrestrial network.)	4 [@ 600 bits/s] 3 [@ 10 500 bits/s]	6 to 11 [@ 600 bits/s] 3 to 7 [@ 10 500 bits/s]
	Call set-up delay (Difference between the time at which an air-originated call request (incoming FITE 18) is received at the AES interworking interface and the time at which the C channel is ready for speech).	12 to 14 [@ 600 bits/s] 10 to 11 [@ 10 500 bits/s]	14 to 23 [@ 600 bits/s] 11 to 14 [@ 10 500 bits/s]
GROUND-ORIGINATIONS	**Call set-up delay** (Difference between the time at which a ground-originated call request (incoming FITE 18) is received at the GES interworking interface and the time at which the C channel is ready for speech and the AES forwards the resultant call indication (outgoing FITE 18) to the AES interworking interface.)	9 to 11 [@ 600 bits/s] 9 [@ 10 500 bits/s]	10 to 17 [@ 600 bits/s] 10 [@ 10 500 bits/s]

FIGURES FOR ATTACHMENT A

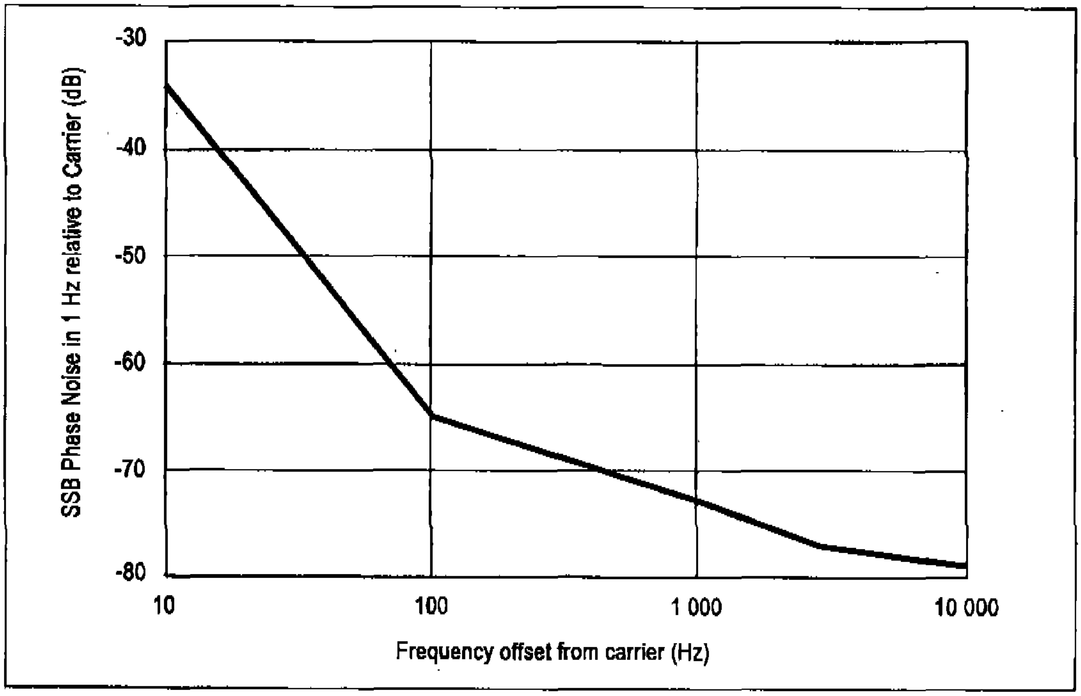


Figure A-1. Phase noise of L-band signals received by AES

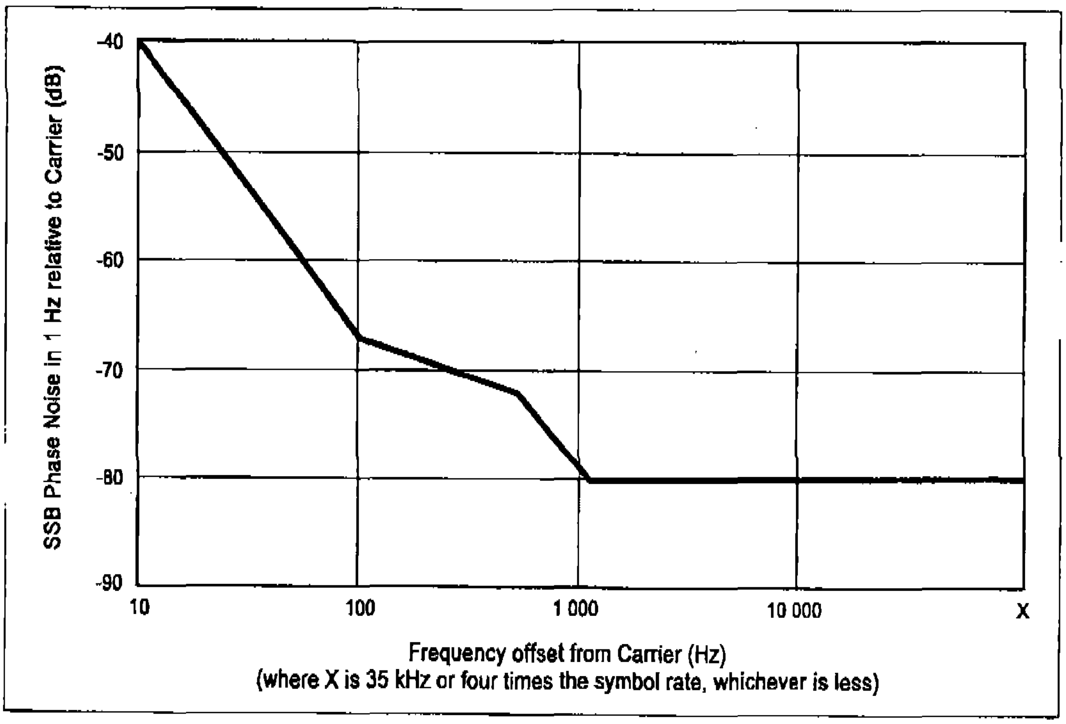


Figure A-2. AES transmit phase noise mask

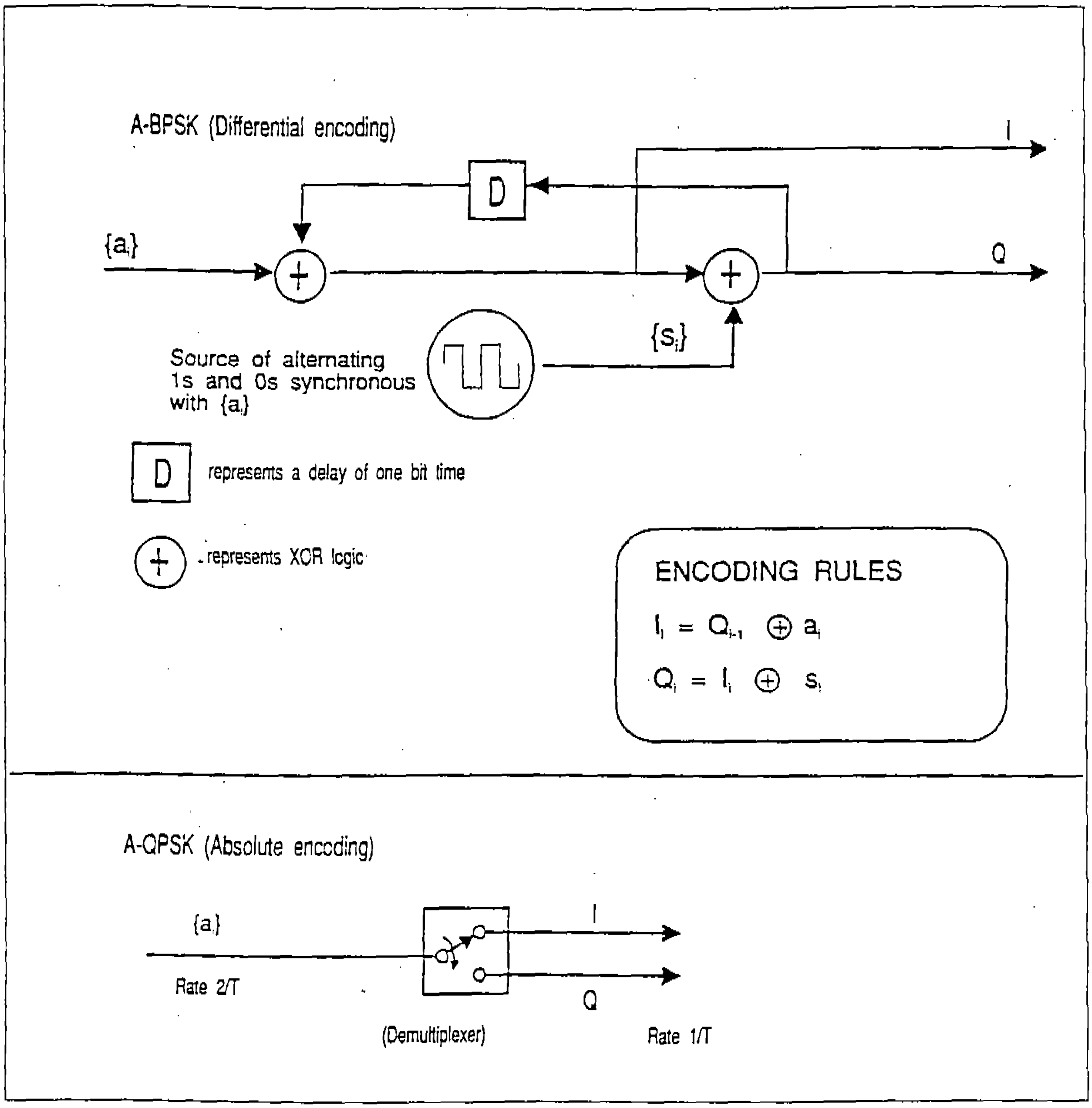
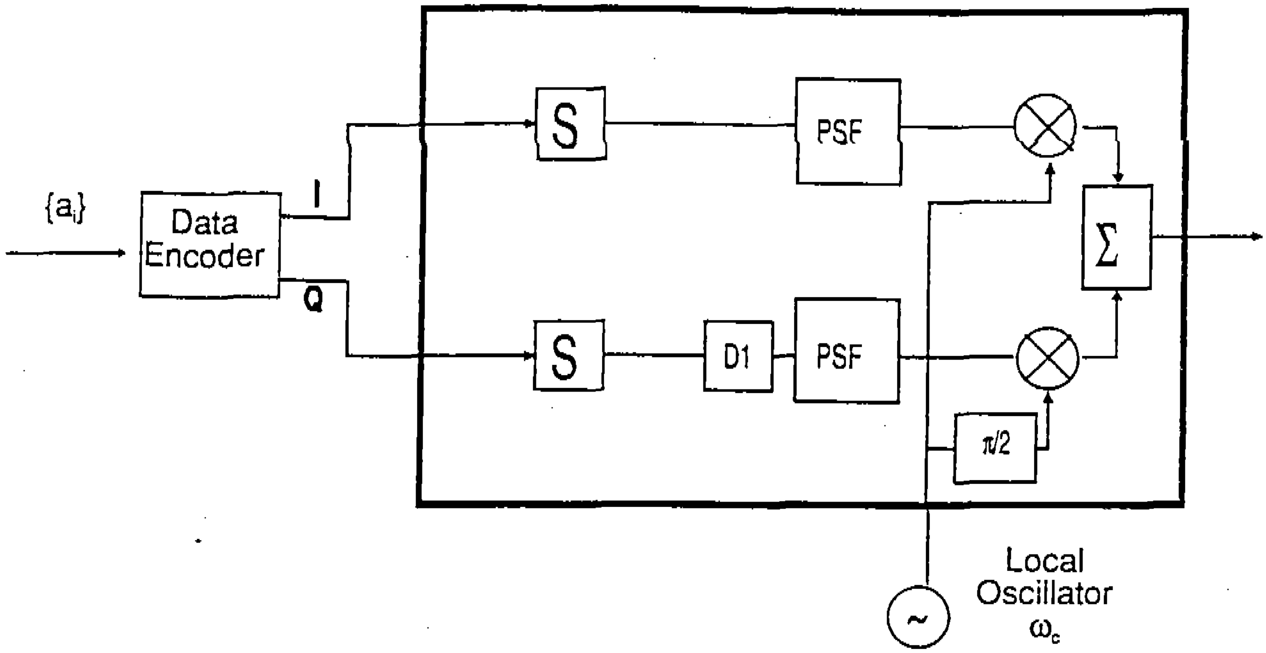


Figure A-3. Data encoders for modulator model



{a_i} is input data sequence. Channel rate is
1/T for A-BPSK
2/T for A-QPSK

{a_i} is mapped into two bit streams on the I and Q lines, each with bit rate 1/T

S is an ideal sampling process:
input = "1", output = δ(t)
input = "0", output = -δ(t)

D1 is a delay of: 0 for A-BPSK
T/2 for A-QPSK

PSF are Pulse Shaping Filters

⊗ represents an ideal linear modulator

Σ represents an ideal combiner

Figure A-4. Ideal modulator (A-BPSK and A-QPSK)

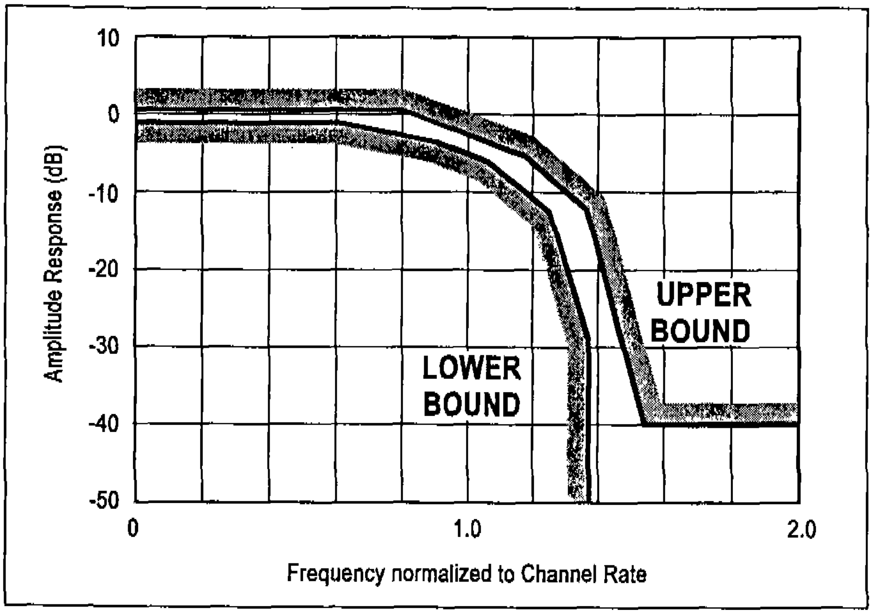


Figure A-5. AES A-BPSK transmit filter response mask

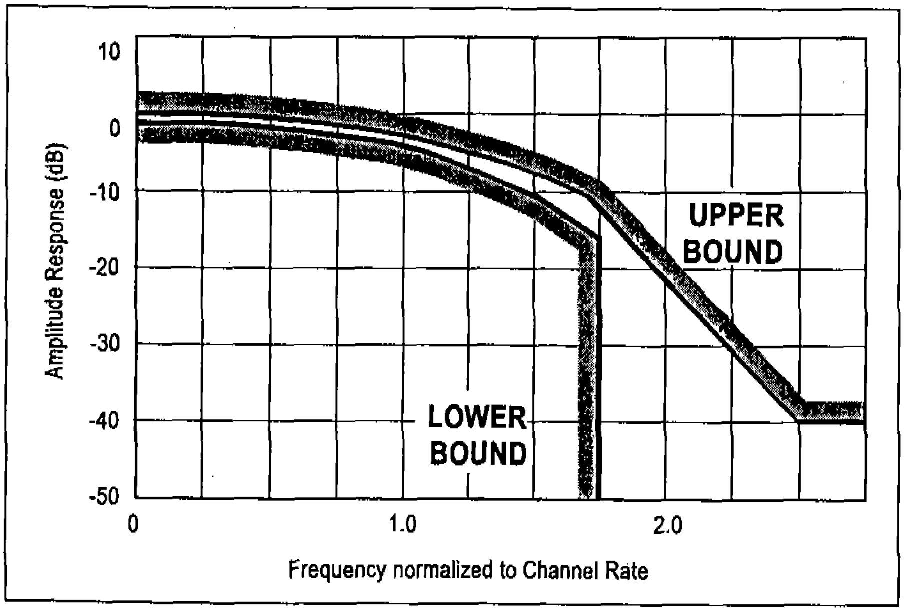


Figure A-6. AES A-QPSK transmit filter response mask for 100 per cent roll-off

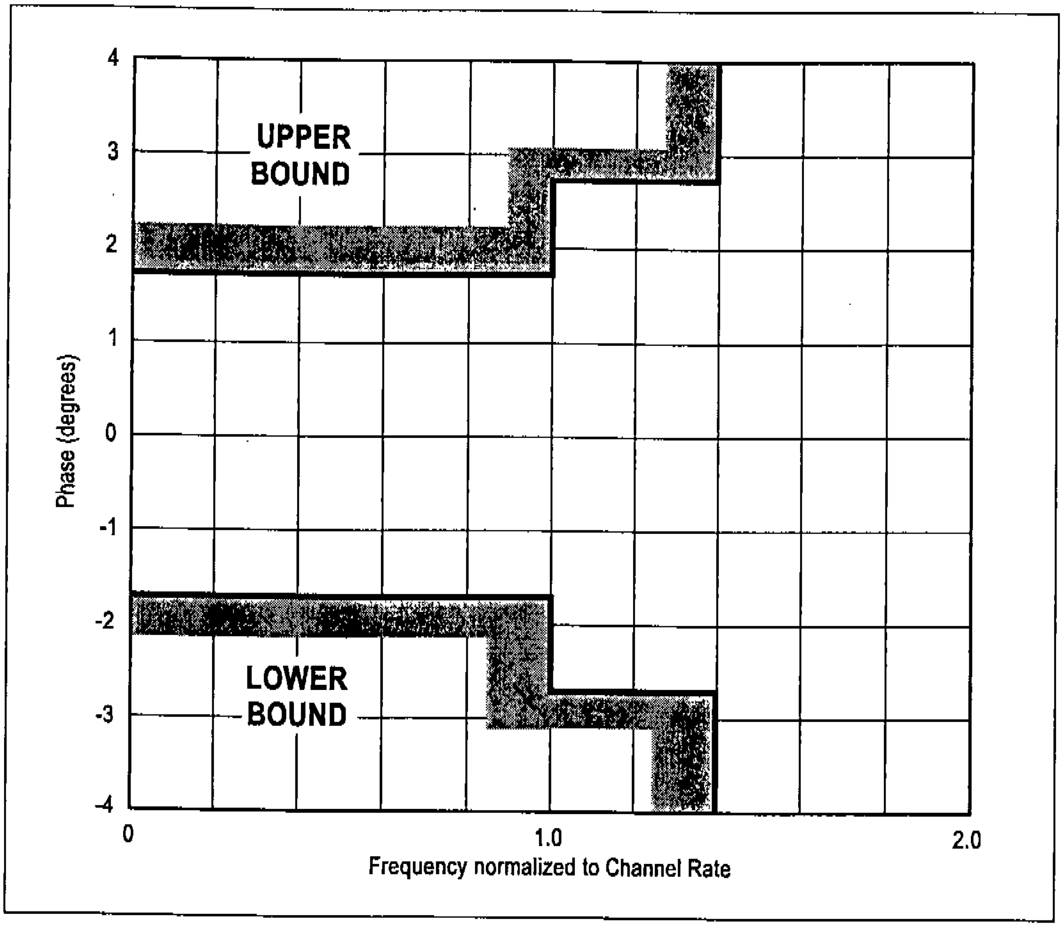
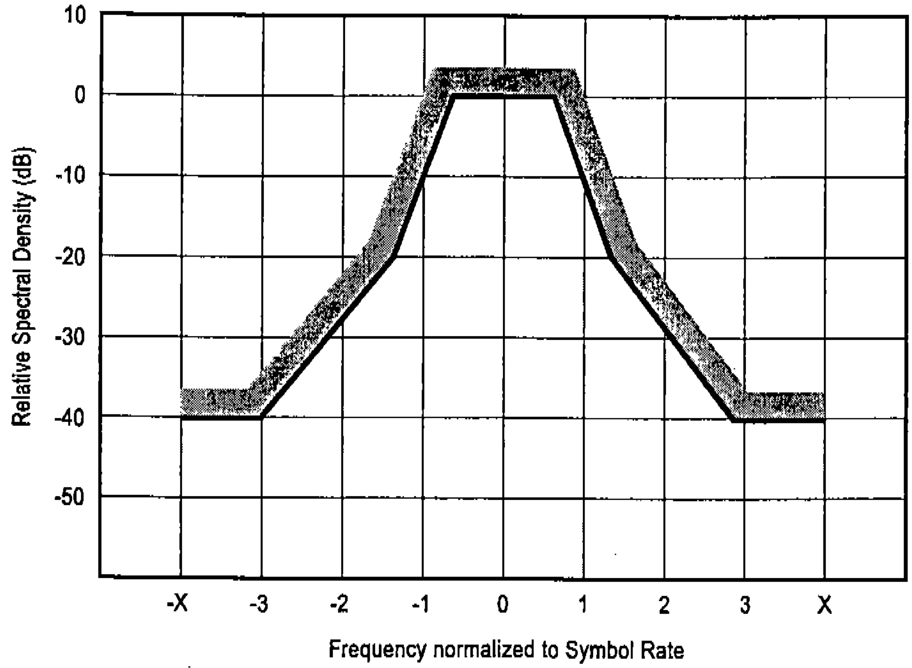


Figure A-7. Phase deviation tolerance for A-BPSK and A-QPSK transmit filter response mask for 100 per cent roll-off



NOTE:
1. The symbol rate is equal to the channel rate for A-BPSK and is half the channel rate with A-QPSK.
2. The frequency X is 35 kHz.

Figure A-8. Required spectral limits for AES transmissions for 100 per cent roll-off

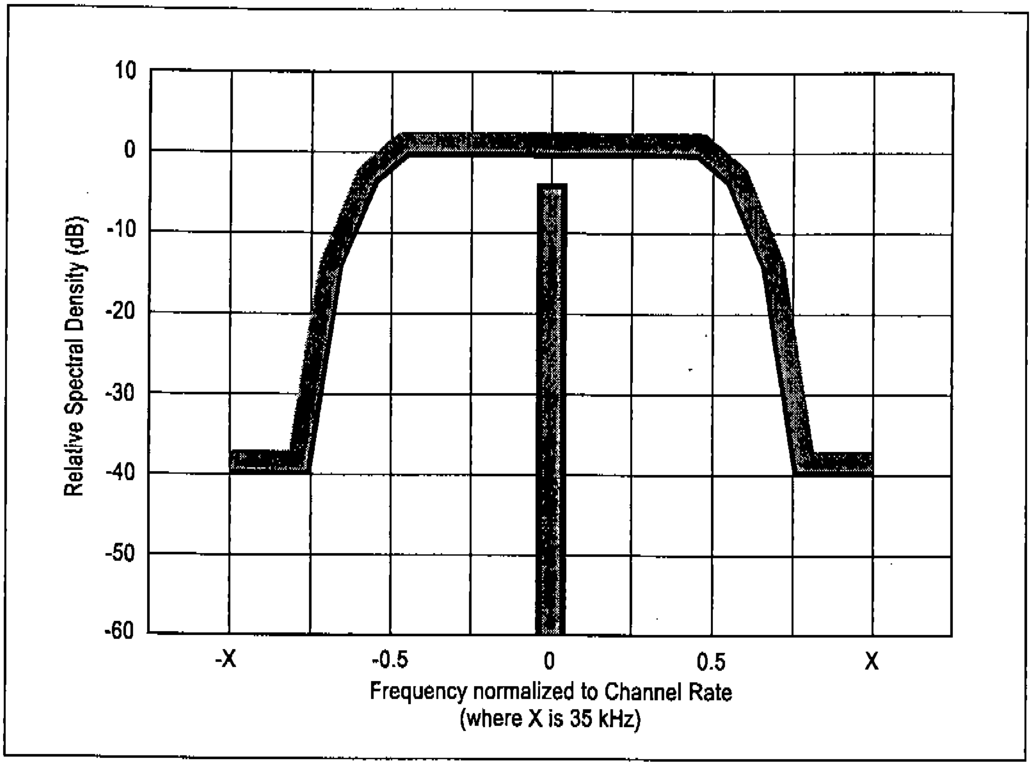


Figure A-9. Spectral mask of A-BPSK received by AES

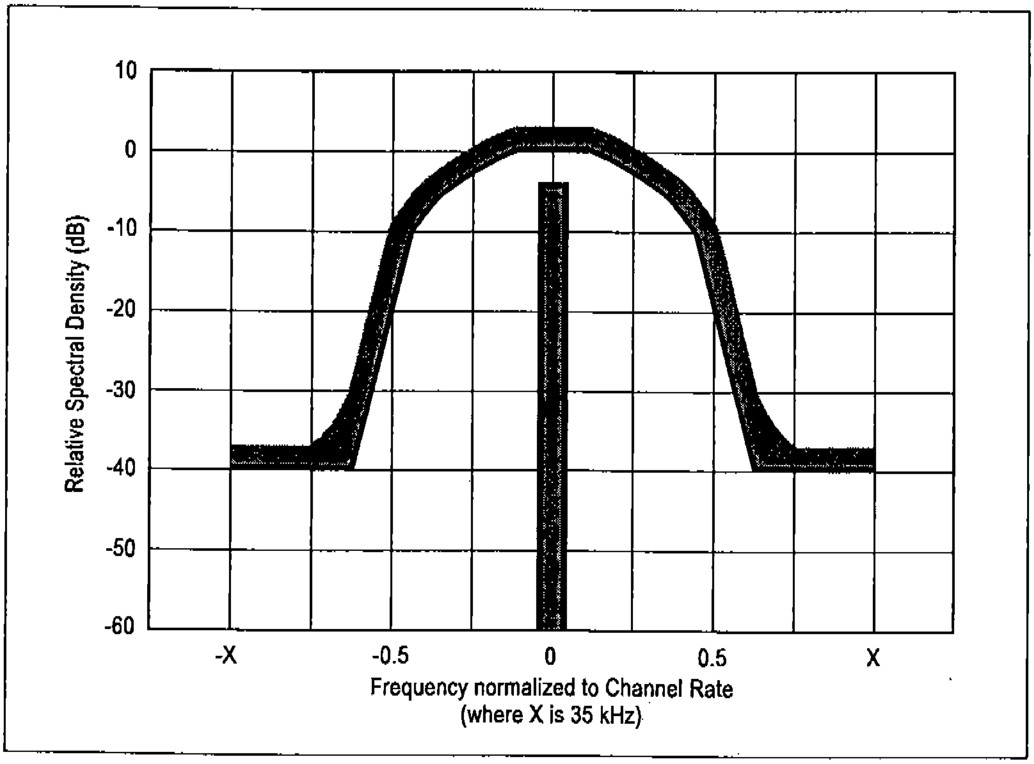


Figure A-10. Spectral mask of A-QPSK received by AES

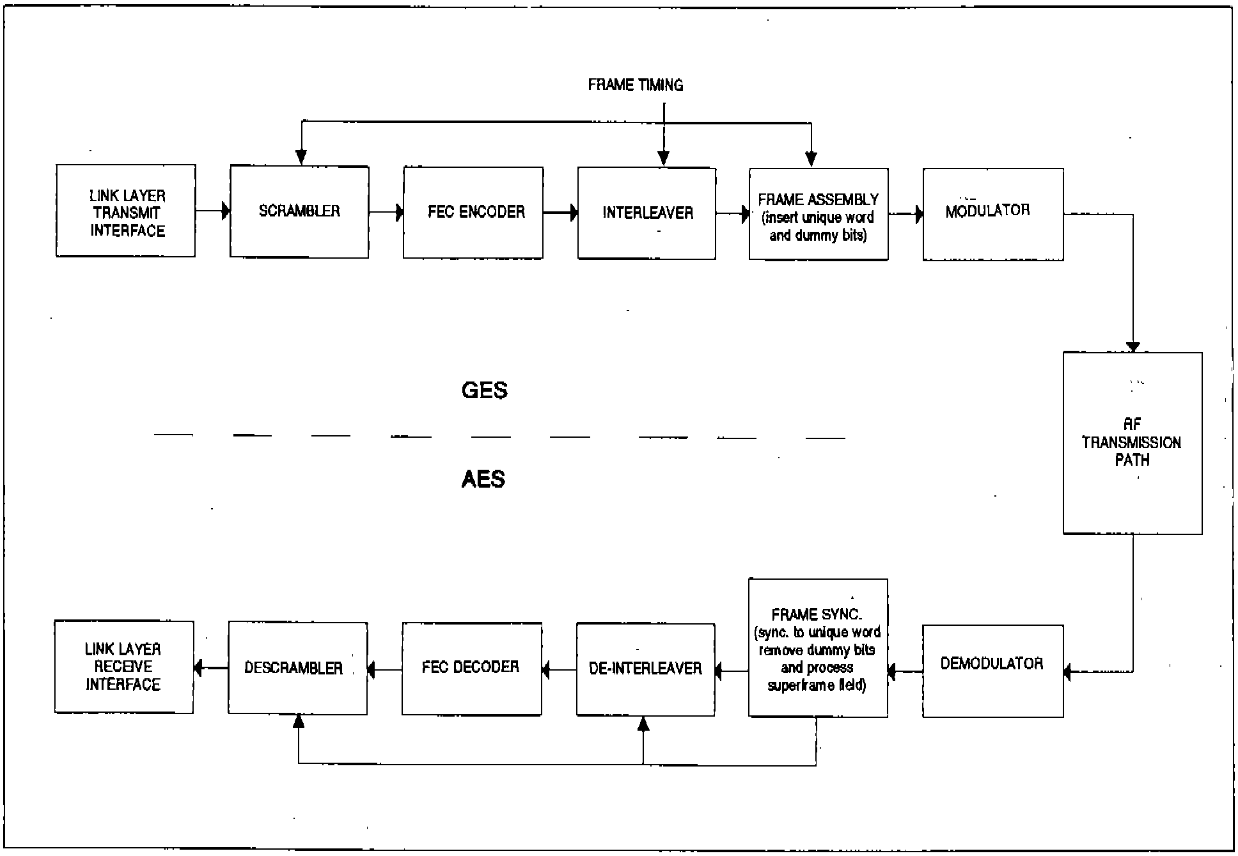


Figure A-11. P channel functional blocks

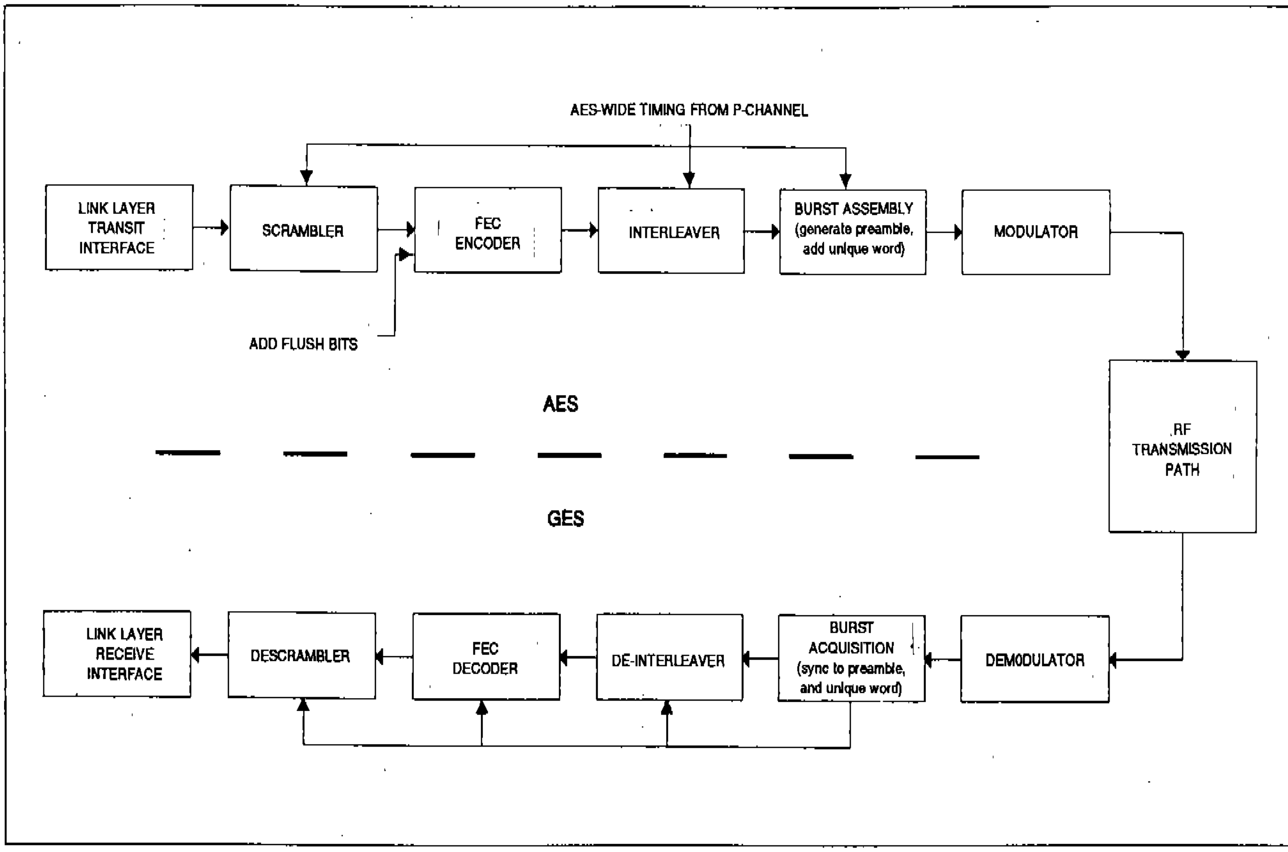


Figure A-12. R and T channel functional blocks

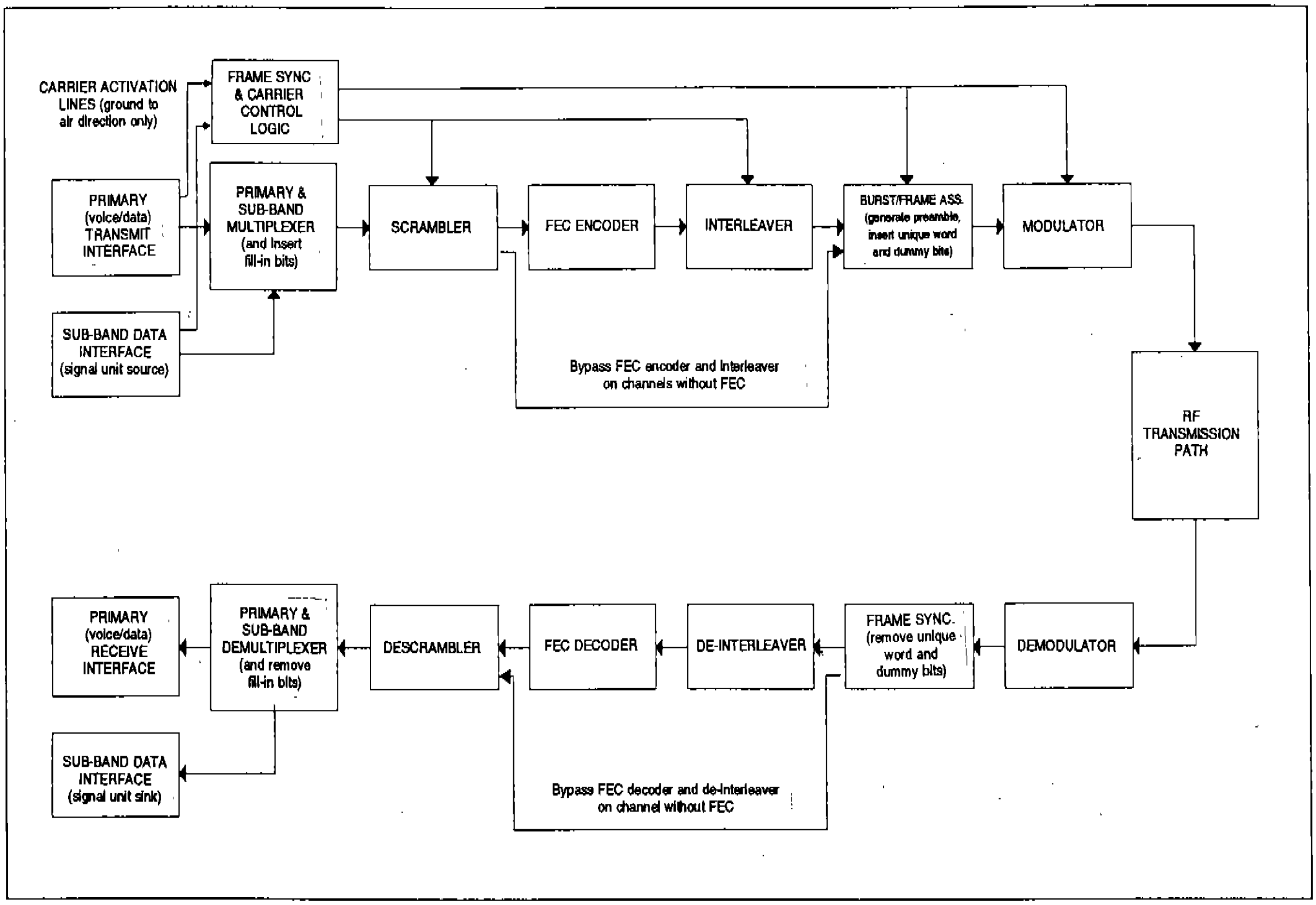


Figure A-13. C channel functional blocks

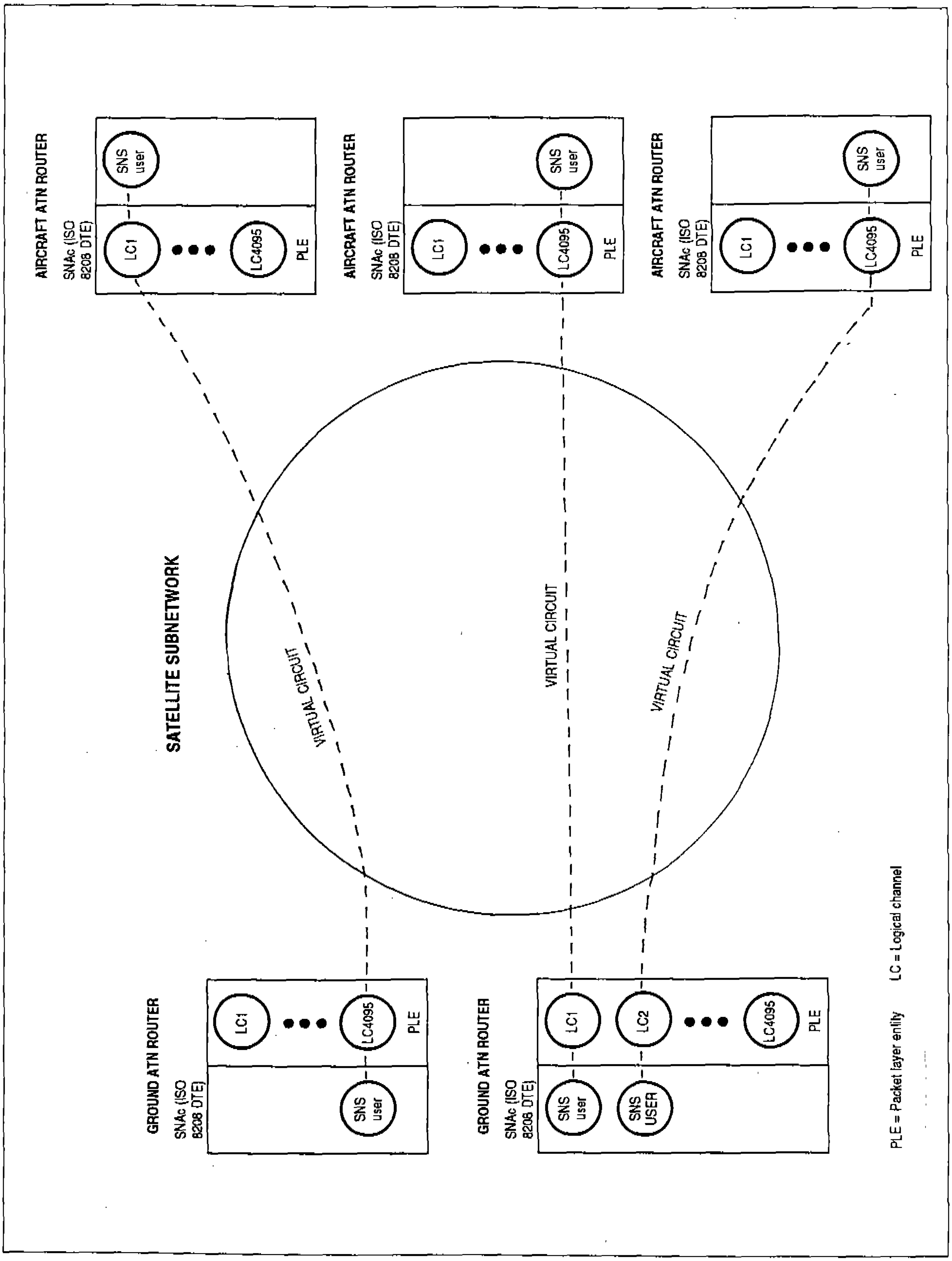


Figure A-14. Satellite subnetwork connection-oriented packet data service

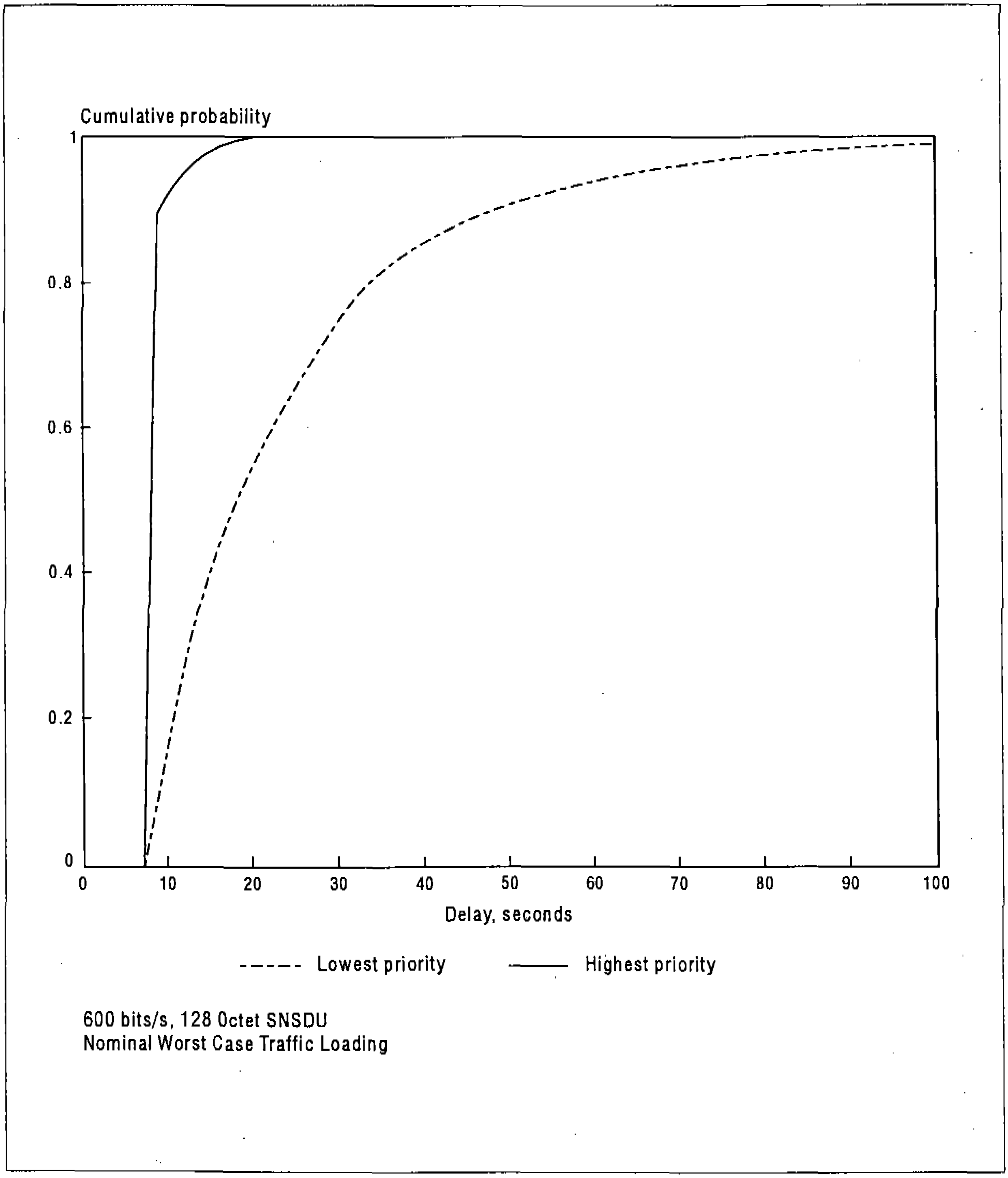


Figure A-15. Typical to-aircraft delay distributions

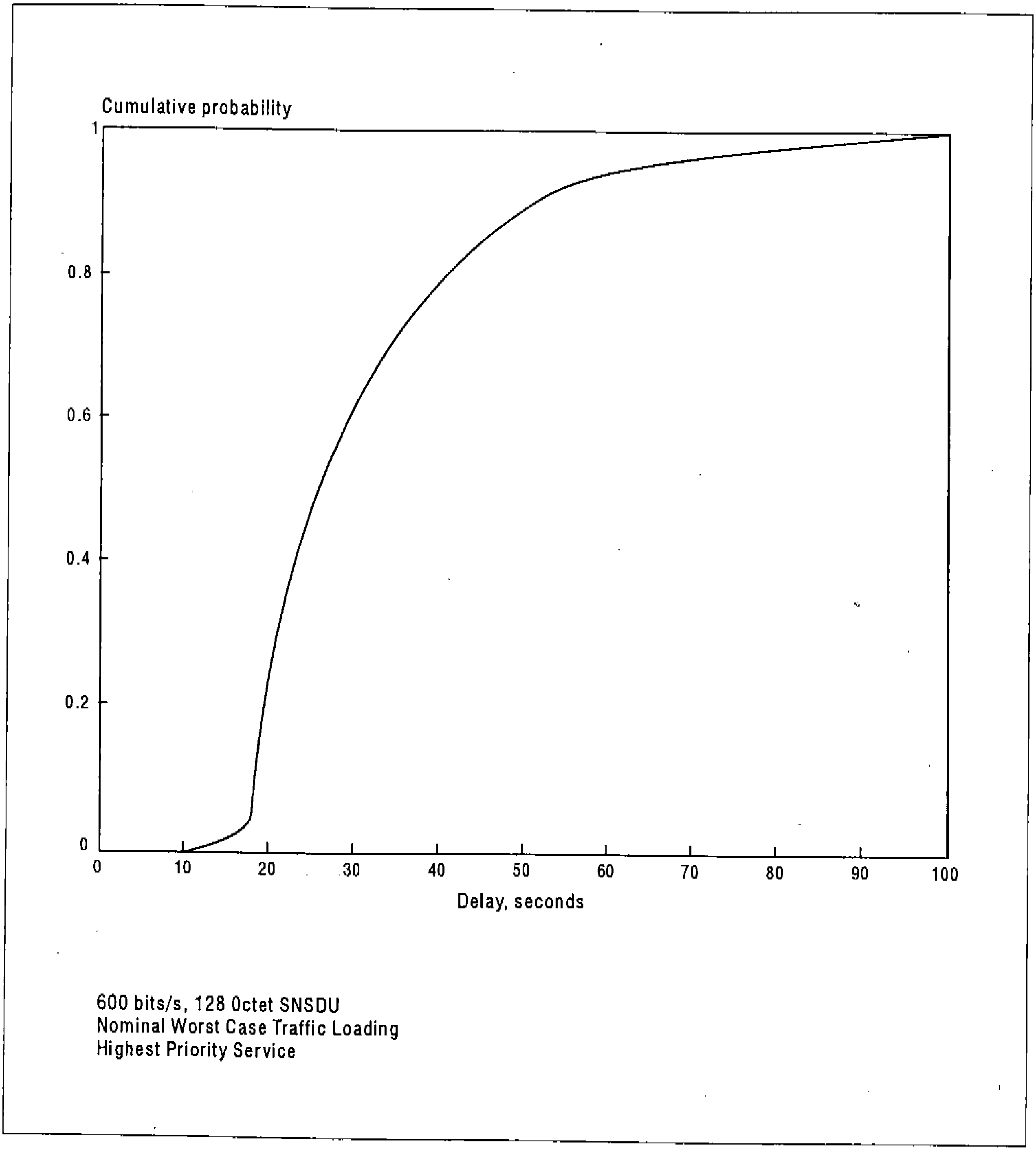


Figure A-16. Typical from-aircraft delay distribution

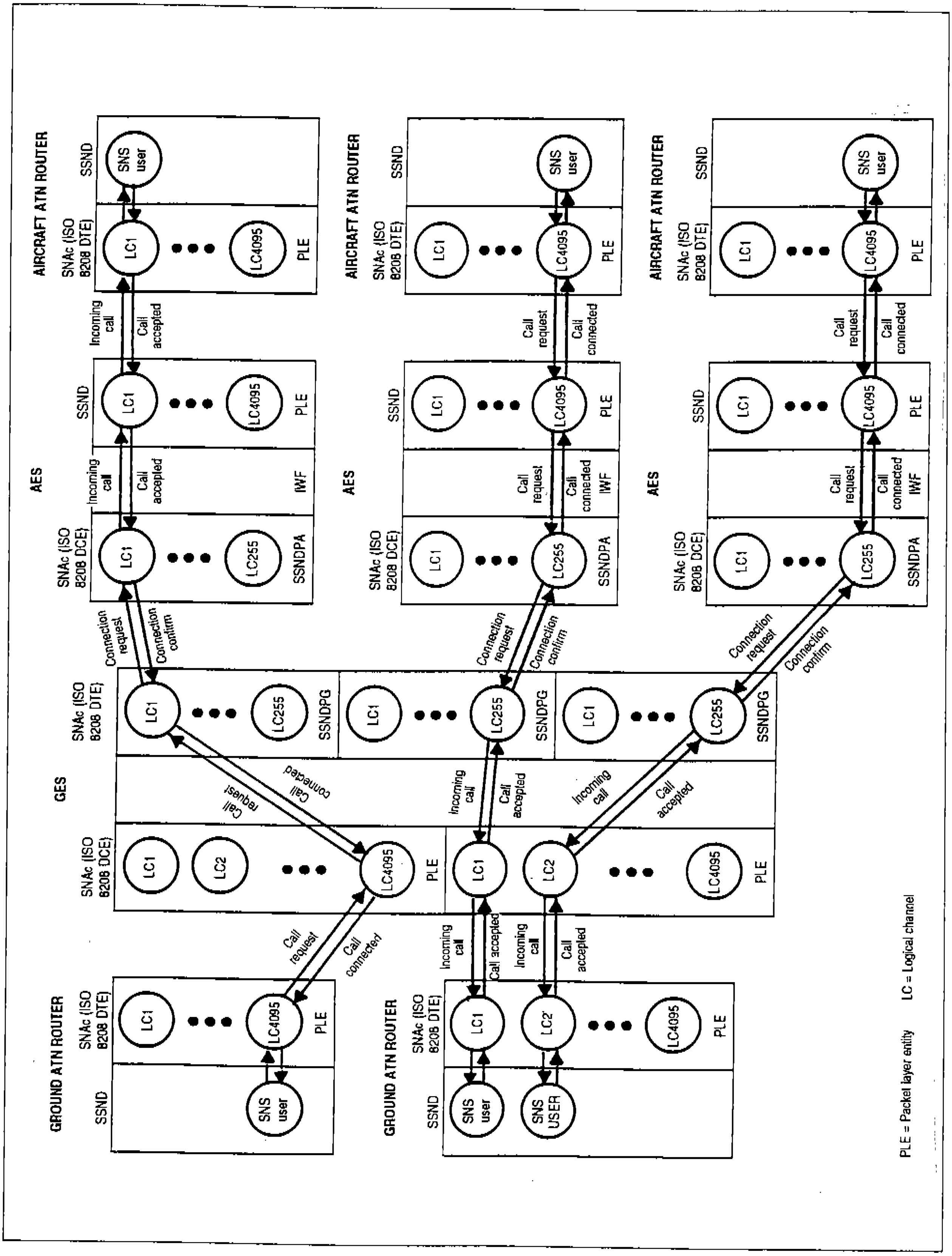


Figure A-17. Satellite subnetwork protocol entities and virtual circuit establishment

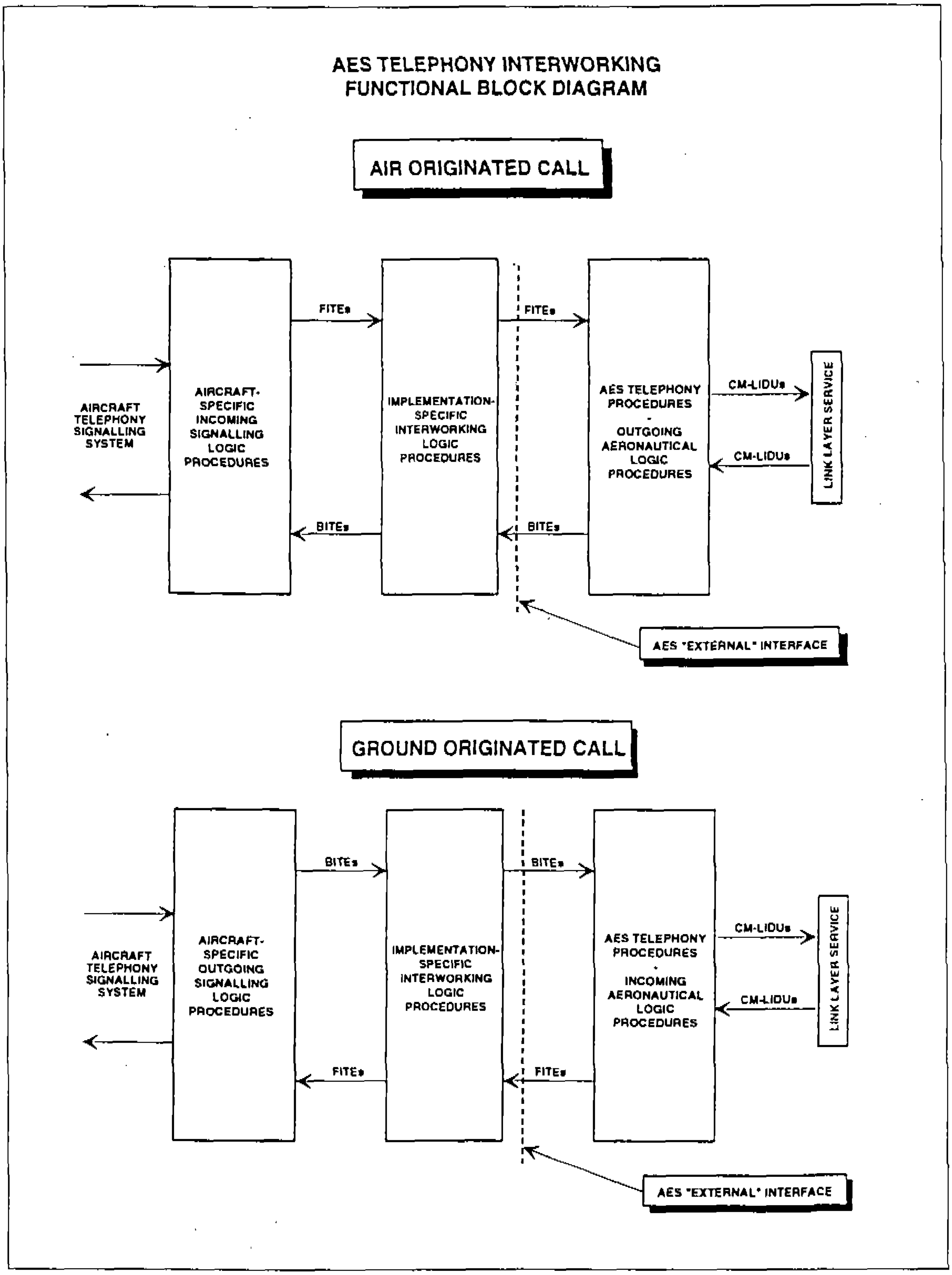


Figure A-18. AES telephony interworking block diagram

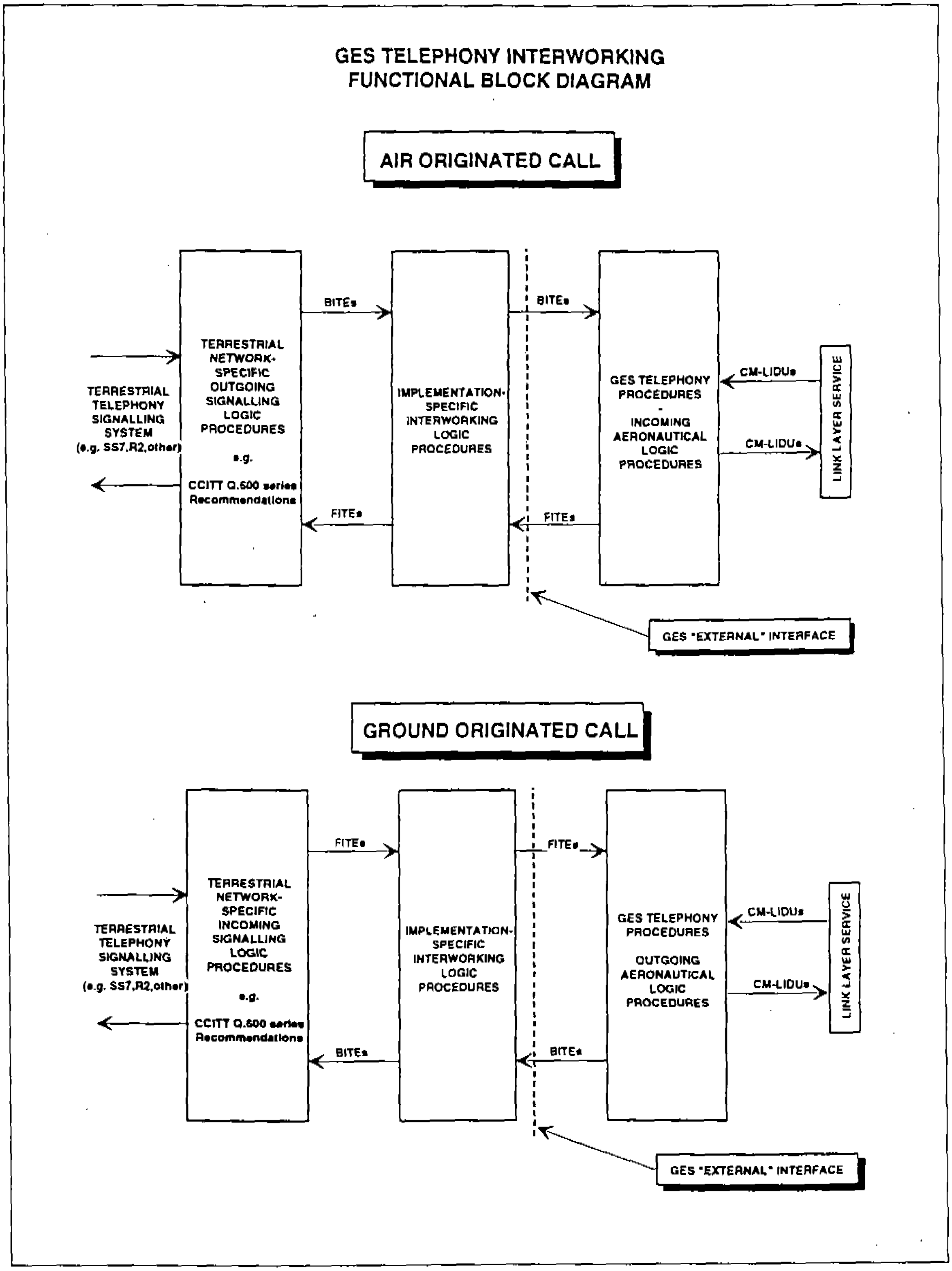


Figure A-19. GES telephony interworking block diagram

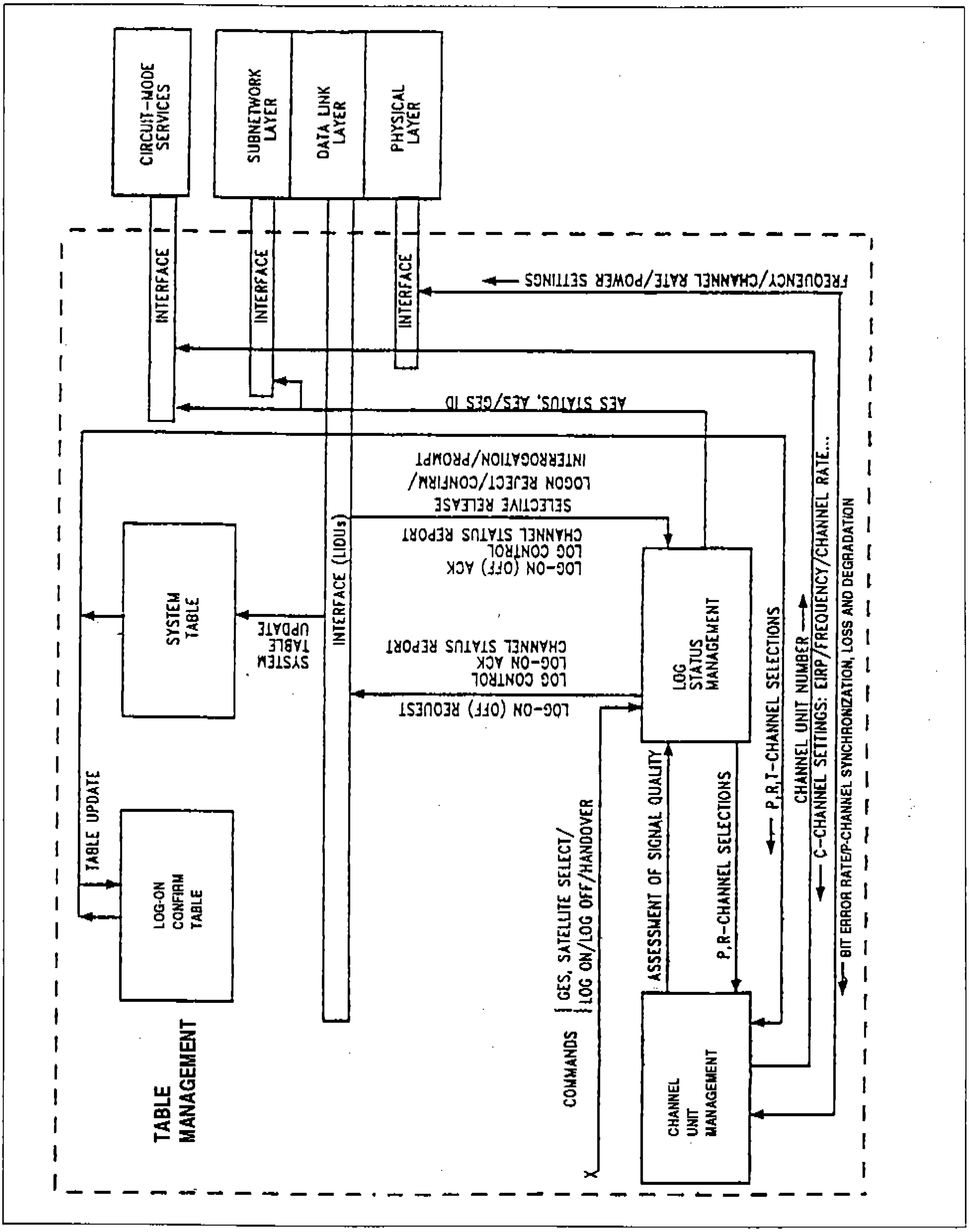


Figure A-20. AES management and interfaces

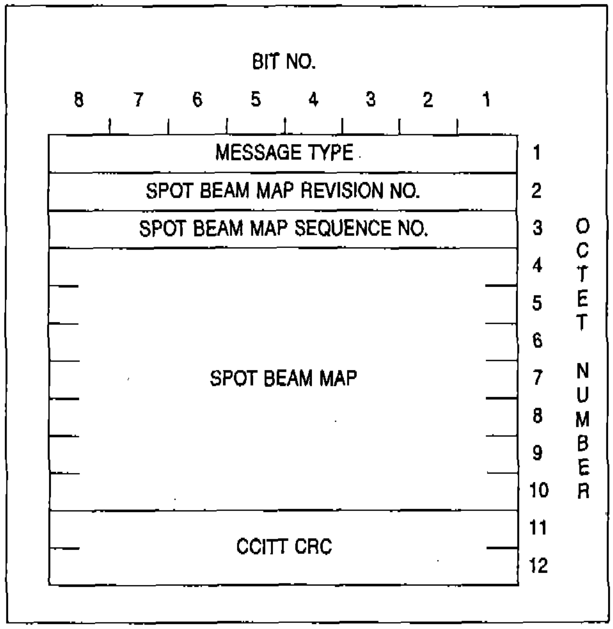


Figure A-21. Spot beam map broadcast

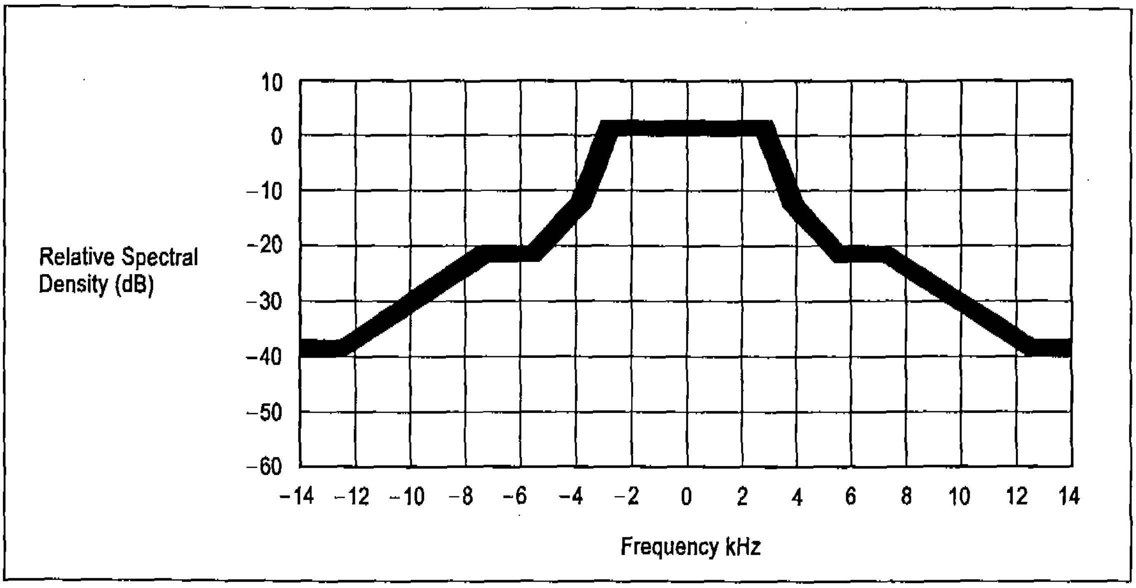


Figure A-22. Required spectral limits for AES transmissions for 60 per cent roll off

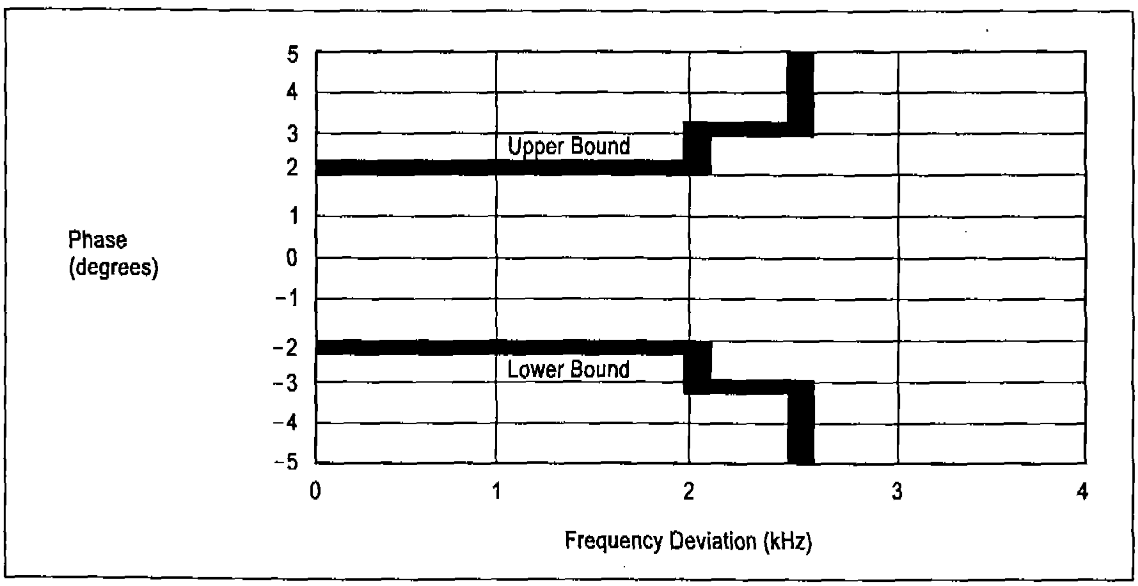


Figure A-23. Phase deviation tolerance for A-QPSK transmit filter response mask for 60 per cent roll off

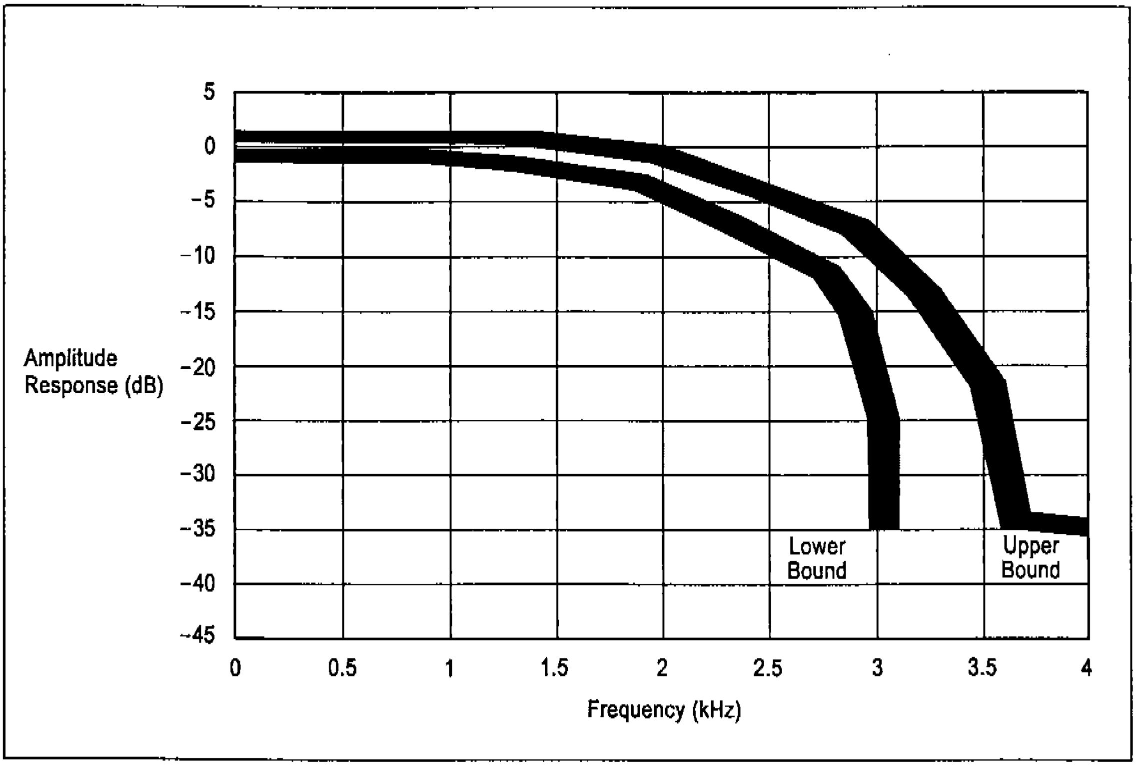


Figure A-24. AES A-QPSK transmit filter response mask for 60 per cent roll-off

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Appendix to Attachment A
PERFORMANCE ANALYSIS

A1. RF link analysis

The typical performance measure for an RF link is the average bit error rate (BER). The satellite subnetwork end-to-end performance is related to the RF link performance by a required average BER. The relationship between a channel BER and the achieved carrier-to-noise density performance depends upon the modulation technique and the channel conditions. For the case of ideal linear modulation techniques and an additive white Gaussian noise channel, this relationship can be derived analytically. For the case of a random fading channel this relationship can be derived through simulation, or using a worst case assumption that all multipath energy is equivalent to noise.

The digital RF communications link can be assured of satisfactory average BER performance if the achieved carrier-to-noise power density ratio is greater than or equal to the carrier-to-noise power density ratio required for communication at the desired average BER:

$$\left(\frac{C}{N_O}\right)_{ACHIEVED} \geq \left(\frac{C}{N_O}\right)_{REQ} \qquad [A.1]$$

where:

$\left(\frac{C}{N_O}\right)_{REQ}$ is the minimum required carrier-to-noise density ratio for communication at the desired average BER.

$\left(\frac{C}{N_O}\right)_{ACHIEVED}$ is the carrier-to-noise density ratio achieved by the end-to-end link.

The required carrier-to-noise density ratio is determined by the particular signalling wave-form used and by the noise and propagation characteristics of the channel. Statistical methods can be used to determine the minimum required carrier-to-noise ratio needed to assure operation at an average BER. Statistical methods can also be used to include the effects of propagation environment and other random losses in the form of a required margin.

Hence, for operation at a desired average BER the following relationship must hold:

$$M_P \times \left(\frac{C}{N_O}\right)_{REQ} \leq \left(\frac{C}{N_O}\right)_{ACHIEVED} \qquad [A.2]$$

where: M_P is the link margin required for the propagation environment and various random RF parameter variations.

The carrier-to-noise performance measures must be allocated to various portions of the RF link, which are discussed below.

A1.1 To-aircraft link analysis

The achieved carrier-to-noise density ratio on the forward link is determined by a number of noise sources in the RF link. With simple, frequency translating transponders, the achieved signal (carrier)-to-noise power ratio can be computed from the expression:

$$\left(\frac{C}{N_{0\ ACHIEVED}}\right)^{-1} = \left(\frac{C}{N_{UF}}\right)^{-1} + \left(\frac{C}{N_D}\right)^{-1} + \left(\frac{C}{I_M}\right)^{-1} + \left(\frac{C}{I_{IS}}\right)^{-1} + \left(\frac{C}{I_{OD}}\right)^{-1} + \left(\frac{C}{I_{OUF}}\right)^{-1} \qquad [A.3]$$

where:

N_{UF}	=	the thermal noise power density of the uplink feeder link.
N_D	=	the thermal noise power density of the L-band downlink.
I_M	=	the intermodulation power density on the L-band downlink due to the satellite transponder.
I_{IS}	=	the intrasystem interference power density.
I_{OD}	=	the downlink L-band intersystem interference power density at the receiver.
I_{OUF}	=	the intersystem interference power density on the feeder link uplink.

An important assumption is inherent in equation [A.3]. It is assumed that in an individual channel bandwidth all the noise sources can be considered to be "white Gaussian" in nature.

A1.2 From-aircraft link analysis

In the same manner as the forward link, the achieved carrier-to-noise density ratio is determined by a number of noise sources in the return link. The achieved carrier-to-noise power density ratio can be obtained from the expression:

$$\left(\frac{C}{N_{0\ ACHIEVED}}\right)^{-1} = \left(\frac{C}{N_{DF}}\right)^{-1} + \left(\frac{C}{N_U}\right)^{-1} + \left(\frac{C}{I_{M\ AES}}\right)^{-1} + \left(\frac{C}{I_{ISR}}\right)^{-1} + \left(\frac{C}{I_{OU}}\right)^{-1} + \left(\frac{C}{I_{ODF}}\right)^{-1} \qquad [A.4]$$

where:

N_{DF} = the thermal noise power density of the downlink feeder link.

N_U = the thermal noise power density of the L-band uplink.

$I_{M\,AES}$ = the minimum operable intermodulation power density expected on the L-band uplink from the multi-carrier operation of the AES high power amplifiers.

I_{ISR} = the intrasystem interference power density.

I_{OU} = the intersystem interference power density at L-band expected on the uplink.

I_{ODF} = the intersystem interference power density on the feeder link downlink.

A1.3 Propagation anomalies and required margins

An idealized RF link can be adversely affected by a number of factors which can be divided into two basic classes: deterministic and nondeterministic. Deterministic factors influencing RF link margin requirements depend on the propagation path established by the relative locations of the aircraft, satellite and earth in a particular situation. Other deterministic factors are fixed by the system design, such as, information bit rates, modulation type, interleaver depths, coding schemes, etc.

The nondeterministic factors that influence the RF link requirements are system design and operational elements specified by the service provider, degradation due to interference and other propagation-related random losses.

Many factors that influence the RF link requirements may be viewed as losses that reduce the available carrier power and degrade link performance. Detailed discussions of several of these factors are included in the following sections.

A1.3.1 Multipath fading

The term "multipath" refers to a condition in which energy reaches the receiver of a telecommunications system by more than one path. Multipath propagation may result from reflection from land and water surfaces and man-made structures. Multipath operation is generally undesirable, because signals arriving over the different paths arrive with variable relative phase, with the result that they alternatively add constructively or destructively in space. Hence, the total received signal will be characterized by fading, involving repeated minima which may fall below the signal level required for acceptable communications performance. Fading is also significantly higher over water as opposed to land. Furthermore, the signals arriving over the different paths also have different time delays, and in digital systems intersymbol interference can result.

A number of investigators have researched the effects of multipath fading on aeronautical satellite communications. The statistical nature of multipath fading for aeronautical channels is therefore well understood. The amplitude of fading is known to have a Rician distribution. Furthermore, the carrier-to-multipath ratio is known to be a function of the elevation angle to the satellite, and can be expected to be less than 10 dB for elevation angles below 10 degrees.

The carrier-to-noise ratio for a channel is affected by multipath and the particular form of modulation and coding. It is appropriate to include the effects of multipath in setting the carrier-to-noise requirement rather than including it in a separate margin; a conservative approach is to treat the multipath energy as equivalent to additive Gaussian noise, and then, in a coded system, to add additional margin for imperfect interleaving.

A1.3.2 Scintillation

Ionospheric scintillation is a phenomenon involving the effects of the sun and the earth's magnetic field that produces random variations in electromagnetic waves traversing the ionosphere. The phenomenon is manifested in satellite-earth station RF links as "scintillation fading"; positive and negative (loss) changes in the amplitude of the received signal that can be significant at the L-band frequencies used for the satellite-to-AES link. Values as high as 27 dB have been observed for short periods of time during severe scintillation events; however, the expected value is substantially lower. Phase shifting is also associated with scintillation fading, the effects of which can further degrade RF link performance.

As satellite RF link power margins are normally small for economic reasons, a loss value due to scintillation fading as low as 0.3 dB could be significant. Scintillation loss is highly correlated with the position and local time of the aircraft, thus is of major concern to certain routes and times of flight. Scintillation events also exhibit a seasonal influence, peaking during the vernal and autumnal equinoxes. Significant scintillation loss can be expected for aircraft located near the geomagnetic equator (between 15 degrees latitude North and South) at aircraft local time between 2130 and 0230 hours, and for aircraft located in polar regions (latitudes greater than ±65 degrees although coverage by geosynchronous satellites is effectively limited of latitudes to 80 degrees or less) at any time of day. Available data indicate that scintillation fading is about twice as intense in the equatorial region as compared with the polar regions. For a stationary earth station, about 1 per cent of equatorial region fades exceed 20 dB, and stay above 15 dB for several seconds. Eastward motions of the ionosphere at rates of 50 to 200 metres/second are typically seen, implying correlation distances of 10 to 100 metres. It would be possible for an eastbound aircraft's velocity to become "synchronized", resulting in substantially longer fading periods.

Fading in the polar regions is less intense, (about 10 dB for a stationary earth station) as compared with the equatorial region. Also, the velocity of the polar ionosphere is typically higher and more variable, in the range of 100 to 1 000 metres/second.

Data regarding the scintillation effects on earth stations in motion — in particular, on the signal-in-space used by AMSS — is currently limited. Further, the probability of an aircraft experiencing significant effects of scintillation is highly sensitive to its route and timing of its flight. Consequently, the effects of scintillation fading have not been accounted for herein.

A1.3.3 POLARIZATION LOSS

The transmission loss between two antennas due to imperfect circular polarization can be calculated by:

$$L_{POL} = 10\ LOG\left(\frac{\left(R_1^2+1\right)\left(R_2^2+1\right)}{\left(R_1R_2+1\right)^2 \cos^2(\theta) + \left(R_1+R_2\right)^2 \sin^2(\theta)}\right) \quad [A.5]$$

where it is assumed that the antennas have the same sense (e.g. righthand circular) and where:

R_i = the voltage axial ratio (AR) of the ith antenna.

θ = the angle between the major axes of the two elliptically polarized waves that would be radiated, one from each antenna.

The polarization loss is determined completely by the axial ratios and relative orientation of their major axes. The worst case situation is when the major axes are orthogonal, i.e. $\theta = 90°$. Various forms of equation [A.5] are possible, depending upon the assumptions about the reference antenna. For link budget calculations, one typically might consider the worst case satellite antenna orientation, and a statistical estimate of the effects of AES antenna orientation.

A1.3.4 PATH LOSS

The path loss due to space is a function only of the frequency and range. The path loss is easily calculated by:

$$L = \left(\frac{4\pi r}{\lambda}\right)^2 \quad [A.6]$$

where:

r = the range from the AES to the satellite in metres.

λ = the wavelength in metres.

In general, the range to the satellite, r, is a function of the geographical position of the AES. Conveniently, the range to the satellite is simply a function of the observed elevation to the satellite and is given by:

$$r = \sqrt{R^2 + (R+h)^2 - 2R\,(R+h)\cos\beta} \quad [A.7]$$

where:

R = the Earth's mean radius ≅ 6 378 km

h = the geosynchronous altitude = 35 786 km (from earth surface at the subsatellite point).

β = $\cos^{-1}\left[\frac{R\cos(\theta)}{R+h}\right] - \theta$

where:

θ = the elevation angle of the satellite relative to level flight.

With the satellite directly overhead, the path loss at 1 545 MHz is 187.3 dB. At 5° elevation, the path loss is 188.5 dB. Therefore, the path loss for aircraft operating with a 5° elevation angle to the satellite is 1.2 dB greater than an aircraft with the satellite directly overhead. In practice, the path loss is calculated for a specific elevation angle to the satellite.

A1.3.5 PRECIPITATION LOSS

Raindrops cause attenuation to radio waves by both absorption and scatter. The magnitude of attenuation is a function of frequency, average droplet size, aircraft latitude, elevation angle and rainfall rate. The relationships among these factors are well established through years of research and experimental measurement, making it possible to predict performance with confidence.

In general, attenuation due to rainfall is not significant at the L-band frequencies used for the AMSS service links. However, the feeder links for the AMSS services will be at much higher frequencies where the rain attenuation could be very significant. Feeder link design must take into account the expected rainfall for the location of the ground earth station, particularly as regards link availability.

The effect of rain attenuation on the feeder link in the forward direction can be compensated for by GES power control. The GES power is increased such that the signal maintains the required level when received at the satellite. One consequence of this increase in power can be to increase the intermodulation products originating at the GES. The link must be designed so that this additional interference will not degrade the over-all achieved carrier-to-noise performance below the required level.

In the return direction, rain attenuation will lower the carrier power to thermal noise ratio for the feeder link. Again, this additional interference must not degrade the over-all achieved carrier-to-noise performance below the required level.

There is no specific allotment in the required margin to account for the effects of rain fading. It is the responsibility of the satellite system designer to ensure that the satellite and GES design is such that the over-all link carrier-to-noise ratio can be maintained under the expected rain conditions in the stated coverage areas.

ATTACHMENT B TO PART I. GUIDANCE MATERIAL FOR THE VHF DIGITAL LINK (VDL)

1. GUIDANCE MATERIAL FOR THE VHF DIGITAL LINK (VDL)

Note.— The Standards and Recommended Practices (SARPs) referred to are contained in Annex 10, Volume III, Part 1, Chapter 6.

2. SYSTEM DESCRIPTION

2.1 The VDL system provides an air-ground data communications link within the aeronautical telecommunications network (ATN). The VDL will operate in parallel with the other ATN air-ground subnetworks.

2.2 VDL ground stations consist of a VHF radio and a computer capable of handling the VDL protocol throughout the coverage area. The VDL stations offer connectivity via a ground-based telecommunications network (e.g. X.25 based) to ATN intermediate systems which will provide access to ground-based ATN end systems.

2.3 In order to communicate with the VDL ground stations, aircraft are required to be equipped with VDL avionics which will include a VHF radio and a computer capable of handling the VDL protocol. The air-ground communication will utilize 25 kHz channels in the VHF aeronautical mobile (route) service band.

3. VDL PRINCIPLES

3.1 Communications transfer principles

3.1.1 Connectivity between applications running in ATN end systems (ES) using the ATN and its subnetworks, including the VDL, for air-ground communication is provided by the transport layer entities in these end systems. Transport connections between airborne and ground end systems shall be maintained through controlled changes of the precise ATN intermediate systems (IS) and VDL network elements that provide this connectivity.

3.1.2 Transport connections between ATN ES are not linked to a particular subnetwork and ISO 8473 network protocol data units transmitted by an ES can pass via any air-ground ATN compatible subnetwork (such as aeronautical mobile-satellite service (AMSS) data link, SSR Mode S data link or VDL) that meets the quality of service (QOS) requirements. A transport connection between an aircraft ES and a ground ES shall be maintained as long as there is at least one air-ground subnetwork connection between the aircraft IS and a ground IS which has connectivity to the ground ES. In order to maximize subnetwork connectivity, aircraft are expected to maintain air-ground subnetwork connections via any subnetwork (AMSS, Mode S or VDL) with which link layer connectivity can be established.

3.1.3 The VDL subnetwork provides connectivity in the form of switched virtual circuits between ISO 8208 data terminal equipment (DTE) entities of aircraft and ground-based ATN intermediate systems. Due to the fact that VHF signals have only line-of-sight propagation, it is necessary for aircraft in flight to regularly establish link connections with new VDL ground stations in order to maintain VHF coverage. An established VDL virtual circuit between an aircraft DTE and a ground DTE is maintained through a controlled change to a ground station through which the ground DTE can be accessed.

3.1.4 VDL virtual circuits may be cleared when the aircraft or ground IS identifies a policy situation where the virtual circuit to the ground DTE is no longer necessary but this shall only happen if another VDL virtual circuit remains established. A policy situation is a situation where considerations other than coverage influence the decision to establish a connection. This could be, for example, a situation where an aircraft is within the designated operational coverage area of ground stations operated by different operators and a decision must be made with which operator to establish a connection. The case where an aircraft crosses a border between two States needs special attention. An aircraft has to establish a virtual circuit to the DTE in the IS of the State entered before clearing the virtual circuit with the DTE in the IS of the State left.

3.1.5 The scenarios for subnetwork connection maintenance are shown in Figure B-1[1]. If the ground stations on each side of a State border do not offer ISO 8208 connectivity to

1. All figures are located at the end of this attachment.

the DTEs of the IS in both States, aircraft crossing the border will have to set up a link connection to a ground station in the State entered before being able to establish a virtual circuit to the IS of that State. Only after establishment of the new link connection and virtual circuit, the aircraft will clear the virtual circuit with the DTE of the IS of the country left over the link which gave access to that IS. If the VDL aeronautical stations on both sides of the State border offer connectivity to the IS in both States, the changeover of the virtual circuits has to take place over the same link connection.

3.2 VDL quality of service for ATN routing

3.2.1 The use of the VDL system for air-ground communications will depend on the routing decisions of aircraft and ground-based ATN intermediate systems (IS). These ISs will decide on the path to be used for air-ground communications based on quality of service values requested by transmitting end systems (ESs).

3.2.2 The IS at each end of the air-ground connections must interpret the requested QOS value and decide which of the available connections can best be met. It is important that the level of QOS which a VDL connection is perceived as providing is set at a level which corresponds to its true performance.

3.2.3 In cases where the VDL is the only data link with which an aircraft has been equipped, all communications must be routed via a VDL connection and the value set for QOS to be provided by the connection must not block the communication.

3.2.4 In other cases where aircraft are equipped with other air-ground data links (such as AMSS and SSR Mode S) there may be simultaneous parallel connections over multiple subnetworks. In these cases, the values for QOS provided by each subnetwork must be set so as to ensure that the VDL connection will be used where appropriate.

3.2.5 It is necessary that co-ordination take place between aircraft operators, ground station operators and ground system operators to ensure that the right balance is achieved between different subnetworks.

4. VDL GROUND STATION NETWORK CONCEPT

4.1 Access

4.1.1 A VDL ground station will provide access for aircraft to the ground ATN IS using the VDL protocol over a VHF channel.

4.2 Institutional issues concerning VDL ground station network operators

4.2.1 An ATS provider wishing to use VDL for air traffic service (ATS) communications needs to ensure that the VDL service is available. The ATS provider can either operate the VDL ground station network itself or arrange for the operation of the VDL stations (or VDL network) by a telecommunications service provider. It seems likely that individual States will make different arrangements for the provision of VDL service to aircraft. Operation and implementation of VDL need to be co-ordinated at a regional level in order to ensure acceptable service on international routes.

4.2.2 The use of a VDL ground station network by entities external to the ATS provider will be subject to service agreements between the ATS provider and the telecommunications service provider. These agreements set out the obligations of the two parties and need, in particular, to be specific on the quality of service provided as well as the characteristics of the user interface.

4.2.3 It seems likely that some VDL ground station network operators will levy user charges. These are expected to be levied either on the aircraft operators and/or on the ATS providers. It is necessary to ensure that the use of VDL is feasible for those aircraft operators intended to use VDL for ATS/AOC communications.

4.3 VDL ground station equipment

4.3.1 A VDL ground station will consist of a VHF radio and a computer which may be separate or integrated with the radio. The VDL functionality of the VHF radio equipment will be similar to that installed in aircraft.

4.3.2 The provision of network status monitoring is an important element in the maintenance of the highest availability possible.

4.4 Ground station siting

4.4.1 The line of sight limitations of VHF propagation is an important factor in the siting of ground stations. It is necessary to ensure that the ground stations are installed in a manner which provides coverage throughout the designated operational coverage area (DOC).

4.4.2 The coverage requirements for VDL depend on the applications that are intended to operate over the VDL. These applications may function, for example, when an aircraft is at en-route altitude, in a terminal area or on the ground at an airport.

4.4.3 En-route coverage can be provided using a small number of ground stations with a large DOC (for example, the range of a VHF signal from a station at sea level and an aircraft at 37 000 ft is approximately 200 NM). Hence, it is in fact desirable that the smallest number of ground stations possible be used to provide en-route coverage in order to minimize the possibility of simultaneous uplink transmissions from ground stations which may cause message collisions on the VHF channel. The factors limiting en-route coverage will be availability of landmass and the availability of a communications link from a ground station to other ground systems.

4.4.4 Terminal area coverage requires, in general, the installation of ground stations at all airports where VDL operation is required in order to ensure coverage throughout the terminal area.

4.4.5 Aerodrome surface communication coverage must be provided by a ground station at the airport but, due to the physical structure of the airport, it may not be possible to guarantee coverage in all areas with a single station.

4.5 Ground station frequency engineering

4.5.1 The choice of the VHF channel on which a ground station will operate depends on the coverage that the ground station will be required to provide. Coverage on a particular channel is provided by a collection of ground stations operating on that channel and the communications on that channel will occupy the channel for all the ground stations in a coverage area.

4.5.2 As with VHF voice communications, VDL communications cannot be limited to propagating only within States and frequency co-ordination between States will be required in the allocation of VDL frequencies. The nature of the protocol does, however, allow for frequency re-use by several ground stations within the same coverage area and hence the rules for the assignment of frequencies are not the same as for voice communications.

4.5.3 The carrier sense multiple access (CSMA) media access control protocol (MAC) layer used in VDL cannot exclude message collisions if some stations using a frequency channel cannot receive the transmissions of other stations, a situation known as a hidden transmitter situation. Hidden transmitters lead to simultaneous transmissions which can cause the intended receiver of one or both transmissions to be unable to decode the received signal.

4.5.4 A frequency will be assigned to providing en-route coverage and all the en-route stations will be set to operate on this frequency. In order to minimize the probability of simultaneous transmissions on the channel by hidden transmitters in a CSMA environment, this channel may not be used for terminal area or aerodrome surface communications except in areas of very low channel loading.

4.5.5 The VDL SARPs call for the provision of a common signalling channel (CSC) on which access to VDL service will be guaranteed in all areas where VDL Mode 2 service is available. This is especially important at airports and on the edge of VDL en-route coverage zones where aircraft are likely to establish initial VDL connectivity. Since the characteristics of Mode 1 and Mode 2 radio frequency transmissions are not compatible, the CSC cannot be used for Mode 1 communications. There is no requirement for a CSC for VDL Mode 1.

4.6 Ground station connection to intermediate systems

4.6.1 In order to provide access to the ground systems which are connected to the aeronautical telecommunications network, a VDL ground station needs to be connected to one or more ATN IS. The purpose of a VDL ground station is to interconnect aircraft with the ground-based ATN via which communications with terrestrial ATN ES can take place.

4.6.2 The ground-based ATN IS can be co-hosted in the VDL ground station computer in which case the VDL subnetwork virtual circuit will end in that computer. This architecture will have an impact on the exchanges required when an aircraft establishes a VDL link with a new ground station. The exact exchange will depend on whether the ground stations contain separate IS or elements of the same distributed intermediate system.

4.6.3 If the IS is not contained in the VDL ground station, it will be connected to the ground station by one of the following means:

a) wide area network (WAN);

b) local area network (LAN); and

c) dedicated communications line.

4.6.4 In all cases, in order to be in accordance with the *Manual of the Aeronautical Telecommunication Network (ATN)* (Doc 9578) for providing an open systems interconnection (OSI) compatible connection-oriented subnetwork service between the aircraft IS and the ground-based IS, the VDL ground station computer will be required to extend the VDL virtual circuit across the terrestrial network or link.

4.6.5 In order to provide simultaneous virtual circuits to several terrestrial ISs, the VDL ground station computer needs to contain a VDL subnetwork entity capable of converting addresses in VDL subnetwork call requests into addresses in the ground-based network.

5. VDL AIRBORNE OPERATING CONCEPT

5.1 Avionics

5.1.1 *VDL avionics.* In order to operate in a VDL network, aircraft need to be equipped with an avionics system providing the VDL subnetwork user (ISO 8208 DTE) function. The system providing this function will also provide the subnetwork user functions for the other air-ground ATN-compatible subnetworks and the aircraft ATN intermediate system function and, hence, its development is necessary in order to provide ATN communications to multiple end-systems or over multiple air-ground subnetworks.

5.2 VDL avionics certification

5.2.1 The VHF digital radio may also provide for double-side band amplitude modulation (DSB-AM) voice capability for emergency back-up to VHF radios used for voice communications. It would be necessary in this case to demonstrate that the VDL functionality of the VDR does not interfere with the DSB-AM voice functionality.

5.2.2 The VDL function in the VHF digital radio provides an air-ground data link service to the VDL subnetwork user entity of the aircraft ATN intermediate system. If the provision of a VHF subnetwork service to an ATN intermediate system were considered an essential service for a particular installation, the VDL functionality of the VDR would need to be certified as an essential function. The use of VDL for ATS communications is not, however, intended to require two aircraft radios to operate simultaneously in VDL mode.

5.3 Registration of aircraft with VDL network operators

5.3.1 For normal communications service, it is to be expected that aircraft operators will be required to register their aircraft with the network operators. In emergency or back-up situations, it must be possible for any VDL-equipped aircraft to establish connectivity over any VDL ground station network.

5.3.2 Registration of aircraft VDL stations with VDL network operators is desirable for network management since, for example, a network operator may identify a temporary fault in the VDL communications from an aircraft and would wish to contact the operator of the aircraft in order to have the fault resolved. Registration of aircraft is also useful in planning the required ground station network capacity. Registration with a VDL ground station network operator does not necessarily imply that the aircraft operator will be charged for use of the VDL ground station network.

FIGURE FOR ATTACHMENT B

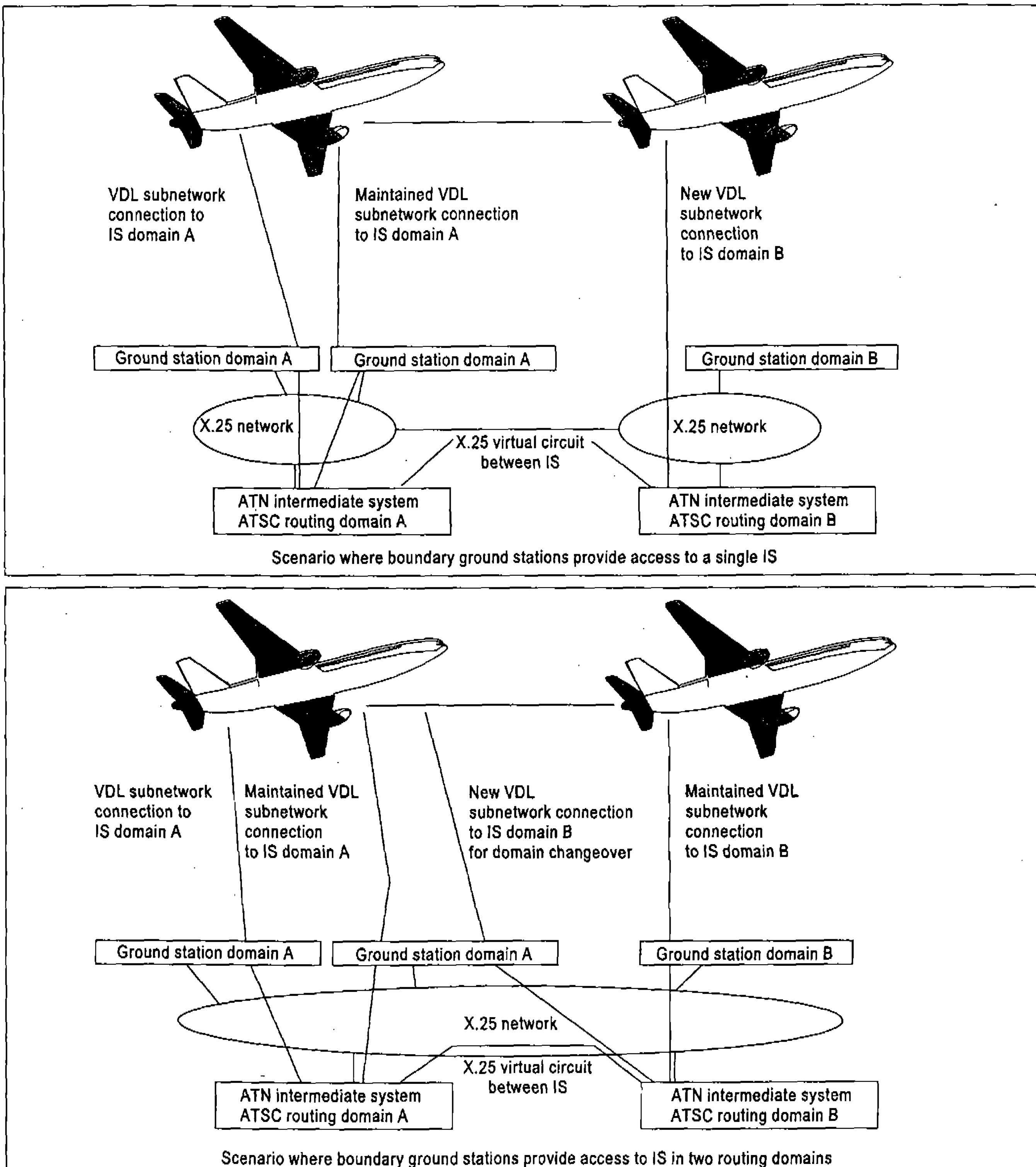

Figure B-1

ATTACHMENT A TO PART II. GUIDANCE MATERIAL FOR COMMUNICATION SYSTEMS

1. VHF COMMUNICATIONS

1.1 Audio characteristics of VHF communication equipment

1.1.1 The aeronautical radiotelephony services represent a special case of the application of radiotelephony, in that the requirement is for the transmission of messages in such a way that fidelity of wave form is of secondary importance, emphasis being upon fidelity of basic intelligence. This means that it is not necessary to transmit those parts of the wave form which are solely concerned with individuality, accent and emphasis.

1.1.2 The effective acceptance bandwidth for 8.33 kHz equipment is required to be at least plus and minus 3 462 Hz. This value considers the general case, i.e. air-to-ground transmissions and consists of 2 500 Hz audio bandwidth, 685 Hz for an aircraft transmitter instability of 5 ppm, 137 Hz for a ground receiver instability of 1 ppm and 140 Hz due to Doppler shift (2.2.2.4 and 2.3.2.6 of Part II refer).

1.2 Off-set carrier system

The following are examples of offset carrier systems which meet the requirements of Part II, 2.2.1.1.1.

a) *2-carrier system.* Carriers should be spaced at plus and minus 5 kHz. This requires a frequency stability of plus or minus 2 kHz (15.3 parts per million at 130 MHz).

b) *3-carrier system.* Carriers should be spaced at zero and plus and minus 7.3 kHz. This requires a frequency stability of plus or minus 0.65 kHz (5 parts per million at 130 MHz).

The following are examples or 4- and 5-carrier systems which meet the requirements of Part II, 2.2.1.1.1.

c) *4-carrier system.* Carriers should be spaced at plus and minus 2.5 kHz and plus and minus 7.5 kHz. This requires a frequency stability of plus or minus 0.5 kHz (3.8 parts per million at 130 MHz).

d) *5-carrier system.* Carriers should be spaced at zero, plus and minus 4 kHz and plus and minus 8 kHz. A frequency stability in the order of plus or minus 40 Hz (0.3 parts per million at 130 MHz) is an achievable and practicable interpretation of the requirement in this case.

Note 1.— The carrier frequency spacings referred to above are with respect to the assigned channel frequency.

Note 2.— In aircraft receivers which employ a measurement of the received carrier-to-noise ratio to operate the mute, the audio heterodynes caused by the reception of two or more off-set carriers can be interpreted as noise and cause the audio output to be muted even when an adequate wanted signal is present. In order that the airborne receiving system can conform with the sensitivity recommendations contained in Part II, 2.3.2.2, the design of the receivers may need to ensure that their sensitivity is maintained at a high level when receiving off-set carrier transmissions. The use of a carrier level override is an unsatisfactory solution to this requirement, but where it is employed, setting the override level as low as possible can ameliorate the problem.

1.3 Immunity performance of COM receiving systems in the presence of VHF FM broadcast interference

1.3.1 With reference to the Note of 2.3.3.2 of Part II, the immunity performance defined there must be measured against an agreed measure of derogation of the receiving system's normal performance, and in the presence of, and under standard conditions for the input wanted signal. This is necessary to ensure that the checking of receiving station equipment on bench test can be performed to a repeatable set of conditions, and results, and to facilitate their subsequent approval. An adequate measure of immunity performance may be obtained by the use of wanted signal of minus 87 dBm into the receiving equipment and the signal modulated with a 1 kHz tone at 30 per cent modulation depth. The signal-to-noise ratio should not fall below 6 dB when the interfering signals specified at Part II, 2.3.3.1 and 2.3.3.2 are applied. The broadcast signals should be selected from frequencies in the range between 87.5 and 107.9 MHz and should be modulated with a representative broadcast type signal.

Note 1.— The signal level of minus 87 dBm assumes a combined antenna and feeder gain of 0 dB.

Note 2.— The reduction in the signal-to-noise ratio quoted above is for the purpose of standardization when checking that receiving station equipment on bench measurements meet the required immunity. In the planning of frequencies and in the assessment of protection from FM broadcast interference, a value not less than this, and in many cases higher, depending on the operational circumstances in individual cases, should be chosen as the basis of the interference assessment.

2. SELCAL SYSTEM

2.1 This material is intended to provide information and guidance relating to the operation of the SELCAL system. It is associated with the Recommended Practices contained in Part II, Chapter 3.

1) *Function.* The purpose of the SELCAL system is to permit the selective calling of individual aircraft over radiotelephone channels linking the ground station with the aircraft, and is intended to operate on en-route frequencies with existing HF and VHF ground-to-air communications transmitters and receivers with a minimum of electrical and mechanical modification. The normal functioning of the ground-to-air communications link should be unaffected, except at such time as the selective calling function is being formed.

2) *Principles of operation.* Selective calling is accomplished by the coder of the ground transmitter sending a single group of coded tone pulses to the aircraft receiver and decoder. The airborne receiver and decoder equipment is capable of receiving and interpreting, by means of an indicator, the correct code and rejecting all other codes in the presence of random noise and interference. The ground portion of the coding device (ground selective calling unit) supplies coded information to the ground-to-air transmitter. The airborne selective calling unit is the special airborne equipment which operates with existing communications receivers on the aircraft to permit decoding of the ground-to-air signals for display on the signal indicator. The type of signal indicator can be chosen to suit operational requirements of the user and may consist of a lamp, a bell, a chime or any combination of such indicating devices.

— END —