

A decorative graphic on the left side of the slide shows a portion of a globe with a grid of latitude and longitude lines. A white airplane is depicted flying across the sky, leaving a white contrail that extends across the globe.

**Universal Access Transceiver
(UAT)
Technical Aspects & MOPS Status**

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NASA GRC CNS Technologies Workshop

May 2001

Outline

- **History**
- **UAT Description**
 - **System Overview**
 - **Some Details**
- **Spectrum and Standards**
- **Summary Attributes**
- **Additional Material - Backup Slides**

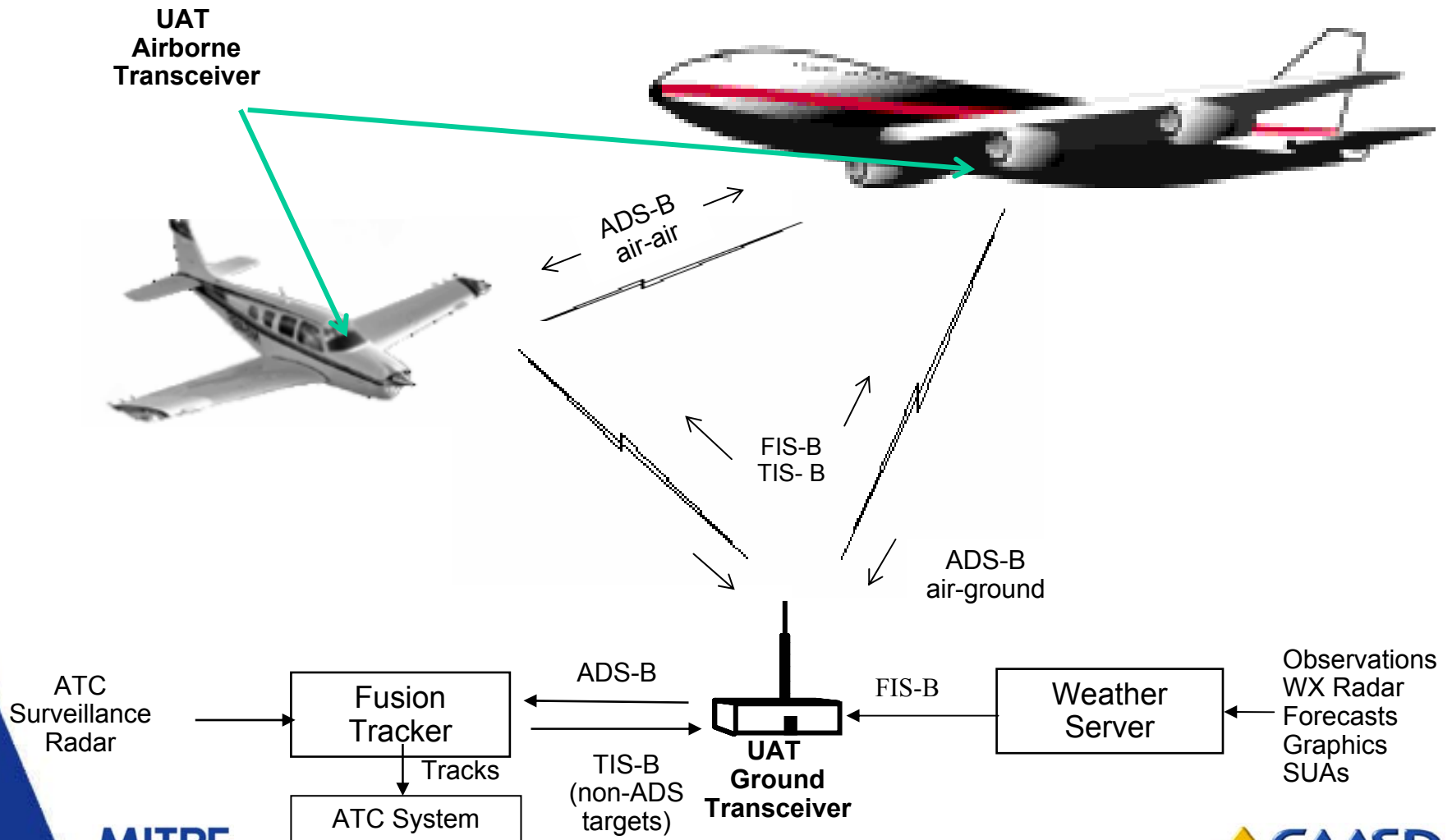
A Brief History of UAT

- **Began around 1995 as part of larger CAASD IR&D initiative on broadcast data link**
 - 6 prototype systems flown on small aircraft
 - Automatic Dependent Surveillance - Broadcast (ADS-B), Traffic Information Service - Broadcast (TIS-B), and Weather uplink demonstrated (graphics and basic text products, METAR)
- **Cargo Airlines incorporate UAT in their evaluation-- UPS-AT develops production UAT**
- **UAT becomes part of SF-21 Link Evaluation study**
- **UAT part of winning bid for FAA's Capstone program**
- **RTCA approves establishment of MOPS working group**

UAT Overview

- **Designed specifically for ADS-B with no constraints from legacy systems**
- **Simplicity and robustness were paramount design objectives**
- **Operates on a single common wideband channel**
- **1 Mbps channel rate**
- **Capable of supporting multiple broadcast applications to foster early equipage**

UAT Applications and Connectivity



Capstone Avionics



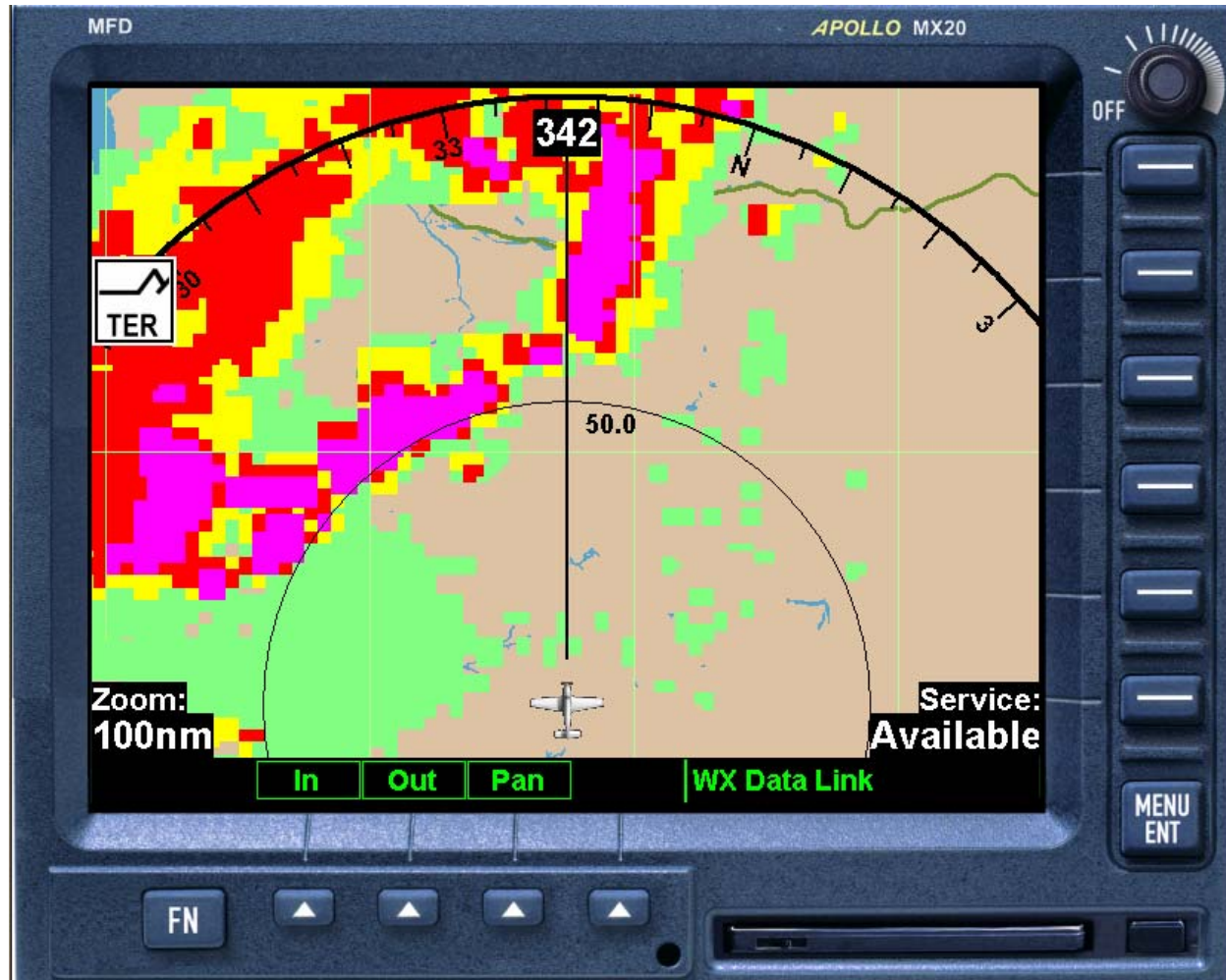
Avionics Install Kit



Capstone Text FIS Display



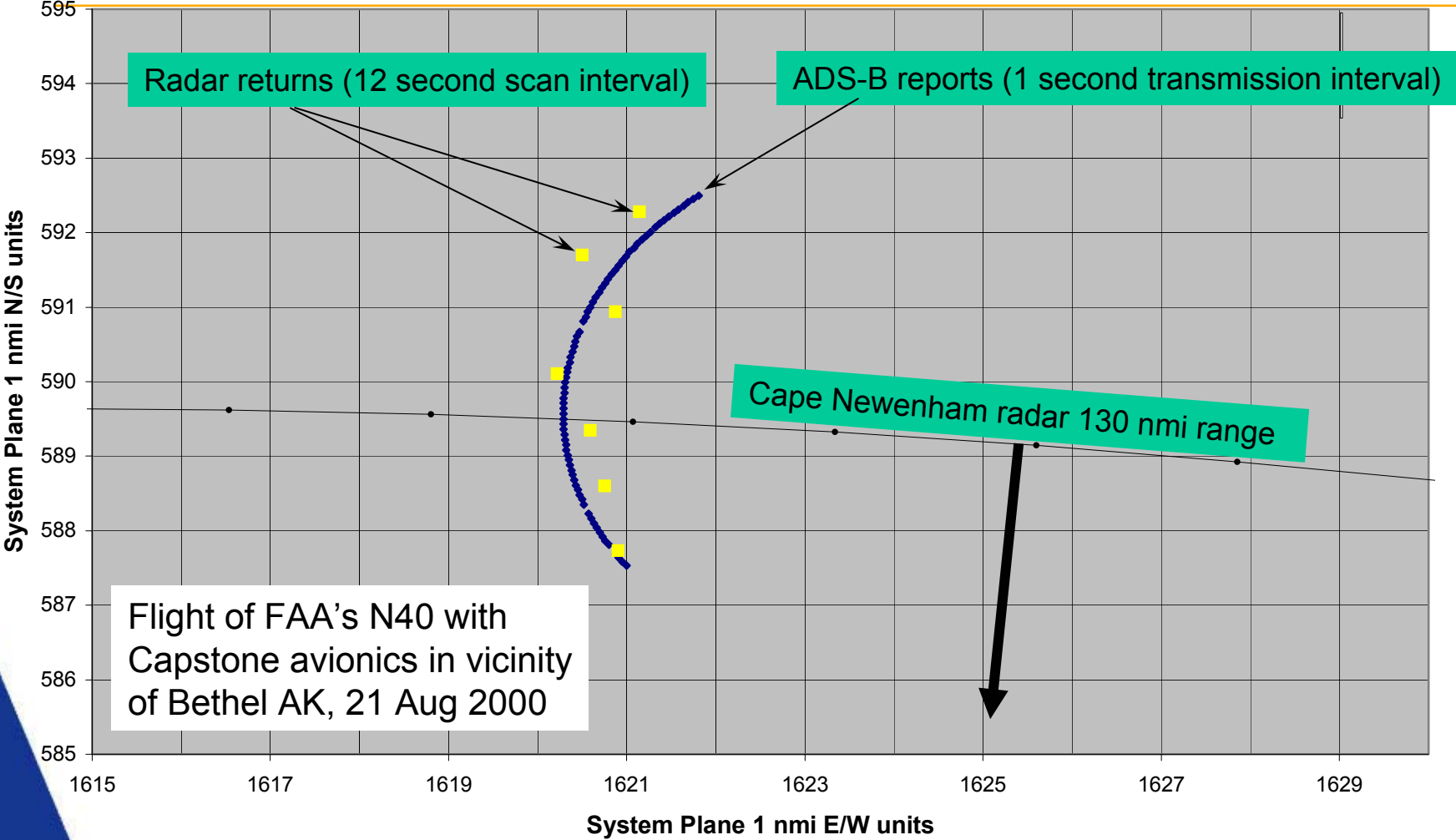
Capstone Graphic FIS Display (NEXRAD)



Capstone Traffic Display (ADS-B/TIS-B)



Cape Newenham Long Range Radar/ADS-B Comparison: Turning Track



Waveform Selection

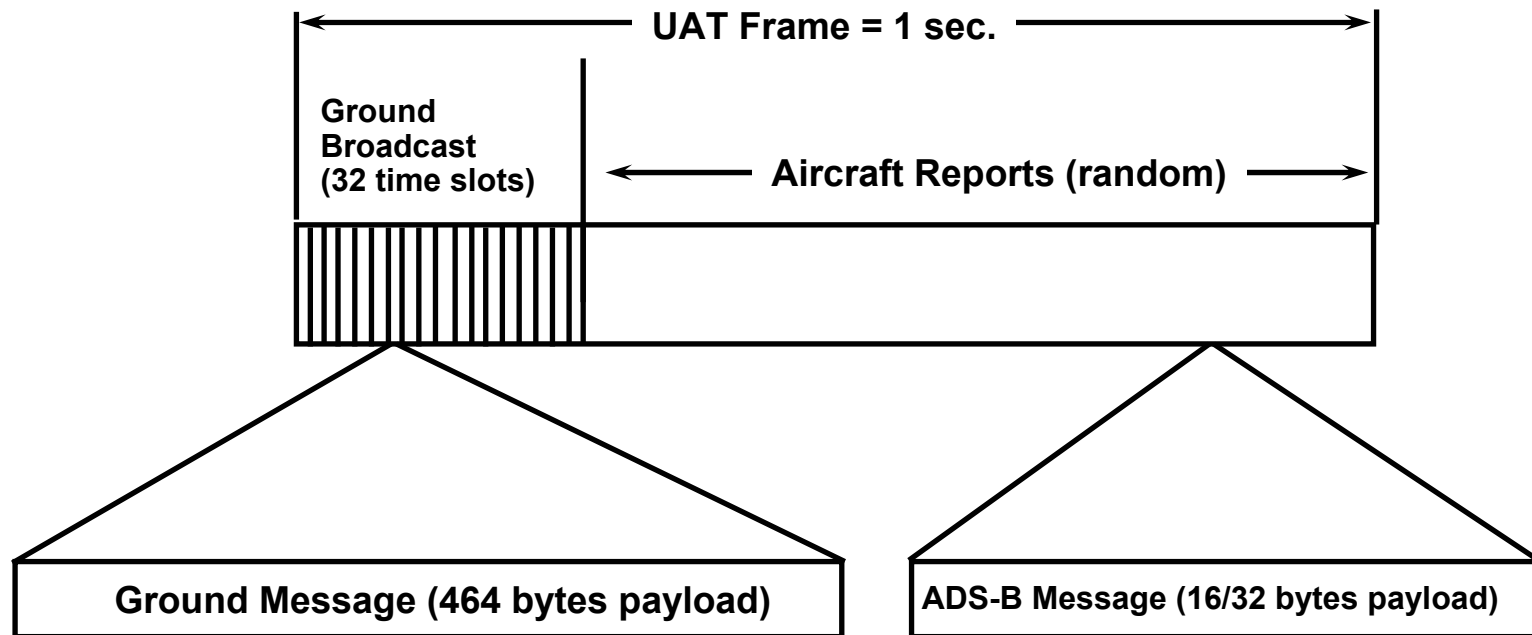
- **Requirements**
 - **Good capture effect**
 - **relatively efficient and low cost power amplifier**
 - **simple/robust decoder**
- **Binary FM with high modulation index chosen**

Frequency Band Selection

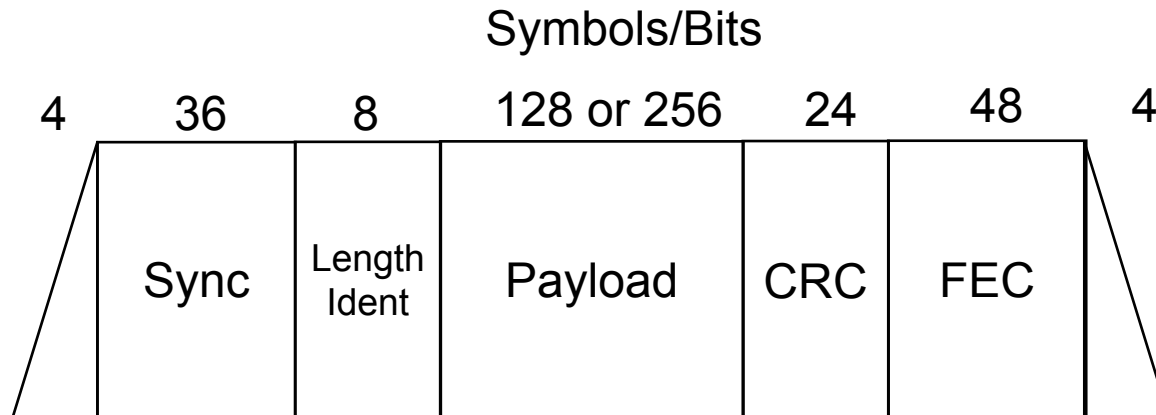
- **ADS-B requires ARNS allocation--3 alternatives:**
 - VHF: 108-118 MHz
 - L-band: 960-1215 MHz
 - C-band: 5000-5250 MHz
- **Extremely difficult to assemble enough contiguous channels at VHF**
- **Propagation loss too high at C band**
- **960-1215 MHz has channelization and current usage most compatible with UAT operation**

UAT Media Access Approach

- **Requirement: Simple and Robust logic for aircraft media access**
- **ADS-B transmissions occur based on pseudorandom selection of one of 3200 Message Start Opportunities (MSO)**



ADS-B Message Format



- **Each aircraft transmits exactly one message each second**
- **Standard Forward Error Correction (FEC) increases message robustness to noise and interference**
- **FEC plus Error Checking (CRC) combine for an extremely low undetected message error rate $<10^{-10}$**

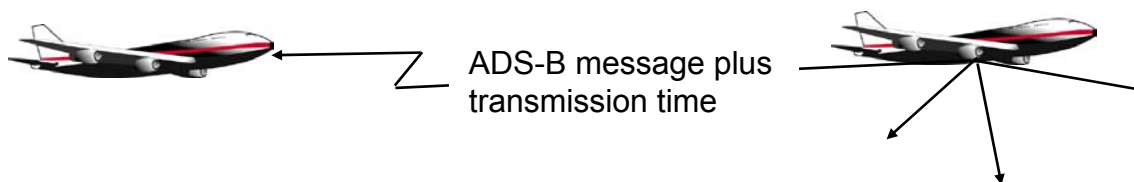
ADS-B Message Set and Transmission Schedule for Full Capability Participant

- **State Vector + Call Sign and Status**
- **State Vector + 2 Trajectory Change Points (TCPs)**
- **State Vector + 2 TCPs**
- **State Vector + [*future payload*]**

- **One transmitted message every second--4 second message rotation**

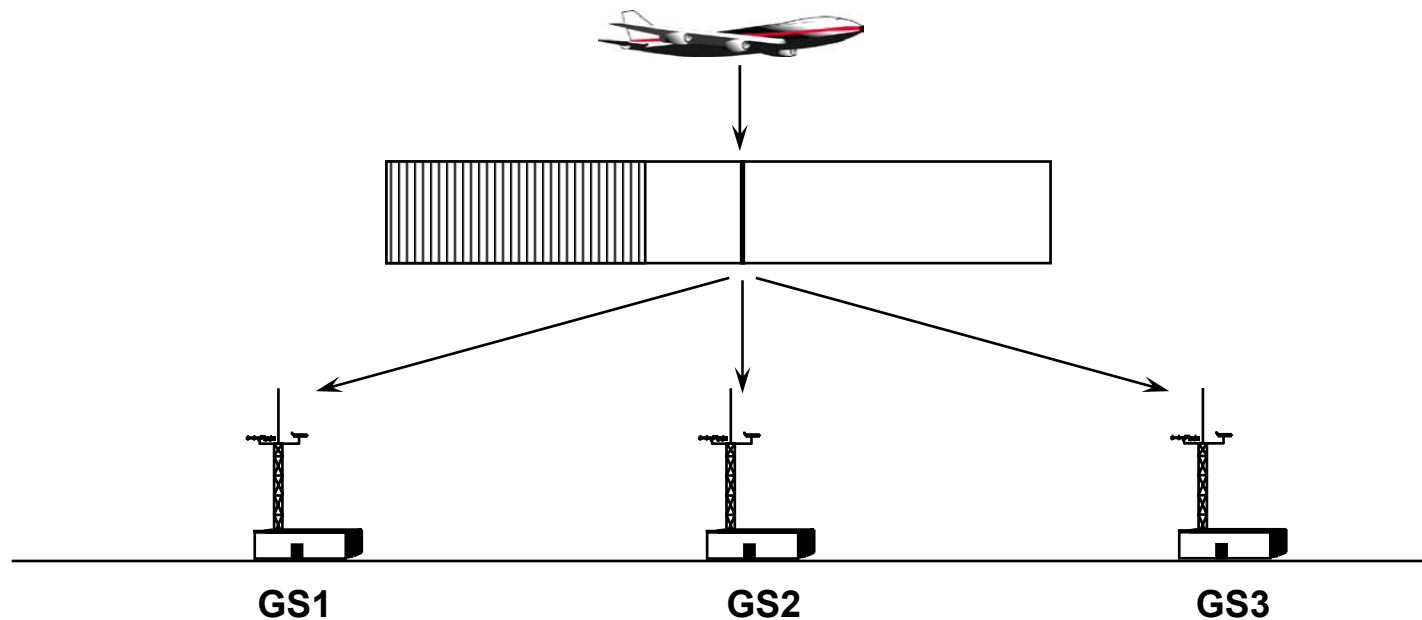
Independent ADS-B Report Validation: Aircraft Perspective

- **ADS-B message payload includes the precise transmission time (MSO)**
- **Receiving aircraft UAT reports precise time of reception with decoded message payload**
- **Application can perform passive range verification of ADS-B reported position**
- **Preliminary UPSAT flight test data showed time-based slant range estimates to be within 0.2 nmi of that indicated by ADS-B**



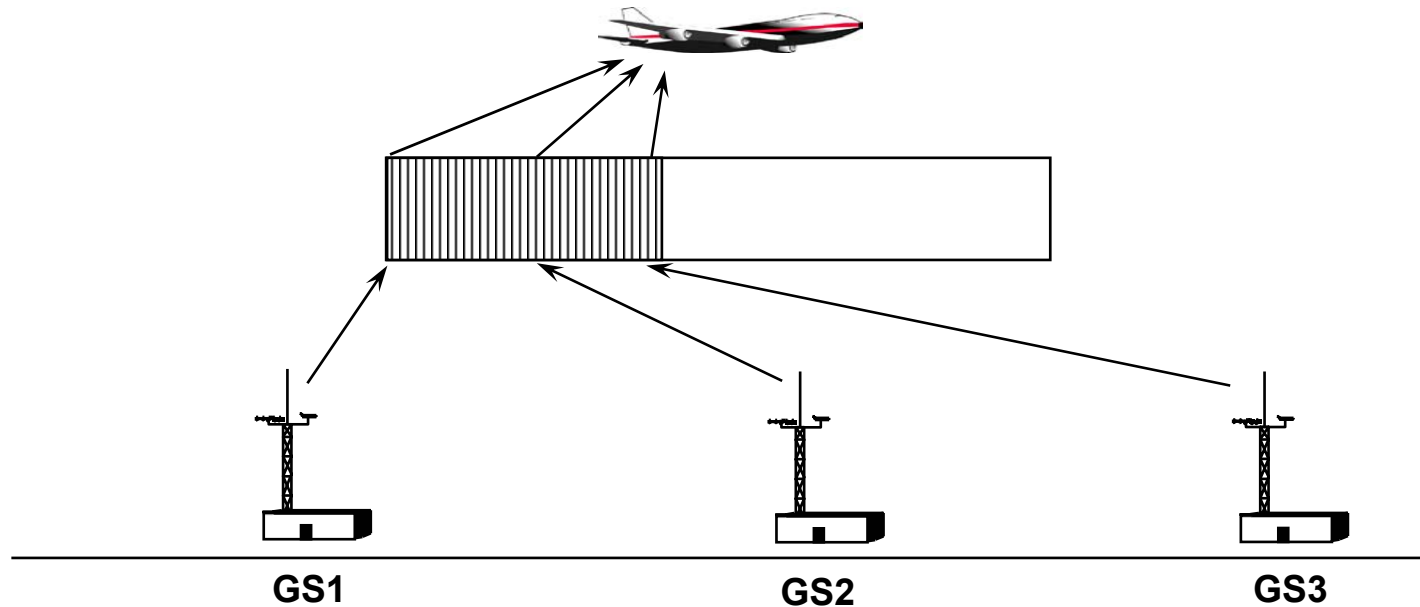
Independent ADS-B Report Validation: Ground ATC Perspective

- Single ground site can perform same range validation as aircraft
- Multiple networked sites allows position estimate based on differential burst arrival times at ground stations



Independent Position Estimate from Ground Messages

- Time slot and ground station location provided in each uplink message header
- Allows aircraft to derive independent position estimate
- Absolute time not required on aircraft
- Absolute time required at ground stations



Spectrum and Standards

- **All experimental assignments to date have been at 966 MHz**
- **All Capstone aircraft are now shifted to 981 MHz “operational” assignment to support “Radar-like services”**
- **RTCA Minimum Operational Performance Standards (MOPS) development underway**
- **ICAO Standards and Recommended Practices (SARPs) development being requested by FAA**

UAT MOPS Status

- **June 2000, FAA requests “RTCA begin immediate work on the development of a UAT Performance Standard”**
- **September 2000, RTCA directs SC-186 to develop UAT MOPS**
 - **WG-5 Established**
- **February 2002 target date for MOPS submission to RTCA for publication**
 - **See notes page for Objectives of WG5**

UAT MOPS Status (concluded)

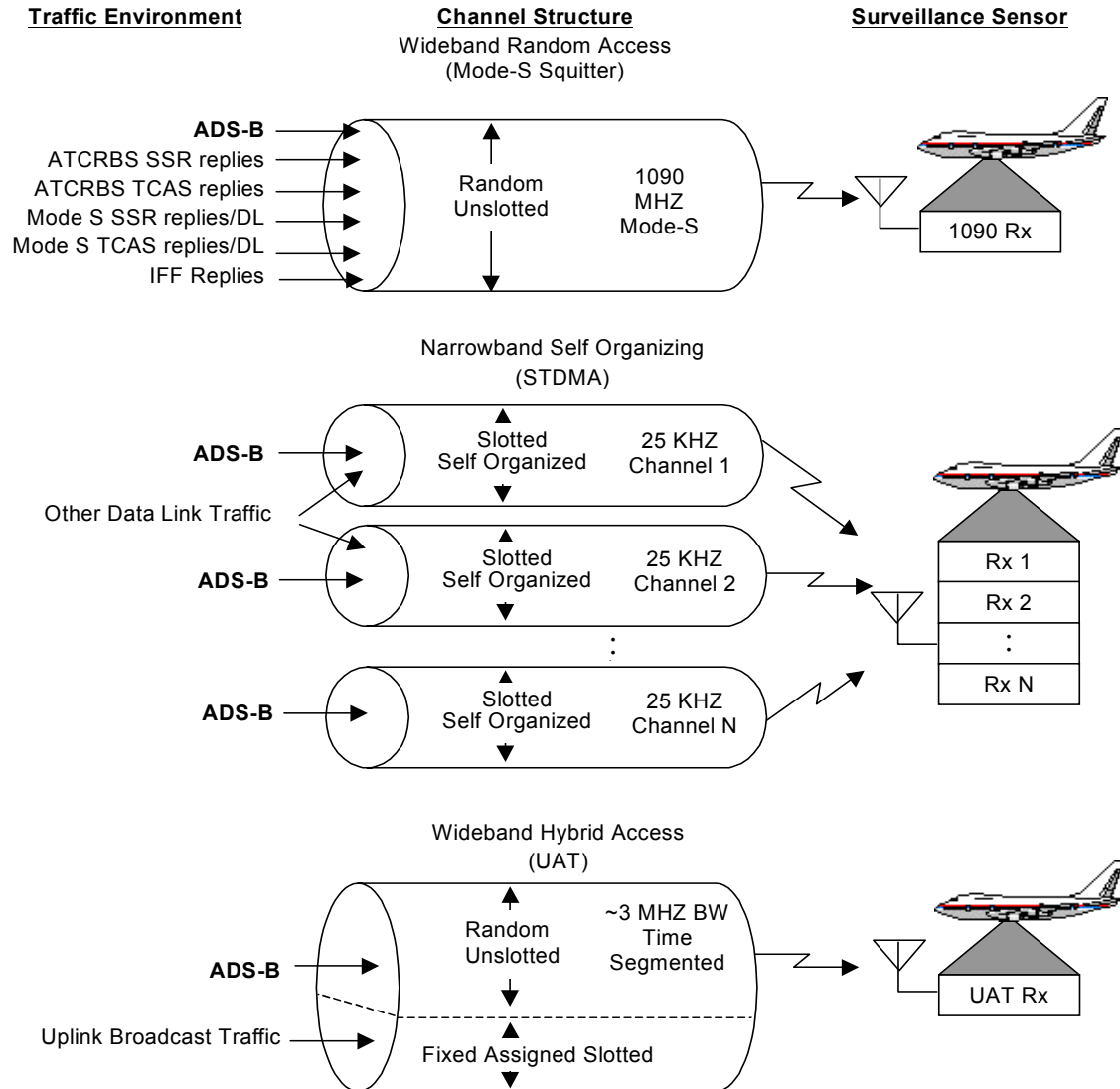
- **Current Activities and Accomplishments**
 - **Selection of a globally viable UAT frequency assignment**
 - **Compatibility with DME and Link 16**
 - **Initial drafts of most sections of the MOPS have been developed for review within WG5**
 - **“<http://adsb.tc.faa.gov>”**

Summary

- **Intended for a dedicated channel--so capacity and performance limited mainly by system self interference**
- **Every ADS-B message has a complete State Vector**
 - **no tracking or message assembly required**
 - **no lat/lon decompression or ambiguity resolution required**
 - **no need to burden application with detection of transmission errors**
- **Full resolution position reporting**
- **Consistent operation in all flight domains**
- **No channel sensing required for tx--minimal tx-only implementations are viable**
- **No tuning procedures required to access full suite of broadcast services**
- **Simple, proven frequency modulation technique**

Backup Material

Overview of ADS-B Link Technologies



Application Performance Results - 1

Low Density Scenario

(ref. -"Findings of the ADS-B Technical Link Assessment Team (TLAT)", April 2001)

	1090 Extended Squitter	UAT	VDL Mode 4
SF21 Performance Criteria			
Aid to visual Acquisition (SV Update Rates to 10 nm)	Supported (by analysis)	Supported (by analysis)	Not supported (by analysis)
Conflict and Collision Avoidance (SV Update Rates to 20 nm)	Supported (by analysis)	Supported	Not supported (all a/c in scenario are en route and above 10000ft)
Separation Assurance and Sequencing (SV and 1 TCP Update Rates to 40 nm)	Likely to be supported (by analysis)	Supported	SV updates supported in 20 to 40 nm and TMAs; TCP change is likely to be met (by analysis); Acquisition was not evaluated;
Flight path de-confliction planning (SV and 2 TCP Update Rates to 90 nm)	Likely to be supported (by analysis)	Supported	SV updates supported TCP change is likely to be met (by analysis); Acquisition was not evaluated;
Airport Surface	Not applicable	Not applicable	Not applicable
Simultaneous approaches (SV Update Rates based upon physical runway separation)	Not applicable	Not applicable	Not applicable

Application Performance Results - 2

Low Density Scenario - continued

(ref. -"Findings of the ADS-B Technical Link Assessment Team (TLAT)", April 2001)

	1090 Extended Squitter	UAT	VDL Mode 4
Additional Eurocontrol Criteria			
ATS Surveillance a/g			
TMA (SV and 4 TCP Update Rates to 60 nm)	Not applicable	Not applicable	Not applicable
En-Route (SV and 4 TCP Update Rates to 150 nm)	Not addressed	Not addressed	Not addressed
ATS Enhanced Surveillance a/g	Not applicable	Not applicable	Not applicable
TMA (SV and 4 TCP Update Rates to 60 nm)			
En-Route (SV and 4 TCP Update Rates to 150 nm)			
A-SMGCS	Not applicable	Not applicable	Not applicable
Taxi (0-5 nm)			
Approach (5-10 nm)			
Autonomous air to air operations – long range (SV and 4 TCP to 150 nm)	Unlikely to be met to 150 nm; may be possible to <120 (by analysis)	Supported	SV updates supported TCP change is likely to be met (by analysis); Acquisition was not addressed

Application Performance Results - 3

Core Europe 2015

(ref. -"Findings of the ADS-B Technical Link Assessment Team (TLAT)", April 2001)

	1090 Extended Squitter	UAT	VDL Mode 4
SF21 Performance Criteria			
Aid to Visual Acquisition (SV Update Rates to 10 nm)	Supported (by analysis)	Supported (by analysis)	Not supported except in Approach and Climb-out areas (by analysis)
Conflict and Collision Avoidance (SV Update Rates to 20 nm)	Supported	Supported	For ranges above 3nm, supported within RSC and supported outside RSC when below 10000ft
Separation Assurance and Sequencing (SV and 1 TCP Update Rates to 40 nm)	Inconclusive	Supported	SV Updates are supported; Proposed TCP scheme not evaluated
Flight path deconfliction planning (SV and 2 TCP Update Rates to 90 nm)	Not supported	Requirement is met only up to 70 nm	Inconclusive
Airport Surface	Not addressed	Not addressed	Not addressed
Simultaneous approaches (SV Update Rates based upon physical runway separation)	Supported (by analysis)	Supported (by analysis)	3sec SV update req. met (by analysis)

Application Performance Results - 4

Core Europe 2015 - continued

(ref. -"Findings of the ADS-B Technical Link Assessment Team (TLAT)" April 2001)

	1090 Extended Squitter	UAT	VDL Mode 4
Additional Eurocontrol Criteria			
ATS Surveillance a/g			
TMA (SV and 4 TCP Update Rates to 60 nm)	Met with a 6-sector antenna	Likely to be met (by analysis)	Not supported with one Ground Station
En-Route (SV and 4 TCP Update Rates to 150 nm)	Met up to 100 nm with 6-sector antenna	Not addressed	SV Update Requirement met up to 70 nm with one omnidirectional antenna inside the RSC. TCP update method provided in Appendix E but not evaluated
ATS Enhanced Surveillance a/g	Not addressed for the transmission of CAP information	All parameters were addressed	Not addressed for the transmission of CAP and TCP information
TMA (SV and 4 TCP Update Rates to 60 nm)	Met with a 6-sector antenna	Likely to be met (by analysis)	Not supported with one Ground Station
En-Route (SV and 4 TCP Update Rates to 150 nm)	Met up to 100 nm	Not addressed	SV Update Requirement met up to 70 nm with one omnidirectional antenna inside the RSC
A-SMGCS			
Taxi (0-5 nm)	Not addressed	Not addressed	Not addressed
Approach (5-10 nm)	Not addressed	Not addressed	Not addressed
Autonomous air to air operations – long range (SV and 4 TCP to 150 nm)	Not supported	Not supported	Not supported

Application Performance Results - 5

Los Angeles Basin 2020

(ref. -"Findings of the ADS-B Technical Link Assessment Team (TLAT)", April 2001)

	1090 Extended Squitter	UAT	VDL Mode 4
SF21 Performance Criteria			
Aid to visual Acquisition (SV Update Rates to 10 nm)	Supported (by analysis)	Supported (by analysis)	Not supported except in Approach and Climbout areas (by analysis)
Conflict and Collision Avoidance (SV Update Rates to 20 nm)	Supported	Supported	Supported beyond 3 nm
Separation Assurance and Sequencing (SV and 1 TCP Update Rates to 40 nm)	Unlikely to be met	Supported	SV Updates are supported; Proposed TCP scheme not evaluated
Flight path de-confliction planning (SV and two TCP Update Rates to 90 nm)	Not supported	Supported	Inconclusive
Airport Surface	Not addressed	Not addressed	Not addressed
Simultaneous approaches (SV Update Rates based upon physical runway separation)	Supported (by analysis)	Supported (by analysis)	3 sec SV update requirement met (by analysis)

Application Performance Results - 6

Los Angeles Basin 2020 - continued

(ref. -"Findings of the ADS-B Technical Link Assessment Team (TLAT)", April 2001)

	1090 Extended Squitter	UAT	VDL Mode 4
Additional Eurocontrol Criteria			
ATS Surveillance a/g			
TMA (SV and 4 TCP Update Rates to 60 nm)	Not addressed	Likely to be met (by analysis)	Not supported with one Ground Station (by analysis)
En-Route (SV and 4 TCP Update Rates to 150 nm)	Not addressed	Not addressed	At least as good as Core Europe 2015 because of the higher transmission rates used (by analysis)
ATS Enhanced Surveillance a/g			
TMA (SV and 4 TCP Update Rates to 60 nm)	Not addressed	Likely to be met (by analysis)	Not supported with one Ground Station (by analysis)
En-Route (SV and 4 TCP Update Rates to 150 nm)	Not addressed	Not addressed	At least as good as Core Europe 2015 because of the higher transmission rates used (by analysis)
A-SMGCS			
Taxi (0-5 nm)	Not Addressed	Not addressed	Not Addressed
Approach (5-10 nm)	Not Addressed	Not addressed	Not Addressed
Autonomous air to air operations – long range (SV and 4 TCP Update Rates to 150 nm)	Not supported	Not supported	Not supported