TACAN - Tactical Air Navigation

What does it do?

TACAN is a radio navigational aid. It provides the following pieces of information:

1. Bearing
2. Course Deviation
3. To/From
4. Distance
5. Beacon Identification Tone
6. Reliability

Bearing - Simple enough. The system provides magnetic bearing to the station you are tuned to. This is the primary function of the system.

Course Deviation - This supplements the bearing by giving you a fly-to command which aids you in flying towards the selected station.

To/From - Again, going the right direction is pretty important so this makes sure you know whether you are flying away or towards your station.

Distance - This is yet another critical piece of information, giving you slant range to the station up to 390 nautical miles (200 nmi max for A/A [air-to-air]).

Beacon Identifier Tone (BIT) - This audio information consists of a morse code trail for identification of the station you are tuned to.

Reliability - The warning flag information lets you know if the system is reliable.

How does it do it?

Like any radio, the transmitter generates a carrier and modulates information on to it. You may remember from tech school that there are four types of modulation: amplitude, frequency, phase and pulse. In the case of TACAN, the information is pulse modulated onto the carrier.

A TACAN station with no aircraft initially modulates squitter onto the carrier, which is basically random noise generated so that the waveform is the proper length. So basically, you end up with a signal which is simply noise:

Now let's say that an aircraft flies into range which is transmitting distance interrogations (because it's in T/R). The station will pick these interrogations up and generate an appropriate response by pulse modulating DME (distance measurement equipment) data into the waveform. If there are more aircraft around, DME will take up more bandwidth per wave, as each aircraft gets its own little band of pulse modulated DME response, which it uses to calculate the range to the station. To keep aircraft from getting mixed up, each uses a random PRF (Pulse Recurring Frequency) when initially interrogating for DME. Also, remember that the station has a delay which is factored into the distance solution. This delay causes a small cone of silence around the station (about 0.1 nm).

In addition, every 30 seconds, the station modulates station identification in the form of BIT data onto the carrier:

That takes care of DME, BIT and squitter which, again, is basically filler so that the waveform is the proper length.

Now for the most important part: bearing. First, we'll take a look at how course bearing information is generated. To fully understand how bearing information is generated, you need to understand the principles of the ground station TACAN antenna:
First, the antenna has a stationary element which transmits the pulse modulated waveform with no amplitude variations. That same stationary center element is surrounded by a rotating element with a reflector.

The reflector directs RF energy away from itself, resulting in a radiation pattern that looks like this:

So now, we rotate the secondary element and as the reflector moves, the outward lobe of the cardioid-like radiation pattern moves around. In effect, this creates a physically amplitude modulated signal, which each aircraft sees differently. Then, we have the reference signal pulse modulated into the composite waveform along with DME, BIT and squitter. Because of the rotating radiation pattern, the waveform is variable for aircraft at different radials, but all aircraft receive the reference signal at the same time. The pulse modulated main reference burst happens to be transmitted when the reflector is due west. Below is a snapshot of what each aircraft receives when the main reference burst is transmitted:

So basically, the aircraft determines its bearing from the station by looking at the waveform of the signal and where the main reference burst is pulse encoded. To provide more accurate bearing information, TACAN uses the same principle again to calculate fine bearing. Yet another rotating element with 9 reflectors produces even more amplitude variations. Again, there is a reference point for the variable amplitude variations. This comes in the form of 9 auxiliary reference bursts:

And, of course, you still have your main reference burst:

DME responses:
And BIT, at 30 second intervals:

What we end up with is a composite signal comprised of 5 pulse modulated components and 2 physically amplitude modulated components (listed below in order of priority):

1. MRB - Main Reference Burst
2. ARB - Auxiliary Reference Bursts
3. BIT - 1350Hz Beacon Identification Tone
4. DME - Distance Measurement Equipment
5. 2700Hz Squitter/Filler

1. 15Hz Variable Course Bearing Signal
2. 135Hz Variable Fine Bearing Signal

**ARN-118 Basics**

First of all, you need to familiarize yourself with the Horizontal Situational Indicator (HSI), since it’s used to display the information cited at the very beginning of this tutorial:

- **Bearing** - Magnetic bearing to your station is indicated by the BEARING POINTER.
- **Course Deviation** - A fly-to command is given by the COURSE DEVIATION INDICATOR or CDI.
- **To/From** - The TO/FROM INDICATOR tells you if you're flying towards or away from the station.
- **Distance** - The RANGE INDICATOR displays slant range.
- **Reliability** - The RANGE WARNING FLAG and DEVIATION WARNING FLAG let you know if TACAN is providing reliable information.

Now, let’s skim over some other LRUs of the ARN-118:
RT-1159 - The receiver/transmitter demodulates TACAN transmissions and also transmits distance interrogations. The R/T gives 3 major outputs: relative bearing, range and beacon audio.

MX-9577 Adaptor - The MX adaptor performs several functions with data provided by the R/T. First, it takes the relative bearing and using an external compass input from a system such as C-12, it calculates magnetic bearing. If you are flying south and the station is in front of you, its relative bearing is 0º. However, the magnetic bearing of the station is 180º. You need magnetic bearing since this the HSI shows information with respect to magnetic north (thus the compass card). Using this magnetic bearing along with the aircraft magnetic heading, the adaptor also creates course deviation and to/from information. Finally, the adaptor processes signals to generate reliability information for the HSI warning flags.

C-10057 - The TACAN control lets you select one of 126X and 126Y channels (252 channels total). There is a test function and associated light. And the control allows you to select the mode of operation. In receive, you will get only bearing and BIT, since you will be unable to transmit DME interrogations. In T/R, you will get range to the ground station as well. In the table below, you can see that aircraft TACAN systems cannot receive aircraft TACAN transmissions in REC or T/R, so one must use the A/A modes (air-to-air). Notice that both aircraft must be spaced 63 channels apart.

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Basic Troubleshooting

Remember that the ground station has those rotating antenna elements, which are for the amplitude variations that help provide course and fine bearing. This means that aircraft are not able to provide bearing to themselves unless they have such an antenna, in which case they would be identified as SECA or ‘Suitably Equipped, Cooperating Aircraft’. This is generally limited to tankers (so that one can find them).
The ARN-118 is a relatively reliable system, however the Control, R/T and Adaptor do fail periodically.

**Control** - This system’s control has a fairly high rate of failure when compared to other systems (other than interphone). And it’s not the whole control that’s going bad either; it’s usually the test button, as it’s not uncommon for it to get stuck or malfunction. If you’re called out on a red streak and they have a solid light on the control, simply turn off the system and turn it back on. If the light illuminates and the system tests immediately without you touching the test button, you probably have a faulty control.

**R/T** - It seems to me that the system often displays multiple symptoms when the R/T is failing, due to poor signal handling, resulting in a bearing pointer that hunts, a range warning flag and a deviation warning flag. If the test light remains illuminated after testing, this generally indicates an R/T problem as well.

This system doesn’t seem to have as problematic cabling problems as most other radio systems, but never discard the possibility that cabling and antennas could be your problem. If you've swapped LRUs and you have a problem indicative of signal loss, you should bring out a TDR before you start chasing down wires.

**MX adaptor** - Given that this LRU is responsible for the generation of your CDI and to/from signals, the adaptor is often responsible for any problems with these indications.

Hopefully, it should be obvious that if improper indications are present on only one indicator, there is some sort of problem associated with the indicator and not the TACAN system (other than a possible loading down of the system). It's also important to remember that the system gets inputs from C-12 as well, which could very well affect bearing indications.

- Take the TACAN test
- On to VHF Nav
- Back to the Menu page