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 sytem.

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?

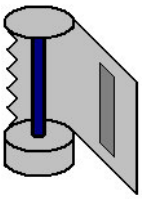
Like any radio, the transmitter generates a carrier and modulates information on to it. You may remember from tech school that there are **four** types of modulation: amplitude, frequency, phase and pulse. In the case of TACAN, the information is **pulse modulated** onto the carrier.

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).

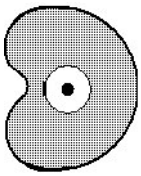
In addition, every 30 seconds, the station modulates station identification in the form of BIT data onto the carrier:

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:

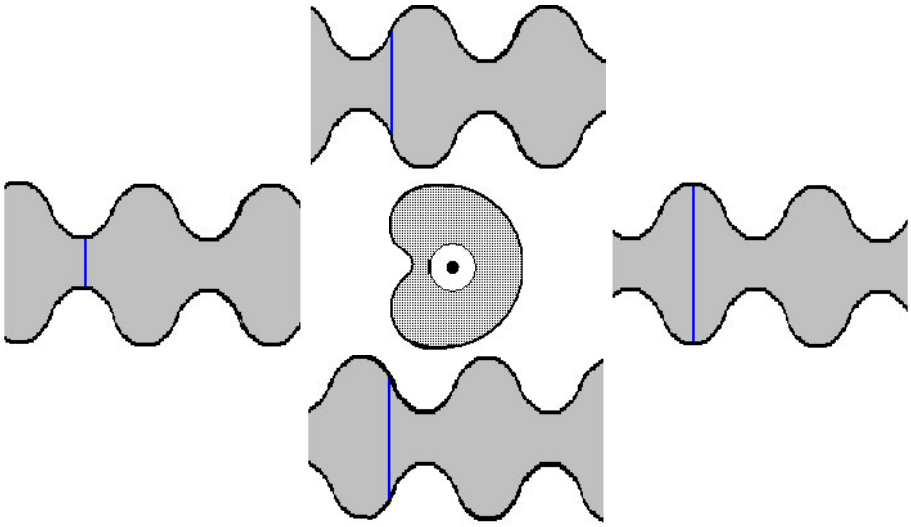


First, the antenna has a stationary element which transmits the pulse modulated waveform with no amplitude variations. That same stationary center element is surrounded by a rotating element with a reflector.

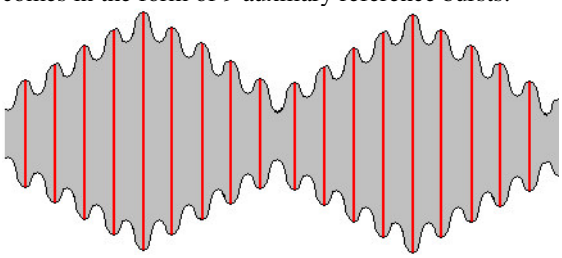
The reflector directs RF energy away from itself, resulting in a radiation pattern that looks like this:



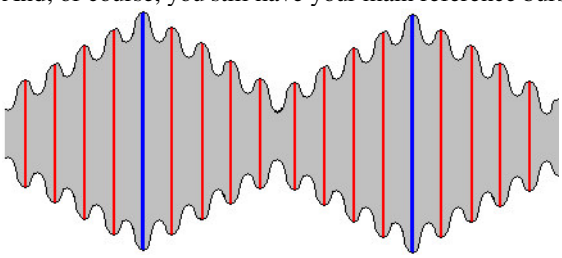
So now, we rotate the secondary element and as the reflector moves, the outward lobe of the cardioid-like radiation pattern moves around. In effect, this creates a physically **amplitude modulated** signal, which each aircraft sees differently. Then, we have the reference signal **pulse modulated** into 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 recieves when the main reference burst is transmitted:



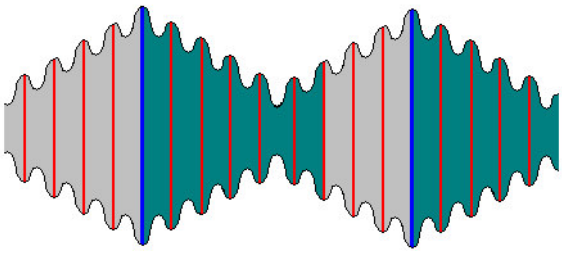
So basically, the aircraft determines its bearing from the station by looking at the waveform of the signal and where the main reference burst is pulse encoded. To provide more accurate bearing information, TACAN uses the same principle again to calculate fine bearing. Yet another rotating element with **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** auxillary reference bursts:



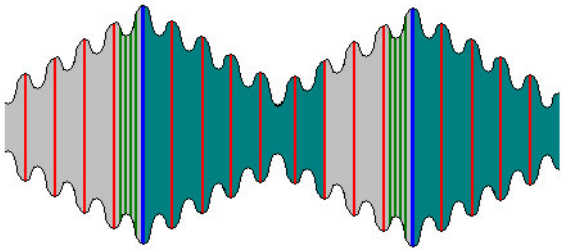
And, of course, you still have your main reference burst:



DME responses:



And BIT, at 30 second intervals:



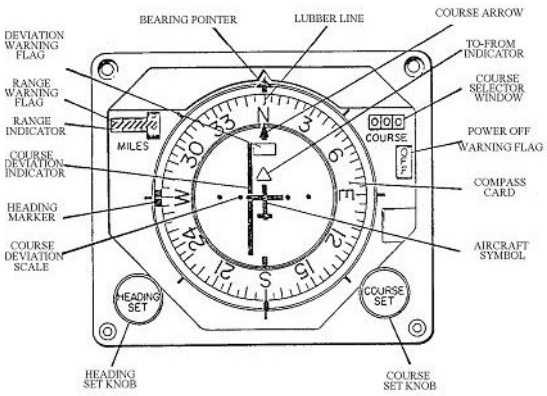
What we end up with is a composite signal comprised of 5 pulse modulated components and 2 physically amplitude modulated components (listed below in order of priority):

1. MRB - Main Reference Burst
2. ARB - Auxillary 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 familarize 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.

ARN-118 Control

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).

Channel	Transmit	REC	A/A REC	Channel	Transmit	REC	A/A REC	Channel	Transmit	REC	A/A REC	Channel	Transmit	REC	A/A REC
1X	1025	962	1088	33X	1057	994	1120	64X	1088	1151	1025	96X	1120	1183	1057
2X	1026	963	1089	34X	1058	995	1121	65X	1089	1152	1026	97X	1025	1184	1058
3X	1027	964	1090	35X	1059	996	1122	66X	1090	1153	1027	98X	1025	1185	1059
4X	1028	965	1091	36X	1060	997	1123	67X	1091	1154	1028	99X	1025	1186	1060
5X	1029	966	1092	37X	1061	998	1124	68X	1092	1155	1029	100X	1025	1187	1061
6X	1030	967	1093	38X	1062	999	1125	69X	1093	1156	1030	101X	1025	1188	1062
7X	1031	968	1094	39X	1063	1000	1126	70X	1094	1157	1031	102X	1025	1189	1063
8X	1032	969	1095	40X	1064	1001	1127	71X	1095	1158	1032	103X	1025	1190	1064
9X	1033	970	1096	41X	1065	1002	1128	72X	1096	1159	1033	104X	1025	1191	1065
10X	1034	971	1097	42X	1066	1003	1129	73X	1097	1160	1034	105X	1025	1192	1066
11X	1035	972	1098	43X	1067	1004	1130	74X	1098	1161	1035	106X	1025	1193	1067
12X	1036	973	1099	44X	1068	1005	1131	75X	1099	1162	1036	107X	1025	1194	1068
13X	1037	974	1100	45X	1069	1006	1132	76X	1100	1163	1037	108X	1025	1195	1069
14X	1038	975	1101	46X	1070	1007	1133	77X	1101	1164	1038	109X	1025	1196	1070
15X	1039	976	1102	47X	1071	1008	1134	78X	1102	1165	1039	110X	1025	1197	1071
16X	1040	977	1103	48X	1072	1009	1135	79X	1103	1166	1040	111X	1025	1198	1072
17X	1041	978	1104	49X	1073	1010	1136	80X	1104	1167	1041	112X	1025	1199	1073
18X	1042	979	1105	50X	1074	1011	1137	81X	1105	1168	1042	113X	1025	1200	1074
19X	1043	980	1106	51X	1075	1012	1138	82X	1106	1169	1043	114X	1025	1201	1075
20X	1044	981	1107	52X	1076	1013	1139	83X	1107	1170	1044	115X	1025	1202	1076
21X	1045	982	1108	53X	1077	1014	1140	84X	1108	1171	1045	116X	1025	1203	1077
22X	1046	983	1109	54X	1078	1015	1141	85X	1109	1172	1046	117X	1025	1204	1078
23X	1047	984	1110	55X	1079	1016	1142	86X	1110	1173	1047	118X	1025	1205	1079
24X	1048	985	1111	56X	1080	1017	1143	87X	1111	1174	1048	119X	1025	1206	1080
25X	1049	986	1112	57X	1081	1018	1144	88X	1112	1175	1049	120X	1025	1207	1081
26X	1050	987	1113	58X	1082	1019	1145	89X	1113	1176	1050	121X	1025	1208	1082
27X	1051	988	1114	59X	1083	1020	1146	90X	1114	1177	1051	122X	1025	1209	1083
28X	1052	989	1115	60X	1084	1021	1147	91X	1115	1178	1052	123X	1025	1210	1084
29X	1053	990	1116	61X	1085	1022	1148	92X	1116	1179	1053	124X	1025	1211	1085
30X	1054	991	1117	62X	1086	1023	1149	93X	1117	1180	1054	125X	1025	1212	1086
31X	1055	992	1118	63X	1087	1024	1150	94X	1118	1181	1055	126X	1150	1213	1087
32X	1056	993	1119					95X	1119	1182	1056				

Basic Troubleshooting

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
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