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TCAS COMPATIBILITY TEST PLAN

by

George Hartranft

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U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
TECHNICAL CENTER
Atlantic City Airport, N.J. 08405

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PURPOSE.

The purpose of this test plan is to identify the data and methods of data collections, to determine the frequency guardbands needed to insure mutual compatibility of TCAS and TACAN/DME.

BACKGROUND.

The present ATCRBS is authorized to operate at 1030 and 1090 MHz. The TACAN/DME channels that can operate at the 1030 and 1090 MHz frequency are reserved for military use only. Guardband protection of the ATCRBS from the TACAN/DME is provided by rarely having the frequencies within $\pm$ 3 MHz of 1030 and 1090 MHz assigned for TACAN/DME usuage. The intent of this test program is to determine if the present ATCRBS guardbands are sufficient for TCAS. (CT-82-100-16LR).

A previous test plan (CT-82-100-16LR) identified a series of tests to measure the compatibility of TCAS, and TACAN/DME. This plan identified a static desired target and assessed the effects of combination of 1090 MHz ATCRBS and Mode S fruit and various TACAN/DME environments in terms of the surveillance tracker reply efficiency and hit/miss pattern relative to this static target. These parameters were measured with ATCRBS fruit rates from 0 to 40K in 5K increments and Mode S fruit rates from 0 to 1K in 100 reply per second increments. The TCAS unit under test was available for compatibility testing for a short period and as a result the effects of all the TACAN/DME environments were not completed. Subsequently concern was voiced by knowledgeable TCAS personnel

that omni TCAS units should be tested at a maximum of 10K ATCRBS 1090 MHz fruit and a maximum of 100 Mode S 1090 MHz fruit. Additional concern was voiced that the compatibility of TCAS should be measured at a higher operational level than the surveillance level. This higher level was identified to be the TAU values obtained by running bench tests with a recently developed TCAS dynamic target simulator.

Theory of Operation.

The CAS units to be tested utilize top and bottom antennas. Both the top and bottom antennas operate in an omni transmit mode and a four loop receive mode or an omni receive mode. The selection of top or bottom antenna and the transmit or receive mode are software controlled. The transmitter operates at 1030 MHz and the receivers operate at 1090 MHz.

In ATCRBS operation, the CAS solicits ATCRBS replies by interrogating Mode C pulse pairs. The ATCRBS replies to these interrogations are received and processed to determine the range, altitude and angle of arrival (AOA). Surveillance tracks are started on subsequent replies that correlate with previous replies. These tracked replies are processed by the ATCRBS surveillance tracker and on determination of an established track, the replies are passed on to the Collision Avoidance System (CAS) tracker. The CAS tracker input to the CAS logic is used to predict potential conflicts with the CAS equipped aircraft.

In Mode S operation, the presence of Mode S equipped aircraft is determined by detecting the squitter transmissions from Mode S transponders. The squitter

transmissions contain altitude information and the Mode S identification code. Once the altitude of the Mode S aircraft is within 3000 feet of the CAS aircraft, the CAS interrogates the Mode S ID to obtain ranging information. This is referred to as the acquisition state. With the range data a determination is made as to that time for the Mode S aircraft to get to the CAS aircraft. This determination is made assuming the Mode S aircraft is traveling a same rapid speed. Depending on the result of this determination the Mode S track is put in the dormant state of the roll call state. If the time to own aircraft is greater than 75 seconds, the Mode S track is put in the dormant state and the track is maintained on squitters. If the time to own aircraft is less than 75 seconds, the Mode S track is put in the roll call state and the track is maintained by active Mode S interrogations from the CAS. The output of the roll call state is passed to the CAS tracker. The operation of the CAS trackerand CAS logic is the same as for an ATCRBS tracked target.

The CAS goes through a sequence of ATCRBS and Mode S interrogations and receive cycles once each second: a sequence each second would be four whisper/shout ATCRBS interrogations, with a twenty mile loop listen window between each ATCRBS interrogation on the top antenna, followed by the same cycle on the bottom antenna. Then an omni listen mode for Mode S squitters on the top and bottom antennas and any appropriate acquisition or roll call Mode S interrogations on the same antenna (top or bottom) that the squitter was received from.

Test Philosophy.

The basic purpose of the test program is to identify the effects of TACAN/DME signal formats on CAS operation.

The primary measure of CAS operation will be the TAU values for various range rate and altitude rate parameters. Associated with these TAU measurements will be the acquisition range, the surveillance reply efficiency and the corresponding hit/miss pattern data for each test sequence.

When measuring the effects of TACAN/DME on CAS performance it is necessary to establish an ATCRBS and Mode S environement that is present at the input to the CAS unit along with the TACAN/DME signals. As indicated earlier this environment has initially been established as 10K of ATCRBS 1090 MHz fruit and 100 Mode S 1090 MHz fruit.

A dynamic target simulator with variable range rate and variable altitude rate has been developed at the Technical Center. This target simulator will be the target of interest for the CAS unit under test. TAU values for the CAS systems maximum range rate and altitude rate will be established initially. The effects of the ATCRBS and Mode S fruit on the TAU values under these same test conditions will then be measured. Finally various TACAN/DME environments will be added to the 1090 MHz fruit and the TAU values again are measured.

The goal is to identify a TACAN/DME environment such that the TAU values with this environment are the same as those established with the 1090 MHz fruit environment.

If time permits, TAU values will be measured for range and altitude rates less than maximum both with and without various rates of 1090 MHz ATCRBS and Mode S fruit.

For all tests the performance level will be selected for a TAU value of 25 seconds.

Test Methodology.

The dynamic target simulator output level will initially be set a -50dBm. TAU values will be established for this signal level with the altitude of the simulator fixed at the same altitude as the CAS unit and the simulator set to maximum range rate. Under these same conditions TAU values will be measured with the 1090 MHz ATCRBS and Mode S fruit and then with the 1090 MHz fruit plus various TACAN/DME environments.

The dynamic simulator output is then set to -60 dBm and -70 dBm and the same series of tests as above are conducted for both -60 and -70 dBm levels.

Once the range TAU values have been established, the target simulator will be configured to to provide the maximum altitude rate change as determined by the CAS unit under test. The sequence of tests for the altitude rate tests will be the same as those for the range rate tests.

Test Configuration.

The test configuration is shown in the simplified block diagram of Figure 1.

The dynamic target simulator provides a Mode C reply to a TCAS transmitter trigger. The simulator provides a selectable constant or variable rate altitude code output and a selectable variable range rate output. Thus an RF Mode C reply is supplied to the TCA S unit by the dynamic simulator.

The ATCRBS and Mode S fruit sources are test equipment designed and fabricated by the Technical Center. These fruit sources have been used in previous compatibility testing. The time and amplitude distributions of these fruit sources as well as the ATCRBS and Mode S code content are discussed briefly in Appendix 1 and in more detail in reports FAA-RD-79-71 Interim Results of DABS/ATCRBS Electromagnetic Compatibility Studies.

The TACAN/DME signal source is a standard Squawk/Naut-1 DME/Transponder test set. This set provides TACAN/DME pulse trains at the appropriate Mode X (12 usec) and Mode Y (30 + 36 usec) pulse spacings at any selectable frequency in L band in one MHz steps.

All TCAS units tested will be delivered with some type of magnetic recording device to record all the CAS units internal fikes once per second.

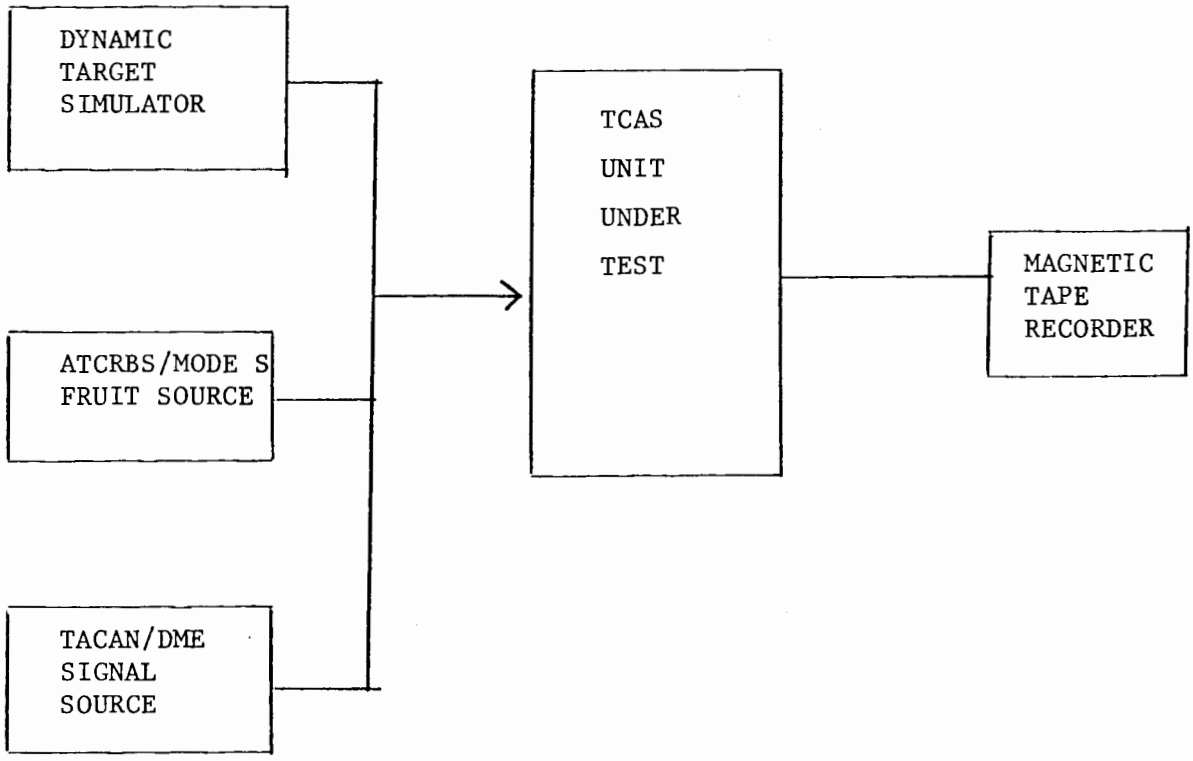

FIGURE 1 - TEST CONFIGURATION BLOCK DIAGRAM

Data Collection.

As indicated earlier all data is automatically collected on the system supplied recorders.

The data of interest for these tests is contained in the surveillance track file and the CAS track file.

The surveillance track file provides the interrogation and hit counters used for reply efficiency determination. The same hit counter and the coast counter in the surveillance track file are used to identify the hit/miss pattern. The system time, the measured range and the surveillance track number in the surveillance track file is used to determine the time and range of acquisition.

The CAS track file provides the time to closest approach (TAU) and the hit and coast counters for TAU measurements and reply efficiency and hit/miss patterns at the CAS level.

Table 1 contains a summary of the criterion, conditions and issues to be addressed by these tests.

TABLE 1

Criterion	Conditions	Issues
TAU = 25 sec	Max range rate & max. altitude rate 10K ATCRBS fruit and 100 Mode S fruit	TAU as a function of ATCRBS and Mode S fruit
TAU = 25 sec	Max range rate & max. altitude rate. 10K ATCRBS and 100 Mode S fruit and various TACAN/DME environments	Identify the TACAN/DME environment that allows TA to be equal to 25 sec.
Surveillance Acquisiton range = to 14 nmi	Max range rate & max. altitude rate. 10K ATCRBS and 100 Mode S fruit and various TACAN/DME environments	Acquisition range as a function of ATCRBS and and Mode S fruit and TACAN/DME environments.
CAS Acquisition range = to 12 nmi	Max range rate & max. altitude rate. 10K ATCRBS and 100 Mode S fruit and various TACAN/DME environments.	Acquisition range as a function of ATCRBS and Mode S fruit and TACAN/ DME environments.
Less than 6 successive track coasts	Max range rate & max. altitude rate. 10K ATCRBS and 100 Mode S fruit and various TACAN/DME envir- onments	Track continuity as a function of ATCRBS and Mode S fruit and various TACAN/DME environemnts.

Data Analysis.

The distribution of TAU times both with and without the environment will be plotted for desired signal levels of -50, -60 and -70 dBm. The mean and standard deviations of TAU for both environment and no environment will be calculated. Standard statistical tests will determine if these two sample populations are from the same population.

Similar data and calculations for the acquisition ranges will also be obtained.

The characteristics of the trackers as a function of the environments will be determined by providing plots of the number of times one miss in a row, two misses in a row, etc. are obtained both with and without the environments. These tracker characteristics can be utilized to determine the reason for any significant change in TAU values caused by the environments..