FAA TECHNICAL CENTER LETTER REPORT

RADAR/BEACON REINFORCEMENT TEST PLAN

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OBJECTIVE.

The objective of this test activity is to determine whether a series of modifications made to the MTD (moving target detector) radar/Mode S system can improve the radar/beacon reinforcement rate of that system. The tests will involve a resolution of an azimuth bias problem in the MTD radar, modifying the algorithm in the Mode S sensor which creates the radar/beacon reinforcement window around the beacon targets, and optimizing the pertinent parameters dealing with radar/beacon reinforcement in the Mode S sensor.

In addition the related radar only tracking function will be monitored to determine the anticipated increase in performance due to the modifications to the Mode S radar/beacon reinforcement function.

INTRODUCTION.

The Federal Aviation Administration Technical Center recently conducted tests and evaluations of the MTD radar/Mode S system. The report written on these tests, MODE S RADAR BASELINE REPORT, No. FAA/CT/82-43 concluded that the radar/beacon reinforcement rate was hampered by an azimuth bias problem in the MTD. This azimuth bias occurred only in tangentially flying targets and was always in the direction of flight. The radar/beacon reinforcement rate on targets affected by this azimuth bias was found to be approximately 50% compared to the overall radar/beacon reinforcement rate being degradated between 3 and 5% by this azimuth bias.

Because of the relatively large radar/beacon reinforcement window at extended ranges, the higher priority reinforcement function steals radar only target reports for correlation. This incorrect correlation adversely affects the radar only tracking performance.

SCOPE OF TESTING.

The scope of testing in this activity will be limited to the use of data collected only in the MTD radar detection coverage area. All data will be filtered by range, elevation angle, and altitude to relate to the MTD coverage area. In addition all data will be filtered in azimuth to remove a known beacon reflection zone. Most data will be collected using targets of opportunity within the filtered area, there will be minimum flight tests required by this approach.

TECHNICAL APPROACH.

The testing to be performed in this approach is divided into three phases. Phase 1 will be to establish a baseline radar/beacon reinforcement rate. Phase 2 will be to measure the improvement in the radar/beacon reinforcement caused by resolving the azimuth bias in the MTD radar. Phase 3 will be to characterize certain modifications and parameter optimizations in the Mode S sensor. The specifics of each phase and the tests to be conducted within each phase are presented in the following sections and are summarized in the test matrix shown in table 1.

PHASE 1. The first test phase will be to determine baseline figures to characterize the radar/beacon reinforcement rate of the MTD radar/Mode S system. The two figures to be used to characterize the radar/beacon reinforcement in the MTD radar/Mode S system are the radar/beacon reinforcement rate and the number of radar only track swaps per scan.

The radar/beacon reinforcement rate describes the percentage of beacon targets which had MTD radar reports merged with them. This means that there was an MTD radar report within a set range and azimuth of the beacon target (said to be in it's radar/beacon reinforcement window). The MTD radar report is then merged with the beacon target to create a radar reinforced beacon report. This figure will be used in phase two to compare the improvement in the radar/beacon reinforcement rate expected by the azimuth bias resolution.

The number of radar only track swaps per scan will be used as a baseline figure to be improved in Phase 3.

PHASE 2. The second test phase will be to measure the improvement in the radar/beacon reinforcement rate of the MTD/Mode S system (compared with the figures collected in Phase 1) after the azimuth bias in the MTD radar has been resolved. Targets of opportunity will also be looked at for several aircraft maneuvers to see if these maneuvers have any effect on the radar/beacon reinforcement rate. These maneuvers will include radial heading aircraft, turning aircraft, and tangential heading aircraft.

PHASE 3. The third test will be to test a pair of modifications to be made to the Mode S sensor to see if the number of the radar only track swaps can be reduced while maintaining the improved radar/beacon reinforcement rate obtained in Phase 2.

The first modification will be to the algorithim which creates the window around the beacon target in which an MTD radar report must be found in order to create a radar reinforced beacon report. The current software uses both a constant range value and a constant azimuth value to create this window. This causes the area of the window to increase with the range of the beacon target. To keep the area of this window a constant the azimuth value will have to vary according to the range of the beacon target it is being formed around. After the first modification is complete the size of the radar/beacon window will be optimized. By making the size of the window as small as possible, while maintaining the improved reinforcement rate obtained in Phase 2, the number of radar only track swaps per scan should be lowered.

DATA COLLECTION PLAN

PHASE 1 and PHASE 2. Since radar data can vary according to the time of day, weather conditions and other uncontrollable atmospheric phenomenon the data collected in Phase 1 and 2 will be collected on the same days in short (approximately 100 - 150 scans) alternating intervals. For the system radar/beacon reinforcement figures a total of over 3500 scans will be required. The radar/beacon reinforcement rate for each tested aircraft maneuver will require over 100 scans of data displaying each maneuver. The data collected in these phases will be taken from live world targets of opportunity though a test flight may be desired to test the resolution of the azimuth bias in the MTD.

PHASE 3. Phase 3 will use as its input, scenarios (run through the ARIES) created from the live world data collected in Phases 1 and 2. Data will first be collected under Phase 2 conditions (with the MTD bias resolved, but with no modification made to the Mode S sensor) to obtain new baseline figures which will reflect any degradation caused by the ARIES scenarios and not the MTD/Mode S system.

After the modification to the algorithm that creates the radar/beacon reinforcement windows has been verified, the parameters used to create this window will be optimized. First the range value will be lowered in steps making sure that no degradation is found in the radar/beacon reinforcement rate. Then the azimuth value will be optimized in the same fashion.

After the algorithm modification and parameter optimization has been completed the number of radar only track swaps per scan and radar/beacon reinforcement rate will be collected with a live world input to determine the final result of the improvements.

DATA ANALYSIS PLAN.

The radar detection coverage area of the MTD radar is much smaller than the coverage area of the beacon targets received by the Mode S sensor. Thus before the data collected under this approach can be analyzed it must first be filtered over the MTD radar detection coverage area as was done in the MODE S RADAR BASELINE REPORT. Only data falling within the area extending from 1 to 48 nautical miles, within an elevation angle of 2 to 16 degrees, and an altitude up to and including 20,000 feet will be used for analysis. An addition area containing a known reflection zone from 120 to 140 degrees will also be prohibited from analysis.

The radar reinforcement rate shall be calculated by taking the total number of beacon targets within the filtered area and finding the percentage of them that are radar reinforced. The same data analysis computer program which was used in the MODE S RADAR BASELINE REPORT can be used to calculate this figure.

The number of radar only track swaps must be calculated manually. By looking at each radar only track as it is dropped it can be determined if it dropped legitimately or if it was dropped due to a lack of data caused by the data being taken by a higher priority user, i.e., beacon reinforcement.

PHASE 1. Since the radar/beacon reinforcement rate to be calculated in this phase is to be used as a baseline figure to compare the results collected in Phase 2, the figure should be calculated from at least 3500 scans of data. This amount of data can be collected, jointly with Phase 2 in two days. If time permits 5000 scans of data will be collected over three days.

The number of tracks swaps will be calculated from 500 scans of data. The smaller number of scans is because of the timely manual data manipulation needed to calculate this figure.

PHASE 2. Under Phase 2, the radar/beacon reinforcement rate will not only be viewed as a result of the phase 2 tests, but also as the baseline figure to compare the data collected under Phase 3.

Phase 2 data analysis will also look at some separate aircraft maneuvers to determine if the heading of the aircraft has any effect on the radar/beacon reinforcement rate. Only 100 - 200 scans per aircraft maneuver will be required for this purpose. The aircraft maneuvers to be looked at are: turning targets, radial heading targets, and tangential heading targets.

Track swaps will be taken over 500 scans of data as in Phase 1.

PHASE 3. The initial test will be to calculate the degradation caused by creating and running an ARIES scenario as opposed to a live world input. This figure will be calculated by testing 3 short (approximately 150 scans) scenarios to determine the degradation to be subtracted from the baseline figure collected in Phase 2.

Since phase three will be concerned with parameter optimization done over many steps the amount of data to be collected at each step will have to be small as compared against Phases 1 and 2. The same 3 scenarios can thus be used throughout Phase 3.

For each step of the parameter optimization process the scenario will be run and a corresponding reinforcement rate calculated. Once a figure is approached which shows a degradation to the reinforcement rate a step backwards will be taken and retested to assure that there was no degradation there. Once the parameters have been optimized a final live world radar/beacon reinforcement rate as well as the number of radar only track swaps will be calculated as done in Phase 1 for the final result.

RADAR/BEACON REINFORCEMENT IMPROVEMENT PROJECT

Purpose: To evaluate several improvements made to the radar/beacon reinforcement rate of the MTD radar/Mode S system

SPECIFIC OBJECTIVES	DR&A PRESENTATION	INTERPRETIVE ANALYSIS
1. Collect baseline statistics, radar/beacon reinforcement rate, track swaps/scan.	Percentage of radar/beacon reinforcement rates for overall system filtered over MTD radar detection coverage area.	Is there a radar/beacon reinforcement problem with orbital heading aircraft due to a bias problem in the MTD?
2. Test for improved radar/beacon reinforcement rate after MTD bias problem is resolved. Collect reinforcement rates for overall system as well as for separate aircraft maneuvers. % reinforcement rate of system % reinforcement rate for turning targets % reinforcement rate for radial headings % reinforcement rate for tangential headings	Percentage of radar/beacon reinforcement rates for overall system filtered over MTD radar detection coverage area, and reinforcements rates for each listed aircraft maneuver. Plots for each aircraft maneuver showing resulting radar/beacon reinforcement.	Was the system radar/beacon reinforcement rate improved with the modified MTD. Is the radar/beacon reinforcement rate a factor of aircraft heading?
Collect number of radar only track swaps per scan	Number of radar track swaps per scan, plots of track swaps.	Is the number of radar track swaps per scan too high?
3. Test for less radar track swaps while maintaining reinforcement rate	Statististics and plots of number of track swaps.	Can the number of track swaps per scan be lowered without lowering the radar beacon reinforcement rate?
a. with variable range/azimuth window b. with pertinate parameters optimized	Percentage of radar/beacon reinforcement rate for overall system as well as for separate aircraft maneuvers.	Can the radar/beacon reinforcement rate be improved through parameter optimization?