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Mode S Performance Test Plan

Charles Baxter

July 1989

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16. Abstract

This document describes the Mode S Performance Tests to be conducted by the Federal Aviation Administration Technical Center. The Mode S Performance Tests will provide a performance baseline and site-adaptation optimization effort for each Mode S configuration (terminal, en route, and multi-sensor). System level accuracy and resolution tests will be conducted using live test aircraft and precision trackers. These tests have not been previously accomplished due to the lack of multiple sensors and precision trackers at the contractor's facility. A stress test effort will also be conducted to characterize the performance of the Mode S sensor beyond its specified requirements.

This plan addresses the National Airspace System requirements and test objective as outlined in the Mode S Master Test Plan. This plan also identifies the organizational responsibilities, resources, coordination efforts, and success criteria necessary to develop a set of test procedures to accomplish the above tests.

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EXECUTIVE SUMMARY

This plan describes the Mode S Performance Tests to be conducted by the Federal Aviation Administration (FAA) Technical Center. There will be two Mode S sensors involved in this test effort; a terminal Mode S sensor and an en route Mode S sensor. The terminal sensor will be located at the FAA Technical Center while the en route sensor will be located 15 miles away in Elwood, New Jersey.

The baseline portion of the performance test effort will begin immediately after completion of the acceptance test of each sensor. The baseline effort is a necessary step between the acceptance tests and the National Airspace System (NAS) Integration/Operational Test and Evaluation (Int/OT&E). The FAA Technical Center baseline will consist of concise repeatable tests and use the same hardware/software configuration that will be supplied to the field. As part of the baseline effort, system level accuracy and resolution tests will be conducted. These tests, consisting of live spatial, accuracy, and resolution flights, are needed to accomplish NAS Production Acceptance Test and Evaluation (PAT&E) requirements. These tests were not part of the Mode S contractor's test effort due to the lack of precision tracking equipment. The baseline tests will be accomplished using the site-adaptation parameters set to the contractor's recommended settings. This should include such items as the local reflection file and antenna parameters being set according to each site's requirements.

The multi-sensor test effort requires the use of multiple Mode S sensors in both netted and non-netted configurations. These configurations were not available to the Mode S contractor. These tests will be performed following the NAS Int/OT&E but before any multi-sensor configuration is to be fielded.

The remaining performance tests (stress and site-adaptation optimization) will also be conducted after the completion of the NAS Int/OT&E. The base performance for both the stress and site-adaptation optimization tests will be decided by the data collected in the baseline tests. The stress test's objective is to characterize the sensor's performance and degradation when stressed with target and fruit loads beyond its accepted capacities. The site-adaptation optimization test's objective is to improve the performance of the Mode S sensors beyond that observed in the performance baseline.

INTRODUCTION.

The purpose of the Mode S Performance Test Plan is to identify the organizational responsibilities, resources, coordination efforts, and success criteria necessary to develop the test methodology required to obtain a baseline of sensor performance. The results of these performance tests will provide a reference of sensor performance against which future changes to hardware/software/firmware can be compared for both terminal and en route Mode S sensors. This plan will specifically address the test methodology required to verify the National Airspace System (NAS) System Level Test and Evaluation (SLT&E) and the Performance Test and Evaluation (PT&E) requirements allocated to the Mode S performance test effort by the Mode S Master Test Plan.

1.1 SCOPE.

This document provides the overall philosophy and approach to the performance testing of the Mode S subsystem. This plan has been written to assure that the performance tests conducted by the Federal Aviation Administration (FAA) Technical Center are done so in a structured and thoroughly documented manner. This plan identifies the necessary support (e.g., personnel, equipment, documentation, etc.) that is required to accomplish the Mode S performance tests. After approval of this plan, the detailed Mode S performance test procedures will be produced in accordance with the information defined within this plan.

The Mode S performance test effort will be carried out in multiple stages referred to as Test Categories. Test Category 1 (Sensor Baseline Performance Tests) will be conducted separately on both the Terminal Mode S sensor at the FAA Technical Center and the En Route Mode S sensor at Elwood, NJ. These tests will be conducted following the acceptance by the FAA of each sensor; first, the terminal sensor and approximately 6 months later, the en route sensor. These tests will be conducted using the contractor delivered settings for the sensor's site adaptable parameters. This should include the installation of the reflector file and antenna parameters setup for each site. If these parameters are not set correctly, then they will be set before commencing with the performance tests. The surveillance and data link test cases of category 1 will be conducted before the start of the Mode S NAS Integration/Operational Test and Evaluation (Int/OT&E). The spatial coverage accuracy tests will be conducted concurrently with the NAS Int/OT&E. This will be done to conserve the number of live flights required by the two test efforts.

Test Category 2 (Mode S Multi-Sensor Performance) will be conducted following the completion of the NAS Int/OT&E and Shakedown efforts on both the terminal and en route sensors. This test effort will examine both the netted and non-netted Mode S Multi-Sensors configurations. This test effort may be conducted after the fielding of single terminal or en route Mode S sensors but will be completed prior to the fielding of any "multi-sensor" Mode S configurations.

Test Category 3 (Sensor Adaption Performance) will be conducted following the completion of the Category 2 Performance Tests. The test procedures for these tests will not be written until after the final reports have been written for categories 1 and 2. The tests in this category will use the baseline data to determine which site-adaptable parameters to optimize and at what loading levels to

begin the stress tests. The Sensor Stress Tests will be designed to determine at what level of loading system degradation occurs and in what manner it occurs. The Site Adaptation Optimization Tests will be designed to improve the performance of the Mode S sensors from the level measured in the performance baseline data.

2. REFERENCE DOCUMENTS.

This section lists the applicable documentation and reference materials which relate to the contents of this plan, or upon which this plan was based.

SPECIFICATIONS:

FAA-E-2716	Mode Select Beacon System (Mode S) Sensor, Amendment 2, Changes 1 - 21, SCN #15

STANDARDS:

FAA-STD-024a	Preparation of Test and Evaluation Documentation, August 17, 1987

FAA ORDERS:

Order 1810.4A	FAA NAS Test and Evaluation Program

PLANS:

DOT/FAA/CT-TN 88/28	Mode S Master Test Plan
TM-PA-0018/045/00	Mode S System Test Plan
CPME-PA-0018/095/00	Mode S Test Plan -- CPME

NAS PROGRAM:

NAS-SS-1000	NAS System Specification Volume I, Volume III Functional and Performance Requirements for the National Airspace System
ATC-86-1165	FAA Technical Center Transition Plan, March 1987
NAS-MD-110	Test and Evaluation (T&E) Terms and Definition for the National Airspace System (NAS), March 1987

3. TEST AND EVALUATION PHILOSOPHY.

The Mode S Performance Test Plan will provide for the verification of the applicable requirements identified in the TVRTM, as discussed in section 4.0 of this plan. FAA Order 1810.4A directs the verification of all requirements and states that these requirements will be verified as early as possible in the procurement process. With this philosophy implemented, ACN-220 will ensure the following performance-related activities are accomplished:

a. The development of a Mode S Performance TVRTM as derived from the FAA Program Office provided PT&E/SLT&E TVRTM.

b. The development of a Mode S Performance Test Plan which contains a cross-reference to each of the performance requirements in the Mode S Performance TVRTM.

c. The development of detailed performance test procedures and appropriate simulation scenario scripts, as necessary, for each of the tests defined in the Mode S Performance Test Plan. These test procedures will be in accordance with this plan and specified tests will be conducted to verify the NAS system level requirements identified in appendix B.

d. The execution of performance tests on the Mode S terminal and en route sensors installed at the FAA Technical Center.

e. The verification and documentation of each test with a success criteria that satisfies the Mode S Performance Test Plan. Sample forms are contained in appendix A.

f. The tracking of all problems encountered during PT&E verification.

g. The delivery of test reports to the ASA-110 Program Office on the pass/failure of the Mode S Subsystem in the area of FAA Technical Center performance testing.

The performance testing, when completed, will:

a. Provide a baseline of sensor performance as a function of target and communications loading.

b. Provide verification of the NAS SLT&E/PT&E requirements allocated in the TVRTM.

c. Provide system adaptation performance as a function of

1. optimization of selected site adaptation parameters, and

2. target and communications loading beyond the limits of the sensor design specifications.

d. Provide a multi-sensor performance baseline.

e. Minimize the risks associated with proceeding to the next project milestone.

f. Minimize field site problems by conducting and documenting the Mode S performance test effort.

4. APPROACH AND CONCEPT.

The Mode S Performance Test Plan will verify the TVRTM requirements by developing a series of tests designed to obtain technical data on the Mode S hardware, software, and sensor level performance. This technical data will be gathered for the Mode S sensors installed in the terminal, en route, and netted configurations. Three categories of testing will be executed:

Category 1 -- Sensor Baseline Performance Tests
Category 2 -- Multi-Sensor Performance Tests
Category 3 -- Sensor Adaptation Performance Tests

Specific test cases are defined for each of the categories:

Category 1 -- Sensor Baseline Performance Tests

Test Cases (separately for terminal and en route)

a. Surveillance
b. Data Link
c. Spatial Coverage

Category 2 -- Multi-Sensor Performance Tests

Test Cases

a. Netted Surveillance and Communication Performance
b. Netted Adjacent Sensor Failure/Recovery
c. Non-Netted Surveillance and Communication Performance

1. Nonselective acquisition
2. Site-addressed acquisition

Category 3 -- Sensor Adaptation Performance Tests

Test Cases (separately for terminal and en route)

a. Site Adaptation Parameter Optimization
b. Surveillance Stress
c. Data Link Stress

The test cases are further subdivided to provide the following information:

a. Objective
b. TVRTM Requirements
c. Test Description
d. Data Analysis
e. Support Requirements
f. Criteria of Success

4.1 TEST DESCRIPTION.

The performance tests described in this section are intended to be conducted after the Mode S contractor satisfactorily completes Site Acceptance Tests at the FAA Technical Center. The category 1 and category 3 tests will be performed separately on the terminal and en route sensors. The category 2 tests will utilize both sensors in multi-sensor configurations of shared surveillance responsibilities. The category 1 and category 2 tests shall be used to establish a baseline of sensor performance against which to evaluate future sensor modifications. The category 3 tests will be performed to optimize selected site parameters, and to ascertain how the sensor performs when subjected to surveillance and communication loads in excess of the accepted baseline levels.

The NAS requirements allocated to this Mode S Performance Test Plan by the Mode S Master Test Plan are identified in the specific test category. It is to be noted that no NAS requirements relate to the multi-sensor category. The following priority has been assigned to the Mode S performance tests: (1) Terminal Sensor Baseline, (2) En Route Sensor Baseline, (3) Multi-Sensor Baseline, (4) Terminal Adaptation Performance, and (5) En Route Adaptation Performance. It is essential that the terminal and en route baseline tests be completed prior to commencing integration testing on the respective terminal and en route sensors at the FAA Technical Center.

4.1.1 Category 1: Mode S Sensor -- Sensor Baseline Performance.

The category 1 baseline performance tests are subdivided into the test cases of Surveillance, Data Link, and Spatial coverage as dictated by the TVRTM requirements allocated to it. The surveillance and data link testing will be performed solely using simulated targets from the Aircraft Reply and Inteference Environmental Simulator (ARIES) and simulated messages from the Communications Interface Driver (CID). (See appendix C for description.) Spatial coverage will be performed using flight test aircraft, targets of opportunity, and the sensor's precisely surveyed Calibration Performance Monitoring Equipment (CPME) locations. Most system adaptation parameter settings will be the nominal values recommended and implemented by the Mode S contractor at the time of acceptance testing. Some parameters, such as beamshaping, reflector tables, and diffraction tables will be developed, if necessary, by the test team prior to performing the baseline tests. Separate tests will be conducted on terminal and en route sensors. Nonselective acquisition will be used for all category 1 testing.

4.1.1.1 Test Case 1 -- Surveillance.

Objective.

The objective of the surveillance tests is to determine surveillance processing capabilities as a function of target loading up to the designed sensor capacity.

TRVTM Requirements.

The following requirements will be verified:

Terminal/En Route

1200	1300	1310	1320
1330	1340	1350	1600
1830			

The appearance of these numbers in the following paragraphs indicate where the specific requirement is being addressed.

Test Description.

Tests will be conducted utilizing simulated dynamic targets to determine the surveillance processing capabilities of the Mode S sensor. The dynamic targets will be generated via several ARIES input scenarios including the Basic 41, Real World, and 700 Capacity (1600) scenarios. These scenarios will represent air traffic control radar beacon system (ATCRBS) and Mode S target capacities up to the sensor design capacity of 700 aircraft. They will be prepared for all ATCRBS, all Mode S, and a mixture of ATCRBS and Mode S targets.

Tests will also be conducted to determine the Probability of Detection as a function of signal strength and fruit levels. Tests will be made using a scenario of orbiting targets at various input signal levels representing various ranges from the sensor. ATCRBS and Mode S fruit environments will be generated as necessary. (See appendix C for description of scenarios.)

In addition to addressing the specific requirements allocated to this surveillance test, the surveillance characteristics of the Mode S sensor will be determined as a function of simulated target load in terms of:

a. Target probability of detection (Pd) (1200)
b. ATCRBS and Mode S code reliability
c. Altitude reporting reliability
d. ATCRBS replies per report
e. Mode S interrogation rate per target
f. Beacon blip/scan ratio
g. Radar reinforced rate

Data extractions shall be made to insure that the following interrogation types can be generated by the Mode S sensor:

a. ATCRBS/Mode S All-Call (1300)
b. ATCRBS Only All-Call (1310)
c. ATCRBS (1320)
d. Mode S All-Call (1330)
e. Mode S Roll-Call (1340)

The Mode S sensor ATCRBS interrogation modes shall be modified to produce an interlace pattern of ATCRBS modes 2, 3A, B, C, and D. Data extractions shall be made of the modulator control unit (MCU) buffer for insuring the interlace patterns were generated by the Mode S sensor (1350).

Data Analysis.

The data extractions gathered during the test conduct phase will be used in performing a comprehensive analysis of a terminal Mode S sensor. The data will be obtained from:

a. Data reduction and analysis (DR&A) programs resident on the Programming Support Facility (PSF) which will compare data tapes extracted simultaneously on the ARIES and Mode S sensor, and/or

b. Analysis programs resident on the Transportable Radar Analysis Computer System (TRACS). (See appendix D.)

Data analysis will consist of subjecting data tapes extracted simultaneously on the Mode S sensor, the ARIES, and the TRACS for each tested scenario to:

a. Quick Look plots and listings
b. ARIES/Mode S analysis
c. Track level analysis
d. Channel management statistics
e. TRACS programs

Appendix E refers to descriptions of the above analysis methods.

Support Requirements.

a. ARIES Test Unit
b. FAA Technical Center PSF
c. TRACS

Criteria Of Success.

The data extracted from the surveillance testing will be subjected to the following criteria to determine if the TVRTM requirements are successfully verified.

a. All transponder equipped aircraft targets with a reply Pd of greater than 0.99, a probability of constant false alarm less then 10**-6, and a received reply power of -76 decibels above 1 milliwatt (dBm) shall be detected (1200).

b. The Mode S sensor shall be able to generate an ATCRBS/Mode S All-Call interrogation type (1300).

c. The Mode S sensor shall be able to generate an ATCRBS Only All-Call interrogation type (1310).

d. The Mode S sensor shall be able to generate an ATCRBS interrogation type (1320).

e. The Mode S sensor shall be able to generate a Mode S All-Call interrogation type (1330).

f. The Mode S sensor shall be able to generate a Mode S Roll Call interrogation type (1340).

g. The Mode S sensor shall be able to generate an ATCRBS interlacing interrogation pattern comprised of the beacon modes 2, 3A, B, C, and D (1350).

h. The sensor shall be able to accept target replies and prepare output surveillance reports for the following per scan target capacity scenarios (1600):

1. Any mixture of 700 Mode S and ATCRBS beacon targets.
2. 1000 primary radar target reports.
3. Nonuniform beacon target distribution of:

   (a) 250 targets within a 90° quadrant;
   (b) 50 targets within a 11.25° sector for up to four consecutive sectors;
   (c) 32 targets within a 2.4° wedge.

i. The sensor's envelope for surveillance detection and data link coverage shall include altitude coverage to 100,000 feet (1830).

The data extracted from the surveillance testing will be additionally subjected to the following criteria to determine if the sensor specification (FAA-2716, par 4.3.3.5.5) requirements are being met.

a. Beacon blip/scan ratio
   ATCRBS---greater than 0.97
   Mode S---greater than 0.98

b. Effective blip/scan ratio (includes radar substitution)
   ATCRBS---greater than 0.99
   Mode S---greater than 0.99

c. Report Code validity
   ATCRBS---greater than 0.97
   Mode S---greater than 0.999

d. Report Altitude validity
   ATCRBS---greater than 0.95
   Mode S---greater than 0.999

e. False reports due to splits and fruit
   ATCRBS---less than 0.3 percent
   Mode S---less than 0.1 percent

f. Track swaps
   ATCRBS---less than 1 percent
   Mode S---not applicable

g. Time in storage (correlating user)
   ATCRBS---less than 3/32 scan
   Mode S---less than 3/32 scan

h. Average reinterrogation rate
   ATCRBS---not applicable
   Mode S---less than 0.10

4.1.1.2 Test Case 2 -- Data Link.

Objective.

The objective of the data link test is to determine the ability of the Mode S sensor to correctly transmit uplink messages to and correctly process downlink messages from as many as 700 Mode S targets per scan.

TVRTM Requirements.

The following TVRTM requirements will be verified:

Terminal/En Route

1400	1410	1500	1510
1610	1620	1630	1700
1710			

The appearance of these numbers in the following paragraphs indicate where the specific requirement is being addressed.

Test Descriptions.

Dynamic input from the ARIES and the CID will be used to create two specific Mode S scenarios. They are the 700 Capacity and the Real World scenarios (see appendix C for description). It should be noted that although this series of testing is for data link communication messages, these messages cannot exist without the presence of Mode S surveillance targets.

During the 700-capacity scenario, the sensor will be evaluated to determine its ability to receive or transmit data link messages (1610, 1620), and to provide efficient data channel utilization (1630). Both scenarios will be used to provide the data necessary to evaluate the uplink (1400) and downlink (1410) message delay, the uplink (1700) and downlink (1710) message storage, the Roll-Call (1500), and the incomplete transaction priority (1510).

ARIES, CID, and Mode S data will be recorded on magnetic tape to facilitate data reduction and analysis.

Data Analysis.

The recorded data will be analyzed to provide a comprehensive analysis of a Mode S sensor. Data analysis will consist of subjecting data tapes extracted simultaneously from the Mode S sensor, the ARIES, and the CID for each tested scenario to:

a. Quick Look plots and listings
b. ARIES/Mode S analysis
c. Track level analysis
d. Mode S/CID compare
e. Channel management statistics
f. Data link analysis

Appendix E refers to descriptions of the above analysis methods.

Support Requirements.

a. ARIES Test Unit
b. CID Test Unit
c. FAA Technical Center PSF

Criteria Of Success.

The data extracted from the data link testing will be subjected to the following criteria to determine if the TVRTM requirements are successfully verified.

a. Uplink messages shall not be delayed more than 1/16 of a scan period from the time received by the sensor until the time they are processed and made available for delivery to the addressed aircraft (1400).

b. Downlink communications shall not be delayed more than 1/16 of a scan period from the time received by the sensor until the time they are made available for transmission from the sensor to their specified destination (1410).

c. In circumstances when there is insufficient time to complete a Mode S roll call on all targets within a beam dwell, the following priority basis shall be used to allocate the available time (1500):

1. Surveillance and high priority standard length messages
2. High priority uplink extended length messages (ELM)
3. Additional (lower priority) standard length messages
4. Uplink ELMs
5. Downlink ELMs

d. Any transactions with an aircraft that are not completed shall be placed on the next schedule, subject to the following priority basis (1510):

1. Surveillance and high priority standard length messages
2. High priority uplink ELM
3. Additional (lower priority) standard length messages
4. Uplink ELMs
5. Downlink ELMs

e. The sensor shall be able to receive or output data link messages for 700 Mode S-equipped aircraft per scan (1610).

f. The sensor shall be able to receive or output data link messages for the following per scan target capacity scenarios (1620):

1. Any mixture of 700 Mode S and ATCRBS beacon targets.
2. 1000 primary radar target reports.
3. Nonuniform beacon target distribution of:

   (a) 250 targets within a 90° quadrant
   (b) 50 targets within a 11.25° sector for up to four consecutive sectors
   (c) 32 targets within a 2.4° wedge

g. The Mode S sensor shall be able to efficiently utilize the data channel under the conditions listed in the data link peaking scenario described in the TVRTM, table 3.2.1.1.6.2.13-1 (1630).

h. The Mode S sensor shall be able to provide data link message storage for 4800 uplink messages (1700).

i. The Mode S sensor shall be able to provide data link message storage for 1100 downlink messages (1710).

4.1.1.3 Test Case 3 -- Spatial Coverage.

Objective.

The objectives of the spatial coverage tests are to; (1) determine the Mode S coverage area, (2) determine the range and azimuth accuracy, (3) determine the range and azimuth resolution, (4) verify stochastic acquisition, and (5) verify the surveillance characteristics that were achieved under the simulated environment.

TRVRTM Requirements.

The following TVRTM requirements will be verified.

Terminal/En Route

1110	1120	1210	1220	
1230	1240	1250	1820	1840

Terminal Only

1800	1900

En Route Only

1260	1810	1910

The appearance of these numbers in the following paragraphs indicate where the specific requirement is being addressed.

Test Descriptions.

Testing will be conducted utilizing targets of opportunity, FAA test aircraft (equipped with Mode S and ATCRBS transponders), and the sensor's CPME locations.

For accuracy tests, a test aircraft flying predetermined flight patterns will be tracked simultaneously by a precision radar tracker and the Mode S sensor. The test data will then be subjected to DR&A techniques in order to insure the following:

a. Range accuracy for Mode S reports (1210)
b. Range accuracy for ATCRBS reports (1220)
c. Azimuth accuracy for Mode S reports (1230)
d. Azimuth accuracy for ATCRBS reports (1240)

e. Proper slant range coverage (1800) Terminal or (1810) En route
f. Proper azimuth coverage (1820)
g. Proper elevation coverage (1840)

The information that will be gathered by the above flight tests will also be used to insure that the Mode S interrogation capabilities (1120) and the monopulse beacon operation (1110) reduce synchronous garble. The terminal Mode S will be tested to verify that it updates surveillance primary targets once per scan (1900) at a rate identical to that of the associated primary radar (1250). The en route Mode S will be tested to verify that it updates surveillance primary targets twice per antenna scan when operating with a back-to-back beacon antenna (1910). The en route Mode S sensor will also be tested in a stand-alone mode for proper coverage (1260).

Reduction of multipath false target testing (1100) will also be conducted. This will be done by first determining the location and orientatation of reflectors that cause false target replies. The information will be used to develop the reflector map. Targets of opportunity will be used to verify that false targets are being identified and also to verify that valid target reports are not filtered.

Resolution testing will consist of recording range and azimuth of two test aircraft flying crossing patterns on both radial and orbital flight paths. Each aircraft will be tracked and its position recorded by a precision radar tracker. The tracker data will be compared to the sensor recorded data to determine the sensor's ability to resolve two targets flying in close proximity.

Live-world testing will be done using targets of opportunity. The surveillance data will be analyzed and compared against that obtained during the simulated surveillance testing. Stochastic acquisition, both initial and adaptive, will be verified using multiple ground-mounted Mode S transponders. An ARIES capacity scenario will be designed to overlay the ground-mounted target returns to investigate any capacity deterioration due to adaptive stochastic processing.

Data Analysis.

An analysis will be made of the live world surveillance performance of a Mode S sensor. Data analysis will consist of subjecting data tapes extracted from the Mode S sensor, the precision tracker, and/or TRACS to:

a. Quick Look plots and listings
b. TRACS programs
c. Track level analysis
d. Resolution analysis
e. Accuracy analysis
f. Nine-point Accuracy analysis

Appendix E refers to descriptions of the above analysis methods.

Support Requirements.

a. Test aircraft equipped with ATCRBS and Mode S transponders
b. FAA preapproved flight plans
c. FAA Technical Center PSF
d. Precision Radar Tracker
e. TRACS

Criteria Of Success.

The data extracted from spatial coverage testing will be subjected to the following criteria to determine if the TVRTM requirements are successfully verified.

a. Sensor-only range errors for Mode S reports (1210) and ATCRBS reports (1220) shall not exceed + or - 30 feet bias and 25 feet root mean square (rms) jitter.

b. Azimuth error for Mode S reports (1230) and ATCRBS reports (1240) shall not exceed + or - 0.033° bias and 0.060° jitter.

c. Mode S shall detect all transponder equipped aircraft targets (within the detection envelope) at a rate of 12 seconds, +1.33 or -1.09, for stand-alone Mode S sensors (en route only).

d. Slant range coverage (1800) shall be 0.5 nautical miles (nmi) to 55 nmi (terminal only).

e. Slant range coverage (1810) shall be 0.5 nmi to 255 nmi (en route only).

f. Azimuth coverage (1820) shall be 360°.

g. Altitude coverage (1830) shall be to 100,000 feet.

h. Elevation coverage (1840) shall be from 0.5 to 45° with respect to the horizontal plane tangent to the earth at the radar antenna.

i. Synchronous garble shall decrease and track reliability shall increase due to the use of the Mode S interrogation capabilities (1120) and the monopulse beacon operation (1110).

j. False target reports resultant from multipath effects shall decrease (1100).

k. Every target within the detection envelope shall be updated every antenna scan (1900) (terminal only).

l. The scan rate of the Mode S sensor shall be identical to that of the associated primary radar (1250) (terminal only).

m. Every target within the detection envelope shall be updated twice per antenna scan when operating with a back-to-back antenna (1910) (en route only).

4.1.2 Category 2: Mode S Multi-Sensor Performance.

Multi-sensor performance testing will examine the Network Management aspects of the Mode S sensor in a live-world environment. This group of tests will be concerned with the coverage obtainable by multiple Mode S sensors. The primary test objective will be to examine the functional ability of the Mode S system to coordinate aircraft surveillance and communication activities in the netted and non-netted modes of operation. The multi-sensor performance category will be divided into two subcategories; (1) Category 2a: Netted Sensor Performance, and (2) Category 2b: Non-Netted Sensor Performance. Each subcategory will utilize both

the FAA Technical Center terminal and the en route Mode S sensors. The two Mode S sensors will connect to a single CID system. The CID will provide the X.25 communication interface. All sensor surveillance inputs will be obtained from live-target situations.

Multi-sensor performance is not addressed by NAS, therefore, there are no TVRTM requirements to be fulfilled by this testing.

4.1.2.1 Category 2a: Netted Sensor Performance.

Category 2a netted sensor performance tests are subdivided into the following two test cases: (1) Netted Surveillance and Communication Performance Test, and (2) Adjacent Sensor Failure Recovery Performance Test. The two Mode S sensors will connect to a single CID system. The CID will simulate an air traffic control (ATC) facility by routing the sensor-to-sensor messages between the netted sensors. Nonselective acquisition will be used for all netted sensor testing.

4.1.2.1.1 Test Case 1 -- Netted Surveillance and Communication Performance.

Objective.

The objective of this test case is to examine how well Network Management accomplishes its function of insuring adequate surveillance of and communication with aircraft in areas of single and common coverage. The impact of sensor coverage mapping functions and capabilities on operations will be assessed.

Test Description.

The netted sensor surveillance testing will be accomplished by utilizing live-flight data. The test aircraft will be flown within the surveillance areas for the netted sensors. Penetration of the primary/secondary regions and the zenith cones for each sensor shall be included in the flight plans. The zenith cone penetration shall include the execution of maneuvers to enhance the testing of netted surveillance functions that require surveillance data from the other sensor.

The CID will simulate the ATC facility function of routing messages between the sensors. Communication messages between sensors will be routed by the CID for unmodified retransmission to the other sensor. The CID will also transmit messages to each Mode S sensor as defined in a scenario file. The CID will record all input and output transactions with the sensors under test.

The multi-sensor characteristics of the Mode S netted sensor will be examined as a function of the live target scenarios in terms of:

a. New target coordination
b. Primary/secondary coordination
c. Surveillance data exchange
d. Surveillance coverage transition
e. ATC data request
f. Coverage map operation
g. System blip scan
h. Data link message delivery

These parameters will be obtained from DR&A programs resident on the PSF which will utilize data tapes extracted simultaneously on the CID and both Mode S sensors.

Data Analysis.

The data gathered during the testing phase will be analyzed in detail to provide a comprehensive analysis of the netted sensor surveillance performance. Data analysis will consist of subjecting data tapes extracted simultaneously on the Mode S sensors, and the CID to:

a. Quick Look plots and listings
b. Track level analysis
c. Data link analysis
d. Network management analysis

Appendix E refers to descriptions of the above analysis methods.

Analysis will be tabulated by scan for each aircraft to determine the amount and percentages of received target reports.

Support Requirements.

a. Test aircraft equipped with ATCRBS and Mode S transponders
b. FAA-preapproved flight plans
c. FAA Technical Center PSF
d. CID Test Unit

Criteria Of Success.

The data extracted from the netted sensor testing will be subjected to the following criteria to determine if the test objectives are successfully verified.

a. New target coordination is performed by the sensor for the test aircraft in the scenario.

b. Primary/secondary coordination is maintained between the sensors for the test aircraft in the scenario.

c. Surveillance data exchange messages are exchanged between the sensors for test aircraft in the scenario in situations where surveillance fill-in is required.

d. Surveillance coverage transition messages are transmitted correctly by each sensor for the test aircraft in the scenario.

e. ATC data requests are processed correctly for each test aircraft in the scenario.

f. Coverage map operation is correct for all boundary transitions for each test aircraft in the scenario.

g. The netted sensors correctly transmitted all uplink messages to the test aircraft and correctly processed downlink messages from the test aircraft in areas of single and common coverage.

4.1.2.1.2 Test Case 2 -- Netted Sensor Failure/Recovery.

Objective.

The objective of this test case is to determine that network management is providing surveillance of and communication with aircraft during an adjacent sensor failure/recovery.

Test Description.

The adjacent sensor failure/recovery testing will be accomplished by utilizing live-flight data. The test aircraft will be flown within the surveillance areas for the netted sensors. The CID will simulate the ATC facility's function of routing messages between sensors as in test case 1.

Two cases of failure/recovery will be analyzed: (1) communication line failure, and (2) induced sensor hardware failure. In each case, a failure will be simulated and then removed to test recovery algorithms. First, the CID will initiate a simulated failure sequence by failing the communication line to one sensor. After a short interval, the communication line to the sensor will be restored. Second, a simulated failure of the Mode S sensor will be induced. The failure will cause that sensor to transmit a failure message. After a short interval, the induced failure will be removed.

The multi-site characteristics of the Mode S sensor will be determined in terms of:

a. Communication line failure and recovery
b. Sensor failure/recovery message protocol

These parameters will be obtained from DR&A programs resident on the PSF which will compare data tapes extracted simultaneously on the CID and both Mode S sensor.

Data Analysis.

The data gathered during the testing phase will be analyzed in detail to provide a comprehensive analysis of the netted sensor performance when dealing with failure/recovery. Data analysis will consist of subjecting data tapes extracted simultaneously on the Mode S sensors and the CID to the:

a. Quick Look plots and listings
b. Track level analysis
c. Data link analysis
d. Network management analysis

Appendix E refers to descriptions of the above analysis methods.

Analysis will be tabulated by scan for each aircraft to determine the amount and percentages of received target reports.

Support Requirements.

a. Test aircraft equipped with ATCRBS and Mode S transponders
b. FAA-preapproved flight plans
c. FAA Technical Center PSF
d. CID

Criteria Of Success.

The data extracted from the multi-sensor failure/recovery testing will be subjected to the following criteria to determine if the test objectives are successfully verified.

a. Communication line failure and recovery are detected by performance monitoring.

b. Adjacent sensor failure and recovery are detected by performance monitoring.

c. An adjacent sensor failure will cause network management to expand the coverage map per the special mode.

d. The local sensor will support the recovery of an adjacent sensor by sending track data messages to the recovered sensor.

e. A sensor-to-sensor communications line failure will cause both sensors to operate in intermittent lockout modes.

4.1.2.2 Category 2b: Non-Netted Sensor Performance.

Category 2b non-netted sensor performance tests are subdivided into the following two test cases: (1) Nonselective Acquisition, and (2) Site-Addressed Acquisition. The tests will utilize both the FAA Technical Center terminal and the en route Mode S sensors. The two Mode S sensors will connect to a single CID system. The CID will simulate ATC facilities for non-netted sensor performance testing. The CID will transmit messages to each Mode S sensors as predefined in a scenario file. No exchange of messages between the Mode S sensors will occur through the CID system.

4.1.2.2.1 Test Case 3 -- Nonselective Acquisition.

Objective.

The objective of this test case is to determine how well network management accomplishes its function of insuring adequate surveillance of and communication with aircraft in areas of non-netted sensor coverage. The assignment of transponder lockout to all-call interrogations will be assessed. The local sensor priority status assignment will be assessed. Nonselective acquisition will be used.

Test Description.

The nonselective acquisition surveillance testing will be accomplished by utilizing live-flight data. The test aircraft will be flown within the surveillance areas for the non-netted sensors.

The characteristics of the Mode S non-netted sensors will be determined as a function of the live target scenarios in terms of:

a. Lockout management
b. Sensor priority status

These parameters will be obtained from DR&A programs resident on the PSF which will compare data tapes extracted simultaneously on the CID and both Mode S sensor.

Data Analysis.

The data gathered during the testing phase will be analyzed in detail to provide a comprehensive analysis of the non-netted sensor surveillance performance. Data analysis will consist of subjecting data tapes extracted simultaneously on the Mode S sensors, and the CID to:

a. Quick Look plots and listings
b. Track level analysis
c. Live world analysis
d. Data link analysis
e. Network management analysis

Appendix E refers to descriptions of the above analysis methods.

The listing will be tabulated by scan for each aircraft to determine the amount and percentages of received target reports.

Support Requirements.

a. Test aircraft equipped with ATCRBS and Mode S transponders
b. FAA-preapproved flight plans
c. FAA Technical Center PSF
d. CID

Criteria Of Success.

The data extracted from this testing will be subjected to the following criteria to determine if the test objectives are successfully verified.

a. Transponder lockout to all-call interrogations is correctly managed by the sensor for the targets in the scenario.

b. The local sensor priority status assignments are performed correctly.

c. To determine the ability of the non-netted sensor to correctly transmit uplink messages to and correctly process downlink messages from targets in areas of single and common coverage.

4.1.2.2.2 Test Case 4 -- Site-Addressed Acquisition.

Objective.

The objective of this test case is to determine how well two non-netted sensors can accomplish their function of insuring adequate surveillance of and communication with aircraft when site-addressed acquisition is used.

Test Description.

The site-addressed acquisition testing will be accomplished by utilizing live-flight data. The test aircraft will be flown within the surveillance areas for the non-netted sensors. The performance of the Mode S non-netted sensors will be determined as a function of the live target scenarios in terms of site-addressed lockout management. The performance parameters will be obtained from DR&A programs resident on the PSF which will compare data tapes extracted simultaneously on the CID and both Mode S sensor.

Data Analysis.

The data gathered during the testing phase will be analyzed in detail to provide a comprehensive analysis of the site-addressed non-netted sensor surveillance performance. Data analysis will consist of subjecting data tapes extracted simultaneously on the Mode S sensors, and the CID to:

a. Quick Look plots and listings
b. Track level analysis
c. Live world analysis
d. Data link analysis
e. Network management analysis

Appendix E refers to descriptions of the above analysis methods.

The listing will be tabulated by scan for each aircraft to determine the amount and percentages of received target reports.

Support Requirements.

a. Test aircraft equipped with ATCRBS and Mode S transponders
b. FAA-preapproved flight plans
c. FAA Technical Center PSF
d. CID

Criteria Of Success.

The data extracted from the site-addressed acquisition testing will be subjected to the following criteria to determine if the test objectives are successfully verified.

a. Transponder lockout to Mode S only all-call interrogations is correctly managed by the sensor for the targets in the live aircraft scenario.

b. The non-netted sensors correctly transmit uplink messages to and correctly process downlink messages from targets in areas of single and common coverage.

4.1.3 Category 3: Mode S Sensor -- Sensor Adaptation Performance.

The Sensor Adaptation Performance tests are intended to determine the impact of varying selected system adaptation parameters on the baseline performance of the Mode S sensor. A secondary effort of this test will be to determine the sensor performance when subjected to target and communication loads in excess of the accepted baseline levels. These levels, as well as the selected adaptation

parameters, will be determined after the category 1 testing is complete and the category 1 baseline report has been written. The test procedures for category 3 will then be written using that data. The adaptation performance testing is not addressed by NAS, therefore, there are no TVRTM requirements to be fulfilled by this testing.

The adaptation performance tests are subdivided into Site Adaptation Parameter Optimization, Surveillance Stress, and Data Link Stress. Most testing will be performed using simulated data obtained from the ARIES and CID. Some parameter optimization testing will utilize targets of opportunity. Separate testing will be conducted on terminal and en route sensors.

4.1.3.1 Test Case 1 -- Site Adaptation Parameter Optimization.

Objective.

The objective of this test is to determine the optimum settings for selected Mode S site adaptable parameters. An additional objective is to develop a set of procedures that may be used for further optimization efforts.

Test Description.

Tests will be conducted utilizing simulated dynamic targets in the same scenarios as used in category 1 baseline testing. Some testing will utilize targets of opportunity to reinforce the results determined during the simulated target tests. Selected Mode S sensor site adaptable parameters will be evaluated at different settings.

During this phase of optimization testing, the surveillance characteristics of the Mode S sensor will be compared against the category 1 baseline data in terms of:

a. Target Pd
b. ATCRBS and Mode S code reliability
c. Altitude reporting reliability
d. ATCRBS replies per report
e. Mode S interrogation rate per target
f. Beacon blip/scan ratio

The data link characteristics of the Mode S sensor will be compared against the category 1 baseline data in terms of:

a. Message uplink delay
b. Message downlink delay
c. Message prioritization
d. Mesage sending capacity
e. Message receiving capacity
f. Message storage uplink
g. Message storage downlink

These parameters will be obtained from:

a. DR&A programs resident on the PSF which will compare data tapes extracted simultaneously on the ARIES and Mode S sensor, and/or

b. Analysis programs resident on the TRACS.

Data Analysis.

The data extractions gathered during the test conduct phase will be analyzed in detail to provide a comprehensive analysis of a Mode S sensor's performance varying as a function of different site adaptable parameter settings. Data analysis will consist of subjecting data tapes extracted simultaneously on the Mode S sensor, TRACS, CID, and the ARIES for each tested scenario to:

a. Quick Look plots and listings
b. ARIES/Mode S analysis
c. Channel management statistics
d. TRACS programs
e. Data link analysis

Appendix E refers to descriptions of the above analysis methods.

Support Requirements.

a. ARIES Test Unit
b. CID
c. FAA Technical Center PSF
d. TRACS

Criteria Of Success.

The data extracted from this testing will be subjected to the following criteria to determine the optimum settings for selected site adaptable parameters:

a. All transponder-equipped aircraft targets with a reply Pd of greater than 0.99, a probability of constant false alarm less then 10**-6, and a received reply power of -76 dBm shall be detected

b. Beacon blip/scan ratio
    ATCRBS---greater than 0.97
    Mode S---greater than 0.98

c. Effective blip/scan ratio (includes radar substitution)
    ATCRBS---greater than 0.99
    Mode S---greater than 0.99

d. Report Code validity
    ATCRBS---greater than 0.97
    Mode S---greater than 0.999

e. Report Altitude validity
    ATCRBS---greater than 0.95
    Mode S---greater than 0.999

f. False reports due to splits and fruit
ATCRBS---less than 0.3 percent
Mode S---less than 0.1 percent

g. Track swaps
ATCRBS---less than 1 percent
Mode S---not applicable

h. Time in storage (correlating user)
ATCRBS---less than 3/32 scan
Mode S---less than 3/32 scan

i. Average reinterrogation rate
ATCRBS---not applicable
Mode S---less than 0.10

j. Uplink messages shall not be delayed more than 1/16 of a scan period from the time received by the sensor until the time they are processed and made available for delivery to the addressed aircraft.

k. Downlink communications shall not be delayed more than 1/16 of a scan period from the time received by the sensor until the time they are made available for transmission from the sensor to their specified destination.

l. In circumstances when there is insufficient time to complete a Mode S roll-call on all targets within a beam dwell, the following priority basis shall be used to allocate the available time:

1. Surveillance and high priority standard length messages
2. High priority uplink ELM
3. Low priority standard length messages
4. Low priority uplink ELMs
5. Downlink ELMs

m. Any transactions with an aircraft that are not completed shall be placed on the next schedule, subject to the following priority basis:

1. Surveillance and high priority standard length messages
2. High priority uplink ELM
3. Low priority standard length messages
4. Low priority uplink ELMs
5. Downlink ELMs

n. The sensor shall be able to receive or output data link messages for 700 Mode S-equipped aircraft per scan.

o. The sensor shall be able to receive or output data link messages for the following per scan target capacity scenarios:

1. Any mixture of 700 Mode S and ATCRBS beacon targets.
2. 1000 primary radar target reports.
3. Nonuniform beacon target distribution of:

(a) 250 targets within a 90° quadrant;

(b) 50 targets within a 11.25° sector for up to 4 consecutive sectors;
(c) 32 targets within a 2.4° wedge.

p. The Mode S sensor shall be able to efficiently utilize the data channel under the conditions listed in the data link peaking scenario described in the TVRTM (1630) (table 3.2.1.1.6.2.13-1) requirement.

q. The Mode S sensor shall be able to provide data link message storage for 4800 uplink messages.

r. The Mode S sensor shall be able to provide data link message storage for 1100 downlink messages.

4.1.3.2 Test Case 2 -- Surveillance Stress.

Objective.

The objective of this test is to determine how the sensor's surveillance performance degrades when subjected to more targets or fruit than the maximum level accepted in category 1 baseline tests.

Test Description.

Tests will be conducted utilizing simulated dynamic targets to determine the sensor surveillance performance when subjected to target and fruit loads beyond the accepted baseline capacity. The dynamic targets will be generated via ARIES scenarios and will represent ATCRBS and Mode S targets.

During this phase of stress testing, the surveillance characteristics of the Mode S sensor will be compared against the category 1 baseline data in terms of:

a. ATCRBS and Mode S code reliability
b. Altitude reporting reliability
c. ATCRBS replies per report
d. Mode S interrogation rate per target
e. Beacon blip scan ratio

These parameters will be obtained from:

a. DR&A programs resident on the PSF which will compare data tapes extracted simultaneously on the ARIES and Mode S sensor, and/or

b. Analysis programs resident on the TRACS.

Data Analysis.

The data extractions gathered during the test conduct phase will be analyzed in detail to provide a comprehensive analysis of a Mode S sensor. Data analysis will consist of subjecting data tapes extracted simultaneously on the Mode S sensor, TRACS, and the ARIES for each tested scenario to:

a. Quick Look plots and listings
b. ARIES/Mode S analysis

c. Channel management statistics
d. TRACS programs

Appendix E refers to descriptions of the above analysis methods.

Support Requirements.

a. ARIES Test Unit
b. FAA Technical Center PSF
c. TRACS

Criteria Of Success.

The data extracted from the surveillance testing will be subjected to the following criteria to determine when, and to what extent, the Mode S sensor surveillance capability has degraded from baseline.

a. Beacon blip/scan ratio
   ATCRBS---greater than 0.97
   Mode S---greater than 0.98

b. Effective blip/scan ratio (includes radar substitution)
   ATCRBS---greater than 0.99
   Mode S---greater than 0.99

c. Report Code validity
   ATCRBS---greater than 0.97
   Mode S---greater than 0.999

d. Report Altitude validity
   ATCRBS---greater than 0.95
   Mode S---greater than 0.999

e. False reports due to splits and fruit
   ATCRBS---less than 0.3 percent
   Mode S---less than 0.1 perccent

f. Track swaps
   ATCRBS---less than 1 percent
   Mode S---not applicable

g. Time in storage (correlating user)
   ATCRBS---less than 3/32 scan
   Mode S---less than 3/32 scan

h. Average reinterrogation rate
   ATCRBS---not applicable
   Mode S---less than 0.10

4.1.3.3 Test Case 3 -- Data Link Stress.

Objective.

The objective of this test is to determine how the sensor's data link performance degrades when subjected to communications loads beyond the maximum load accepted in category 1 baseline tests.

Test Descriptions.

Tests will be conducted utilizing simulated messages to determine the sensor data link performance when subjected to communication loads beyond accepted baseline capacity. Dynamic input from the ARIES and CID will be used to create various Mode S and ATCRBS message scenarios. It should be noted that data link messages cannot be transmitted without the presence of Mode S surveillance targets.

During this phase of stress testing, the data link characteristics of the Mode S sensor will be compared against the category 1 baseline data in terms of:

a. Message uplink delay
b. Message downlink delay
c. Message prioritization
d. Mesage sending capacity
e. Message receiving capacity
f. Message storage uplink
g. Message storage downlink

All CID, ARIES, and Mode S data will be recorded on magnetic tape to facilitate DR&A program use in the evaluation process.

Data Analysis.

The data gathered during the test conduct phase will be analyzed in detail to provide a comprehensive analysis of a Mode S sensor. Data analysis will consist of subjecting data tapes extracted simultaneously from the Mode S sensor, the ARIES, and the CID for each tested scenario to:

a. Quick Look plots and listings
b. ARIES/Mode S analysis
c. Data link analysis
d. Mode S/CID analysis
e. Channel management statistics

Appendix E refers to descriptions of the above analysis methods.

Support Requirements.

a. ARIES
b. CID
c. FAA Technical Center PSF

Criteria Of Success.

The data extracted from the data link testing will be subjected to the following criteria to determine when, and to what extent, the Mode S sensor data link capability has degraded from baseline.

a. Uplink messages shall not be delayed more than 1/16 of a scan period from the time received by the sensor until the time they are processed and made available for delivery to the addressed aircraft.

b. Downlink communications shall not be delayed more than 1/16 of a scan period from the time received by the sensor until the time they are made available for transmission from the sensor to their specified destination.

c. In circumstances when there is insufficient time to complete a Mode S roll-call on all targets within a beam dwell, the following priority basis shall be used to allocate the available time:

1. Surveillance and high priority standard length messages
2. High priority uplink ELM
3. Low priority standard length messages
4. Low priority uplink ELMs
5. Downlink ELMs

d. Any transactions with an aircraft that are not completed shall be placed on the next schedule, subject to the following priority basis:

1. Surveillance and high priority standard length messages
2. High priority uplink ELM
3. Low priority standard length messages
4. Low priority uplink ELMs
5. Downlink ELMs

e. The sensor shall be able to receive or output data link messages for 700 Mode S-equipped aircraft per scan.

f. The sensor shall be able to receive or output data link messages for the following per scan target capacity scenarios:

1. Any mixture of 700 Mode S and ATCRBS beacon targets.
2. 1000 primary radar target reports.
3. Nonuniform beacon target distribution of:

   (a) 250 targets within a 90° quadrant;
   (b) 50 targets within a 11.25° sector for up to four consecutive sectors;
   (c) 32 targets within a 2.4° wedge.

g. The Mode S sensor shall be able to efficiently utilize the data channel under the conditions listed in the data link peaking scenario described in the TVRTM (1630) (table 3.2.1.1.6.2.13-1) requirement.

h. The Mode S sensor shall be able to provide data link message storage for 4800 uplink messages.

i. The Mode S sensor shall be able to provide data link message storage for 1100 downlink messages.

5. TEST PLAN ACTIVITY FLOW.

The sequence of the Mode S performance test activities conducted at the FAA Technical Center are presented in the following subsections.

Figure 5-1 depicts the overall flow of FAA Technical Center activities that are related to the Mode S performance testing. From this figure, it is evident that the Mode S contractor will deliver and perform installation and checkout on the two Mode S sensors scheduled for the FAA Technical Center. During this time, ACN-220, ACN-320, and ASM-160 will ensure that an accurate inventory of deliverables is recorded. Once these activities have been accomplished, the contractor shall then proceed with their System Acceptance Test activities.

Following these contractor activities, ACN-220 will accept the Mode S for verification. First, a Test Readiness Review (TRR) shall be conducted and an overall assessment of the availability and completeness of the performance test materials will be discussed. This review will be conducted by ACN-220 prior to the commencement of the performance testing.

Upon completion of the performance testing, another TRR will be conducted to discuss the readiness to proceed into the next phase of verification at the FAA Technical Center, the Integration Testing and Shakedown. Once the decision to proceed has been made, ACN-220 shall conduct the Integration Testing, and ASM-160 will perform the Shakedown Testing.

6. TESTING ORGANIZATIONAL ROLES AND RESPONSIBILITIES.

This section describes the roles and responsibilities of the FAA and other organizations that will be participating in the MODE S performance test activities conducted at the FAA Technical Center. The participating personnel are divided into two groups; Test Management and Test Support.

6.1 TEST MANAGEMENT GROUP.

The function of this group is to direct all test efforts relative to the Mode S performance test activity. This group will be comprised of representatives from ACN-220. Specific responsibilities of the Test Management group are as follows:

a. Establish policies related to the Mode S Test and Evaluation (T&E) activities.

b. Concur with all test plans and procedures related to Mode S T&E activities.

c. Distribute Mode S T&E activity-related documentation to all participating organizations for review.

d. Assign roles and responsibilities to the Mode S Test Support group.

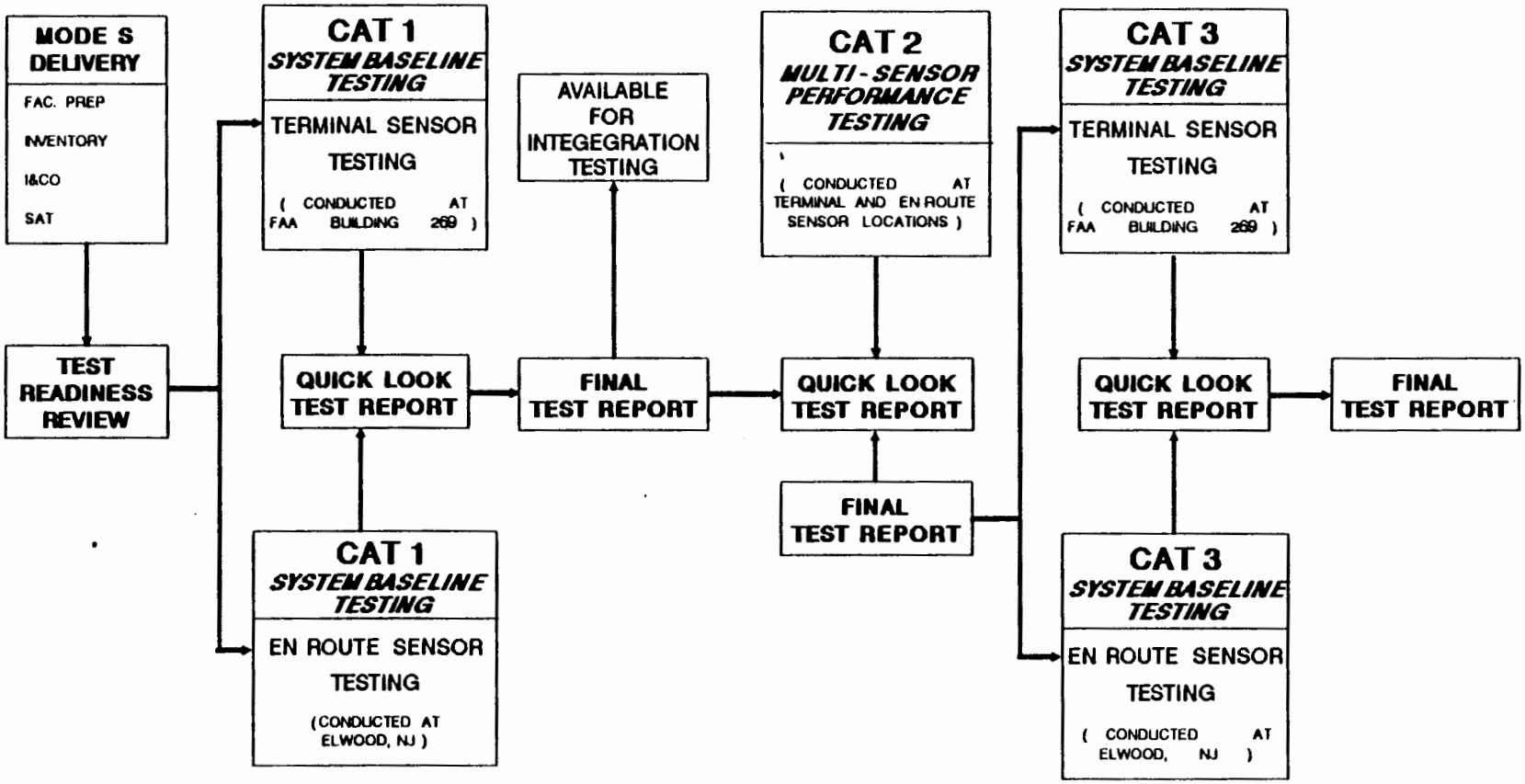

FIGURE 5-1. MODE S PERFORMANCE ACTIVITY FLOW DIAGRAM

6.2 TEST SUPPORT GROUP.

The Mode S Test Support group will consist of a group of specialists who are knowledgeable in specific technical areas. The role of this group will be to support the Mode S Test Management group in developing test requirements, plans, procedures, scenarios, and other test support tools. This group will also assist in conducting tests, performing test analysis, and producing test reports. The Mode S Test Support group will be comprised of personnel from organizations shown in table 6-1. Responsibilities of the members are also noted.

6.3 TEST MANAGER (ACN-220).

There will be one test manager assigned to each performance test. The test manager's duties include: scheduling the required facilities, assigning duties to the test team members, conduct the pretest and post-test reviews, as well as, supervising the collection of test data. The test manager will be responsible for the data reduction and analysis, and associated documentation and reports required by each test.

TABLE 6-1. MODE S FAA TECHNICAL CENTER PERFORMANCE TEST SUPPORT GROUP RESPONSIBILITIES

Government/FAA	Primary Roles/Functions
ACN-220	Prepare test plans and procedures; conduct testing; prepare test results following test completion; coordinate and schedule all Mode S Performance Test activities; determine noncritical/critical test requirements; provide test coordination services and direction for the implementation of this plan and issue final test reports.
AES-210	Provide NAS system-level requirements.
ASM-160	Provide assistance and support to the implementation of this plan by reviewing test plans, test data, and test reports.
ACN-300	Operate and maintain the test facility laboratories.

Support Contractor	Roles/Functions
Joint Venture (JV)	As directed by the Mode S Program Manager (ASA-110), the JV will provide training support and contractor test documentation, as well as assistance and corrective action in the event of test malfunction.
System Engineering and Integration Contractor (SEIC)	Support Mode S test activities, as directed by ACN-220.

7. DOCUMENTATION REQUIREMENTS AND CONTROL.

This section describes the method that will be utilized to ensure traceability of requirements to the test categories and test cases defined in section 4 of this plan and also identifies the test documentation, reviews, and reports that are necessary for performance testing. The TVRTM contained in appendix B identifies the Mode S requirements that will be verified through Mode S performance testing. This matrix was developed using FAA-STD-024a, appendix IV as a guide to outline the NAS-SS-1000 requirements.

7.1 DOCUMENTATION.

The required documents for planning, conducting, and reporting the Mode S performance test activities, are presented below. Figure 7-1 illustrates the sequence of documentation preparation while table 7-1 defines each product and when it should be completed.

7.1.1 Performance Test Plan.

This plan establishes the test configurations, requirements, objectives, and general test descriptions.

7.1.2 Test Procedures.

The test procedures will contain instructions for testing the requirements associated with each test category. Included will be detailed instructions for data analysis. A checklist of the materials needed for the test will be included within each procedure.

7.1.3 Test Mission Log.

The Test Mission Log shall be completed by the test manager during the pretest review. This log will contain any open items (TBDs or discrepancies from the test procedure), the test objectives, the hardware/software configuration, a list of test team members and their assignments.

7.1.4 Test Conduct Log.

The Test Conduct Logs will be used by the test team members to record specific events during the test (as noted by the test procedure).

7.1.5 Test Summary Log.

The Test Summary Log shall be completed by the test manager during the post-test review. This log will be used to record any deviations from the test procedures that had not been noted in the Test Mission Log. The log will also contain a summary of the test conduct and a preliminary assessment of the test results.

```
 _____________________________
>      Performance Test Plan  >
>_____________TVRTM_________>

 _____________________________
>      Performance Test       >
>_________Procedures_________>

 _____________________________
>    Pretest Review Documents >
>      Test Mission Log       >

 _____________________________
>      Actual Test Documents  >
>        Test Conduct Log     >
>        Test Anomaly Reports >
>_____________________________>

 _____________________________
>    Post-Test Review Documents >
>       Test Summary Log      >

 _____________________________
>     Quick Look Test Report(s) >
>_____________________________>

 _____________________________
>       Final Test Report(s)  >
>_____________________________>
```

FIGURE 7-1. MODE S PERFORMANCE TEST DOCUMENTATION FLOW

TABLE 7-1. TEST LOGS/DOCUMENTS/REPORTS MATRIX

Logs/Documents/Reports	Required Completion	Assigned To
Performance Test Plan	February/1989	ACN-220
Performance Test Procedures	To be determined (TBD)	ACN-220
Test Mission Log	Pretest review	Test Manager
Test Conduct Log	During test	Test Manager
Quick Look Test Report	15 days after test	Test Manager
Final Test Report	30 days after performance testing is completed.	Test Director

7.1.6 Test Anomaly Report.

The Test Anomaly Reports shall be completed by the test manager during the post-test review. Test Anomaly reports shall be written to describe any hardware/software/system anomalies encountered during the test. These reports shall list in detail as much information about the anomaly as is known. Anomaly reports will be assigned for further investigation and may result in the writing of trouble reports on the various hardware/software/systems involved.

7.1.7 Quick Look Test Reports.

For each test category, a Quick Look Test Report will be produced by the test manager within 15 working days after test completion. The report will provide an indication of the outcome of the test and will highlight any test discrepancies and their significance. The report will present the data collected, the evaluation methods used, and a summary of the evaluation results.

7.1.8 Final Performance Test Report.

A Final Performance Test Report will be produced and delivered to the Mode S program manager within 30 working days after the final test has been run. The report will document the results of the test analysis and assess the sensor's ability to perform the required tasks. The Final Performance Test Report will contain the following:

a. Description of the test configurations.

b. Reference to the applicable test plan and procedures.

c. Identification of the specific tests and the dates of the test runs.

d. The specific test objectives, including reference to applicable requirements and specifications.

e. A description of the criteria used for evaluation of each test, including the range of data and parameter values tested.

f. A summary of the results of each test. A matrix will also be included that translates the test results into the success criteria and compares it with the specification requirement.

g. Detailed test results listing the results of the test based on the data collected during the test. For each step of a test procedure where a discrepancy occurred, identification of the procedure step number, the expected response, the actual response, the significance of the discrepancy, and the impact of the discrepancy on the validity of preceding or following steps of the test procedure shall be provided.

h. Conclusions and Recommendations - An overall analysis of the Mode S System functional performance will describe the functional capability as demonstrated in the performance testing. If applicable, this section will include assessment of the manner in which the test environment is different from the operational environment and its effect on the functional performance capability. A conclusion statement will be provided for each operational deficiency, describing its impact on the Mode S System, as well as recommendations for correcting or otherwise overcoming the operational deficiency.

7.2 REVIEWS.

The following subsections describe the pretest reviews and the post-test reviews that will be held for each performance test. These reviews will be chaired by the test manager and attended by the other members of that test's test team.

7.2.1 Pretest Review.

This review will be scheduled prior to the start of the test. The purpose of this review will be to accomplish the following:

a. Identify any needed changes and redline the procedures accordingly.

b. Review the hardware and software configurations of the test environment.

c. Ensure that all items in the material check list (contained in the test procedure) have been received.

d. Generate a record of the pretest briefing minutes.

7.2.2 Post-Test Review.

This review will be held upon test completion. The test manager will prepare a post-test review package. This package will include the following:

a. The "as-run" hardware and software configuration.

b. Any procedure step or configuration deviations, test discrepancies, anomalies and their significance to the test results.

c. A summary of the outcome of the test. This summary will be derived by reviewing the following:

1. The preliminary test assessment
2. All Test Conduct Logs
3. Any preliminary data analysis
4. All test anomaly reports generated

8. PERFORMANCE TESTING TRAINING.

The contractor will provide training for test personnel as required by the Mode S contract. This training will be in the form of 4 weeks of on-the-job training (OJT), which will take place prior to acceptance testing of the FAA Technical Center terminal Mode S sensor.

9. ACRONYMS.

ARIES	Aircraft Reply and Interference Environmental Simulator
ARTCC	Air Route Traffic Control Center
ATC	air traffic control
ATCRBS	air traffic control radar beacon system
BFTA	Beacon False Target Analysis
CD	Common Digitizer
CID	Communications Interface Driver
COMDIG	Common Digitizer Data Reduction
CPME	Calibration Performance Monitoring Equipment
dBm	decibels above 1 milliwatt
DR&A	data reduction and analysis
ELM	extended length messages
FAA	Federal Aviation Administration
JV	Joint Venture
MCU	modulator control unit
NAS	National Airspace System
nmi	nautical miles
OJT	on-the-job training
PAM	peripheral adapter module
Pd	probability of detection
Pfa	probability of false alarm
PSF	Programming Support Facility
PT&E	Performance Test and Evaluation
QARS	Quick Analysis of Radar Sites
rms	root mean square
RSCANS	Radar Statistical Coverage Analysis
RTQC	real-time quality control
SEIC	System Engineering and Integration Contractor
SLT&E	System Level Test and Evaluation
SPSS	Statistical Package for the Social Sciences
T&E	Test and Evaluation
TBD	to be determined
TRACON	Terminal Radar Approach Control
TRACS	Transportable Radar Analysis Computer System
TRR	Test Readiness Review
TVRTM	Test Verification Requirements Traceability Matrix

APPENDIX A

SAMPLE FORMS

MODES TEST CONDUCT LOG

DEVICE/POSITION: _____ PAGE _____ of _____
TEST: _____ DATE: _____/_____/_____

Procedure Step Page	Action Output Produced	Observations Noted
_____/	_____/	_____
_____/	_____/	_____
_____/	_____/	_____
_____/	_____/	_____
_____/	_____/	_____
_____/	_____/	_____
_____/	_____/	_____
_____/	_____/	_____
_____/	_____/	_____
_____/	_____/	_____
_____/	_____/	_____

TEST MANAGER _____

TEST MISSION LOG
OPEN ITEM STATUS SHEET

PROCEDURE # _____ PAGE ____of _____

TEST MANAGER _____ DATE ____/____/___

OPEN ITEM ID NUMBER	DISPOSITION/ACTION	QUALITY CONCURRENCE

TEST MISSION LOG

TEST PROCEDURE # _____ PAGE _____OF _____

TEST MANAGER _____ DATE _____/____/____.

TEST OBJECTIVES:

(1)
(2)
(3)

HARDWARE CONFIGURATION

SOFTWARE CONFIGURATION

LIST OF PARTICIPANTS

1.
2.
3.
4.

TEST SUMMARY LOG

TEST NUMBER: _____ DATE: _____

TEST TITLE: _____ TEST MANAGER: _____

PROCEDURE STEP	DATA RECORDED	SIGNIFICANT RESULTS/OBSERVATION NOTED

TEST SUMMARY LOG

TEST NUMBER:_____ DATE: ____/____/_____

TEST TITLE:_____

PRELIMINARY ASSESSMENT OF TEST RESULTS:

_____

_____

_____

_____

_____

_____

_____

ANOMALIES and DEVIATIONS:

_____

_____

_____

_____

TEST MANAGER _____

APPENDIX B

MODE S PERFORMANCE TEST VERIFICATION REQUIREMENTS TRACEABILITY MATRIX (TVRTM)

TVRTM Title: MODE S PERFORMANCE TEST PLAN

TVRTM Legend: _____

Test Levels

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Locations
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KS - Key Site

Criticality
C - Critical
NC - Non-Critical

Test Plan Cross Reference
CAT 1 - Baseline Performance
CAT 2 - Multi-sensor Performance
CAT 3 - Adaptation Performance

Verification Methods
I - Inspection
A - Analysis
T - Test
D - Demonstration
NA - Not Applicable

UNIQUE PERFORMANCE REQ No	NAS-SS-1000 REQUIREMENT STATEMENT	Test Levels: Operational OT&E/SD	Test Levels: System SLTE	Test Levels: System NAS INTE	Test Locations: TC	Test Locations: KS	Criticality C/NC	Test Plan Cross Reference: CAT 1	Test Plan Cross Reference: CAT 2	Test Plan Cross Reference: CAT 3	Organization Responsible For Test Plan/Conduct	Verification Method	Referenced Paragraph in MTP
1100	Verify Mode S reduces false target reports that result from multipath effects. (AES OT&E Requirement 2.4)	X			X		C	X			ACN-220	T	6.2.1.1
1110	Verify Mode S reduces garble by use of monopulse beacon operations. (AES OT&E Requirement 2.5)	X			X		C	X			ACN-220	T	6.2.1.1
1120	Verify Mode S reduces garble by use of Mode S aircraft interrogation capability. (AES OT&E Requirement 2.5)	X			X		C	X			ACN-220	T	6.2.1.1
1200	Mode S shall detect all transponder equipped aircraft targets (within the detection envelope specified in 3.2.1.1.6.2.1) with a reply probability of detection (Pd) greater than 0.99, with a probability of constant false alarm (Pfa) less than 10-6 in any one second, when received reply power is greater than -76 decibels below the level of a milliwatt (dBm) referenced to the sensor RF port in the absence of signal (RF) interference. (3.2.1.1.6.2.2)		X		X		NC	X		X	ACN-220	T	6.2.1.1

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1210	Mode S shall detect all transponder equipped aircraft targets (within the detection envelope specified in 3.2.1.1.6.2.1) with a sensor-only range error not exceeding + or - 30 feet bias (including long term drift) and 25 feet rms jitter for Mode S reports. (3.2.1.1.6.2.3)		X		X		NC	X			ACN-220	T	6.2.1.1
1220	Mode S shall detect all transponder equipped aircraft targets (within the detection envelope specified in 3.2.1.1.6.2.1) with a sensor-only range error not exceeding + or - 30 feet bias (including long term drift) and 25 feet rms jitter for ATCRBS reports. (3.2.1.1.6.2.3)		X		X		NC	X			ACN-220	T	6.2.1.1
1230	Mode S shall detect all transponder equipped aircraft targets (within the detection envelope specified in 3.2.1.1.6.2.1 and using the government furnished five-foot open array antenna) with a long term combined sensor plus antenna azimuth accuracy for Mode S reports, which shall not exceed: a. bias of + or - 0.033 degrees for elevation angles less than 2 degrees. (exclusive of antenna windload but including long term drift); (3.2.1.1.6.2.4.a)		X		X		NC	X			ACN-220	T	6.2.1.1

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	b. Jitter less than 0.060 degrees, 1 Sigma for elevation angles less than 20 degrees) (3.2.1.1.6.2.4.b)												
1240	Mode S shall detect all transponder equipped aircraft targets (within the detection envelope specified in 3.2.1.1.6.2.1 and using the government furnished five-foot open array antenna) with a long term combined sensor plus antenna azimuth accuracy for ATCRBS reports, which shall not exceed: a. bias of + or - 0.033 degrees for elevation angles less than 2 degrees. (exclusive of antenna windload but including long term drift); (3.2.1.1.6.2.4.a)		X		X		NC	X			ACN-220	T	6.2.1.1
	b. Jitter less than 0.060 degrees, 1 Sigma for elevation angles less than 20 degrees) (3.2.1.1.6.2.4.b)												
1250	Mode S shall detect all transponder equipped aircraft targets (within the detection envelope specified in 3.2.1.1.6.2.1) at a rate identical to that of the associated primary radar (3.2.1.1.6.2.5)		X		X		C	X			ACN-220	T	6.2.1.1

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1260	Mode S shall detect all transponder equipped aircraft targets (within the detection envelope specified in 3.2.1.1.6.2.1) at a rate of 12 seconds, +1.33 or −1.09 seconds for stand-alone Mode S sensors (3.2.1.1.6.2.5).		X		X		C	X			ACN-220	T	6.2.1.1
1300	The Mode S sensor shall generate an ATCRBS/Mode S All Call interrogation type. (3.2.1.1.6.2.6)		X		X		NC	X			ACN-220	T	6.2.1.1
1310	The Mode S sensor shall generate an ATCRBS Only All Call interrogation type. (3.2.1.1.6.2.6)		X		X		NC	X			ACN-220	T	6.2.1.1
1320	The Mode S sensor shall generate an ATCRBS interrogation type. (3.2.1.1.6.2.6)		X		X		NC	X			ACN-220	T	6.2.1.1
1330	The Mode S sensor shall generate an Mode S All Call interrogation type. (3.2.1.1.6.2.6)		X		X		NC	X			ACN-220	T	6.2.1.1

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1340	The Mode S sensor shall generate an Mode S Roll Call interrogation type. (3.2.1.1.6.2.6)		X		X		NC	X			ACN-220	T	6.2.1.1
1350	The Mode S sensor shall be capable of interlacing patterns of the beacon modes (2, 3A, B, C, D) in the ATCRBS interrogations; (3.2.1.1.6.1.2.b)		X		X		C	X			ACN-220	T	6.2.1.1
1400	The Mode S sensor shall delay uplink data link messages no more than 1/16 of a scan period from the time of receipt until they are processed and available for delivery to discretely addressed Mode S transponder equipped aircraft (3.2.1.1.6.2.9) (Additional processing as specified in 3.2.1.1.6.2.10 shall be accomplished. except when collocated with an ASR-9)		X		X		NC	X			ACN-220	T	6.2.1.1
1410	The Mode S sensor shall delay downlink data link messages no more than 1/16 of a scan period from the time the message is received until it is available for transmission from the sensor to the destinations specified in Table 3.2.1.1.6.3-1. (3.2.1.1.6.2.9) (Additional processing as specified in 3.2.1.1.6.2.10 shall be accomplished. except when collocated with an ASR-9)		X		X		NC	X			ACN-220	T	6.2.1.1

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1500	When sufficient time exists to complete a Mode S roll-call on all targets within a beam dwell the Mode S sensor shall allocate the available time on the following priority basis: 1. Surveillance and high priority standard length messages; 2. High priority uplink extended length messages (ELM); 3. Additional (lower priority) standard length messages; 4. Uplink ELM's; 5. Downlink ELM's. (3.2.1.1.6.1.5.a)		X		X		NC	X			ACN-220	T	6.2.1.3
1510	Transactions not completed on an aircraft shall be placed on the next schedule, subject to the following priority basis: 1. Surveillance and high priority standard length messages; 2. High priority uplink extended length messages (ELM); 3. Additional (lower priority) standard length messages; 4. Uplink ELM's; 5. Downlink ELM's. (3.2.1.1.6.1.5.a)		X		X		NC	X			ACN-220	T	6.2.1.3

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1600	The Mode S sensor shall accept target replies and prepare output surveillance reports (selected entities from Table 3.2.1.1.6.3-1) subject to the following per scan capacities: a. Any mixture of 700 Mode S and ATCRBS beacon tartgets. b. 1000 primary radar target reports c. Non-uniform beacon target distribution of: (1) 250 targets within a 90 degree quadrant; (2) 50 targets within a 11.25.degree sector for up to 4 consecutive sectors; (3) 32 targets within a 2.4 degree wedge. These surveillance target capacities shall be met simultaneously for a uniform range distribution of targets within 50 nmi using 2.4 degrees beamwidth and a 4.8 second scan rate. These conditions may occur consecutively in any order. (3.2.1.1.6.2.11)	X		X		NC	X			ACN-220	T	6.2.1.1/6.2.1.
1610	The Mode S sensor shall be capable of receiving or outputting data link messages for 700 Mode S equipped aircraft per scan. (3.2.1.1.6.2.12)	X		X		NC	X			ACN-220	T	6.2.1.1

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UNIQUE PERFO-RMANCE REQ No	NAS-SS-1000 REQUIREMENT STATEMENT	Test Levels: Operational OT&E/SD	System SLTE	System NAS INTE	Test Locations TC	Test Locations KS	Criticality C/NC	Test Plan Cross Reference CAT 1	CAT 2	CAT 3	Organization Responsible For Test Plan/Conduct	Verification Method	Referenced Paragraph in MTP
1620	The Mode S sensor shall be capable of receiving or outputting data link messages under following per scan target capacities: a. Any mixture of 700 Mode S and ATCRBS beacon tartgets. b. 1000 primary radar target reports c. Non-uniform beacon target distribution of: (1) 250 targets within a 90 degree quadrant; (2) 50 targets within a 11.25 degree sector for up to 4 consecutive sectors; (3) 32 targets within a 2.4 degree wedge. (3.2.1.1.6.2.13.a)	X			X		NC	X			ACN-220	T	6.2.1.1

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1630	The Mode S sensor shall provide efficient data channel utilization under any data link scenario realizable within the channel time line. Demonstration of efficient data channel utilization shall be accomplished by simultaneously satisfying, within one scan, the requirements as summarized in the following data link peaking scenario:	X		X		NC	X			ACN-220	T	6.2.1.1

Table 3.2.1.1.6.2.13-1
Data Link Peaking Scenario

Type of peaking (per scan)	Number of Mode S Targets	Targets Receiving (N) Comm-A's, where N = 1	2	4	8	Targets Transmitting (N) Comm-B's, where N = (note 4) 1	2	3	4	Targets Receiving Uplink ELM's (1)	Targets Receiving Downlink ELM's (1)
2.4 degree wedge											
CASE I (2)	12	4	0	5	3	3	2	1	1	1	0
CASE II (5)	32	0	32	0	0	14	0	0	0	0	0
11.25 deg Sector (3)	50	24	0	20	6	8	4	2	2	8	3
90 deg Quadrant	250	140	0	85	25	32	16	8	8	40	15

Note: (1) 16 - Segment ELM'
(2) 12 targets in 2.4 degree wedge for two consecutive wedges;
(3) 50 targets in 11.25 degree sectors for four consecutive sectors;
(4) Includes air-initiated COMM-B as follows:
2.4 degree wedges: 5
11.25 degree sector: 8
90.0 degree quadrant: 30
No more than one message per aircraft, for 700 aircraft, uniformly distributed in range;
(5) 32 targets in 2.4 degree wedge.

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1700	The Mode S sensor shall provide data link message storage for 4800 uplink messages (3.2.1.1.6.2.14.a)		X		X		NC	X			ACN-220		6.2.1.1
1710	The Mode S sensor shall provide data link message storage for 1100 downlink messages (3.2.1.1.6.2.14.b)		X		X		NC	X			ACN-220		6.2.1.1
1800	The Mode S envelope for terminal surveillance detection and data link coverage shall include a slant range of 0.5 to 55 nmi, (3.2.1.1.6.2.1.a)		X		X		NC	X			ACN-220	T	6.2.1.1
1810	The Mode S envelope for en route surveillance detection and data link coverage shall include a slant range of 0.5 to 255 nmi, (3.2.1.1.6.2.1.a)		X		X		NC	X			ACN-220	T	6.2.1.1
1820	The Mode S envelope for surveillance detection and data link coverage shall include 360 degrees azimuth coverage. (3.2.1.1.6.2.1.b)		X		X		NC	X			ACN-220	T	6.2.1.1

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1830	The Mode S envelope for surveillance detection and data link coverage shall include altitude coverage to 100,000 ft. (3.2.1.1.6.2.1.c)		X		X		NC	X			ACN-220	T	6.2.1.1
1840	The Mode S envelope for surveillance detection and data link coverage shall include elevation coverage from 0.5 to 45 degrees, with respect to the horizontal plane tangent to the earth at the radar antenna. (3.2.1.1.6.2.1.d)		X		X		NC	X			ACN-220	T	6.2.1.1
1900	The Mode S terminal sensor shall update surveillance reports on all targets within the detection envelope every antenna scan. (3.2.1.1.6.2.7)		X		X		C	X			ACN-220	T	6.2.1.1
1910	The Mode S en route sensor shall update surveillance reports on all targets within the detection envelope twice per antenna scan when operating with a back-to-back beacon antenna, except when Mode 4 is using the front face antenna. (3.2.1.1.6.2.7)		X		X		C	X			ACN-220	T	6.2.1.1

TVRTM Title: MODE S PERFORMANCE TEST PLAN

TVRTM Legend: _____

Test Levels

Operational
OT&E/SD - Operational Test and Evaluation/Shakedown

System Level
SLTE - System Level Test and Evaluation
NAS INTE - NAS Integration Test and Evaluation

Locations
TC - FAA Technical Center
KS - Key Site

Criticality
C - Critical
NC - Non-Critical

Test Plan Cross Reference
CAT 1 - Baseline Performance
CAT 2 - Multi-sensor Performance
CAT 3 - Adaptation Performance

Verification Methods
I - Inspection
A - Analysis
T - Test
D - Demonstration
NA - Not Applicable

UNIQUE PERFO-RMANCE REQ No	NAS-SS-1000 REQUIREMENT STATEMENT	Test Levels: Operational OT&E/SD	Test Levels: System SLTE	Test Levels: System NAS INTE	Test Locations TC	Test Locations KS	Criticality C/NC	Test Plan Cross Reference CAT 1	Test Plan Cross Reference CAT 2	Test Plan Cross Reference CAT 3	Organization Responsible For Test Plan/Conduct	Verification Method	Referenced Paragraph in MTP
2000	The NAS shall provide en route cooperative surveillance coverage from 6,000 ft MSL, up to and including 60,000 ft over non-mountainous terrain, and from 6,000 ft MSL or MEA, whichever is higher, to 60,000 ft in mountainous terrain; (3.2.1.2.7.4.b)			X	X		NC	X			ACN-220	T	6.2.1.1

APPENDIX C

ARIES/CID TEST SCENARIO DESCRIPTIONS

The following paragraphs list and describe the Aircraft Reply and Interference Environmental Simulator (ARIES)/Communication Interface Driver (CID) test scenarios that will be used in Mode S performance testing. The CID will use the same scenarios that are developed for ARIES. Each target may have its own Comm-B message, but the same Comm-D message will be used for all targets.

BASIC 41. This scenario consists of 41 dynamic targets performing various types of maneuvers including straight line tracks, turning tracks, overtaking patterns, and crossing tracks. The purpose of this scenario is to gather baseline data on the sensor's ability to maintain tracking in many complex situations.

CAPACITY. This scenario begins as a light load and gradually builds to a 700 target per scan capacity load. The targets then move to the distribution defined in the FAA-E-2716 specification section 3.3.2.5. and 3.3.2.5.1. It also incorporates the data link peaking scenario defined in NAS-SS-1000 section 3.2.1.1.6.2.13. The purpose of this scenario is to gather data on the sensor's ability to handle a capacity situation.

PROBABILITY OF DETECTION. This scenario will be designed to provide the simulated targets for the probability of detection (Pd)/probability of false alarm (Pfa) measurements. The scenario will consist of orbiting targets at various ranges from the sensor. A different rf signal level for each orbiting target will be used to establish the probability of detection baseline as a function of signal strength.

REAL WORLD SIMULATIONS. These scenarios will be designed to duplicate the flight parameters of aircraft in an actual terminal or en route environment. The data used to generate the scenarios will be extracted from selected operational Terminal Radar Approach Control (TRACON) and Air Route Traffic Control Center (ARTCC) facilities. The purpose of these scenarios is to determine the surveillance and data link performance parameters using realistic simulations.

FRUIT. The three fruit scenarios are: (1) No Fruit, (2) Moderate Fruit, and (3) Heavy Fruit. Moderate fruit consists of 4,000 ATCRBS fruit per second and 50 Mode S fruit per second. Heavy fruit consists of 40,000 ATCRBS fruit per second and 200 Mode S fruit per second.

APPENDIX D

TEST TOOL DESCRIPTIONS

ARIES Test Unit.

The Aircraft Reply and Inteference Environmental Simulator (ARIES) is a capacity test device for the production Mode S beacon system. The design and development of the ARIES was the responsibility of the FAA Technical Center. The ARIES system is designed to simulate a radar beacon environment of up to 700 aircraft plus high rates of intefering beacon replies (fruit) for the purpose of testing the operation of Mode S sensors under heavy load. The ARIES equipment consists of interrogation receiving circuitry, reply generation circuitry, time of year clock, a computer system, and associated computer peripheral equipment. The computer system implemented is a Concurrent Computer Corporation model 3230 with a 800/1600 baud tape device.

Communication Interface Driver (CID) Test Unit.

The Communication Interface Driver (CID) test unit was developed by the FAA Technical Center. This test unit will be used to simulate air traffic control (ATC) messages used as input to the sensor for data link testing. It is designed to test the Mode S ATC and non-ATC communication functions under capacity conditions. The CID consists of hardware and software elements which perform the generation, simulation, and analysis of the ATC and non-ATC messages and protocols. The computer system implemented is a Concurrent Computer Corporation model 3230XP with a 1600-baud tape device.

Transportable Radar Analysis Computer System (TRACS).

The Transportable Radar Analysis Computer System (TRACS) test unit was developed by ASM-160. This test unit will be used to record and analyze Mode S data. TRACS has the capabilities of recording data from up to three 9600 baud modem channels of common digitizer (CD) formatted data. By use of a self-contained emulator board, the TRACS can run the radar analysis programs currently being used on the FAA en route radar systems. The hardware consists of a IBM PC/AT or compatible computer, modem interface board, and a IBM 370 emulator board.

APPENDIX E

DATA REDUCTION AND ANALYSIS PROGRAM DESCRIPTIONS

The three types of data reduction programs used during these tests will be:

1. Data reduction programs provided by Mode S manufacturer

   a. Quick Look
   b. Nine-Point Accuracy
   c. Live world
   d. Accuracy
   e. Tape merge

2. Data analysis programs developed by FAA Technical Center for Mode S

   a. Surveillance Analysis
   b. Channel Management Statistics
   c. Resolution Analysis
   d. Data Link Analysis
   e. Network Management Analysis
   f. Plot program
   g. Mode S/CID Compare
   h. ARIES/Mode S Compare

3. The data analysis programs that run on the Transportable Radar Analysis Computer System (TRACS)

   a. Quality Precheck
   b. Quick Analysis of Radar Sites (QARS)
   c. Beacon Code Sort
   d. Common Digitizer Record
   e. Common Digitizer Data Reduction (COMDIG)
   f. Beacon False Target Analysis (BFTA)
   g. Radar Statistical Coverage Analysis (RSCANS)

The following paragraphs describe the above listed data reduction and analysis (DR&A) programs:

Quick Look. Allows the user to view or print Mode S sensor extracted data. Category type, scan number, time of year, air traffic control radar beacon system (ATCRBS) code, Mode S address, track number, range, azimuth, and altitude are available parameters for filtering to determine which data is viewed or printed. These parameters may be grouped into logical expressions using "OR" and "AND" logic functions to produce multiple filter expressions to produce a particular type of data output. These outputs are in the form of data listings with labels specifying the type or units of the data presented.

Nine-Point Accuracy. This program uses a set of nine reported positions to calculate a line through these nine points so that smoothed position data may be extracted. This provides a means of measuring target reporting relative accuracy. Results are plotted as a function of range, azimuth, and elevation angle. A listing is produced describing the position errors.

Live World. Analyzes the performance of a Mode S sensor by tracking aircraft along a flight path and gathering statistical data on each track. The printout contains a statistical summary of sample size, probability of detection (Pd), ID reliability, altitude reliability, replies per report and extra reports.

Accuracy. Compares data from a Mode S sensor with data from the Nike tracker. Performs a statistical analysis on the positional errors. A listing is generated of selected data with corresponding range reports and the errors in the coordinates (range, azimuth, and height). The means and standard deviations are calculated and listed for inspection.

Tape Merge. The extracted data from up to three sensor tapes may be combined into a consolidated file, and this composite file can then be analyzed and/or written to tape.

Surveillance Analysis. Performs track level analysis by processing the surveillance file records recorded on a Mode S data extraction tape. This program produces three types of output; track matrices, surveillance history charts, and track summary bar charts. The track matrices will provide a large number of statistics such as, track life, blip/scan ratios, range and azimuth predicted errors, track firmness, and track initiations. The surveillance history charts will contain three lines of output for each track; track update, track status and network management information. The bar charts illustrate range or azimuth versus target range, or range error or azimuth error in frequency of occurrences.

Channel Management Statistics. Analyzes the performance of the Mode S channel management algorithms. It reduces Mode S data extraction tapes that contain the following; Channel Management Table, Channel Configuration Table, ATCRBS interrogations and replies, all-call interrogations and replies, and roll-call interrogations and replies. The program output consists of a listing, a plot of selected Mode S periods, and a statistical summary. The major statistics are; interrogation rate, reinterrogation rate, completion percentages, conforming reply percentages, successful transaction percentages, and lost channel time.

Resolution Analysis. The aircraft resolution capability of the Mode S sensor is analyzed by comparing a Mode S sensor data extraction tape against a radar tracker data extraction tape. Analyzes data from planned live-test flights of two aircraft flying at different altitudes but varying degrees of closeness in range and azimuth. Plots how often the two aircraft are resolved versus their range and azimuth separation.

Data Link Analysis. Provides a comprehensive analysis of the Data Link function. Messages are tested for proper procedural handling, correct priority, message delay times, message storage capacity, efficient data channel utilization, message error rates, message loss rates.

Network Management Analysis. Analyzes network management of the Mode S sensor by comparing sensor operation against the networking algorithm.

Plot Program. This program is capable of plotting target report data from a Mode S data extraction tape, as well as, from an ARIES data extraction tape. Plots of ARIES scenarios, and sensor outputs will be used to evaluate target conflict situations.

Mode S/CID Compare. This program is used to verify the Communications Interface Driver versus Mode S interface. Summary lists are produced, of the total number of correlated and uncorrelated messages to and from the Mode S sensor. Listings of messages that correlate or do not correlate are optional.

ARIES/Mode S Compare. The ARIES/Mode S Analysis compares data extraction tapes of targets that are simulated by ARIES and input to the sensor with the sensor surveillance data and prepares statistical analysis to portray the surveillance characteristics of the sensor. These comparisons may be done at the reply, report, surveillance file, and disseminated report level. Parameters measured include Pd, code reliability, blip/scan ratio, and round reliability.

Quality Precheck. This program is usually run before making a CD Record run, in order to validate that incoming data is from the correct facility and that the interface is working properly. The output listing is a summary that provides the following information: site ID, Search real-time quality control (RTQC) time, peripheral adapter module (PAM) addresses, Number of parity errors, number of invalid message labels, number of beacon, search, map, and status messages.

Quick Analysis Of Radar Sites (QARS). This program is used at the Air Route Traffic Control Centers in the digitizer certification process. Parameters measured are; Blip/Scan, Collimation, Radar Reinforced, Split Rates, Ring-around, Reflections, Mode 3/A Reliability, Mode C Reliability, and Permanent Echo verification. The QARS program can be used as a daily performance check of a digitized radar system, and provides a hard copy summary.

Beacon Code Sort. This program is used to obtain a sorted list of Mode 3/A beacon codes. The list may be used to select codes for further analysis. The normal program output includes a numerical listing of discrete and non-discrete beacon codes. Discrete codes are listed first, then the non-discrete codes appear. If a minimum duration was requested, only the discrete codes which appeared for that specified length of time or greater will be listed. Each entry will consist of the Mode 3/A code, start time, stop time, start range, stop range, start azimuth, stop azimuth, start altitude, and stop altitude.

Common Digitizer Record. This data extraction program has the capability to record and store on hard disk over 50,000 CD formatted messages. Will accept data from up to three 9600 baud modems simultaneously. Each input may be from a different sensor. The stored data becomes the data base for use by the other TRACS programs.

Common Digitizer Data Reduction (COMDIG). This program is used extensively for analysis of digitized radar systems. The data previously stored by CD Record is read and processed according to the requested task.

Task 0 -- List a particlar message type, such as beacon, search, map, etc..

Task 1 -- Same as Task 0, except that scan summaries are available as well as multi-scan averages.

Task 2 -- List all duplicate beacon codes or list up to five selected codes.

Task 3 -- List all beacon and search messages that fall within an area defined by a box centered on a particular Mode 3/A target message. The box size may be varied, both in range and azimuth. The default for the box size is 3.5 nautical miles (nmi).

Task 4 -- List all messages within a selectable geographic area.

Task 5 -- List all messages which pass a field 1 and/or a field 4 test.

Beacon False Target Analysis (BFTA). This program does a comprehensive analysis of all beacon false targets, including splits, ring-a-round, and reflections. A major use of this program will be to identify the position and orientation of beacon reflectors. This is done using targets of opportunity. The reflectors identified by BFTA will be used to update the Mode S reflector map.

Radar Statistical Coverage Analysis (RSCANS). This program will provide a statistical summary of the beacon and search coverage of the sensor. The program requires very large CD Record files of random air traffic, 50,000 messages or more. The output consists of graphs and scattergrams that will allow the user to determine the three dimensional coverage of the sensor. RSCANS uses Statistical Package for the Social Sciences (SPSS) for much of the analysis.