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FUNCTIONAL TESTING AIRBORNE NAVIGATION EQUIPMENT.(U)
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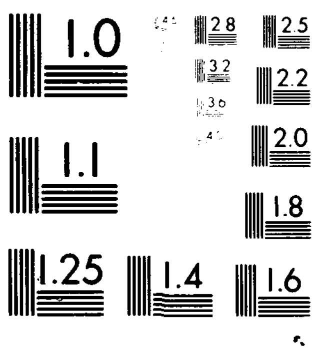
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document provides guidance and procedures for performance testing airborne navigation equipment. The document addresses the following: Flight Planning, Range Test, Rotor Modulation, Accuracy, and Influence of Weather. It provides the test officer with general information and guidance in test preparation, test controls, test conduct, and data reduction.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-105
*Test Operations Procedure 6-3-205 3 March 1981
AD No

FUNCTIONAL TESTING AIRBORNE NAVIGATION EQUIPMENT

1. SCOPE. This TOP establishes procedures and provides guidance for the functional testing of aircraft airborne navigation equipment. Navigation equipment, in the context of this TOP, includes airborne automatic direction finders, omnirange receivers, heading reference, distance measuring, station keeping, position fixing and weather radar. Functional testing implies the test item is properly installed and calibrated into the designated aircraft and evaluated throughout the operational range of the aircraft mission scenario. The primary objectives

*This TOP supersedes MTP 6-3-205, Navigation Equipment, Automatic, 17 Dec 70; MTP 6-3-207, Position Fixing Navigation Equipment, 19 Apr 71; MTP 6-3-208, Airborne Station Keeping Devices, 1 Aug 71; MTP 6-3-209, Radio Navigation Equipment, AM/FM, 1 Aug 71; and MTP 6-3-080, TACAN Equipment, Airborne, General, 8 May 70.

of the functional test are: (1) To determine if the navigation equipment under test performs its intended function in accordance with the requirements presented in the applicable approved documents; Letter of Requirements (LR), Letter of Agreement (LOA), Required Operational Characteristics (ROC), Materiel Needs (MN), etc., as reflected in the test directive; (2) To evaluate the human factors engineering (HFE) functional characteristics; and (3) To evaluate the installation and operational compatibility of the aircraft interface, subsystems, and other instrumentation and equipment.

2. FACILITIES, EQUIPMENT, INSTRUMENTATION, AND SUPPORT REQUIREMENTS.

Functional developmental testing will be accomplished within the operational environment of the designated aircraft and in accordance with standard Army operational and maintenance procedures established for the navigation equipment under test. Facilities, equipment, instrumentation, and support requirements to support the developmental test should be defined in the test directive or the maintenance support plan (MSP); however, if these data are not defined, the following should be addressed as a minimum to support the test:

2.1 Facility.

CHARACTERISTICS	MINIMUM REQUIREMENTS
Operational airfield	As required to support test aircraft.
Test range	Providing man-made and natural terrain obstacles as appropriate.
Radar equipped weather facility	In high probability area of inclement and severe weather as appropriate.
Airspace	As appropriate to conduct test.
Maintenance support	As required to support aircraft and test equipment.
Instrumentation/avionics facility	As required to support test.
Data reduction facility	As required to support data reduction.

2.2 Equipment.

Maintenance support	Standard Army tool set.
Photographic	Color camera (motion, still), as required.
Appropriate aircraft and aircraft support equipment	As required.

CHARACTERISTICS	MINIMUM REQUIREMENTS
Meteorological equipment	As required.
Equipment required by referenced TOP's	As required.
2.3 Instrumentation.	As required.
2.4 Support Requirements.	
2.4.1 Personnel.	
Photographic	As required.
Instrumentation	As required.
Data reduction	As required.
Maintenance	As required.
Pilots	As required
Human Factors Engineer	As required.

2.4.2 References.

a. Army Regulation 70-10, Test and Evaluation During Development and Acquisition of Materiel.

b. Army Regulation 385-16, System Safety.

c. AMC Regulation 700-38, w/TECOM Supplement 1 and USAAVNDTA Supplement 1, Test and Evaluation — Incidents Disclosed During Materiel Testing.

d. DARCOM Regulation 70-8, w/TECOM Supplement 1, DARCOM Value Engineering Program.

e. DARCOM Regulation 700-13, w/TECOM Supplement 1, Integrated Logistics Support Performance Evaluation Report (ILSPER).

f. AMC Regulation 385-12, w/TECOM Supplement 1, Life Cycle Verification of Materiel Safety.

g. TECOM Regulation 108-2, Audio Visual Services; Administrative and Technical Procedures, as implemented by USAAVNDTA Memo 108-1.

h. MIL-C-55163, Calibration of Test and Measuring Equipment.

i. MIL-H-46855, Human Engineering Requirements for Military Systems, Equipment and Facilities.

j. MIL-S-1472, Human Engineering Design Criteria for Military Systems, Equipment and Facilities.

k. TM 55-411, Maintenance Quality Control and Technical Inspection Guide for Army Aircraft.

l. TOP 6-3-514, Qualitative Frequency Accuracy and Stability.

m. TOP 7-3-058, Built-In Test Equipment.

n. TOP 7-3-059, Diagnostic and Inspection Equipment (Aviation).

o. TOP 7-3-519, Photographic Coverage.

p. TOP 7-3-530, Vulnerability and Security (Aviation Materiel).

q. Requirements documents (LR, LOA, ROC, MN, etc.).

3. PREPARATION FOR TEST. This section provides guidance for planning a functional developmental test of airborne navigation equipment. Consummate the planning phase with a detailed test plan. The test plan will establish the test methodology and provide the procedures for gathering and reducing data to accommodate each developmental test objective. The test plan will also identify all facility, instrumentation equipment, and support requirements including any specialized training requirements. Follow the appropriate test planning steps as outlined below to insure a complete, thorough, and cost-effective test.

3.1 Review. Review all pertinent data related to the materiel development test.

a. Requirements documents (LR, LOA, ROC, MN, etc.).

b. Applicable materiel available from the procuring agency or developer/contractor.

c. Pertinent reports on previous tests of like equipment.

d. Any other applicable source of information (AR's, TOP's, TM, etc.).

3.2 Test Objective. Establish the test objectives. The test objectives should be available in the test directive; however, if this data is not available, review the requirements documents for developmental criteria, and establish appropriate subtest objectives such as:

a. Initial Inspection. Determine the condition and completeness of the navigation system in accordance with TOP 7-3-503.[1] Perform the following as a minimum:

(1) An inventory check against the basic issue item list (BIL). Submit an equipment performance report for any discrepancies in accordance with reference 2.4.2.

(2) Remove all protective coverings and preservatives, and inspect for defects.

(3) Check for completeness of assembly.

(4) Examine the system support package for completeness, discrepancies, or defects and submit Completeness and Timliness Questionnaire in accordance with reference 2.4.2.f. Also submit an equipment performance report as required in accordance with reference 2.4.2.c.

b. Physical Characteristics. Determine the physical characteristics of the navigation equipment in accordance with TOP 7-3-500.[2] Perform the following as a minimum:

(1) Photograph as appropriate and note the legibility and effectiveness of the equipment's legends, markings, etc.

(2) Determine the physical dimension, weight, and volume of all subsystem components.

(3) Determine the weight volume of the total system.

c. Installation Characteristics. Determine the installation/removal characteristics of the navigation equipment in accordance with TOP 7-3-502.[3] Perform the following as a minimum:

(1) Evaluate the installation instructions for accuracy and completeness.

(2) Evaluate the installation technique and mounting provisions to protect the airborne radar equipment against shock and vibrations, as applicable.

(3) Evaluate all subsystem, system or equipment interfaces (plugs, cables, connectors, etc.) for positive response and secure locking.

(4) Evaluate the system/component installation characteristics for ease and quickness. Assess the following:

(a) Accessibility.

(b) Mounting flexibility.

(c) Quick disconnect design.

d. Compatibility. Determine if the navigation system is compatible with each aircraft for which it was designed, compatible with the mission objective of the designated aircraft, and compatible with all other instruments and equipment on the designated aircraft. Do this in accordance with the compatibility TOP 7-3-509.[4]

e. Functional Performance Test. Determine the adequacy and suitability of the navigation equipment to perform its intended function in all applicable operational environments and flight modes in which the designated aircraft is expected to perform. If instrumentation of the aircraft is required to verify the performance sensitivity of the test instrument, see TOP 6-3-526.[5]

f. Reliability, Availability, and Maintainability (RAM). Evaluate the RAM characteristics of the navigation equipment in accordance with TOP 7-3-507[6] and TOP 7-3-508.[7]

g. Technical Manuals. Determine the adequacy of the technical manuals in accordance with TOP 1-2-609.[8]

h. Personnel Training. Assess the scope of training required to efficiently operate and use the navigation equipment under all aircraft flight environments in the designated aircraft mission scenairo. Assess any maintenance training required to maintain the equipment. (See TOP 7-3-501)[9]

i. Human Factors and Lighting Characteristics. Assess the navigation equipment for readability characteristics, and for a positive response reaction to the the data displayed. See TOP 1-2-610[10] and TOP 7-3-527.[11] Follow the testing procedures as presented in paragraph 5, Functional Performance Test, this TOP. Pay particular attention to the lighting and HFE considerations.

j. Safety. Identify and evaluate any characteristic of the navigation equipment which could lead to a flight safety consideration. Such a condition could result from insufficient or extraneous information as well as critical information grouping/layout or display technique. Insure that all failure modes are failsafe (See TOP 7-3-506).[12]

3.3 Schedule. Prepare a detailed test time line depicting each test associated event which must occur to accomplish the test objectives and to insure facilities, logistics, personnel, and support equipment are available in a time frame conducive to accomplishing a comprehensive and cost-effective test. The time line should show sufficient time periods allotted to accomplish each test objective, insuring that adequate amounts of test data are taken to project required statistical confidences to the test results. The following schedule items should be addressed as a minimum.

a. Facility. Schedule the applicable facility requirements presented in section 2.1. Facility requirements associated with adverse flight conditions due to meteorological environmental considerations should not be overlooked. Flights at night and, in particular, under instrument meteorological conditions (IMC), place the greatest demand on the equipment.

b. Instrumentation Equipment and Support. Schedule, as applicable, instrumentation support test equipment and support requirements as presented in sections 2.2, 2.3, and 2.4.

c. Logistics. As appropriate, schedule logistics requirements including ground handling equipment, administrative transportation of both personnel and equipment, aircraft fueling, and other servicing accommodations.

3.5 Plan of Test. Develop a detailed test plan in accordance with TECOM Regulation 70-24.[13] This plan will provide the test data requirements and the data collection procedures to satisfy each test objective.

3.5 Test Safety. Assess any potential safety consideration for test personnel and equipment. Take appropriate steps (training, safety checklist, posters, etc.) to insure that the safety measures are observed throughout the test. Acquire any test safety releases, as required.

3.6 Environmental Impact. Determine if there are any environmental considerations. If environmental considerations exist, develop procedures or outline precautions to be observed to protect the environment.

3.7 Security. Security safeguards for the United States Government and for the security of the proprietary rights of the test materiel developer must be considered early in the test planning stage. The following steps must be taken:

a. Consult the TECOM security classification guide for the project, as appropriate.

b. Consult the primary test agency security representative for security guidance. Coordinate with security personnel of other test support agencies and industry, as appropriate.

c. Take appropriate security measures throughout the test to safeguard intra-industry proprietary rights and to safeguard the security of Government property.

4. TEST CONTROLS. The developmental test will be conducted and test data will be recorded in strict compliance with the test directive. If specific directions are not available, the following guidelines will prevail:

a. Reduce measurements to universal metric and English units.

b. Round out numerical observations to the nearest tenth.

c. Report time to the nearest hundredth of an hour.

d. Accomplish and record physical characteristics in compliance with TOP 7-3-500.[14]

e. Instrumentation and test equipment must be properly calibrated and have a current calibration certificate.

f. Conduct all tests and collect data in compliance with prescribed and/or standard procedures and when deviations are required, justification will be documented.

g. Record and process all data in a timely fashion.

h. Assign only properly trained and qualified personnel to participate in the conduct of the test. In particular, pilot qualification/capability must reflect the expertise necessary to fly the test profile with precision and safety.

i. Conduct the airborne navigation test in a test environment representative of the operational environment intended for its use.

j. Conduct each test run under documented conditions, such that the test results could be duplicated or compared.

k. Follow the detailed test plan; document any deviations from same.

l. Avoid nonessential test delays due to aircraft scheduled maintenance. This can be accomplished through coordination and planning.

5. FUNCTIONAL PERFORMANCE TEST. The performance aspects of the navigation system under test shall be verified in accordance with the test directive. If specific guidance is not available, performance will be verified in accordance with the following methodology. Data checklists and data forms to be completed are presented in Appendixes A and B, respectively.

5.1 Radio Receiving Set, VHF Omnirange (VOR).

5.1.1 Method.

5.1.1.1 Flight Planning. Using a map of the local test area, plot a flight course as follows:

a. Triangular, having flight legs of a minimum of 40 nautical miles, but not more than 50 nautical miles.

b. Each leg should have ground features that can be easily identified from an altitude of 1,000 feet. The ground features should be at approximately five-mile intervals and marked on the map for each inflight reference.

c. The flight path must originate at a VOR ground station and should have a VOR ground station at the vertex of each triangle leg.

5.1.1.2 Range Test. Fly the aircraft over the planned flight course at 1,000 feet absolute altitude using the following procedures:

a. During the flight, enter all applicable data that can be obtained from the flight profile on the range test data collection form.

b. Turn all communication and navigation radios, transponder, and other onboard electronic devices to the "on" position.

c. Tune the test VOR receiver to the flight path originating VOR ground station. Identify the ground station and record the clarity of the voice reception and its effect on the course indicator.

d. Fly the aircraft from the ground station on a radial that will intersect with the ground station at the first flight leg termination point.

e. Note and record the point of mileage at which the "insufficient signal flag" appears. This mileage can be interpolated from the ground points that were marked on the flight planning map. (Note: Between 35 and 40 nautical miles can be expected.)

f. At the point the "insufficient" signal flag appears, retune the test VOR receiver to the VOR ground station at the termination point of the first flight leg.

g. Fly inbound to the selected ground station. At a point approximately three (3) miles prior to reaching the ground station, observe the "to-from" flag. Continue this observation as the ground station is overflown and for an additional three (3) miles past the ground station. Record the accuracy of the "to-from" flag operation, any course needle oscillations, and any abnormal operation of the test VOR receiver.

h. Perform a 180-degree turn and fly inbound to the ground station. When the ground station is reached, turn to a heading that will establish a flight path on the second leg of the planned triangular flight.

i. Repeat the procedures outlined in paragraphs a through f above for the remaining flight.

j. Conduct the planned flight, during both daylight and darkness, a minimum of five (5) times each. Repeat the flights during all available weather conditions prevailing during the test period.

5.1.1.3 Operational Accuracy. Operate the test VOR receiver over FAA certified checkpoints, and record the radial indicated by the test item. (Accuracy should be within ±6 degrees.) At airfields equipped with FAA certified ground checkpoints, operate the test item and record the radial. (Accuracy should be within ± 4 degrees.)

5.1.1.4 Rotor Modulation. When approaching and overflying VOR ground stations, observe the course deviation needle for jitter (windshield wiping effect). Record the approximate needle deflection either in degrees, fraction of an inch, or needle widths.

5.1.1.5 Fly a minimum of five (5) different courses at the published minimum reception altitude, to and from the VOR ground stations. Record the VOR ground station identifier and approximate location from the ground station for those instances where sufficient operating signal is lost.

5.1.2 Data Required.

a. Completed VOR range data sheets.

b. Accuracy of the VOR airborne performance as compared to the FAA certified checkpoints.

c. Accuracy of the VOR ground performance as compared to the FAA certified ground checkpoints.

d. Report all test incidents in accordance with reference 2.4.2.c.

5.2 Automatic Direction Finding.

5.2.1 Method.

a. Install the test automatic direction finding (ADF) equipment in the test bed aircraft in accordance with the published specifications.

b. Fly the test bed aircraft along selected ground tracks, separated by at least 60 degrees, from and to a low frequency (LF) ground station to determine maximum usable reception range. Bearing indicator needle oscillation totaling 20° (±10°) or loss of aural signal will determine maximum usable range. Fly the test bed aircraft at the minimum enroute altitude as published by the FAA for the ground stations used. Record the following data during each flight:

(1) Maximum reception range in nautical miles.

(2) Bearing indicator needle oscillation in degrees.

(3) Null width of the received signal.

(4) Ground stations used.

(5) Altitudes flown for each ground station used.

c. Fly the test bed aircraft over selected ground tracks to and from a low frequency ground station to determine the test item's capability for track following. Fly a minimum of four (4) ground tracks inbound, crossing over and outbound for each ground station selected. Record any difficulties in tracking attributable to the test ADF. Record time required for station passage indication, hunting of the bearing needle, and any unusual equipment performance during station passage.

d. Use the test ADF to perform homing operations to a LF ground station. Plan flight routes that are separated by at least 60 degrees. Record the null width at several ranges during the homing flight. Record the null width and the effect of volume adjustment on the null width. Record the adequacy of station passage indications; i.e., the move of the null away from the nose of the aircraft; and then an immediate swing of the course needle to the 180 degree position. Record comments on the adequacy of the test ADF to direct the aircraft to a homing facility.

e. Execute radio compass approaches using the manual and automatic modes of operation of the test ADF. Record the displacement distance from the selected ground track during low approaches and the null width during low approaches and station passage. Record excessive needle oscillations and erroneous needle reversals. Repeat the approaches a sufficient number of times to determine the adequacy of the manual and automatic mode of operation.

f. Conduct the above flights during the hours of daylight, darkness, and during weather conditions prevailing during the test period. Record any abnormal operational characteristics observed that are attributed to meteorological conditions.

g. Conduct the flights with all other onboard communications and navigation radios, transponder, and other electronics systems operating. Record any interference introduced into the test ADF by the other systems or any interference introduced into the other onboard systems by the test ADF.

h. Conduct sling load operations using various items as test loads. Record any effects on the test ADF operation caused by the sling loads.

5.2.2 Data Required.

a. Completed ADF data sheets.

b. Adequacy of station passage indications.

c. Adequacy of the ADF when used as an approach aid.

d. Any abnormal operational characteristics attributed to meteorological conditions.

e. Any incompatibility between the test item and other onboard equipment.

f. Any adverse effects caused by sling load operations.

g. Report all test incidents in accordance with reference 2.4.2.c.

5.3 Heading Reference System.

5.3.1 Method.

a. Systems providing heading reference information to navigation system, perform the following:

(1) Obtain test bed aircraft equipped with the heading reference system and the appropriate navigation set.

(2) Check out the heading reference system according to the instructions in the draft literature.

(3) Apply power repeatedly for three cycles, each time from a cold start, and determine warmup time and any effects which the "power on" procedure has on the equipment.

(4) Plan a navigational course, over land, which is comprised of a minimum of three legs, the legs terminating in easily recognizable points at which geographic coordinates are known. Each leg shall be a minimum of fifty nm.

(5) Where applicable, program the navigation set with all preflight information required including the destination coordinates.

b. Independently operating systems or instruments, perform the following:

(1) The procedures of para 5.3.1a (1) through (3) above.

(2) Plan a geographically calibrated test course which includes a surveillance radar and optical tracking site at the center.

(3) Select four points, each of which is located at a distance of approximately fifteen nm from the tracking site. These points shall serve as aircraft "entry points" into the test range and shall be selected to satisfy the following:

(a) The exact geographic coordinates with respect to the tracking center shall be known.

(b) Two points shall be selected so as to allow headings on cardinal directions.

(c) Two points shall be selected so as to allow headings on major intercardinal directions (i.e., multiples of 45 degrees).

(d) Each point will be characterized by an easily recognizable landmark at the altitudes to be flown with the operator observing VFR.

(4) Establish a voice communications network with the tracking site and all aircraft.

c. Heading reference — navigation combination, perform the following:

(1) Fly the aircraft over the test course at least three times in each direction at an altitude that will insure visual accuracy when flying over the known landmarks. Conduct the flights under visual flight conditions.

(2) Use the navigation set to maintain heading.

(3) When the test bed is over the known points, note the indicated present position coordinates.

(4) Repeat all flight procedures at nap-of-the-earth altitudes employing simulated tactical flight maneuvers.

(5) The above procedures will be performed in each of the equipment modes.

d. Independent systems or instruments, perform the following:

(1) Begin all radial approaches toward the tracking site from beyond the entry point. On passage over the starting point, assume the precise heading required for exact over-station passage. Correct for deviation, variation, and drift.

(2) Use only the heading reference set for navigation, and maintain a constant barometric altitude.

(3) Continue toward the station and when flyby occurs, i.e., crossing the imaginary line which passes through the station normal to the radius representing the intended track, have the ground station determine the air distance of the aircraft from the ground station: for large distances, the slant range determined by radar; for small errors, the angle of passage given by optical determination can be utilized.

(4) Repeat the procedures for all entry points elected.

e. Effects of atmospheric conditions. Perform selected procedures of paragraphs c and d during periods when changes in atmospheric conditions exist to determine the effects on performance characteristics. These periods and/or conditions shall include:

(1) Night hours.

(2) Hours at sunrise and sunset.

(3) Poor weather conditions (rain, fog).

(4) High and low temperature.

5.3.2 Data Required.

a. Heading reference — navigation combination, record the following:

(1) The types and numbers of aircraft utilized in the test and the navigation set used.

(2) Time from power on to when test item is fully operational.

(3) Any problems with the system after successive power on applications.

(4) Details of the test course planned including:

(a) Coordinates of terminal points.

(b) Distance between each pair of points.

(c) True course between each pair of points.

(5) Record the present position coordinates from test item of the known point on completion of the traverse of each leg of the test course.

b. Independent systems or instruments, record the following:

(1) The types and numbers of aircraft utilized in the test and a description of the heading reference device.

(2) Time from power on to when test item is fully operational, and any equipment problems caused by repetitive power on procedures.

(3) A plan drawing of the test range, including entry points and their geographic locations, i.e., coordinates and distance to tracking station.

(4) Altitudes flown for each radial approach.

(5) The slant range distance of the aircraft from the station on passage or angular error.

c. Effects of atmospheric conditions, record the following:

(1) The various atmospheric conditions under which tests were conducted.

(2) Flight procedures used.

(3) Indications of equipment malfunction or loss in performance.

d. Report all test incidents in accordance with reference 2.4.2.c.

5.4 <u>Distance Measuring Equipment (DME).</u>

5.4.1 <u>Method.</u>

a. <u>Range and Accuracy.</u>

VOR/TACAN/DME

NOTES: 1. The VOR/TACAN/DME range and accuracy test shall be conducted in a test area where range radar coverage is available and where a VOR/DME or VORTAC transponder can be used as the hub for the flight test courses.

2. The flight test courses shall consist of approximately six flight paths centered upon the ground transponder as illustrated in Figure 1. The radials shall be spaced at equal angles insofar as possible to minimize "siting" effects.

(1) After selecting the test courses, determine (with the aid of the equation or nomographs given in Appendix A) the approximate maximum range at which testing shall be initiated.

(2) Direct the aircraft containing the test item to fly over the test course at a velocity of approximately 50 per cent of the aircraft's rated ground speed and at an initial altitude of 1500 feet above the ground station.

(3) Direct the test pilot to fly each leg of the test course in each direction. The pilot shall continuously interrogate the ground to determine the points at which inbound lock and outbound lock occur. Onboard recording equipment shall monitor and record DME readout, altitude, pitch, roll, yaw, and time synchronization marks. The test pilot shall introduce varying degrees of aircraft pitch, roll, and yaw during the test in order to evaluate test item performance as a function of aircraft attitude.

(4) Record numerous readouts between the lock-unlock points to provide statistical data on the frequency distribution of DME error. The range radar station shall provide time correlated space positions of the aircraft.

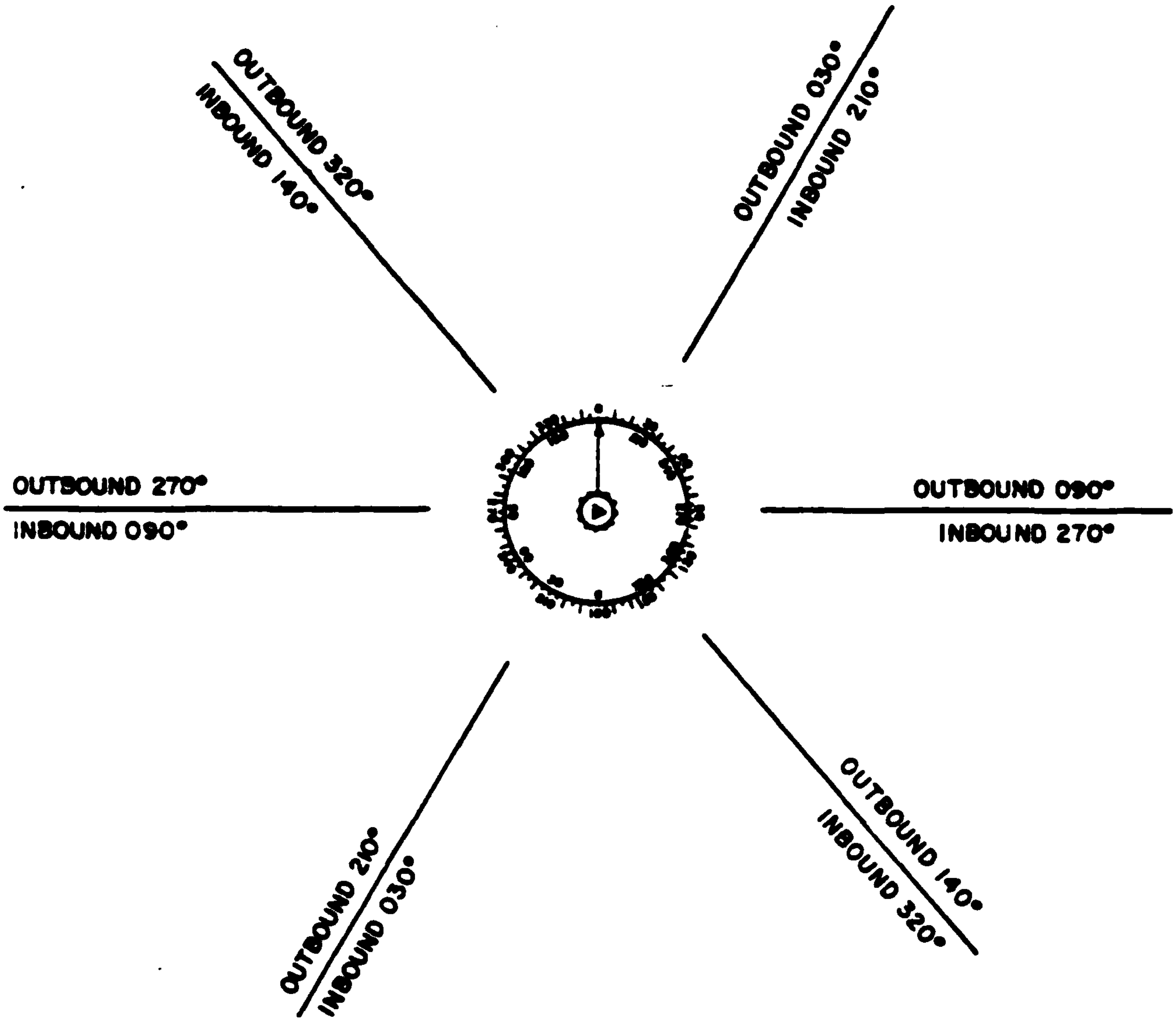
(5) Repeat the above procedure for aircraft altitudes of 3,000, 6,000, 9,000, 12,000, and 15,000 feet and additional intermediate and extreme values as dictated by the test item's specifications.

(6) Repeat the entire test sequence as necessary to provide a sufficient number of measurements for drawing statistically valid conclusions. The background document MTP 6-1-003,[15] Determination of Sample Size, should be consulted for background information and details.

b. VHF/FM-DME. Conduct the VHF/FM-DME range and accuracy test in a manner similar to that indicated in para 5.3.1, except substitute a tactical ground radio set equipped with the DME applique unit for the VOR/DME or VORTAC transponder.

c. Tellurometers.

(1) Place the master unit at a point which has been accurately "located" by conventional ground survey methods. This point shall have sufficient elevation to insure line-of-sight to at least ten surveyed positions at varying distances, directions, and elevations. At least one position shall be at a distance which is approximately ten greater than the stated distance measuring capabilities of the test item.



Typical airborne DME test flight paths.

Figure 1.

(2) Place the remote unit at one of the selected surveyed positions and, following the operating instructions of the appropriate instruction manual, obtain a measurement readout of the master unit-remote unit separation distance.

(3) Repeat the measurement a sufficient number of times to simulate a number of units tested one time each (Ref MTP 6-1-003).[16]

(4) Successively place the remote unit at each of the remaining surveyed positions and obtain distance readings as indicated above.

d. Warmup.

NOTE: The warmup test shall be conducted in an open field configuration with the interrogator/master unit bench mounted as convenient, and the transponder/remote unit located a sufficient distance away so as to achieve a convenient mid-scale distance reading.

(1) Insure that the interrogator/master unit has been in the "off" position a sufficient length of time for it to reach thermal equilibrium with the environment and, conversely, insure that the transponder/remote unit has been in the "on" position a sufficient length of time to achieve stable operation.

(2) Turn on the interrogator/master unit and note the elapsed time between equipment turn-on and achievement of stable distance measurement readout.

(3) Repeat the above procedures a minimum of five times in order to be able to compute the mean warmup time.

(4) Repeat steps (1) and (2) above at the lowest and highest ambient temperatures available without the use of an environmental chamber.

(5) Repeat the entire test sequence listed above in the following variations:

(a) Insure that the transponder/remote unit is in thermal equilibrium with the environment and the interrogator/master unit has achieved stable operation and thereby reverse the initial test conditions.

(b) Insure that both the transponder/remote unit and the interrogator/master unit are in thermal equilibrium with the environment, and simultaneously turn on both units.

e. Warning and Restricting Devices. The engineering evaluation of the test item's warning and restricting devices shall be performed as an open-field test with the airborne interrogator unit either bench-mounted or mounted in a parked aircraft. The transponder unit shall be placed a sufficient distance from the interrogator to achieve a convenient on-scale distance reading. The transponder unit operator shall (1) Attempt voice transmission during interrogation and reply, and (2) Complete the following questionnaire following the attempt:

(1) Does the transponder unit positively indicate when it is being interrogated?

Yes ( ) No ( ) Comment ____________

(2) Does the transponder unit positively indicate when it is replying to an interrogation?

Yes ( ) No ( ) Comment ____________

(3) Is the design of the transponder unit such that it prevents voice transmission during interrogation or reply?

Yes ( ) No ( ) Comment ____________

(4) If voice transmission is possible during interrogation or reply, is there a detrimental effect on the distance readout?

Yes ( ) No ( ) Comment ____________

f. Influence of Weather. The influence of varying degrees of meteorological phenomena on the range and accuracy of the test item shall be determined by repeating the procedures outlined in para 5.4.1a under the following weather conditions:

(1) Heavy rainfall.

(2) Dust.

(3) Lightning.

(4) Operation over hot, sun-heated surfaces.

NOTE: Quantitative assessment of the net effect of varying intensities of the above conditions will be difficult to achieve due to the inherent problem of locating the desired weather phenomenon within the test area. If this problem can be overcome, the very occurrence to which the test item is subjected, such as heavy rainfall, may obscure the aircraft from the tracking system. Because of these problems, collection of a sufficient number of data points to allow a statistical analysis may not be practicable and all airborne test items may have to be tested in a ground survey manner as indicated in para 5.4.1.c.

5.4.2 Data Required.

a. Data to be recorded in addition to specific instructions listed for each individual subtest shall include:

(1) An engineering log book containing, in chronological order, pertinent remarks and observations which would aid in a subsequent analysis of the test data. This information may consist of temperature, humidity, and other appropriate environmental data, or other description of equipment or components, and functions and deficiencies, as well as theoretical estimations, mathematical calculations, test

conditions, intermittent or catastrophic failures, test parameters, etc., that were obtained during the test.

(2) Instrumentation or measurement system mean error or stated accuracy.

(3) Test item sample size (number of measurement repetitions).

(4) Test item control settings.

b. VOR/TACAN/DME. Range and accuracy test data for VOR/TACAN/DME test items shall consist of:

(1) DME readout vs time.

(2) Time correlated space position data.

(3) Meteorological conditions.

(4) Aircraft altitude; degree of pitch, roll, and yaw.

(5) Test course identification.

c. VHF/FM-DME. Range and accuracy test data for VHF/FM-DME test items shall be recorded as indicated in para 5.4.2b.

d. Tellurometers. Tellurometers range and accuracy test data shall consist of:

(1) Distance (DME) readout.

(2) Ground survey data (distance, elevation, azimuth).

(3) Meteorological conditions.

e. Warmup. Warmup test data to be recorded shall be:

(1) Ambient temperature.

(2) Interrogator/master unit warmup time.

(3) Transponder/remote unit warmup time.

(4) Simultaneous warmup time.

f. Warning and Restricting Devices. Warning and restricting devices test data shall consist of answers to the questionnaire given in para 5.4.1e together with pertinent comments and/or clarifying remarks.

g. Influence of Weather. Influence of weather test data to be recorded shall consist of values of those parameters indicated in para 5.4.2b.

h. Report all test incidents in accordance with reference 2.4.2.c.

5.5 Doppler.

5.5.1 Method.

a. Hover Capability.

(1) This test will be conducted if the doppler has a hover display.

(2) The test will consist of determining the capability of the hover circuitry display to measure and present heading and drift velocities. The hover display is normally activated when the aircraft's speed decreases to a particular point. The test will consist of:

(a) Determining the speed at which the display is activated.

(b) Flying the aircraft above and below the activation speed to cause the hover indicator to become activated and deactivated.

(c) Reading the hover indicator each time the indicator is activated or deactivated.

(3) The accuracy of the ground speed components will be tested. A ground vehicle with calibrated speedometer will be used as a reference, and the aircraft will follow the vehicle at matching speeds. The aircraft will be flown so that its velocities are measured in all quadrants of the hover indicator.

(4) The following procedures should be performed:

(a) Select a suitable road for the test.

(b) Calibrate the ground vehicle's speedometer.

(c) Mount the doppler system on the aircraft.

(d) Perform normal preflight checks on the doppler system.

(e) Fly the aircraft at matching speeds with the ground vehicle.

(f) Go faster and slower than the hover activation and deactivation speed several times.

(g) Read the hover indicator scales each time the activation and deactivation speed is reached.

b. Accuracy.

(1) This test is to determine the accuracy with which the system can measure and display distance traveled along true ground track, and the accuracy with which the system can measure and present an electrical output proportional to drift angle.

(2) The test procedure for true ground track accuracy measurements are as follows:

(a) Select a road, and accurately and plainly mark a length not less than 30-50 miles between two checkpoints.

(b) Mount the doppler on the test aircraft.

(c) Perform normal preflight checks on the doppler system.

(d) Disconnect the heading reference signal.

(e) Supply a true ground track signal.

(f) Fly the doppler over the premarked test course.

(g) Observe the doppler system's present position when the aircraft flies over the test course markings.

(3) Drift Angle Accuracy Measurements.

(a) Select a strip of terrain of predetermined length within range of ground-based cameras.

(b) Mount the doppler system on the test aircraft.

(c) Perform normal preflight checks on the doppler system.

(d) Set a multichannel recorder for operation onboard the test aircraft.

(e) Instrument the system to record the d-c analog voltage of drift angle on the recorder.

(f) Synchronize the timing pulses of the recorder and the ground-based cameras.

(g) Fly the aircraft, with the doppler system indicating little or no drift angle, over the preselected strip of terrain.

(h) Photograph the aircraft's actual yaw angle.

5.5.2 Data Required.

a. Hover Test.

(1) Record ground vehicle's type, number, and speedometer calibration date.

(2) Names of ground vehicle operators and aircraft pilot.

(3) Hover system activate and deactivate speeds.

(4) Compass headings and locations.

(5) Ground speed components after each test.

b. Accuracy.

(1) Aircraft's type and number.

(2) Name of aircraft pilot.

(3) Road location and distance between checkpoints.

(4) Distance traveled as indicated by the doppler system.

c. Report all test incidents in accordance with reference 2.4.2.c.

5.6 Station Keeping.

5.6.1 Method.

5.6.1.1 Operational Performance. Evaluate the operational performance of airborne station keeping devices as follows:

a. Flight Procedures. The pilot will control the aircraft utilizing information provided by the station keeping device. During all tests, adequate separation between aircraft in formation and ground obstacles will be assured by a safety pilot qualified and current in the operation of the test bed aircraft.

b. Formation Flight. The test bed aircraft will be operated in the number two and the number three position in a "V" formation of three aircraft and also in the number three position of a three aircraft echelon formation. With the test bed aircraft flying in each of the selected positions and controlled or described in "a" above, the flight leader will maneuver his aircraft at tactical formation flight speeds through right and left turns, climbs, descents, accelerations, and decelerations. Each maneuver will be performed a minimum of twelve times to provide an adequate sample size.

c. Traffic Pattern.

(1) Evaluate the capability of the station keeping device in providing the pilot information necessary to maintain the proper aircraft position while flying airfield traffic patterns.

(2) Fly the test bed aircraft to the terminal area of the selected airfield; enter and fly the prescribed traffic pattern and altitude designated for the selected airfield. Note any deviations from the prescribed traffic pattern that will enhance the utilization of the station keeping device. For an adequate sample size, fly the traffic pattern a minimum of twelve times at a permanent Army airfield and at least twelve times at an unimproved, remote area landing site.

d. Air-to-Air Rendezvous. Plan a rendezvous between the test bed aircraft and one other aircraft. Designate a geographical or radio fix rendezvous location and utilize standard air navigation methods in proceeding to the rendezvous point. Upon approaching the rendezvous point within range of the station keeping device, utilize the information it provides to identify and to position the test bed aircraft in formation with the other aircraft. Perform a minimum of six rendezvous at an altitude of 3,000 feet and at 500 feet.

e. Landing Approach. Proceed to the destination fix for the selected airfield at minimum enroute altitude. Conduct an approach from the destination fix to the airfield utilizing information provided by the station keeping device. Determine the minimum safe height (DH) and minimum descent altitude (MDA) specified for the selected airfield. Perform the approach a minimum of eighteen times to provide an adequate sample size.

f. Reliable Range. Operate the airborne station keeping device with both ground and airborne natural targets and beacon replies, and determine its reliable range.

5.6.2 Data Required.

a. Operators', observers', and test controllers' records and questionnaires.

b. Narrative comments and observations.

c. Photographs, still and movie.

d. Diagrams and sketches.

e. Data item will be identified and annotated with respect to:

(1) Test, subtest, test phase.

(2) Source.

(3) Time.

f. Sample size (number of measurement repetitions).

g. Instrument or measurement system mean accuracy.

h. Traffic patterns flown.

i. Execution of air-to-air rendezvous.

j. Landing approach.

k. Report all test incidents in accordance with reference 2.4.2.c.

5.7 Position Fixing System.

5.7.1 Method.

5.7.1.1 Operation.

a. Determine the extent of the system service area.

b. Operate the vehicle about the stated or theoretical perimeter of maximum range (where appropriate, use the reference or master transmitter location as the center of coverage).

c. Determine for at least eight entry points (equally spaced radially) into the coverage pattern, the maximum range in the respective direction of the entry point. Use a median altitude for aerial vehicles.

d. Determine at each of the entry points the effect of altitude by flying from the minimum to the maximum practical altitude for the aircraft.

5.7.1.2 Vehicle Antenna Pattern.

a. Locate the vehicle at a point in the field of coverage for the system where a secure lock is obtained (oscilloscope patterns or coordinate readouts are stable).

b. Rotate the vehicle through 360 degrees, and at each 30 degree point note the change in displays.

c. Where gross changes are detected, utilize smaller radial segments for a more detailed analysis of pattern changes.

5.7.1.3 Navigation (point-to-point)/Position.

a. Operate the vehicle point-to-point using only the service area and pattern maps (if appropriate).

b. Select four routes or paths, one in each quadrant within the boundaries of the service area, with the starting and terminal points of each path having precise coordinate data.

c. Operate along each path utilizing different speeds for successive runs, and at least two different altitudes for aerial vehicles.

d. Record the coordinate display data at the start and finish of each run, and determine the error at each point.

5.7.1.4 Effects of Atmospheric Conditions.

a. Repeat selected operational procedures of section 5.7.1.1 during periods when changes in atmospheric conditions exist. Include the following:

(1) Sunrise and sunset.

(2) Electrical storms.

(3) Nocturnal hours.

(4) Poor weather conditions, poor visibility (rain, fog).

(5) High and low temperatures.

b. Note, during the conduct of test operations, any of the following:

(1) Changes in the extent of coverage.

(2) Changes in antenna patterns.

(3) Degradation in system properties; sensitivity, stability, etc.

5.7.1.5 Effects of Geographic Surface Conditions.

a. Conduct point-to-point travel procedures using the system for navigation. Utilize geographic locations which lie within the coverage of the system and which allow operation over the following types of surfaces:

(1) Water-land interfaces.

(2) Isolated bodies of water.

(3) Mountain ranges.

(4) Areas with varying degrees and types of vegetation.

b. Note, during the conduct of each operation, evidence of the following:

(1) Abrupt changes in system performance and position of the vehicle at the time of change.

(2) Alterations in system performance for extended periods and general system performance.

5.7.1.6 Tactical Missions.

a. Evaluate the system as an aid to the conduct of tactical operations either through simulated maneuvers or by incorporating system equipped vehicles into programmed troop maneuvers. Include, where possible, the following operations:

(1) Reconnaissance and surveillance.

(2) Rendezvous with ground units.

(3) Support of dismounted units.

(4) Engagement of mechanized units.

(5) Air-to-air rendezvous.

(6) Instrument approaches.

b. Have all involved crewmen, on completion of mission, complete reports which summarize comments on the usefulness of the test system.

5.7.2 Data Required.

5.7.2.1 Operation. For each of the entry points, record the coordinates and the range at pattern acquisition; and, for aerial vehicles, maximum readings for different altitudes at the same entry coordinates.

5.7.2.2 Vehicle Antenna Pattern. Record the angular position of the vehicle axis and the change in displays, e.g., time change in microseconds or readout coordinate changes.

5.7.2.3 Navigation (point-to-point)/Position - Record the following:

a. Coordinate data for the flight path points selected.

b. Speeds (and aircraft altitudes) for each operation.

c. System coordinate readings at start and finish.

d. Any evidence of voids in transmission, instabilities, drifting, loss of transmitted signals, etc.

5.7.2.4 Effects of Atmospheric Conditions. Record for each of the test operations comments regarding the effectiveness of the system and any difficulties experienced.

5.7.2.5 Effects of Geographic Surface Conditions. Record the following:

a. Complete details of each flight conducted.

b. Comments regarding system effectiveness and any loss of performance characteristics.

5.7.2.6 Tactical Missions. Record the following:

a. A description of each mission procedure performed.

b. Summary of comments from all crewmen regarding the system performance.

5.7.2.7 Report all test incidents in accordance with reference 2.4.2.c.

6. DATA REDUCTION AND PRESENTATION.

6.1 Data Reduction. Identify, organize, and correlate raw test data as to time, parameter grouping, and test run. As required, convert raw test data measurements to engineering units. Analyze the performance data for the aircraft navigation system to satisfy the test objectives and determine compliance or noncompliance with the criteria or specifications.

6.2 Data Presentation.

a. Prepare a narrative document of the test results to include diagrams, graphs, photographic, tabular, and other reduced data, as required, to support the test conclusions and recommendations. The degree to which the test item satisfies the test criteria or specifications in the operational environment should be clearly evident.

b. In the instance of a total or partial failure of the test item to perform its intended function, assess the implications of the failure and present recommendations, as applicable.

Recommended changes to this publication should be forwarded to Commander, US Army Test and Evaluation Command, ATTN: DRSTE-AD-M, Aberdeen Proving Ground, MD 21005. Technical information may be obtained from the preparing activity: Commander, US Army Aviation Development Test Activity, ATTN: STEBG-QA, Fort Rucker, AL 36362. Additional copies are available from the Defense Technical Information Center (DTIC), Cameron Station, Alexandria, VA 22314. This document is identified by the accession number (AD No) printed on the first page.

APPENDIX A-1

PRETEST CHECKLIST

FUNCTIONAL TESTING AIRBORNE NAVIGATIONAL EQUIPMENT

1. Have facilities, test equipment, instrumentation, and support requirements been scheduled or secured? See para 2 - 2.4.2, this TOP. Yes___No___.

2. Has appropriate test planning been accomplished in accordance with para 3.1 - 3.7, this TOP? Yes___No___.

3. Have test control measures been implemented such that test results could be duplicated or compared? See para 4a - 4k, this TOP. Yes___No___.

APPENDIX A-2

POST-TEST CHECKLIST

FUNCTIONAL TESTING AIRBORNE NAVIGATION EQUIPMENT

1. Have test data been collected, recorded, and presented in accordance with TOP? Yes____No____. Comment: ____

2. Were the facilities, test equipment, instrumentation, and support accommodations adequate to accomplish the test objective? Yes____No____. Comment: ____

3. Have all data collected been reviewed for correctness and completeness?

Yes____No____. Comment: ____

4. Were the test results compromised in any way due to insufficient test planning?

Yes____No____. Comment: ____

5. Were the test results compromised in any way due to test performance procedures?

Yes____No____. Comment: ____

6. Were the test results compromised in any way due to test control procedures?

Yes____No____. Comment: ____

7. Were the test results compromised in any way due to data collection, reduction, or presentation technique? Yes____No____. Comment: ____

APPENDIX B

DATA COLLECTION FORMS

VOR RANGE DATA SHEET

Pilot ____________________ Copilot ____________________ Date ____________

Weather Conditions ____

Flight Duration __________ hrs to __________ hrs. Total Hours ____________

1. Voice Reception:

Signal Clarity	Noise Level
1. Very bad	1. Very high
2. Bad	2. High
3. Good	3. Low
4. Very good	4. Very low
5. Excellent	5. None

2. Range:

VOR Station Identification	Range at Which Insufficient Signal Flag Appeared
1. ________	____________ nm
2. ________	____________ nm
3. ________	____________ nm
4. ________	____________ nm
5. ________	____________ nm
6. ________	____________ nm

3. Accuracy of the "to-from" indications. ______________________________

____.

4. Needle jitter. Yes____No____.

5. Quantity of rotor modulation.____

6. Day/night operational characteristics comparison.____________________

____

7. Effects of environmental conditions._________________________________

____

____

8. Accuracy of the test item when using the airborne FAA certified checkpoints______ degrees .____

9. Accuracy of test item when using the FAA certified ground checkpoints __________ degrees.____

10. List those instances where the test item interfered with the operation of other onboard electrical equipment or where other onboard electrical equipment interfered with the operation of the test item. ________________________________

____

11. List any instances where the test item failed to receive an adequate operating signal while flying at the published minimum reception altitude. __________________

____

____

ADF DATA SHEET

Pilot____________________Copilot____________________Date__________

Weather Conditions ______________________________________

Flight Duration __________hrs to __________hrs. Total Hours __________

1. Signal Reception:

Signal Clarity	Noise Level
1. Very bad	1. Very high
2. Bad	2. High
3. Good	3. Low
4. Very good	4. Very low
5. Excellent	5. None

2. Accuracy of the station passage indication.____________________

____

3. Hunting of the bearing needle ________degrees and describe the flight conditions under which the hunting occurred.____________________________

____

____

4. Effects of environmental conditions. ____________________________

____

5. List those instances where the test item interfered with the operation of other onboard equipment or where other onboard equipment interfered with the test item.

____

____

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APPENDIX C

FUNCTIONAL TESTING AIRBORNE NAVIGATION EQUIPMENT

1. TOP 7-3-503, Arrival Inspection/Pre-Operational Inspection (Aviation Materiel).
2. TOP 7-3-500, Physical Characteristics (Aviation Materiel).
3. TOP 7-3-502, Installation Characteristics.
4. TOP 7-3-509, Compatibility/Related Equipment (Aviation Materiel).
5. TOP 6-3-526, Functional Requirements/Aircraft Test Instrumentation.
6. TOP 7-3-507, Maintenance (Maintainability, Availability).
7. TOP 7-3-508, Reliability (Aviation Materiel).
8. TOP 1-2-609, Instructional Material Adequacy Guide and Evaluation Standard (IMAGES).
9. TOP 7-3-501, Personnel Training.
10. TOP 1-2-610, Human Factors Engineering.
11. TOP 7-3-527, Internal/External Lighting (Aviation Materiel).
12. TOP 7-3-506, Safety.
13. TECOM Regulation 70-24, Research and Development: Documenting Test Plans and Reports, w/changes 1 and 2.
14. TOP 7-3-500, Physical Characteristics (Aviation Materiel).
15. MTP 6-1-003, Determination of Sample Size.
16. Ibid.

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