1 May 1967

U. S. ARMY TEST AND EVALUATION COMMAND
COMMODITY ENGINEERING TEST PROCEDURE

TERRAIN AVOIDANCE EQUIPMENT

1. OBJECTIVE

The objective of this materiel test procedure is to present a series of engineering tests necessary and sufficient to determine the technical performance of terrain avoidance equipment.

2. BACKGROUND

The basic function of a terrain avoidance system is to provide information, either in the form of a situation display to the aviator or commands sent directly to the aircraft's autopilot, which will allow safe control of the aircraft while utilizing low-level flight techniques. The system will supplement aircraft navigation aids to permit the conduct of low-altitude flight missions under restricted visibility and to facilitate map-of-the-earth flights.

A collection of textual terms peculiar to terrain avoidance systems is included in the glossary.

3. REQUIRED EQUIPMENT

Equipment and facilities required for the performance of engineering tests of terrain avoidance equipment shall consist of:

a. Aircraft equipped with:

1) Position Fixing and Navigation System
2) Absolute altimeters
3) Airborne tape recorder or telemetry equipment
4) Motion and still picture cameras

b. Instrumented flight test range(s)
c. Adequate ground test area (clear line of sight for 18 miles)
d. Environmental test chamber
e. Bench test facilities
f. Tactical vehicles as required

4. REFERENCES

A. Povejsil, Raven & Waterman, Airborne Radar, D. Van Nostrand Company, Inc., 1961.
B. Helicopter Survival and Obstacle Clearance, Bell Helicopter, Inc., 1962.
C. Studies and Simulation of Terrain Avoidance Problems (U), ASD-TDR-63-612, Vol. 1., USAF Avionics Laboratory, 1963 (Classified Confidential).

D. Study of Pictorial Warning and Obstacle Clearance, Melpar, Inc., 1961.
E. Radar Set AN/APN-100 (XE-1), Technical Manual, Emerson, Inc.
F. Scavullo & Burgess, Range Testing, D. Van Nostrand Company, Inc., 1961.

5. SCOPE

5.1 SUMMARY

The engineering tests required to comprehensively measure the performance of terrain avoidance equipments are listed below with their respective objectives. These tests constitute the scope of this materiel test procedure, and shall be conducted as in Table I.

a. Failsafe - The objective of this test is to determine if the failsafe features of the test item provide positive indication when the test item is unreliable.

b. Obstacle Detection/Resolution - The objective of this test is to determine the test item's ability to detect obstacles of various radar cross sectional areas in the presence of background clutter and to determine the quality of the situation display in the aircraft.

c. Automatic Profile Following - The objective of this test is to determine the capability of the system to provide the necessary signals to an automatic pilot to safely direct the movement of the aircraft while following a terrain profile through the use of an automatic pilot.

d. Manual Profile Following - The objective of this test is to determine the capability of the test item to supply the pilot with the information necessary to safely direct the aircraft while following a terrain profile.

e. Automatic Vertical Terrain Clearance - The objective of this test is to determine the capability of the test item to control the aircraft via the autopilot whenever a terrain feature protrudes through the barometric altitude at which the aircraft is being flown.

f. Manual Vertical Terrain Clearance - The objective of this test is to determine the capabilities of the test item to provide the pilot with the information necessary to effect vertical terrain clearance.

g. Lateral Terrain Clearance - The objective of this test is to determine the test item's ability to provide the pilot with the information required for him to maneuver his aircraft in the horizontal plane and fly around any terrain feature protruding through the selected barometric altitude.

h. Automatic Dual Mode - The objective of this test is to determine the capabilities and limitations of the test item in this mode of operation to enable the pilot to make maximum use of the terrain for cover and concealment.

i. Manual Dual Mode - The objective of this test is to determine the capabilities and limitations of the test item in this mode of operation to enable the pilot to make maximum use of the terrain for cover and concealment.

j. Ground Mapping - The objective of this test is to determine the effectiveness of the test item when operated in the Ground Mapping Mode as an aid to enroute navigation.

k. Over Water - The objective of this test is to determine the ability of the test item to operate correctly over land/water interfaces, and its ability to detect waterborne objects.

l. Over Ice Caps and Snow - The objective of this test is to determine the test item's ability to function properly when operating over ice caps or deep snowfields.

5.2 LIMITATIONS

Most terrain avoidance systems are oriented to the longitudinal axis of the aircraft and are stabilized for pitch, roll, and yaw. To achieve this stabilization, pitch data is provided by the angle of attack sensor, roll data by the displacement gyro, and yaw may be provided in the form of "drift angle" from the navigation system. The evaluation of these stabilization sensor mechanisms which provide inputs to the terrain avoidance system is not a primary consideration of this materiel test procedure and the sufficiency of these items must be assured separately even though their performance is monitored during the terrain avoidance flight test conduct. It is assumed herein that the test item possesses sufficient stabilization. Environmental tests are not within the scope of this MTP.

6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Scheduling

The terrain avoidance materiel test program is divided into two major test phases; a flight test or dynamic phase and a ground test or static phase. The ground test phase shall consist of the failsafe test and shall be performed as a prerequisite to the flight test phase as the test results may indicate a need to modify the test courses employed in dynamic testing. The flight tests shall be performed with the test item mated to the aircraft and suitable on-board recording instrumentation provided to monitor test item command signals and aircraft instrumentation sensors as indicated in Table II.

6.1.2 Preoperating Tests and Inspections

6.1.2.1 Qualified personnel shall ensure that the test item has been inspected and examined with respect to MTP 6-2-507, Safety.

6.1.3 Preflight Preparation

6.1.3.1 Unless otherwise indicated in the individual test procedures, the pilots assigned to the flight test portions of the test program shall be alloted duties as follows:

a. Flight Test Pilot - The flight test pilot shall occupy a position in the aircraft so as to maintain visual contact with the terrain. He shall monitor the actions of the subject pilot during flight, shall record all indicated test data, shall indicate start and finish of data runs (where applicable); and

TABLE I

TEST	Test Item Mode of Operation					Test Phase	
	VTCM	LTAM	PFM	DM	GMM	Dynamic	Static
Failsafe	x	x	x	x	x		x
Obstacle Detection	x	x			x	x	
Automatic Profile Following			x			x	
Manual Profile Following			x			x	
Automatic Vertical Terrain Clearance	x					x	
Manual Vertical Terrain Clearance	x					x	
Automatic Dual Mode				x		x	
Manual Dual Mode				x		x	
Ground Mapping					x	x	
Over Water			x			x	
Over Ice Caps and Snow			x			x	

Test Item Mode of Operation & Test Phase for
each Individual Test of the Overall Test Program

shall take control of the aircraft when, in his opinion, the terrain avoidance system has filed or any other dangerous situations exist.

b. Subject Pilot - The subject pilot shall be hooded to simulate Instrument Flight Rules (IFR) conditions. He shall fly the aircraft, with the terrain avoidance system set in the specified mode of operation, using only the information presented to him by the system (and standard aircraft instrumentation, as necessary) to avoid contact with the terrain.

6.1.3.2 When the test item is subjected to flight testing, adherence to the following safety considerations is mandatory as an equipment malfunction could have catastrophic consequences, especially in flights at low altitudes and high speeds.

a. The flight test pilot will at all times observe Visual Flight Rules (VFR) conditions.

b. The gross weight of the aircraft shall be held to a minimum by calculating and varying the fuel load to meet the requirements of each flight; thus facilitating emergency maneuvers.

c. Unless restricted to rigid test criteria, and unless otherwise indicated in the individual procedures, test flights shall be conducted at absolute altitudes of 1000, 500, 200 and 100 feet and at ground speeds representing the 50, 75 and 90 percent values of the test aircraft's rated still-air velocity range. If 50% is below the safe manuvering speed of the test aircraft, the low speed value will be selected as speed appropriate to the test aircraft not below 120% of Vstall. When these conditions are in effect, the highest specified clearance altitudes and lowest aircraft velocity shall be flown first and succeeding flights progressing to the lowest specified clearance altitude and highest aircraft velocity. The aircraft shall not be flown at a lower altitude, however, until the data from the preceding altitude's flight have been evaluated by the test engineer and he has certified that the test item will be safe for employment at the lower altitude. Should the specific test being conducted reveal that the test item commands do not exceed aircraft capabilities under the above mentioned conditions, testing should continue at higher aircraft velocities, lower absolute altitudes, higher barometeric altitudes, or over more abruptly changing terrain to empirically determine the conditions at which the test item commands begin to exceed aircraft capabilities. At no time, however, should testing inhibit flight safety or attempt to exceed aircraft performance limits.

6.1.3.3 Figure 1 illustrates a hypothetical flight test base line course as will be encountered during the dynamic test phase of the evaluation program. The test course shall be selected such that the aircraft is periodically within the test range tracking instrumentation line of sight so as to allow frequent space positioning check points for correlation with or correction of the navigator data.

In all flight test procedures, the navigator will be used to maintain aircraft track between range instrumentation positioning check points.

TEST PARAMETERS / TEST		FAILSAFE	OBSTACLE DETECTION	AUTOMATIC PROFILE FOLLOWING	MANUAL PROFILE FOLLOWING	AUTO VERTICAL TERRAIN CLEARANCE	LATERAL TERRAIN CLEARANCE	AUTOMATIC DUAL MODE	GROUND MAPPING	OVER WATER	OVER ICE CAPS AND SNOW
RECORDED ON GROUND	SPACE POSITION VS. TIME		X	X	X	X	X	X	X	X	X
	MODE OF OPERATION	X	X	X	X	X	X	X	X	X	X
	ALTITUDE CLEARANCE SET		X	X	X	X		X		X	X
	GROUND PHOTOS		X						X		
	SIMULATED FAILURE	X									
	ANTENNA ORIENTATION								X		
	METEOROLOGICAL CONDITIONS		X	X	X	X	X	X	X	X	X
RECORDED IN AIRCRAFT	FAILSAFE INDICATION	X									
	TIME		X	X	X	X	X	X	X	X	X
	DISPLAY PHOTOS	X	X	X	X	X	X	X	X	X	X
	EVENT MARKER		X	X	X	X	X	X	X	X	X
	DISTANCE TO DESTINATION		X	X	X	X	X	X	X	X	X
	DOPPLER X		X	X	X	X	X	X	X	X	X
	DOPPLER Y		X	X	X	X	X	X	X	X	X
	DRIFT ANGLE (YAW)		X	X	X	X	X	X	X	X	X
	ANGLE OF ATTACK (PITCH)		X	X	X	X	X	X	X	X	X
	ROLL ANGLE		X	X	X	X	X	X	X	X	X
	G - LOAD		X	X	X	X	X	X	X	X	X
	TURN RATE		X	X	X	X	X	X	X	X	X
	GROUND SPEED		X	X	X	X	X	X	X	X	X
	AIR SPEED		X	X	X	X	X	X	X	X	X
	BAROMETRIC ALTITUDE		X	X	X	X	X	X	X	X	X
	ABSOLURE ALTITUDE		X	X	X	X	X	X	X	X	X
	TEST ITEM COMMAND	X	X	X	X	X	X	X	X	X	X

TABLE II. TEST DATA TO BE RECORDED

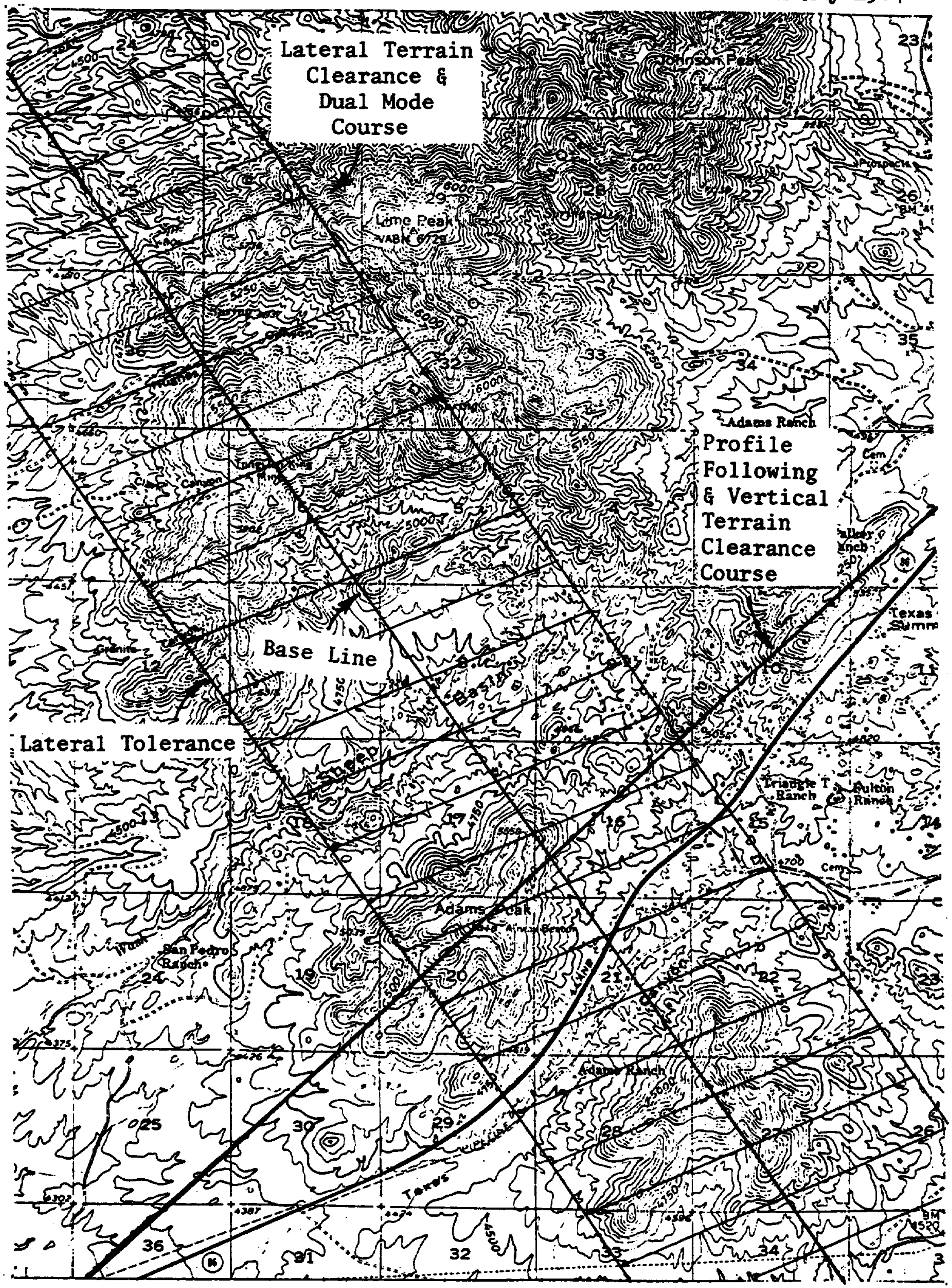

FIGURE 1. HYPOTHETICAL FLIGHT TEST COURSES

6.1.4 Measurement Accuracy

To produce data from which valid conclusions may be drawn, the test procedures outlined herein should be subjected to repetition to simulate several units tested. The background document MTP 6-1-003, Determination of Sample Size, should be consulted prior to testing in order to ensure statistical validity of the resultant data.

As the error in final measurement is the result of the summation of the error contributions of the test item and error contributions of the measurement system; all instrumentation errors and their associated standard deviations should be investigated and catalogued prior to testing.

The optical or radar space positioning instrumentation shall be time correlated with the on-board aircraft instrumentation and shall be the prime standard for aircraft space positioning data. In the event that the aircraft positioning data, with frequent prime standard positioning checks being made for comparison and correction.

6.2 TEST CONDUCT

6.2.1 Failsafe

The test item shall be placed in normal operation on a test bench or in a parked aircraft as desired. Failures will be simulated throughout each subsystem of the test item to include as a minimum, those items outlined below. The test engineer shall note the response of the test item's displays and failsafe indicators as the test item is subjected to simulated failures as follows:

a. Total loss of power to the test item
b. Loss of power to each subsystem of the test item
c. Loss of individual signal inputs to the command computer, i.e. (radar altimeter, pitch sensor, roll sensor, etc.).
d. Mechanical jamming of the antenna
e. Loss of antenna stabilization against pitch, roll, and drift angle.
f. Other mechanical or electrical failures deemed appropriate for the individual test item.

6.2.2 Obstacle Detection/Resolution

The test item's ability to detect obstacles of various radar cross sectional areas becomes complicated at small depression angles when reflections from land surfaces form a clutter background which tends to obscure received radar echoes. The ground return which competes with, or obscures, the obstacle echo is generally confined to the return from ground elements at the same apparent range as the target. Such returns can be received either on the main beam or the sidelobes of the antenna pattern.

The test method consists of manually flying the aircraft containing the test item toward various obstacles in accordance with the following procedure:

a. Select a variety of prominent man-made obstacles of assorted type, size, and construction from those available in the vicinity of the test range. Examples of typical obstacles are:

1) Radio Transmitting towers
2) High voltage transmission lines and towers
3) Water towers
4) Non-reflective radio test masts and towers
5) Tower mounted radar reflectors
6) Any two or more of the above located in close physical proximity

b. Direct the aircraft containing the test item to fly toward the obstacle at a low altitude commensurate with obstacle height and aircraft safety. For the initial flight, the test item shall be operated in the Vertical Terrain Clearance Mode and the aircraft velocity held at 50% of the aircraft's rated still-air speed range or slowest appropriate maneuvering speed not below 120% of Vstall.

c. On-board instrumentation shall be used to provide the data required in paragraph 6.3.3.3 a., at specific check points along the flight path. Check points should be established at distances of ½, 1, 3, 6, 9, and 18 miles from the obstacle.

d. The above procedure shall be repeated to include the test item operation in the LTAM and GMM modes and aircraft velocities as specified in paragraph 6.1.3.2 c.

6.2.3 Automatic Profile Following

The tactically important capability of the test item to direct automatic terrain following flight shall be tested over a preselected test course of known profile. The aircraft containing the test item shall fly over the test course at various speeds and altitudes as outlined in paragraph 6.1.3.2 c.

The test course shall be approximately 50 miles in length over terrain of rapidly changing profile and shall be located adjacent to optical or radar tracking facilities.

The method of test is as follows:

a. Direct the aircraft containing the test item to fly over the base line course at absolute altitude of 1000 feet and a ground speed of 50% of the test aircraft's rated still-air velocity range, or slowest appropriate maneuvering speed not below 120% of Vstall.

b. The aircraft shall be under the control of the automatic pilot/terrain avoidance equipment when over the base line course, and the procedures given in paragraph 6.1.3 shall be observed.

c. Record all data indicated by paragraph 6.3.3.2b., for flight in both directions over the base line course for aircraft absolute altitudes of 1000, 500, 200, and 100 feet with velocities at each altitude of 50, 75, and 90 percent of the aircraft's rated still-air velocity range, or slowest appropriate maneuvering speed not below 120% of Vstall.

6.2.4 Manual Profile Following

The manual profile following test shall consist of a repetition of the automatic profile following test except that the subject pilot will control the motion of the aircraft in the vertical plane relying on the terrain avoidance system display indicators for necessary information. Aircraft flight and general test procedures shall be as specified in paragraph 6.2.3.

6.2.5 Automatic Vertical Terrain Clearance

The automatic vertical terrain clearance test shall be conducted in a manner similar to the automatic profile following test. The test procedure is as follows:

a. Select a test course base line of approximately 50 miles in length which covers prominent orographic features and is adjacent to optical or tracking facilities.

b. The test aircraft shall be under the control of the automatic pilot/terrain avoidance equipment and automatic pilot shall be engaged in the barometric hold mode of operation when flying over the base line course. The barometric flight altitude shall be equal to the altitude of the most prominent terrain feature thereby ensuring that the line of flight is tangent to the highest orographic protrusion on the test course base line.

c. After the aircraft has cleared the terrain feature by the preselected clearance margin, the subject pilot will return the aircraft to the original barometric altitude. Clearance margins to be preselected for testing shall include the 10, 50, and 90 percent values of the range of clearances afforded by the test item.

d. Record all data indicated by paragraph 6.3.3.2 d., for flight in both directions over the test course at velocities representing the 50, 75, and 90 percent points of the aircraft's still-air velocity range, not to be below 120% Vstall.

6.2.6 Manual Vertical Terrain Clearance

The manual vertical terrain clearance test shall consist of a repetition of the automatic vertical terrain clearance test, except that the subject pilot will control the motion of the aircraft in the vertical plane by relying on the terrain avoidance system display indicators for necessary information. Clearance margins, aircraft velocities, and general test procedures, excepting automatic control of the aircraft, shall remain as stated in paragraph 6.2.5.

6.2.7 Lateral Terrain Clearance

The lateral terrain clearance test shall be conducted in accordance with the following procedure:

a. Select a test course base line of approximately 50 miles in length which is adjacent to optical or radar tracking facilities. The base line shall be laid out such that it covers at least one prominent orographic feature. Lateral tolerance from the base line course shall be allowed such that there is at least one unobstructed flight path within the base line tolerance at an altitude of one-half of the difference between the highest and lowest terrain altitudes covered by the base line.

b. The subject pilot will attempt to fly the base line course using the information provided by the system and confining all terrain avoidance maneuvers to the horizontal plane. Navigation through the lateral terrain clearance course shall be accomplished through the use of the Navigator.

c. The test course shall be traversed in both directions at an initial altitude representing 90% of the difference between the highest and lowest terrain altitudes encountered. The initial aircraft velocity shall be 50% of the aircraft's still-air velocity range, or slowest appropriate maneuvering speed not below 120% of Vstall.

d. The test procedure should be repeated for aircraft velocities of 75 and 90 percent of the aircraft's stated still-air velocity range and at altitudes representing 75 and 50 percent of the difference between the highest and lowest terrain altitudes covered by the base line course.

6.2.8 Automatic Dual Mode

The automatic dual mode test shall be performed over the base line course established for the lateral terrain clearance test in accordance with the following general procedure:

a. The test item shall be coupled directly to the aircraft's automatic pilot to effect vertical maneuvers while lateral maneuvers shall be controlled by the subject pilot using the information presented by the test item's display unit to make maximum use of the terrain for cover and concealment.

b. Navigation through the course shall be accomplished by use of the Navigator.

c. The test course shall be traversed in both directions at those altitudes and velocities specified in paragraph 6.1.3.2 c.

6.2.9 Manual Dual Mode

The manual dual mode test shall consist of a repetition of the automatic dual mode test except that the subject pilot will maneuver the aircraft in the vertical plane using the pitch command indicator and maneuver the aircraft in the horizontal plane using information derived from test item horizontal scan as displayed on the cathode ray tube (CRT). The general test procedure is as follows:

a. The test item's vertical scan will be fed to the pitch command indicator and the horizontal scan fed to the CRT. Navigation through the course will be accomplished by the use of the Navigator.

b. Subject pilot will fly the base line course in both directions, making maximum use of the terrain for cover and concealment.

c. Aircraft altitudes and velocities shall be those specified in paragraph 6.1.3.2. c.

6.2.10 Ground Mapping

The ground mapping test shall be performed as follows:

a. Direct the aircraft to fly a plotted course over rugged terrain at a constant barometric altitude which is 200 feet higher than the highest terrain feature. Aircraft velocity shall be 50% of the aircraft's rated still-air velocity range. Not to be below 120% Vstall. The subject pilot will observe Visual Flight Rules.

b. Flight Test Pilot shall photograph the test item's CRT display for subsequent comparison with maps of the terrain.

c. The test shall be repeated for constant barometric altitudes of 500 and 1000 feet higher than the highest terrain feature.

6.2.11 Over Water

The over water test presents the test item with surface interface conditions such as would be encountered in a transition from flight over water to flight over land or flight over waterborne objects. The method of test proceeds as follows:

a. Select suitable test course(s) of approximately 50 miles in length which are located adjacent to optical or radar tracking facilities and which cover the following terrain surface interface:

1) Land to sea transition
2) Sea to land transition
3) Sea to land transition over an abrupt obstacle and similar land to sea transition.

b. Direct the aircraft to fly over the base line course while the system is operated in the automatic profile following mode at the clearance altitudes specified in paragraph 6.1.3.2 c., and following the test procedures as specified in paragraph 6.2.3.

c. Repeat the test to include flight over waterborne objects such as a Coast Guard Cutter or equivalent sized vessel.

6.2.12 Over Ice Caps and Snow

Airborne radar devices may be subject to large errors when operating over ice caps or deep snowfields. This error results primarily from the opaqueness of thick masses of ice, or snow to high frequency radio waves and may be of such a magnitude as to constitute a serious safety hazard to aircraft employing terrain avoidance equipment. Additionally, it is noted that terrain avoidance radars may suffer a loss of signal return over an ice/water interface owing to absorption of the signal in the partially melted boundary area between the ice and the water.

The test method proceeds as follows:

a. Select a base line course which covers snow/ice and ice/earth interfaces of known profile and which is accessible to optical or radar tracking facilities.

b. Direct the aircraft containing the test item to fly over the base line course at an absolute altitude of 1000 feet and a ground speed of 50% of the test aircraft's rated still-air velocity range, not to be below 120% Vstall.

c. The aircraft shall be under the control of the automatic pilot/terrain avoidance equipment when over the base line course, and the procedures given in paragraph 6.1.3 shall be observed.

d. Record all data indicated by paragraph 6.3.3.2 k., for flight in both directions over the base line course for aircraft absolute altitudes of 1000, 500, 200 and 100 feet with velocities at each altitude of 50, 75, and 90 percent of the aircraft's rated still-air velocity range.

e. Repeat the above procedure to include flight over ice/water interfaces.

6.3 TEST DATA

6.3.1 Preparation for Test Data

Data to be recorded prior to testing shall include but not be limited to:

a. Nomenclature of the test item
b. Serial number of the test item
c. Test aircraft identification

6.3.2 Data Common To All Tests

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

a. An engineering log book containing in chronological order pertinent remarks and observations which would aid in a subsequent analysis of the test data.
b. Instrumentation or measurement system mean error or stated accuracy.
c. Test item sample size (number of measurement repetitions).
d. Test item control settings.

6.3.3 Test Conduct Data

In addition to the narrative description of required test conduct data which is given in the following paragraphs, Table II indicates, in matrix form, test data to be recorded versus test title.

6.3.3.1 Ground Test Data

Specific data requirements for the gound test are given as follows:

a. Failsafe

1) Test item mode of operation
2) Nature of simulated failure
3) Positive failsafe indication
4) Test item display indication before and after simulated failure

6.3.3.2 Flight Test Data

Detailed data requirements for flight testing are given in Table II with salient requirements for each individual test reiterated as follows:

a. Obstacle Detection/Resolution

1) Obstacle type, size, and construction
2) Still photographs of the obstacles as seen from the ground
3) Description of terrain surrounding the obstacle
4) Meteorological conditions
5) Test item display photographs correlated to aircraft position and velocity with respect to obstacle

b. Automatic Profile Following

1) Test course terrain profile
2) Time correlated space positioning coordinates
3) Test item command and aircraft instrumentation signals
4) Meteorological conditions

c. Manual Profile following

1) Test course terrain profile
2) Time correlated space positioning coordinates
3) Test item command and aircraft instrumentation signals
4) Meteorological conditions

d. Automatic Vertical Terrain Clearance

1) Test course terrain profile
2) Time correlated space positioning coordinates
3) Test item command and aircraft instrumentation signals
4) Meteorological conditions

e. Manual Vertical Terrain Clearance

1) Test course terrain profile
2) Time correlated space positioning coordinates
3) Test item command and aircraft instrumentation signals
4) Meteorological conditions

f. Lateral Terrain Clearance

1) Test course terrain clearance
2) Time correlated space positioning coordinates
3) Test item command and aircraft instrumentation signals
4) Meteorological conditions

g. Automatic Dual Mode

1) Test course terrain profile
2) Time correlated space positioning coordinates
3) Test item command and aircraft instrumentation signals
4) Meteorological conditions

h. Manual Dual Mode

1) Test course terrain profile
2) Time correlated space positioning coordinates
3) Test item command and aircraft instrumentation signals
4) Meteorological conditions

i. Ground Mapping

1) Still photographs of the test item's CRT display unit
2) Test item antenna orientation
3) Test item command and aircraft instrumentation signals
4) Meteorological conditions

j. Over Water

1) Test course terrain profile
2) Sea state
3) Description of waterborne object
4) Still photograph of waterborne object
5) Time correlated space positioning data
6) Test item command and aircraft instrumentation signals
7) Meteorological conditions

k. Over Ice Caps and Snow

1) Test course snow/ice/earth profile
2) Time correlated space positioning data
3) Test item command and aircraft instrumentation signals
4) Meteorological conditions

6.4 DATA REDUCTION AND PRESENTATION

Processing of raw test data shall, in general, consist of computing mean values and standard deviations of measurements and measurement errors, and organizing data into tabular and graphical form. All test data should be properly marked for identification and correlation, and grouped according to test title.

Common to all flight tests shall be the need for reducing data to accurately ascertain the test aircraft's space position coordinates and photographs of the test item's display unit shall be correlated to testing time.

Specific instructions for the reduction and presentation of individual test data are outlined in succeeding paragraphs. Time correlatable photographs of the test item's display unit shall be provided for each of the flight test data presentations.

6.4.1 Failsafe

Failsafe data shall be presented in tabular form under the parameter headings indicated in paragraph 6.3.3.1 a. Photographs of the test item's display indicator shall be presented if deemed more suitable than narrative type descriptions thereof.

6.4.2 Obstacle Detection/Resolution

Obstacle detection/resolution numerical test data shall be reduced to aircraft velocity and position with respect to the obstacle. These data shall be correlatable to the on-board photographic presentations and shall be presented in tabular form in conjunction with a narrative description of the size, type, and construction of the obstacle encountered. Photographs of the test item's display unit taken at each check point shall be presented as shall still photographs of the obstacle as seen along the test aircraft's link of flight.

6.4.3 Automatic Profile Following

Automatic profile following data shall be reduced to and presented as graphs of the following test parameters:

a. Absolute altitude versus testing time as shown in Figure 2. One such graph shall be presented for each aircraft test velocity and direction.

b. G-load versus testing time for each aircraft altitude, velocity, and direction. Aircraft G-load shall be plotted on the ordinate and testing time plotted on the abscissa.

c. Aircraft pitch angle versus testing time for each aircraft altitude, velocity and direction.

Terrain description data shall consist of a selection from the following table which best describes the terrain encountered.

Terrain	Conductivity σ in emu	Dielectric constant ϵ in esu
Dry, sandy flat coastal land	2×10^{-14}	10
Marshy, forested flat land	8×10^{-14}	12
Rich agricultural land, low hills	1×10^{-13}	15
Pastoral land, medium and forestation	5×10^{-14}	13
Rocky land, steep hills	2×10^{-14}	10
Mountainous (hills up to 300 feet)	1×10^{-14}	5
Cities, residential areas	2×10^{-14}	5
Cities, industrial areas	1×10^{-15}	3

6.4.4 Manual Profile Following

Manual profile following data shall be reduced and presented in a manner similar to that given for the automatic profile following test.

6.4.5 Automatic Vertical Terrain Clearance

Automatic vertical terrain clearance test data shall be reduced to and presented as graphs of the following test parameters:

a. Absolute altitude versus testing time as shown in Figure 2. One such graph shall be presented for each aircraft test velocity and direction.
b. Aircraft G-load versus testing time.
c. Aircraft pitch, roll, and yaw versus testing time.

6.4.6 Manual Vertical Terrain Clearance

Manual vertical terrain clearance data shall be reduced and presented as indicated in paragraph 6.4.5 above.

6.4.7 Lateral Terrain Clearance

Lateral terrain clearance data shall be reduced to a presented as a plot of the aircraft's actual flight course on a suitable topological map of the test area. The test course base line and aircraft position at 10 second intervals should be clearly indicated. One such plot shall be presented for each

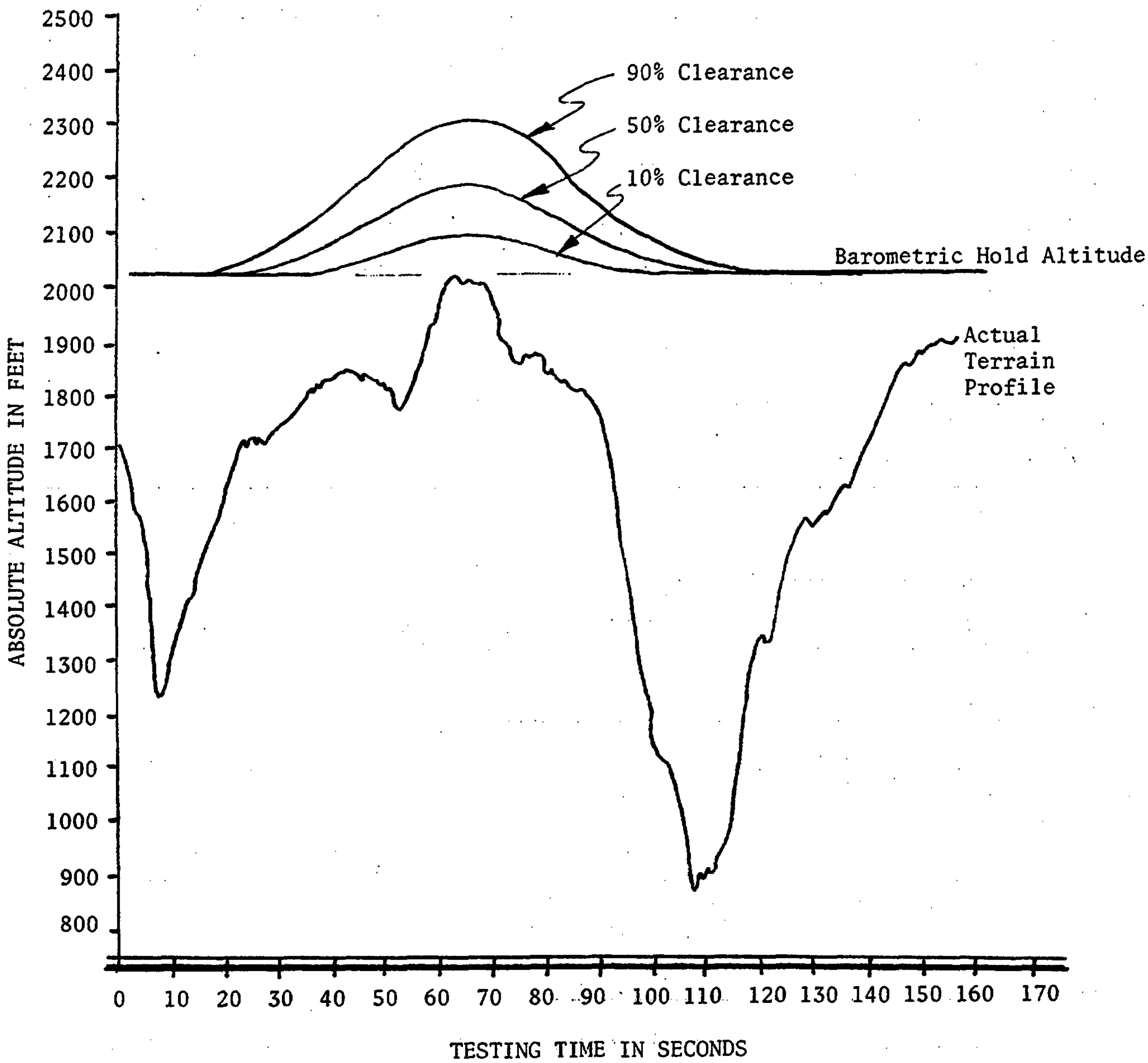

FIGURE 2. Hypothetical Terrain Clearance Accuracy Curve.

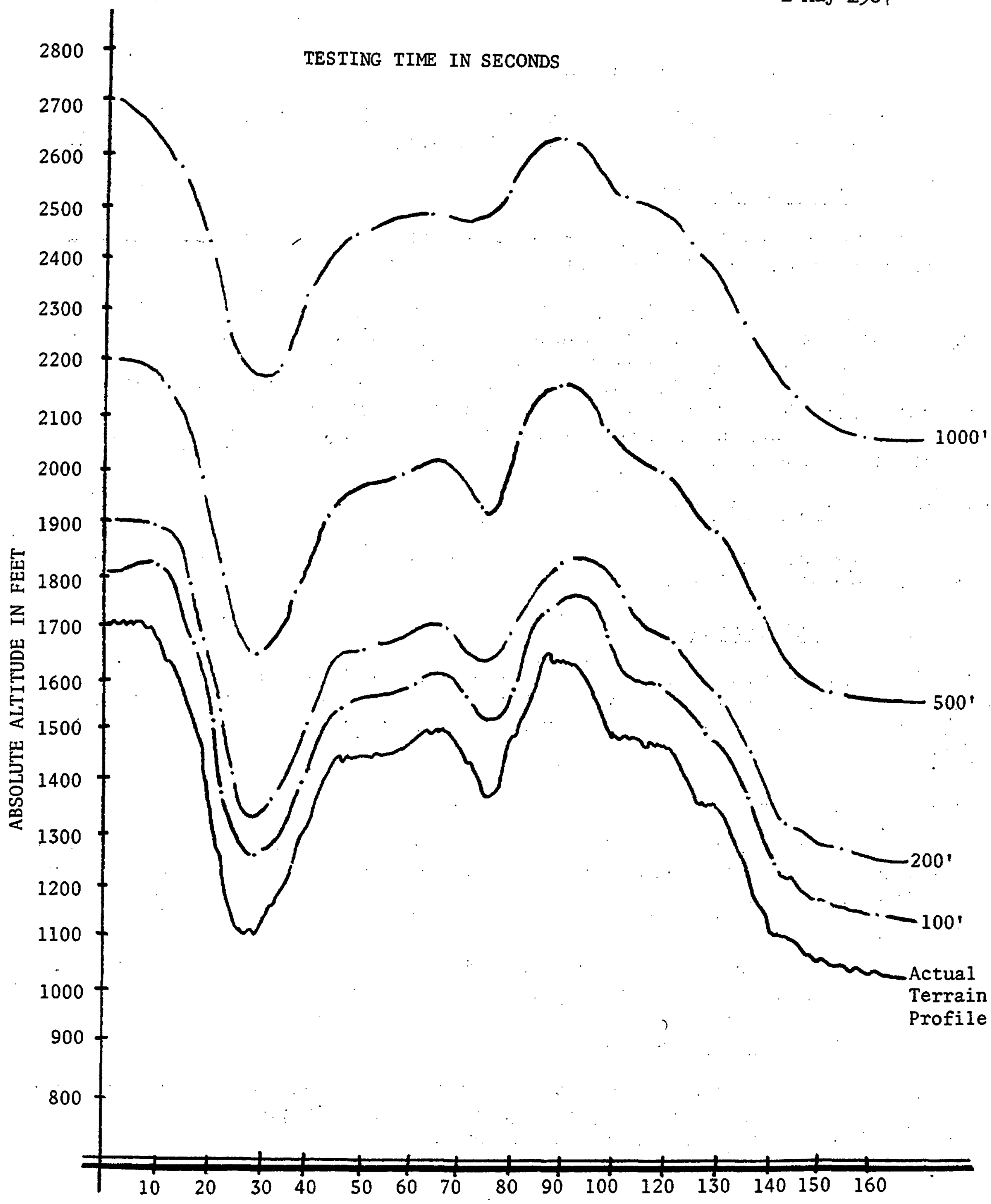

FIGURE 3. Hypothetical Profile Following Test Accuracy Curve.

aircraft velocity, direction, and altitude.

Additionally, aircraft turn rate yaw and roll angles should be presented in graphical form as a function of testing time in 10 second intervals.

6.4.8 Automatic Dual Mode

The automatic dual mode test data shall be reduced to the following graphical presentations for each aircraft altitude, velocity, and direction:

a. A plot of the actual aircraft course on a suitable topological map of the test area. The test course base line and actual aircraft position at 10 second intervals shall be clearly indicated thereon.

b. A graph similar to that shown in Figure 3, indicating actual aircraft altitude above the terrain as a function of testing time.

c. Graphs of aircraft G-load and pitch, yaw, and roll angles as functions of testing time.

6.4.9 Manual Dual Mode

Manual dual mode test data shall be reduced and presented as outlined for the automatic dual mode test.

6.4.10 Ground Mapping

Ground mapping test data shall be presented in the form of comparative test item display photos, and topological maps. Display photos shall be identified with respect to test item antenna orientation, and aircraft altitude and position.

6.4.11 Over Water

The over water test data shall be reduced and presented in accordance with the instructions outlined in paragraph 6.4.5 with the additional requirement that the Beaufort number which describes the sea state be computed and noted on the interface profile charts.

Profile charts for flight over waterborne objects shall include scaled silhouettes of the vessels and notations as to sea state.

6.4.12 Over Ice Caps and Snow

Over ice caps and snow data shall be reduced and presented in accordance with the instructions given in paragraph 6.4.5. Terrain profiles shall accurately indicate the altitude of all surface interfaces.

APPENDIX A

TERRAIN AVOIDANCE EQUIPMENT MODES OF OPERATION

VERTICAL TERRAIN CLEARANCE MODE (VTCM)

The aircraft flies at a predetermined barometric altitude and has freedom of deviation from a straight-line course in a vertical plane only. Any terrain or obstacle protruding through the line of flight altitude will be avoided by means of a vertical maneuver. After clearing the obstruction with a desired predetermined clearance, the aircraft returns to the original barometric altitude.

LATERAL TERRAIN AVOIDANCE MODE (LTAM)

The aircraft flies and is confined to a predetermined barometric altitude. No restrictions are imposed on the pilot as far as lateral maneuvers are concerned. Any obstructions which extend above the assigned altitude are avoided by means of a lateral maneuver.

PROFILE FOLLOWING MODE (PFM)

The aircraft flies at a desired predetermined absolute altitude and is restricted in lateral maneuvers to a straight line course; thus the terrain profile is followed.

DUAL MODE (DM)

This mode provides for both lateral and vertical deviations from a straight-line course to permit maximum exploitation of the terrain features.

GROUND MAPPING MODE (GMM)

This mode of operation is primarily employed as an enroute navigational aid, providing the pilot with a display of the terrain ahead of the aircraft that can be directly related to a topographical map. There are no restrictions as to freedom of movement or altitude reference.

GLOSSARY

TERRAIN - Configuration of the natural surface of the earth, including the vegetation which covers the surface.

OBSTACLE - Any man-made object which is erected on the terrain and has a vertical extension such that it may obstruct the movement of the airborne vehicle.

TERRAIN AVOIDANCE - Circumvention of physical contact with the terrain. The term is generally expanded to include avoidance of obstacles.

CLEARANCE ALTITUDE - Altitude of the aircraft above the terrain and obstacles.

RADAR CROSS-SECTIONAL AREA - The area intercepting that amount of power which, when scattered equally in all directions, produces an echo at the radar equal to that from the target; or in other terms,

$$\sigma = \frac{\text{power reflected toward source/unit solid angle}}{\text{incident power density}/4\pi}$$