AD 718605

19 November 1968

Materiel Test Procedure 6-2-095
Electronic Proving Ground

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

3478

FUZE JAMMER COUNTERMEASURES EQUIPMENT

1. OBJECTIVE

The objective of this Materiel Test Procedure is to describe the procedures required to determine the technical performance characteristics of electronic countermeasures, (ECM) equipment designed to operate against electronic proximity-fuzed enemy projectiles.

2. BACKGROUND

The proximity fuze of the variable-time (VT) variety is essentially a combination radio frequency transmitter and receiver. A short time after a VT-fuzed projectile or missile leaves the weapon, the fuze becomes armed and begins sending out continuous electromagnetic waves. As the projectile approaches an object, the waves are reflected back to the fuze and picked up by the receiving unit. The interaction of the transmitted and reflected waves results in a "beat frequency" within the unit. When the beat frequency reaches a predetermined intensity, an electronic switch operates to cause an electric charge to flow through an electric firing squib which activates the projectile explosive train. VT fuze features and types differ, principally in arming-time and frequency characteristics, dependent upon the weapon projectile combination and the tactical application. VT fuze types may contain an impact element that will detonate, on impact, any shell that fails to function normally on proximity approach to the target. The objective of VT fuze ECM systems (fuze jammers) is to detonate incoming VT-fuzed projectiles at a premature point on the trajectory, thus reducing their lethality. The basic techniques are (1) the early detection and determination of the VT fuze frequency and (2) the radiation of an electromagnetic wave toward the projectile of a frequency to create a response within the fuze which simulates a normal target proximity response at a pre-normal time. New VT fuze ECM systems are developed or older systems redesigned to keep pace with or anticipate advances in VT fuze design and application on the assumption or knowledge that a potential enemy can employ equally sophisticated devices. The technical performance and operational safety of new and modified systems must be determined by means of comprehensive engineering tests including the use of actual or simulated threat items of latest design.

3. REQUIRED EQUIPMENT

The items listed herein are the minimum required in the performance of tests covered by this MTP. Additional items may be necessary to meet special test requirements.

a. Signal generators
b. Oscillators
c. Frequency meters/counters

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d. RF power meters/wattmeters
e. Field intensity measuring sets
f. Spectrum analyzers
g. Oscilloscopes
h. Oscillographs
i. Magnetic tape recorders
j. Vacuum-tube voltmeters
k. Multimeters
l. RF attenuators, terminations, and couplers
m. Photographic equipment, still, cine, and CRT types
n. Theodolites or equivalent
o. Fire support units with required number, type, and caliber of weapons.
p. Fixed wing and/or rotary wing aircraft of required type with test item and test instrumentation installation capabilities.
q. Stripped aircraft (airframe only or equivalent mockup) of selected type.
r. Electronic/electromagnetic-type laboratory.
s. Integrated surface-to-surface artillery range for ground-based test items.
t. Integrated test facility with antiaircraft fire capability for airborne test items.

4. REFERENCES

A. MIL-STD-449(-), Measurement of Radio Frequency Spectrum Characteristics
B. MIL-STD-463(-), Electromagnetic Interference Technology-Definition and System of Units
C. FM 6-20-2, Field Artillery Techniques
D. FM 6-40, Field Artillery Cannon Gunnery
E. TM 9-1900, Ammunition, General
F. Classified FM's and TM's
G. ETA-6, Test Plan-Performance Evaluation of the ECM Set AN/MLQ-8(U), USAEPG, October 1962
H. ETA 21/A, Combined Engineering-User Test of the VT-Fuze ECM (AN/MLQ-8(XE-3)) in 3/4-ton Truck (U), USAEPG, October 1962
I. ETA 22/A, Combined Engineering-User Test of the VT-Fuze ECM AN/VLQ-(-) (XE-1) in APC (U), USAEPG, October 1962
J. ETA 23/A, Complete ET-UT of the AN/PLQ-2 (XAE-3) Man-Transportable VT-Fuze Jammer (U), (Test Plan) USAEPG, October 1962
K. ETA-TP-158 (R1), Plan of Test for Integrated Engineering/Service Test of AN/PLQ-2(XE-1) VT-Fuze ECM (U), USAEPG, October 1964
L. USAEPG-CTP-164 (R1), Coordinated Test Program of Advanced Countermeasures Set AN/MLQ-( ) (U), USAEPG, June 1965
M. USAEPG-TP-223, Plan of Test of Countermeasures Set AN/ALQ-67(XE-2) (U), USAEPG, March 1966
N. MTP 6-2-020, Radar Antenna Subsystem Tests

5. SCOPE

5.1 SUMMARY

5.1.1 Technical Performance

This test procedure describes the tests required to determine and evaluate the technical performance characteristics of ECM equipment designed to provide protection from enemy proximity (VT) fuzed projectiles. Specific subtests include:

5.1.1.1 Parameter Subtests

These subtest procedures describe the tests required to determine performance characteristics of selected portions of the test item. Specific subtests include:

a. Receiver Subtest - The objective of this subtest is to determine the technical performance characteristics of ECM receivers in terms of the following:

1) Frequency Range
2) Sensitivity
3) Selectivity
4) Dynamic Range
5) Standard Response
6) Search Rates

b. Transmitter Subtest - The objective of this subtest is to determine the technical performance characteristics of ECM Transmitters in terms of the following:

1) Frequency Range
2) Power Output
3) Modulation
4) Emission Spectrum

c. Antenna Subtest - The objective of this subtest is to determine the radiation pattern characteristics of ECM radar antennas.

5.1.1.2 Field Subtests

These subtest procedures describe the tests required to determine the technical performance characteristics of the test item during actual operation under controlled conditions, against appropriate weapons firing VT fuzed ammunition. Subtests include:

a. Optimum Jammer Parameters - The objective of this subtest is to determine the optimum test item parameters for predetonating the majority of single-round fire and the resultant spatial area of effectiveness under varying conditions.

b. Volley Fire Effectiveness - The objective of this subtest is to

determine the effectiveness of the test item against volley fire, in terms of the following:

1) Area of protection
2) Effectiveness against different fuze types
3) Effectiveness versus size of volley
4) Effect of fuze arming time
5) Effect of angle of fall

5.1.1.3 Field Test (Airborne Test Items)

These subtest procedures describe the tests required to determine the effectiveness of airborne test items, designed to protect manned or unmanned Army Aircraft from VT fuzed ground fire. Specific subtests include:

a. Area of Normal VT Fuze Action - The objective of this subtest shall be to determine the distances from the airframe where 50% and 90% normal VT (NVT) action occurs with the test item inoperative.

b. Area of Protection - The objective of this subtest is to determine the area of protection about the airframe, provided by the test item.

c. Effectiveness versus Fuze Type - The objective of this subtest is to determine the effectiveness of the test item against VT fuzes of different types and frequencies.

d. Effectiveness against Salvo Fire - The objective of this subtest is to determine the test item's effectiveness under sustained fire conditions.

e. Maximum Effectiveness Subtest - The objective of this subtest is to determine the maximum effectiveness of the test item against VT fuzes while using the airframe as target point.

5.1.2 Common Engineering Tests

The following Common Engineering Tests, applicable to this commodity, are not included in this MTP:

a. 6-2-500 Physical Characteristics
b. 6-2-502 Human Factors Engineering
c. 6-2-503 Reliability
d. 6-2-504 Design for Maintainability
e. 6-2-507 Safety

5.2 LIMITATIONS

This MTP excludes consideration of test item features, functions or characteristics requiring application of security measures. Test for classified items and components shall be developed at the time of the test plan preparation for each item type based on specifications and requirements set forth in instruction manuals, the QMR/SDR or equivalent sources.

6. PROCEDURES

6.1 PREPARATION FOR TEST

Before any tests are performed on this commodity, the item must have successfully completed MTP 6-2-507, Safety.

6.1.1 Pre-scheduling Conditions

a. During the organization of the test plan, a survey of facilities, personnel and land areas which can be utilized for the various tests within the allocated test time frame, shall be made.

b. A test plan shall be prepared prior to scheduling which will include a table showing the subtests to be performed during each phase.

NOTE 1: The selection of subtests described in this MTP, for a given test item, shall be governed by the following:

a. Test item design features
b. Concept of employment
c. Classes and types of weapons, projectiles and VT fuzes to be tested.

NOTE 2: The test plan shall specify sufficient repetition of tests and subtests to produce statistically valid data, with respect to the number of available test item samples, the number of weapon system types, and the number of VT fuze types.

NOTE 3: Provision shall be made in the test plan for adjustments during test progress as may be indicated by monitored test results.

6.1.2 Pre-testing Conditions

a. Personnel responsible for conducting the test shall ensure that applicable instructions and design specifications are available.

b. Reports of previous tests shall be available to test personnel when appropriate.

c. Operating instructions for test instruments, to be used during testing, shall be obtained and made available to test personnel.

d. A test log book or folder shall be prepared and utilized to record data obtained during testing.

e. Availability of test range facilities shall be checked and firm scheduling verified.

f. All test instrumentation shall be assembled and calibrated to within desired tolerances as required.

g. Primary AC/DC power shall be checked to ensure correct values.

h. Arrangements shall be made with supporting and participating agencies, activities and facilities.

i. Required authorization shall be obtained for electromagnetic radiation at specific frequencies, power levels, and modulations for desired periods.

j. Personnel responsible for test conduct shall insure the inventory,

assembly and inspection of test item samples.

k. Test personnel shall be briefed prior to testing on the purpose of the test and the degree of accuracy expected.

6.2 TEST CONDUCT

6.2.1 Parameter Subtests

6.2.1.1 Receiver Subtest

The receiver subtest shall be performed in accordance with procedures outlined in MTP 6-2-242 (Receiver-Transmitter, General).

6.2.1.2 Transmitter Subtest

The transmitter subtest shall be performed in accordance with procedures outlined in MTP 6-2-242 (Receiver-Transmitter, General).

6.2.1.3 Antenna Subtest

The antenna subtest shall be conducted in accordance with procedures outlined in MTP 6-2-020 (Radar Antenna Subsystem Tests).

NOTE: Airborne system antennas shall be tested by one of the two methods described in the appendix.

6.2.2 Field Subtests

The following procedures shall apply to all Field Subtests:

a. Deploy the test item and threat weaponry on the test range in a manner similar to figure 1.

NOTE: The test area shall be of adequate size, equipped with communication facilities, a protective bunker in the impact area and a minimum of three appropriately positioned observation posts. All locations shall be surveyed to the required degree of accuracy.

b. Equip observation posts with theodolites or equivalent instrumentation for determining projectile air burst space position.

c. Locate an appropriately equipped frequency monitoring facility in such a manner so as to accomplish the measurement and recording of all jammer and VT fuze frequencies.

NOTE 1: Fire support shall be provided by qualified artillery units controlled by their organizational fire direction center. Selection of weapon types and calibers shall be governed by the test item concept of employment and test directive requirements.

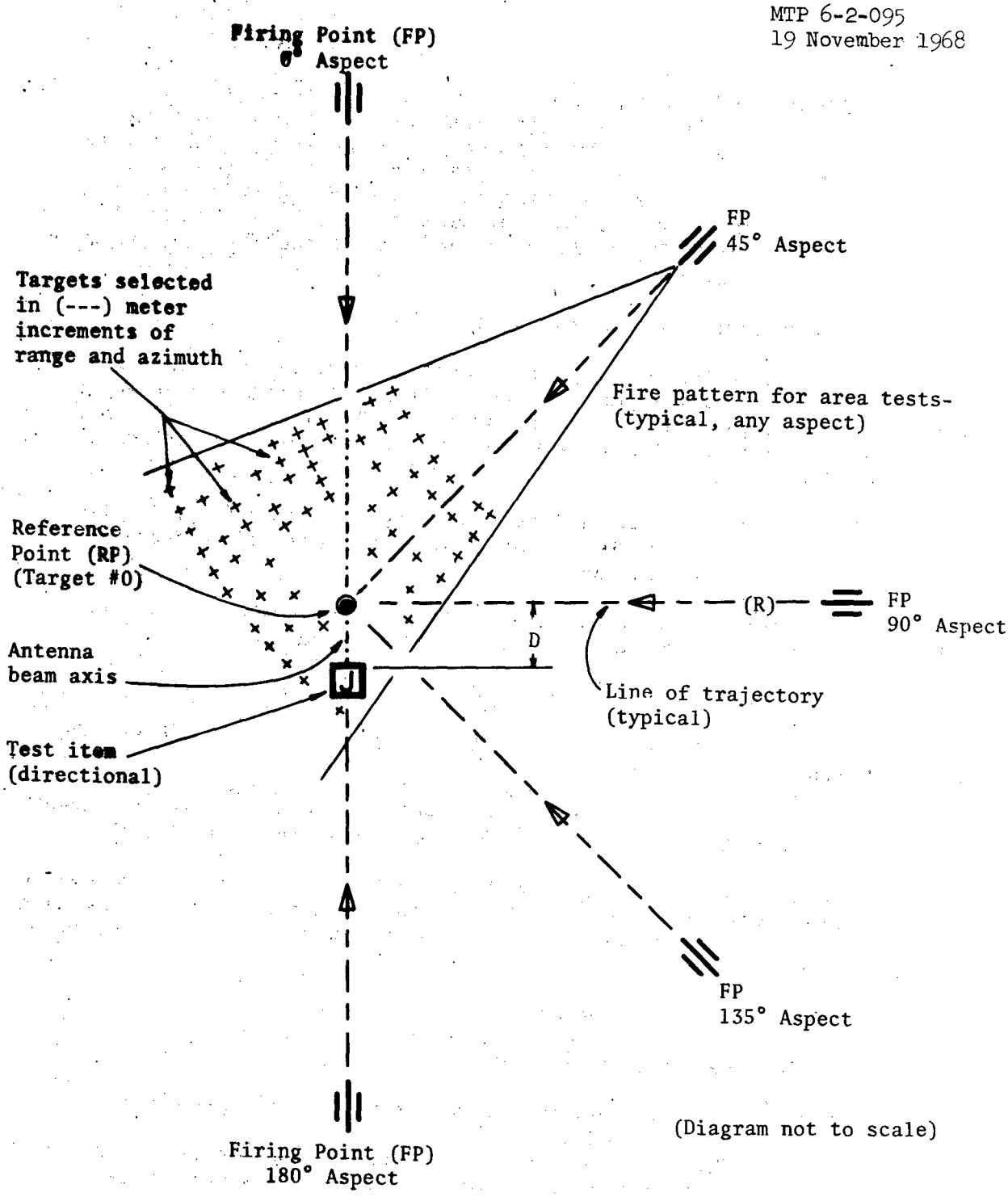


Figure 1. Test Setup for Ground-based Test Items.

NOTE 2: Although Figure 1 depicts a directional-type test item, omnidirectional types shall be tested in an equivalent type set-up, by shifting the reference point as required.

NOTE 3: Reference points and jammer-RP distances, D, shall be based on an optimum point of the jammer antenna pattern as determined from parameter tests. The weapon range (R=FP-RP), shall be the optimum for each type of weapon employed.

6.2.2.1 Optimum Jammer Parameters and Effective Area

a. Emplace the test item and selected weapon as shown in Figure 1.

b. Conduct low-angle single-round fire, 10 rounds per target, using only one VT fuze type (frequency) for directions of fire at 0, 45, 90, 135, and 180 degrees with the test item antenna at nominal elevation and vertically polarized. (Normal CVT settings shall be used.)

NOTE: Fire at target points shall progress from #0(RP), in all directions, to the points where pre-detonations decrease to five per target.

c. Record the number of pre-detonations, normal VT fuze functions and impact detonations per target and target identification.

NOTE: An additional round shall be fired for each dud.

d. Record the azimuth and elevation angles of each air burst observed at each observation post.

e. Repeat the procedures above (a-d), using high angle fire.

f. Repeat the procedures above (a-d), at the most effective aspect and with low-angle fire for each of the VT fuze types prescribed for the weapon.

g. Repeat procedures a-d with the test antenna at different positions about its three orthogonal axes to determine the optimum antenna fuze coupling.

h. Repeat procedures in g. above at the most effective aspect using high-angle fire.

6.2.2.2 Volley Fire Effectiveness

a. Emplace weapon as indicated in 6.2.2.1,a.

NOTE 1: Numerical values stated herein are for illustrative purposes only.

NOTE 2: For each test condition, observation posts and auxiliary observers shall record the air burst position of each round for each volley and the numbers of each fuze action, i.e. predetonation, normal VT and point detonation. The position of closely grouped air bursts may be recorded as the man measured position.

b. Fire one 10-round volley of one fuze type at each target until

the area is determined in which the test item predetonates 50% or more fuzes per target under each of the following conditions:

1) Antenna polarization, vertical; all fire aspects; low angle-of-fall.
2) Same as 1) above except antenna polarization, horizontal.
3) Antenna polarization, 45°; aspects 45° and 90°; low angle-of-fall.
4) Antenna polarization vertical with main axis elevated to 45°; 0° and 45° aspects; low angle-of-fall.
5) Antenna polarization vertical with 0° elevation; 45° aspect; high angle-of-fall.

c. Successive 10-round volleys of each available fuze type shall be fired at one target; 45° aspect and vertically polarized antenna.

d. Volleys of 6, 10, 18, and 36 rounds shall be fired at selected targets (e.g. 10) in the previously determined area of protection (b. above); 45° aspect and optimally positioned antenna.

e. Arming time effect shall be determined by firing 10-round volleys of one fuze type at selected targets (e.g. six); 45° aspect and optimum polarization. Three volleys shall be fired on each target for each fuze setting, e.g. normal T-1 (flight time minus 1 second) and delayed arming time of T+2 (flight time plus 2 seconds). The "delayed-arm-time" fire shall be repeated with the test item turned off to determine the effect of delayed arming time on burst heights with no jamming action present.

f. Angle-of-fall effect shall be determined by varying the angle-of-fall while maintaining other parameters essentially constant; optimum antenna polarization, 45° aspect. With reference to Figure 2, three 10-round volleys of one VT fuze type shall be fired on each target point, beginning with #1 and with the test item at location #1. Initial test item location shall be the same as in paragraph 6.2.2. and the initial target point, selected from the same test, as the maximum range target on the 45° FP-RP line at which less than 30% predetonations were obtained. The test item and target points shall then be moved progressively closer to the FP in approximately 200 meter increments, maintaining parallelism and the 45° aspect as shown, until predetonations exceed 90%. The fire direction center shall provide the computed angle-of-fall for each target point.

6.2.3 Field Test - Airborne Test Items

The following procedures shall apply to all field subtests concerning airborne test items:

a. Deploy the test item and threat weaponry on the test range in a manner similar to Figure 3.

1) Install a suitable power supply in the airframe as shown in Figure 3. (The Airframe shall be of a type contemplated in the concept of employment).
2) Suspend the airframe from the catenary system as shown in

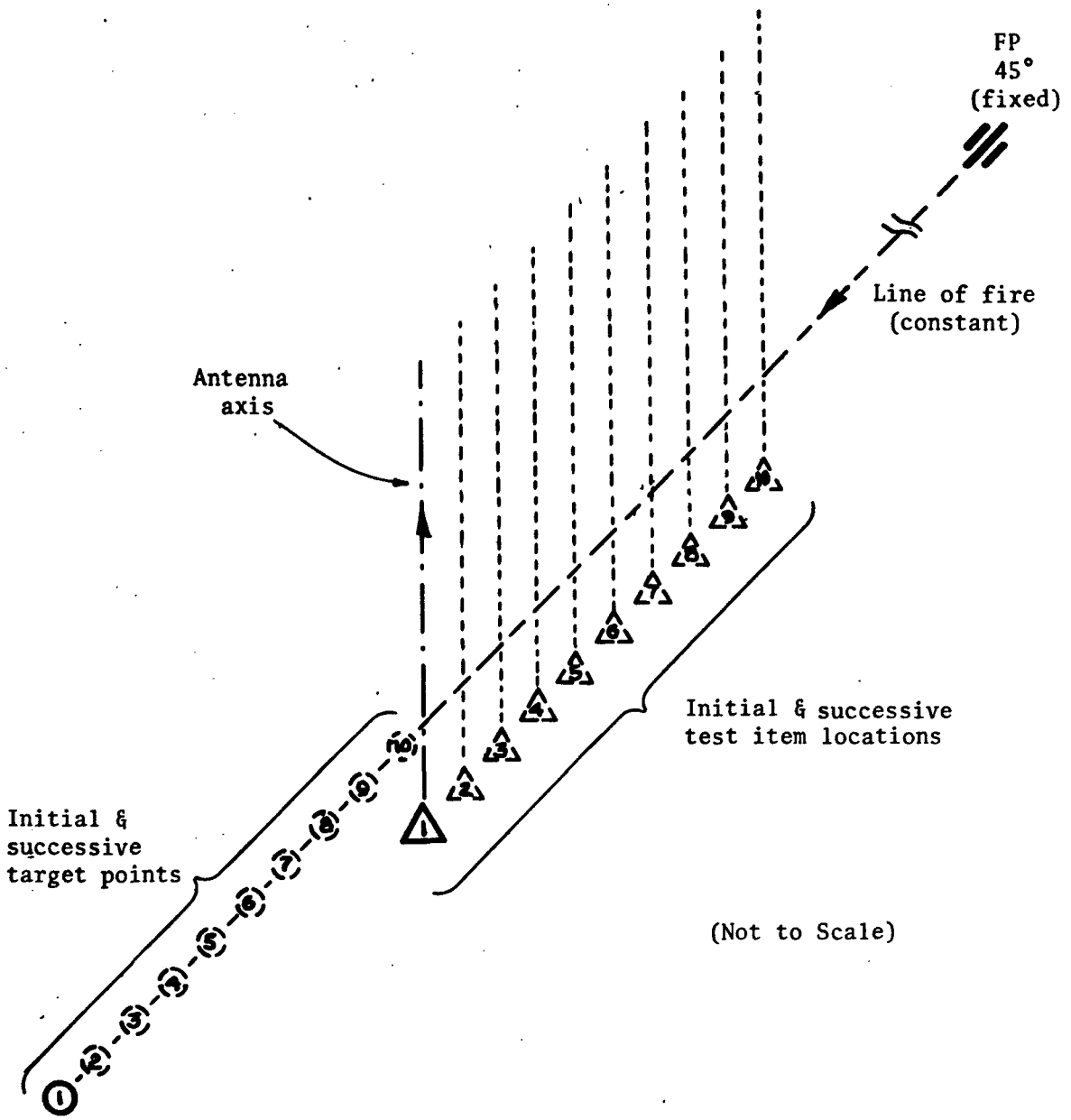


Figure 2. Test Setup for Angle-of-Fall Effect.

Figure 3. and equip with nose, tail and wing-tip tag lines for adjusting airframe attitude (pitch, roll and yaw).

3) Make required airframe adjustments to an accuracy of ±2°, using transits or equivalent instruments.

NOTE: Realistic simulation of the relative aspects which exist between the aircraft and the projectile during the flight is essential to provide a valid check of the test item's capabilities during firing tests. Since the test facilities described herein fix the approach trajectory of the projectile, it becomes necessary to adjust the attitude of a test target airframe (with installed test item) to simulate the electromagnetic coupling conditions. Simulation of the electromagnetic coupling which would exist during a tactical mission flight shall be accomplished by selecting a representative number of points along typical flight paths and then positioning the target airframe into the appropriate static attitude for each point.

b. Prepare a diagram of the hypothetical flight paths discussed in the note above, and show the selected check points referenced to a ground weapon position. An accompanying table shall be prepared listing the resulting aspect angles in terms of roll, pitch and yaw, of the target airframe for each check point.

c. Observers shall be located at three observation posts (OP) located around the test item area for the purpose of reporting the fuze action of each round of each volley and the space position of burst relative to the airframe for each test condition.

NOTE: Observers shall be equipped with theodolites or equivalent instruments, for the determination of air burst positions. In addition, a permanent record of airburst positions shall be obtained by a photo-instrumentation complex consisting of cine-theodolites, positioned at surveyed locations for the above stated purpose.

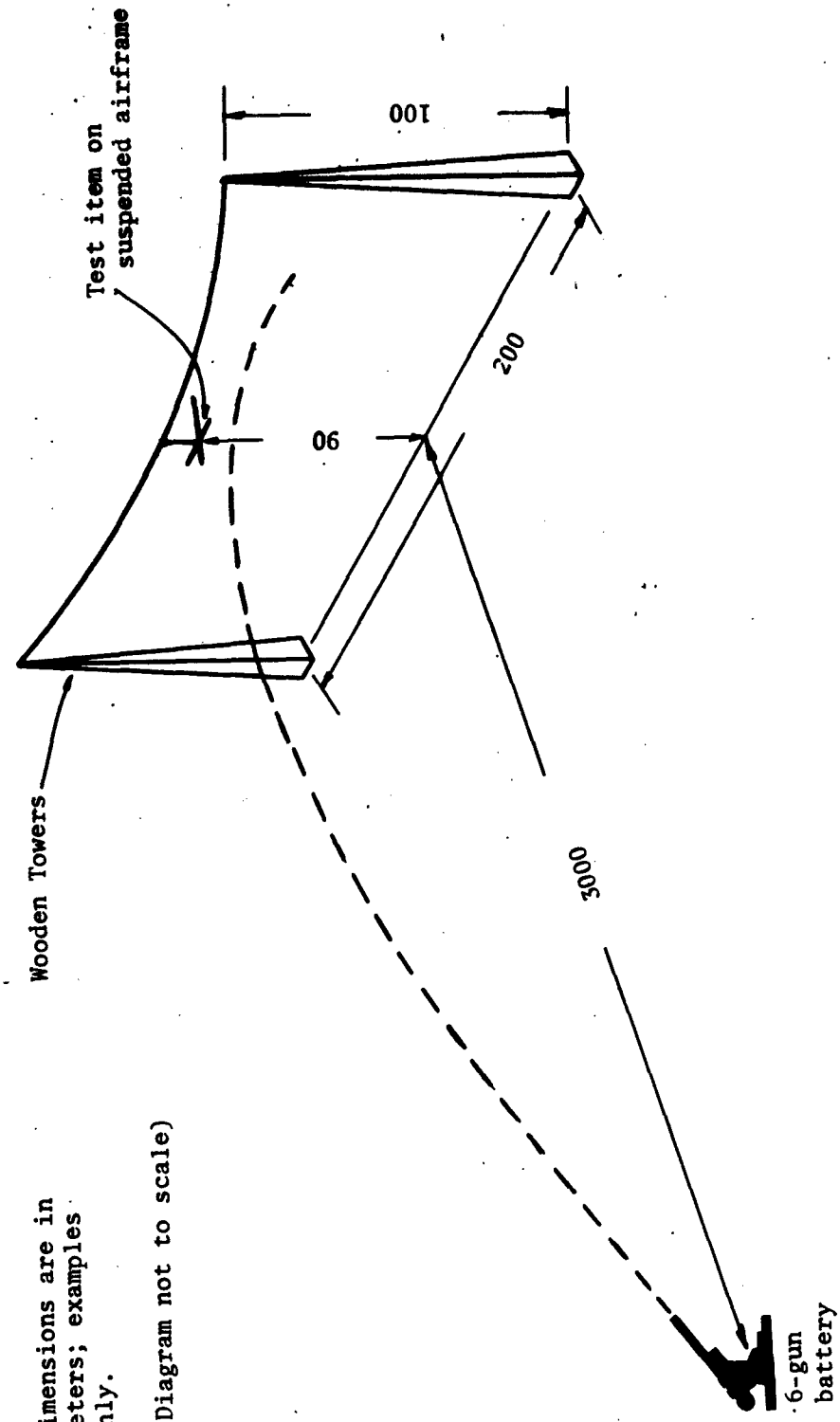
d. Conduct registration fire as required, with the test item inoperative, to ensure accuracy and to determine projectile trajectories by means of flash ranging instrumentation integral to the test facility.

6.2.3.1 Area of Normal VT Fuze Action

a. Fire single rounds initially on a point half-way between the airframe and either the right or left tower. (Number of rounds shall be determined by test coordinator.)

b. Repeat single round fire, allowing successive rounds to approach the airframe in increments of approximately 3 meters until 50% and 90% distances have been determined. (Distances at which 50% and 90% of the rounds are predetonated by the test item.)

c. Record 50% and 90% distances in the test log.



NOTE: Dimensions are in meters; examples only.

(Diagram not to scale)

Figure 3. Example of Test Setup for Airborne Test Items.

d. Fire 10 volleys consisting of six rounds each, at a selected point within the 90% NVT area, with the airframe adjusted to selected attitudes as shown in table, prepared as directed in 6.2.3.b.

e. Repeat a through d for each fuze type and frequency.

6.2.3.2 Area of protection

a. Energize the test item while in the suspended position.
b. Fire a suitable number of two (2) volley missions at the 90% area.
c. Record the following data pertaining to each mission fired:

1) Test item operating parameters including:

a) Search rate
b) Power
c) Frequency

2) Antenna orientation and polarization
3) Weapon identification, class, caliber
4) Fuze type, frequency and lot number
5) Aspect angle (degrees)
6) Target airframe attitude
7) Fire mission: number of single rounds, volleys or salvos and number of rounds per volley or salvo
8) Target point designation
9) Firing angle: High, >800 mils; low, <800 mils
10) Angle-of-fall (mils)
11) Fuze action (by round): predetonation, normal VT (NVT), impact detonation (graze), dud
12) Air-burst position: azimuth and elevation angle (mils)
13) Firing data contained in standard artillery records.

6.2.3.3 Effectiveness versus Fuze Type

a. Repeat the procedures given in 6.2.3.2., for each fuze type and for each fuze frequency.

b. Repeat the procedures given in 6.2.3.2, using mixed fuze frequencies in a suitable number of six round volleys.

6.2.3.4 Effectiveness Against Salvo Fire

a. Fire an appropriate number of salvos, of from 10 to 15 seconds in duration, at the 90% NVT target points at an approximate rate of 1 round per second, per weapon using one fuze type and mixed frequencies per salvo, with the target aircraft in one selected attitude.

NOTE: In Army field artillery usage, salvo fire is that method in which weapons are discharged one after the other. Not to be confused with Navy usage wherein salvo is the equivalent of an artillery volley.

b. Record data indicated in 6.2.3.2., c.
c. Repeat this subtest if required, based on the results of three fired salvos.

6.2.3.5 Maximum Effectiveness Test

If the results of the foregoing tests indicate the test item is an effective jammer, the procedure of paragraph 6.2.3.4, shall be repeated using the airframe itself as the target point.

6.3 TEST DATA

6.3.1 General

Test data developed on the subject test items is generally comparable and shall consist of maps, photographs, diagrams, logs data collection forms, and processed photo-instrumentation material described below.

6.3.1.1 Maps

Maps, photographs, sketches, and diagrams shall depict the

a. Test area with orientation reference information
b. Test facility features
c. Test item location(s), installation details and any special features.
d. Fire support locations, aspect angles, lines of fire and target points.
e. Observation post and frequency monitoring locations
f. Flight patterns/paths with data check points
g. Distances involved

6.3.1.2 Block Diagrams

Block diagrams shall be prepared for electrical/electronic and comparable instrumentation setups, showing the test item, test equipment, and interconnections with appropriate notations and cross-references.

6.3.1.3 Event Logs

A chronological record of events shall be maintained throughout the test period. This record becomes the major tool in the process of data compilation and correlation. Examples of information to be recorded are:

a. Dates and times of occurrences listed below.
b. Subtests and test phases.
c. Test item installations and changes.
d. Measurements.
e. Coordination activities with supporting agencies, e.g. fire support.

f. Cross-references to other records.
g. Deviations from or modifications of original test plan.
h. Test item malfunctions.
i. Unusual conditions affecting test results; cause of delays and and corrective action.
j. Test personnel.

6.3.1.4 Test Data Collection Forms

Data collection forms generally shall be in columnar format designed for the test item, each subtest and each data collection point. Standard artillery firing data records prepared by the fire support unit shall be included in the data package resulting from each field subtest. The heading portion of all forms shall contain spaces for recording the following minimum information:

a. Test and subtest identification.
b. Test item identification.
c. Date and time.
d. Meteorological data temperature, relative humidity, weather conditions.
e. Location.
f. Test equipment or instrumentation.

6.3.2 Parameter Test Data

6.3.2.1 Receiver Subtest

Record data in accordance with applicable portions of MTP 6-2-242.

6.3.2.2 Transmitter Subtest

Record data in accordance with applicable portions of MTP 6-2-242.

6.3.2.3 Antenna Subtest

Record data in accordance with applicable portions of MTP 6-2-020.

6.3.3 Field Subtests

6.3.3.1 General

Record the following general data as appropriate for each field test.

a. Test item operating parameters including:

1) Search rate
2) Power
3) Frequency

b. Antenna orientation and polarization.

c. Weapon identification, class, caliber.
d. Fuze type, frequency and lot number.
e. Aspect angle (degrees).
f. Target airframe attitude.
g. Fire mission: number of single rounds, volleys or salvos and number of rounds per volley or salvo.
h. Target point designation.
i. Firing angle: high, >800 mils; low <800 mils.
j. Angle-of-fall (mils)
k. Fuze action (by round): predetonation, normal VT (NVT), impact detonation (graze), dud.
l. Air-burst position: azimuth and elevation angle (mils)
m. Firing data contained in standard artillery records.

6.3.3.2 Optimum Jammer Parameters and Effective Area

a. Record data listed in 6.3.3.1.
b. Record the number of predetonations, normal VT fuze functions and impact detonations per target and target identification.
c. Record the azimuth and elevation angles of each air burst as monitored or observed at each observation post.

6.3.3.3 Volley Fire Effectiveness

a. Record data listed in 6.3.3.1.
b. Record the airburst positions of each round, observed by the observers, for each volley and numbers of each fuze action, for each test condition.

6.3.4 <u>Field Test-Airborne Test Items</u>

a. Record data listed in 6.3.3.1.
b. Record hypothetical flight paths on diagram prepared according to 6.2.3.b.
c. Record coordinates of the selected points along the hypothetical flight path according to 6.2.3., b., and record the resulting aspect angles of the airframe (attitude) for each point.

6.3.4.1 Area of Normal VT Fuze Action

a. Record 50% and 90% distances according to 6.2.3.1.b.
b. Record data listed in 6.3.3.1.

6.3.4.2 Area of protection

Record data listed in 6.3.3.1.

6.3.4.3 Effectiveness versus fuze type

Record data listed in 6.3.3.1.

6.3.4.4 Effectiveness against Salvo Fire

Record data listed in 6.3.3.1.

6.4 DATA REDUCTION AND PRESENTATION

6.4.1 Parameter Subtests

6.4.1.1 Receiver Subtest

Reduce and present data according to procedures given in MTP 6-2-242.

6.4.1.2 Transmitter Subtest

Reduce and present data according to procedures given in MTP 6-2-242.

6.4.1.3 Antenna Subtest

Reduce and present data according to procedures given in MTP 6-2-020.

6.4.2 Field Tests

6.4.2.1 Field test data shall be compiled and correlated manually using the table of tests and the master log as the major guides. Data reduction shall be accomplished, insofar as practicable, by automatic data processing methods to facilitate sorting, computation, and presentation of results for each combination of test parameters.

Test results shall be presented in a manner to portray the reduction of lethality provided by the test item as expressed in terms of per cent predetonations versus each test parameter.

6.4.2.2 Area of coverage data shall be presented in diagrammatic and supporting tabular form to depict the spatial areas of protection provided by ground and airborne test items under the different conditions of-

a. Direction of fire (aspect)
b. Range
c. Volume of fire
d. Fuze type (electromagnetic characteristics)
e. Angle-of-fall
f. Arming time
g. Antenna polarization and orientation

NOTE: Spatial area of protection in this context is defined as the space about the test item outside which a given percentage of approaching VT-fuzed projectiles can be predetonated by the test item.

6.4.2.3 Results of the following subtests shall be presented in the form of

graphs and supporting tables of reduced data.

a. Effectiveness against different fuze types
b. Effectiveness versus size of volley and salvo fire
c. Effect of different fuze arming times
d. Effect of angle-of-fall

APPENDIX A

AIRBORNE SYSTEM ANTENNA MEASUREMENTS

Two methods of obtaining antenna field patterns of airborne test items are suggested and described herein as supplemental information to MIL-STD-449(-) and MTP 6-2-020 (references 4.A. and 4.N.) which do not specifically include airborne antennas. Other methods may be devised as dictated by prevailing circumstances. The choice of methods is essentially dependent upon the availability of test and support facilities. However, the basic measurement requirements applicable to the antenna type are to be fulfilled; the methods described deal primarily with implementation.

Method 1. The most accurate and preferred method entails the use of a specially instrumented test facility illustrated simply in Figure A-1. The setup, including the selected test airframe, is generally comparable to the test setup described in paragraph 6.2.3.1 and Figure 1 with the exception that the test item antenna only is mounted in the prescribed location on the airframe. The transceiver portion of the test item is replaced by a signal generator of required characteristics to supply test signals to the test item antenna.

The sensors shown in Figure A-1 are essentially the test antennas of a field intensity measuring (FIM) system. Sensor antenna polarization is adjusted for optimum coupling with the test item antenna. All five sensor outputs are measured and recorded simultaneously on a multi-channel magnetic tape recorder. Other recorder channels carry a reference timing code and voice annotations for data correlation. An oscillograph is connected to additionally record one sensor output and is used as a correlation means or test log by adding hand written entries of time, events, and test parameters. The system is calibrated before, during, and after all pattern measurements to ensure the required degree of accuracy. Calibration signal recordings are interleaved with data recordings on each channel.

The test airframe heading is changed in 15° increments throughout 360° with 0° heading being perpendicular to the suspension line. A level attitude (0° roll and pitch) is maintained throughout the test. With the signal generator operating at one of selected test frequencies and stable power output, the sensor outputs are measured and recorded at each airframe heading. The procedure is repeated for each prescribed test frequency.

The resultant data is reduced to form, in effect, a three-dimensional, hemispherical pattern of the antenna field for each test frequency. One practical form of data presentation is a series of five polar plots, each one depicting the polar pattern measured by one sensor.

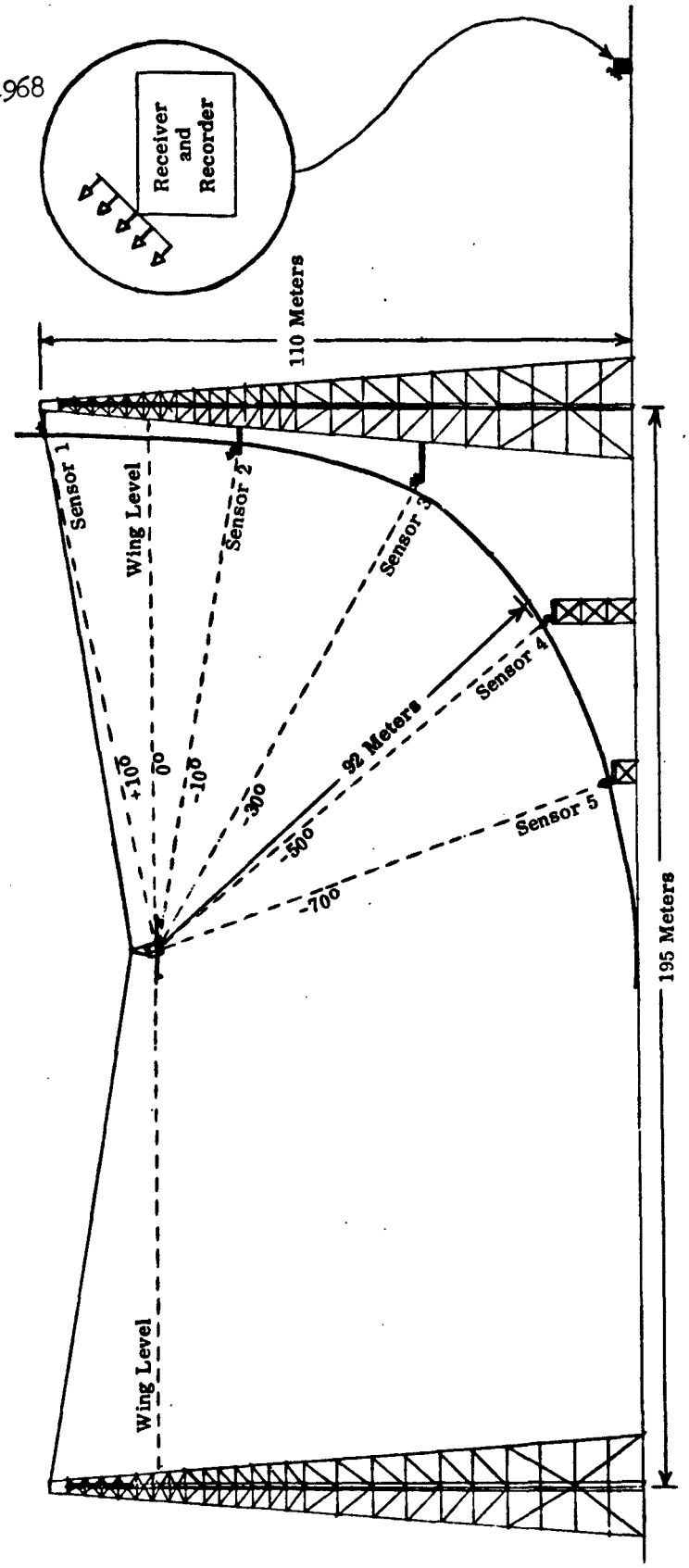


Figure A-1. Example of Test Facility for Airborne Antenna Pattern Measurements.

Method 2. In this method, the test item antenna is mounted on the appropriate operational aircraft which is flown in precise patterns over a ground-based field intensity measuring system. As in Method 1, the test item antenna is fed by a signal generator instead of the normal equipment.

The field intensity measuring system (FIM) is located in the approximate center of flat terrain of adequate area which is free of obstructions and sources of electromagnetic interference. The FIM antenna should be elevated as high as possible to approximate a free-space condition. The FIM includes a strip-chart recorder for recording measurement data and a reference time code simultaneously. A ground-based tracking radar system located near the test area provides aircraft space position data relative to range time code and prescribed data points. Other test instrumentation includes a voice radio communication net linking ground and airborne personnel and a range timing radio net for precise correlation of aircraft position with measurement data.

The aircraft is flown over flight paths as shown in Figure A-2 and each flight pattern repeated at several equally spaced altitudes. Data points shown in Figure A-2 are the points at which the aircraft space position is to be correlated in time with the antenna field strength measurement. The number and spacing of flight lines, altitudes, and data points are determined by the test item and test requirements. Spacings shown are approximately equal although closer spacing of the higher altitude flights and an increase of data points in the weak signal areas may be indicated for more fine-grained data. Each series of flight patterns is repeated for each selected test frequency and FIM antenna polarization.

Data recorded by the FIM and radar systems is reduced to polar plots, each series depicting a three-dimensional field pattern relative to each of the other test parameters, e.g. frequency and polarization.

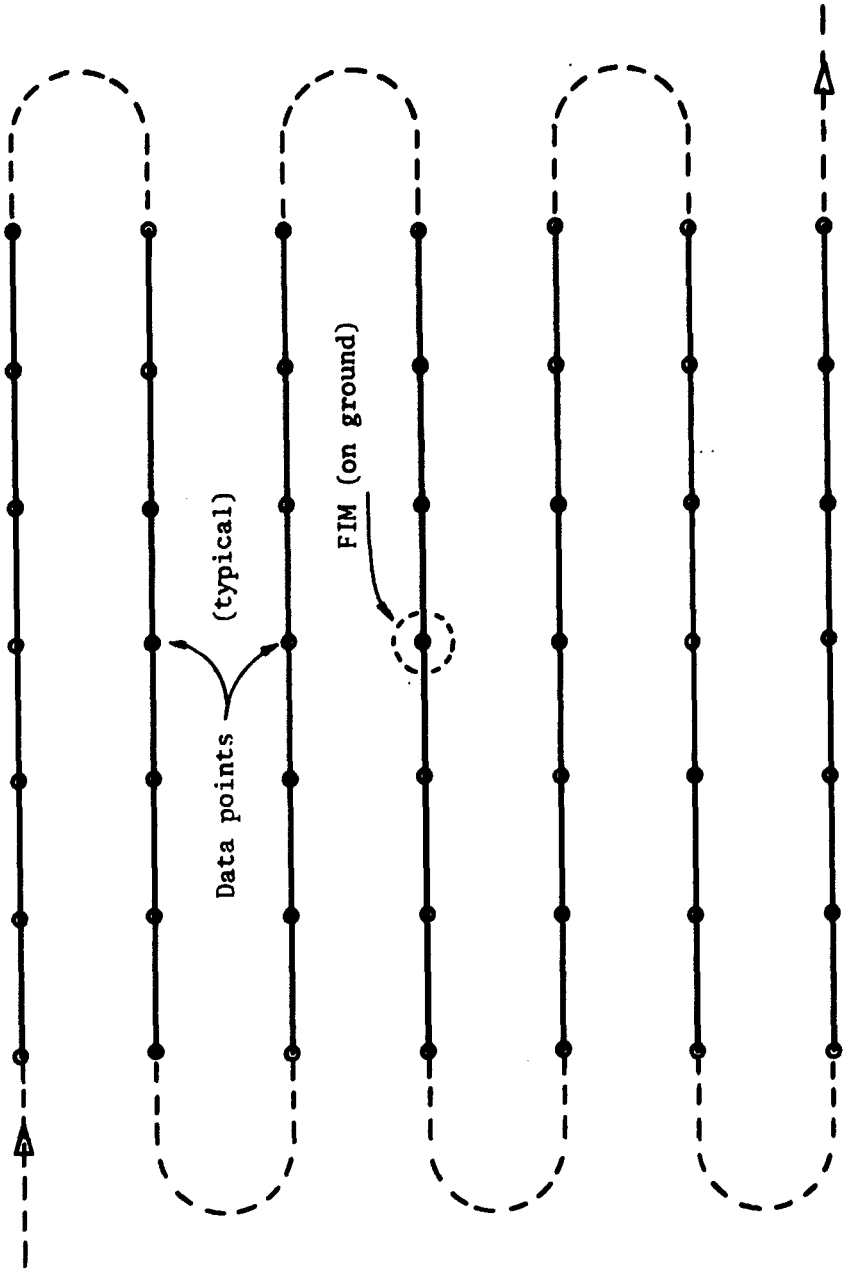


Figure A-2. Example of Flight Pattern for Method 2 Antenna Measurements.