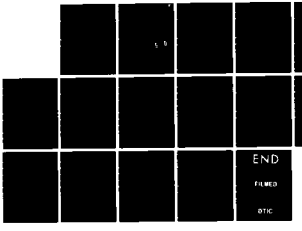
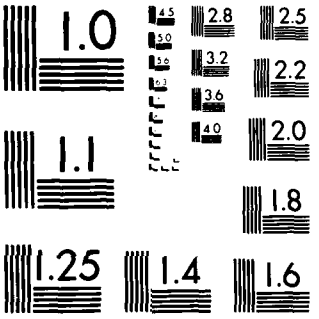
AD-A149 387 COLD REGIONS LOGISTIC SUPPORTABILITY TESTING OF MISSILES AND ROCKE SYSTEMS(U) ARMY TEST AND EVALUATION COMMAND ABERDEEN PROVING GROUND MD 26 OCT 84 1/1

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Cold Weather Field Test
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document describes test methods and techniques necessary to perform a logistic supportability test of missiles and rocket systems in a cold regions environment.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

AMSTE-RP-702-104
*Test Operations Procedure 5-4-006 26 October 1984
AD No.

COLD REGIONS LOGISTIC SUPPORTABILITY TESTING OF MISSILES AND ROCKET SYSTEMS

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1. SCOPE. This document describes test methods and techniques necessary to perform a logistic supportability test of missiles and rocket systems in a cold regions environment.

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

2.1 Facilities

Characteristic	Minimum Requirements
Impact Area	As Required.

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Characteristic	Minimum Requirements
Shops	Shop w/capability to perform maintenance at the organizational, DS, and GS levels.
Office and administration work area.	Sufficient to accommodate the test team.
Calibration shop.	Capable of calibrating maintenance tools and test equipment furnished to support the test item.

2.2 Equipment

Item	Minimum Requirements
Standard tool set.	Operator level, organizational, DS/GS level of maintenance authorized to support the test item.
Maintenance support.	To include: Draft publications, repair parts, accessories, special and common tools, support and ground handling equipment, multi-purpose test equipment.
Comparison items.	When specified.
Vehicles.	Sufficient to accommodate the test team.

2.3 Instrumentation

Item	Minimum Requirements
Stop watches	±0.1 second (less than 1% error)
Temperature measuring devices	±1°C (±2°F)
Anemometer	±2%

2.4 References

2.4.1 Army Regulation 70-10, Test and Evaluation During Development and Acquisition of Materiel[1]*

*Footnote number matches reference number in appendix F.

2.4.2 Army Regulation 200-2[2], Environmental Quality, Environmental Effects of Army Actions.

2.4.3 Army Regulation 385-16[3], System Safety and Engineering Management.

2.4.4 AMC Regulation 70-13, w/TECOM Supplement 1[4], Test and Evaluation Incidents Disclosed During Materiel Testing.

2.4.5 AMC Regulation 70-8, w/TECOM Supplement 1[5], AMC Value Engineering Program.

2.4.6 FM-9-207[6], Operation and Maintenance of Ordnance Materiel in Cold Weather.

2.4.7 AMC Regulation 700-15, w/TECOM Supplement 1[7], Integrated Logistic Support Performance Evaluation Report.

2.4.8 MIL-STD-1472[8], Human Engineering Design Criteria for Military System Equipment and Facilities.

2.4.9 Requirements documents (LR, ROC, etc.).

2.4.10 AR 70-38[15], Research Development Test and Evaluation of Materiel for Extreme Climatic Conditions, dated 15 September 1979.

3. PREPARATION FOR TEST.

3.1 Facilities. The test facilities should be in normal operating condition with, as a minimum, those maintenance shops required to keep the test item and support equipment equipped and functioning.

3.2 Equipment. The initial inspection and operational checks will normally be conducted as part of the arrival inspection subtest for the item. However, project personnel must insure that, as a minimum, the checks outlined in the draft equipment publications are made. When a reference or comparison item is used, it should be subjected to the same tests as those applied to the test item.

3.3 Instrumentation. Instrumentation should be checked for accuracy and calibrated for the temperatures at which it will be used prior to starting the test.

3.4 Data Required. Accurate timing, recording, and analysis of all maintenance actions are essential in determining whether the maintenance criteria for the test item are met. This can be done only by means of a detailed, accurate data collection system.

4. TEST CONTROLS. Maintenance is performed as appropriate by qualified personnel, normally military with appropriate Military Occupational Speciality (MOS) at each maintenance level (crew, organizational, direct support

(DS) and general support (GS)) as specified in the acquisition plan and in accordance with the draft maintenance allocation chart. This maintenance will be conducted using the tools, test, calibration and diagnostic equipment, and maintenance shop facilities of the same type that will be issued to the field for support of the end item or system.

5. PERFORMANCE TEST. Testing will normally be conducted simultaneously and in conjunction with other test operations. Separate, independent test functions, real or simulated, will be performed as required to insure a complete exercise of all the logistic supportability aspects of the test system. Throughout the course of the logistic supportability test, the range of temperatures that the test item is designed to operate in must be made known to the entire test team. Therefore, the test item's temperature must be monitored at all times and special provisions made to insure the test item is kept within the specified temperature range. The scope of the logistic supportability testing will encompass all subelements listed below consistent with the availability of support elements and the maturity of the test hardware. These data should be delineated in the detailed test plan.

- End item requirements
- Supply support
- Technical data/equipment publications
- Support and test equipment
- Manpower and personnel, training, and training devices
- Transportation and handling
- Facilities
- Stowage

These basic subelements may be further subdivided to enhance the clarity and understanding of an individual subtest. Subelement breakouts/divisions are usually dependent upon the maturity and complexity of the test system and test constraints (time, dollars) placed on the test effort. Specific criteria for each subelement test must be extracted from program documentation (requirements, specifications, purchase description, IEP/TDP, etc.). If specific criteria are not available, they may be generated by CRTC and will be subject to confirmation during the test plan approval process. Although the logistic supportability test is subdivided, the evaluation of the subelements is a constant overlapping effort. As maintenance and repair are being performed, manuals, repair parts, tools, test measurement and diagnostic equipment (TMDE) and the adequacy of new equipment training are continually being evaluated. The following is a brief explanation of each logistic supportability test subelement listed above and specific guidance to conduct each logistic supportability subelement test.

5.1 End Item Requirements. This subelement of the logistic supportability test contains a quantitative and qualitative analysis of maintainability for the test system. The quantitative analysis will quantify the logistic supportability through calculation of the maintainability indices. The qualitative analysis will assess the overall design characteristics for good maintainability. These subtests complement each other and provide a insight as to the maintainability of the test item/system.

5.1.1 Quantitative Analysis (Maintainability Indices). Unless otherwise directed, the quantitative analysis will, as a minimum, reflect the following logistic/maintainabiltiy indices:

- Operational availability (Ao)
- Achieved availability (Aa)
- Inherent availabiltiy (Ai)
- Mean-time-to-repair (MTTR)-Point Estimate at each maintenance level
- Maintenance Ratio (MR)

Definitions of these indices have been taken from TECOM Supplement 1 to AMC Regulation 700-15[7] and are presented in appendix D.

a. Data Required. The demonstrated quantitative measures of the logistic supportability are recorded within this subelement. To be identified is each scheduled and unscheduled maintenance action. Each maintenance action must be carefully assessed and accurately documented to include the following essential information (see End of Maintenance Action Interview Sheet, appendix C).

(1) What maintenance tasks were performed and the difficulties encountered (if any) while performing the maintenance action. Special emphasis will be placed on performing maintenance outdoors under the prevailing weather conditions while wearing the cold/dry uniform.

(2) Record of what, when, where necessitated the maintenance action.

(3) Complete description of the maintenance action.

(4) Identification (model, series, serial number, etc.) of the system/subsystem/component requiring the maintenance action.

(5) Determination whether the action was scheduled or unscheduled.

(6) Classification as to maintenance category. In the test arena, this classification is oftentimes assessed by project personnel knowledgeable as to the complexity of the maintenance action and the Army maintenance concept.

(7) Maintenance timeline correlating number of personnel required and time expended on each maintenance task to include the time devoted to (1) troubleshooting, (2) active maintenance (repair), (3) logistic delay (supply, administration, etc.).

(8) Service time (hours, rounds, miles, cycles, etc.) accumulated on the test item when the maintenance action was required.

(9) Mission impact statement.

(10) Record of all parts which were repaired or replaced and POL products replaced due to contamination or loss. Parts and consumables will be identified by noun nomenclature, national stock number (NSN), functional group number, and part number, as available.

(11) Whether the maintenance actions was performed outdoors under the prevailing weather conditions or under shelter.

(12) Air temperatures and wind chill during maintenance action.

(13) Clothing the mechanics were wearing during the maintenance action.

(14) Completed supportability analysis chart in accordance with TECOM Supplement 1 to DARCOM Regulation 700-15[7].

b. Analysis. Based on the data recorded in paragraph (1) above, compute the maintainability indices presented in paragraph (a) as required by the Test Design Plan (TDP) and/or other controlling documents. Indices should be computed for the primary equipment and separately for the support and test equipment. All values used in computing the indices will be included with the computations in the test report. As a minimum, each of the maintainability indices will be computed in accordance with the point estimate equations (based on the normal distribution) presented at appendix D in compliance with TECOM Supplement 1 to AMC Regulation 700-15[7]. However, in many cases, other assessment methodology appears more appropriate. Appendix E provides an outline with supportive discussion to accomplish a minimum maintainability analysis. Determine whether the test item meets the maintainability design requirements as specified by the requirements document or other established criteria.

5.1.2 Qualitative Analysis (Design of System for Maintainability). This subtest evaluates maintainability design features to determine if the design requirements have been met. Good maintainability design features will include:

- Modular contruction
- Ease of access while wearing the cold-dry uniform
- Ease of access to batteries and adequacy of space in battery compartment
- Built-in self-test features
- Readily accessible test points

- Mechanical features such as: Quick connector, built-in work platform, adequate work space, protective devices (guards, covers, grounding, etc).

a. Data Required. Evaluate each of the above design features and make an assessment whether the difficulty involved and time needed to accomplish a particular maintenance operation are excessive based on experience with similar equipment. Safety is always a consideration when data is collected.

(1) In compliance with TECOM Supplement 1 to AMC Regulation 700-15[7], comment on whether the test item is designed as follows:

(a) To minimize maintenance and supply requirements through attainment of optimum durability and service life of materiel.

(b) To eliminate field maintenance problems encountered in earlier design items.

(c) For ease of maintenance while wearing the cold-dry uniform by assuring accessibility to facilitate inspection, repair, and replacement.

(d) For maximum interchangeability of components.

(e) For maximum detection of conditions which will adversely affect the conduct of maintenance operations or generate excessive maintenance and supply requirements.

(f) To achieve maximum compatibility of maintenance operations with common tools and test, measurement, and diagnostic equipment (TMDE).

(g) To enable removal of major components as individual units and when feasible, to use standardized components which are compatible with similar equipment already in the military system.

(h) To facilitate cleaning. Report adverse effects of steam cleaning if this method of cleaning is appropriate.

(i) To insure equipment is not easily damaged when subjected to abnormal operations, abuses, or overloads for short periods of time.

(j) Adequacy of marking of test points, circuits, and connectors.

(k) Adequacy of safety provision for maintenance operations.

(2) Interview mechanics after each maintenance action; evaluate and record the following:

(a) Adequacy of hoisting, lifting, and towing provisions required for maintenance.

(b) Ease of maintenance tasks.

(c) Physical effort required for performing maintenance.

(d) Adequacy of working space for performing maintenance.

(e) Simplicity in servicing and performing maintenance duties.

(f) Effects of engine fumes on mechanics during maintenance.

(g) Freedom of the mechanics to reach and work adequately as influenced by the configuration or placement of components, or by the mechanic's clothing or size (cold-dry uniform).

(h) Servicing factors such as lubrication of equipment, replenishing tanks and reservoirs.

(i) Whether standard parts and tools are used.

(j) Adequacy of system and personal protective devices.

(k) Comments and recommendations for improvement.

b. Analysis. All data collected in sections 5.1.1 and 5.1.2 above reflect on the design of the test system for maintainability. These data must be integrated into a unified assessment of the characteristics of the test system to be maintained in accordance with the TOP or other controlling documents.

5.2 Supply Support. Supply support data are required to determine the overall logistic supportability of the test item/system. The substitution of unauthorized repair parts are not authorized. Supply data generated during development test, particularly parts consumption data, will assist logistic personnel to determine the required logistic support for the test item/system.

5.2.1 Data Required. Throughout the test, do the following and record appropriate data, as required:

a. For each maintenance action, examine all replacement parts to determine interchangeability.

b. Assess repair parts design for ease of installation, alignment, and checkout.

c. Evaluate nonstandard parts to determine if they can be replaced with standard items already in the logistic system.

d. Examine repair parts with respect to the prescribed maintenance category authorized to stock and/or requisition the items. Repair parts authorized at each maintenance level should be consistent with the authorization of tools and equipment to accomplish the repair action.

e. Examine repair parts to evaluate modular design criteria.

f. Compare repair parts with parts manuals to determine if data in the parts manual are adequate for identification and requisition by logistic personnel in the field.

g. Complete the supply support chart in accordance with TECOM Supplement 1 to AMC Regulation 700-15[7] for each maintenance action.

5.2.2 Analysis. Assess the impact of each supply support anomaly uncovered in relation to the test item's mission. Include comments as to the qualitative effects of supply support inadequacies on the maintenance indices calculations, paragraph 5.1.1 above.

5.3 Technical Data/Equipment Publications. The subtest is conducted to insure that the test item technical data/equipment publications are technically adequate, complete, and easily understood, by the maintenance personnel for whom they are intended. Each manual must be evaluated at the appropriate maintenance level for compliance with the military specifications and standards prescribing format, technical content and standards of production (MIL-M-38784[9] and MIL-M-63000(TM) series[10]). Comments, as appropriate, will be made (by separate correspondence or by EPR) to the preparing agency with information copies to the AMC Materiel Readiness Support Activity and appropriate US Army Training and Doctrine Command (TRADOC) agencies. TOP 1-2-609[11] (IMAGES), provides a repeatable, systematic, and quantifiable method for analyzing the technical data/equipment publications. Special emphasis will be placed on that section of the technical data/equipment publications pertaining to operations under unusual conditions-cold.

5.3.1 Data Required. Each maintenance action performed during the test will be done in accordance with specific procedures provided in the appropriate publication. All test item operations and inspections will be conducted in accordance with the specific procedures provided in the appropriate publication. Complete the technical data/equipment publication chart in accordance with TECOM Supplement 1 to AMC Regulation 700-15[7].

5.3.2 Analysis. Evaluate the technical data/equipment publications subjectively and quantitatively. As a minimum, address the following issues:

a. Simplicity, clarity, and completeness of the manuals commensurate with the training and skills of the targeted operational and maintenance personnel.

b. Adequacy and completeness of troubleshooting instructions.

c. Adequacy and completeness of the preventive maintenance procedures.

d. Adequacy and completeness of safety instructions to personnel and equipment.

e. Adequacy and completeness of environmental protection instructions during operation and maintenance actions.

f. Adequacy and completeness of lubrication and/or other servicing charts. Identify lubrication or other servicing commodities not in the Army supply system.

g. Adequacy and completeness of transport, handling, and packaging instructions.

h. Adequacy of instruction commensurate with the level of skill and previous training of the operational and maintenance personnel. Identify additional or special training requirements and inadequacies pertaining to cold weather operation and maintenance.

i. Inadequacies or suggested improvements to equipment publications will be reported on DA Form 2028 or IMAGES Forms, if IMAGES is used.

5.4 Support and Test Equipment. This subelement of the Logistic Supportability Test is conducted to determine the adequacy of the support and test equipment provided in the system support package. All maintenance performed on the test item will be accomplished using the test and support equipment provided in the system support package.

5.4.1 Data Required

a. During the conduct of the Logistic Supportability Test, all maintenance actions which require use of support equipment furnished through the system support package will be performed with the appropriate equipment. For each maintenance action, complete the Support and Test Equipment Chart

in accordance with TECOM Supplement 1 to AMC Regulation 700-15[7], and record the following:

(1) Maintenance category prescribed and recommended for use of each item of support and test equipment.

(2) Comments on adequacy of support and test equipment for intended use.

(3) Comments on adequacy of printed instructions for use of support and test equipment.

(4) Comments on whether the support and test equipment is excessive or could be replaced with common items.

b. Identify any support and test equipment needed but not available in the system support package.

c. Identify any problems associated with the use of common support and test equipment during maintenance or checkout of the test item/system.

5.4.2 Analysis. Discuss any problems associated with the use of common support and test equipment with respect to the test item/system.

5.5 Personnel, Training, and Training Devices. This subelement of the Logistic Supportability Test is designed to evaluate the overall interfaces between the personnel, training and equipment required to maintain and operate the test item/system. The training devices addressed in this subelement are those provided in the system support package for support of the test item/system.

5.5.1 Data Required. Issues to be addressed within this subelement should be available in the Test Design Plan (TDP), Independent Evalution Plan (IEP), or other controlling document. If specific data requirements are not available, the following data elements should be addressed:

- Adequacy of number of personnel projected in the maintenance concept required to logistically support the test item.

- Appropriateness of the MOS and skill level of the prescribed personnel.

- Adequacy of personnel training to perform the logistic supportability function.

- Adequacy of the training devices to accomplish the training mission in support of the logistic supportability function.

TOP 7-3-501[12] entitled "Personnel Training," addresses each of the above issues and should be utilized as appropriate.

5.5.2 Analysis

a. Analyze the data recorded in compliance with TOP 7-3-501[12] and address the following issues in the test report:

(1) Methods used to train, update, and familiarize test personnel with the test item/system, as related to the training planned for the field operation.

(2) Suitability of training documents.

(3) Maintenance level MOS, skill level, and number of personnel projected for each major maintenance task.

(4) Additional training requirements identified during test conduct.

(5) Effectiveness of training in terms of:

- Meeting all training requirements.

- Trainees' ability to comprehend and effectively perform the required instructions/maintenance tasks.

- Number of times trainee needed assistance from higher maintenance level or contractor personnel and why.

b. Identify any incident/accident which results from a lack of training. Determine potential seriousness and suggest corrective actions.

5.6 Transportation and Handling. This subelement of the Logistic Supportability Test addresses the adequacy of the procedures and hardware provided for transport of the test system in a nonmission-performing mode. This implies handling the test system in accordance with its transportability scenario (e.g., on-load/off-load and transport of the item by government or commercial carriers utilizing appropriate handling components). This subelement is not normally evaluated as it is not usually cold weather related. The cold weather considerations deal with the adequacy of the new equipment packing and packaging.

5.6.1 Data Required. Test issues and data required to evaluate the transportability and handling characteristics of the test item/system should be available in the TDP, IEP or other controlling documents. However, if

specific guidance is not available and other test agencies will not be testing the same item, the following data, if collected and evaluated, will generally satisfy this subtest.

a. Physical characteristics to include:

(1) Physical description to include basic envelope dimensions (length, width, height) for each component or group of components packaged together (in the shipping configuration) during transport.

(2) Weight and cubage for each item/shipping package.

(3) Center of gravity for each item/shipping package.

(4) Location and handling limitations for each hard point (lifting and tie down attachments).

b. Identify each piece of equipment required to load or unload the test item.

c. Determine transporter and handling equipment characteristics:

(1) Mode (air, rail, truck, etc.).

(2) Weight and handling limitation (hard points, lifting and tie down attachments).

(3) Floor loading constraints.

(4) Center of gravity envelope for cargo compartment.

(5) Loading ramp angles, and crest angle.

(6) For external helicopter transport, record the complete rigging setup (orientation, attach points, tether length, swing envelope) and flight constraints.

d. Record the following data during transport of the test item in its operational scenario:

(1) Record of displacement (pitch, yaw, roll) of the transporter.

(2) Record of test item deflections correlated to transporter displacement.

(3) Record of floor loading caused by the test item during transport.

(4) Record critical clearances during loading and transport.

(5) Damage to test item caused by loading, unloading, or transporting the test item as applicable.

(6) Damage to transporter or handling equipment incurred during loading, unloading, or transporting the test item, as applicable.

e. Prepare a loading diagram and record the center of gravity of the transporter loaded with the test item.

f. Record the degree of disassembly required for loading and transport, as required.

g. Record any special servicing or preparation of the test item required for loading and transport.

h. Record measurements of shock and vibration forces sustained by the test item during transport.

5.6.2 Analysis. Evaluate the data gathered. Address all criteria statements concerning transportability. Qualitatively address the following:

a. The ease or difficulty of loading, unloading, and transport of the test item.

b. The adequacy of handling devices (sling, spreader bars, hooks, handles, etc.).

c. Human factors engineering of the handling and transport methodology.

d. Safety (personnel and equipment) of the transportability methodology (TOP 1-1-012).

e. Mission impact resulting from test item damage sustained during handling or transport as applicable.

f. Extent of preparation, packing, and packaging of the test item prior to transport.

g. The relative ease or difficulty of converting from operational to transport configuration, and back to operation, in the required time frame.

h. Security of the test item during preparation, transport, and reassembly.

i. Adequacy of special handling equipment, devices, fixtures, or jigs.

5.7 Facilities. Facilities are normally not evaluated, but if evaluated include all physical assets (buildings, fixtures, runways, ranges, etc.) and their organizational components (TDA structure, personnel, and equipment) required to accommodate a specific functional requirement germane to the logistic support of the test item/system. Training requirements should not be overlooked, as well as facilities required for storage of repair parts, spares, and data. The materiel developer should provide unique facility requirements for test purposes, e.g., a semimobile clean room, special data processing/reduction equipment, special test checkout/calibration and maintenance equipment, etc. This data, in conjunction with the logistic support knowledge gained through test experience locally and at the contractor support level, will provide the test officer some insight into the facilities needed in the field environment. As applicable, the facility planning documents provided by the materiel developer should be consulted and the proposed facilities evaluated in accordance with the issues, criteria, and/or requirements included in the IEP or TDP. In cases where the IEP is not available or where the IEP or TDP is not explicit, the facility proposed in the planning documents should be evaluated in accordance with the following:

5.7.1 Data Required. The logistic supportability function encompasses all support activities associated with the operation, maintenance, servicing, storage, repair parts system, and training of personnel to support the test item/system. As a minimum, record the following data:

a. Instances where a facility (government, contract, or commercial) utilized during test was inadequate to accomplish the logistic supportability function for which it was intended.

b. Instances during test where a facility's physical location (government, contractor, or commercial) adversely affected the logistic supportability of the test item.

c. Instances where a facility's physical environment (temperature, ventilation, contamination, cleanliness, etc.) adversely affected the logistic supportability of the test item.

d. Instances where a facility's standard fixed equipment (government, contractor, commercial) would not readily perform a logistic supportability function for the test item/system.

5.7.2 Analysis. Using test data recorded above on existing facilities and issues and requirements extracted from the appropriate requirements documents, qualitatively evaluate whether the facilities projected are

adequate for the logistic supportability function for which they were intended. As a minimum, address the data collected above and extrapolate potential impact on the logistic supportability facilities planned for the test item/system. Also address the following:

a. Comment on whether all logistic supportability equipment planned for the projected test item support facility is required.

b. Comment on whether the planned fixed equipment can be installed and operated in existing facilities without adversely affecting other ongoing facility functions.

5.8 Stowage. This subelement of the Logistic Supportability Test addresses the adequacy of the storage space provided for basic issue items (BII), troop-installed authorized items, publications, and cold weather combat gear.

5.8.1 Data Required Test issues and data required to evaluate the stowage requirements should be available in the IEP, TDP or other controlling documents. However, if specific guidance is not available, the following data, if collected and evaluated, will generally satisfy this subtest.

a. Comments of maintenance evaluators and test supervisory personnel pertinent to the adequacy of the space and protection provided for BII, publications.

b. Physical checks of items in stowage for damage after each type of mission encountered.

5.8.2 Analysis. Evaluate the data gathered. Address all criteria statements concerning stowage. Qualitative address all problems with stowage encountered.

6. DATA REDUCTION AND PRESENTATION. Data reduction/analysis and presentation will be IAW the TDP, and TECOM Pamphlet 70-3[13].

6.1 Data Reduction/Analysis. Data reduction in general involves identifying, correlating, and organizing raw test data into data sets which can be analyzed to form a complete and comprehensive picture of the overall logistics supportability of the test item. Each test incident will be analyzed to determine the implication/impact, if any, to each of the logistic supportability subelements presented in paragraph 5.1, Test Method. Address each problem/deficiency cited in each of the logistic supportability subelements and qualitatively relate its impact on the maintenance indices calculated in the end item requirements subelement.

6.2 Data Presentation. Prepare a narrative of the test results to include diagrams, photographs, tables, and other reduced data as required, to support the test conclusions and recommendations. Establish the degree to which the test item/system logistic supportability satisfies the test criteria.

Recommended changes to this publication should be forwarded to Commander, US Army Test and Evaluation Command, ATTN: AMSTE-AD-M, Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: Commander, US Army Cold Regions Test Center, ATTN: STECR-AN, APO Seattle, WA 98733. Additional copies are available from the Defense Technical Information Center (DTIC), Cameron Station, Alexandria, VA 22304-6145. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A PRETEST CHECKLIST

1. Have facilities, test equipment, instrumentation, and support requirements been scheduled or secured? See paragraph 2 of this TOP. YES_____ NO_____.

2. Has appropriate test planning been accomplished in accordance with paragraph 3, this TOP? YES_____ NO_____.

3. Have test control measures been implemented such that test results could be duplicated or compared? See paragraph 4, this TOP. YES_____ NO_____.

4. Have all test personnel been briefed on the test procedure?

YES_____NO_____.

5. Have the necessary security arrangement been made for this test?

YES____ NO____.

APPENDIX B - POST-TEST CHECKLIST

1. Have test data been collected, recorded, and presented in accordance with this TOP? YES_____ NO_____. Comment:_____

_____

2. Have all data collected been reviewed for correctness and completeness? YES_____ NO_____. Comment:_____

_____

3. Were the facilities, test equipment, instrumentation, and support accommodations adequate to accomplish the test objectives? YES_____ NO_____.

_____

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? YES_____ NO_____. Comment: _____

_____

APPENDIX C - END OF MAINTENANCE ACTION QUESTIONNAIRE

Name_____ Rank_____ Date_____
(last) (first)

Unit_____ MOS_____

Question 1.

a. Are hoisting, lifting, and towing facilities adequate to maintain the test item?

_____6 - Extremely Adequate
_____5 - Very Adequate
_____4 - Adequate
_____3 - Adequate at Times
_____2 - Very Inadequate
_____1 - Extremely Inadequate

b. Comments: _____

_____

_____

Question 2. The following questions pertains to equipment publications

a. Were the publications complete?

_____6 - Extremely Adequate
_____5 - Very Adequate
_____4 - Adequate
_____3 - Adequate at Times
_____2 - Very Inadequate
_____1 - Extremely Inadequate

b. Comments: _____

_____

_____

c. Were the publications accurate?

_____6 - Extremely Accurate
_____5 - Very Accurate
_____4 - Accurate
_____3 - Accurate at Times
_____2 - Very Inaccurate
_____1 - Extremely Inaccurate

d. Comments: _____

_____

_____

e. Were the publications easy to read?

_____6 - Extremely Easy
_____5 - Very Easy
_____4 - Easy
_____3 - Difficult at Times
_____2 - Very Difficult
_____1 - Extremely Difficult

f. Comments: _____

_____

_____

g. Were the publications easy to follow?

_____6 - Extremely Easy
_____5 - Very Easy
_____4 - Easy
_____3 - Difficult at Times
_____2 - Very Difficult
_____1 - Extremely Difficult

h. Comments: _____

_____

_____

i. Adequate instructions to complete maintenance actions?

_____6 - Extremely Adequate
_____5 - Very Adequate
_____4 - Adequate
_____3 - Adequate at Times
_____2 - Very Inadequate
_____1 - Extremely Inadequate

j. Comments: _____

_____

_____

k. Adequate instructions for part requisitioning?

_____6 - Extremely Adequate
_____5 - Very Adequate
_____4 - Adequate
_____3 - Adequate at Times
_____2 - Very Inadequate
_____1 - Extremely Inadequate

l. Comments: _____

_____

_____

Question 3. Did you encounter any difficulties performing the maintenance action in any of the following areas?

a. Maintenance operations?

_____6 - Extremely Easy
_____5 - Very Easy
_____4 - Easy
_____3 - Difficult at Times
_____2 - Very Difficult
_____1 - Extremely Difficult

b. Comments: _____

_____

_____

c. Working space?

_____6 - Extremely Adequate
_____5 - Very Adequate
_____4 - Adequate
_____3 - Adequate at Times
_____2 - Very Inadequate
_____1 - Extremely Inadequate

d. Comments: _____

_____

_____

e. Use of tools and test equipment?

_____6 - Extremely Adequate
_____5 - Very Adequate
_____4 - Adequate
_____3 - Adequate at Times
_____2 - Very Inadequate
_____1 - Extremely Inadequate

f. Comments: _____

_____

_____

g. Changing replaceable components (such as filters, belts, etc.?

_____6 - Extremely Easy
_____5 - Very Easy
_____4 - Easy
_____3 - Difficult at Times
_____2 - Very Difficult
_____1 - Extremely Difficult

h. Comments: _____

_____

_____

i. Lubrication replenishing tasks and reserviors, etc.?

_____6 - Extremely Easy
_____5 - Very Easy
_____4 - Easy
_____3 - Difficult at Times
_____2 - Very Difficult
_____1 - Extremely Difficult

j. Comments: _____

_____

_____

APPENDIX D - MAINTAINABILITY INDICES DEFINITIONS

a. Operational availability.

$$Ao = \frac{\textit{Operating Time + Standby Time}}{\text{Operating time + standby time + scheduled and unscheduled maintenance time + logistic + administrative downtime.}}$$

b. Achieved availability (Aa).

$$Aa = \frac{\text{Operating Time}}{\text{Operating time + scheduled and unscheduled maintenance time}}$$

c. Inherent availability (Ai).

$$Ai = \frac{\text{Operating Time}}{\text{Operating time + unscheduled (corrective) maintenance time}}$$

d. Mean-time-to-repair (MTTR). Point Estimate.

$$MTTR = \frac{\text{Total unscheduled active maintenance time}}{\text{Total number of unscheduled active maintenance tasks}}$$

e. Maintenance ratio (MR). Compute for each category of maintenance including overall MR.

$$MR = \frac{\text{Total scheduled and unscheduled (corrective) active maintenance man-hours}}{\text{Total operating time}}$$

APPENDIX E - NUMERICAL ANALYSIS OF MAINTAINABILITY INDICES

I. OUTLINE: The following outline is a chronological procedure for doing a minimum maintainability numerical analysis. Discussion to follow at parapraph II.

A. Compute the following indices:

1. MTTR (point estimate).

2. Availability.

a. Inherent (Ai).

b. Achieved (Aa).

c. Operational (Ao).

3. Maintenance Ratio (MR).

B. Special Topics, As Required.

II. DISCUSSION:

A. Maintenance Indices.

1. Mean-time-to-repair (MTTR): The MTTR is that ratio of the time it takes at a specific level of maintenance, (crew, organizational, direct support) to repair the test item. MTTR can also be calculated as an overall ratio for repair of the test item. When examining the data that are used in the calculations, screen the excessive maintenance times and explain the reasons why they were excessive (i.e., inadequate equipment publications, poor design, etc.). Calculate the MTTR using all the data and then with the excessive time removed. The MTTR estimates of the maintenance time will depict what can be expected when the problems are corrected.

2. Availability. The availability of a system or equipment is the probability that it is fully operational at any point in time when operated and maintained under stated conditions. This maintainability index is widely used in the armed services as well as industry, and is usually stated in terms of application design, test, or operational use. Associated terms are (1) Inherent availability (Ai), the design standard; (2) Achieved

Availability (Aa), actual test experience; (3) Operational Availability (Ao), actual field operational environment.

a. Ai (Inherent Availability): This is the probability of operational availability in the "ideal" maintenance and operational environment when used under stated conditions. Ai is defined as follows:

$$Ai = \frac{OT}{OT + TUM}$$

Where: OT = The operating time during a stated time period.

TUM = Total unscheduled active maintenance time in clock hours during the stated period.

As can be seen from the equation, standby time (ST), scheduled maintenance time (SMT), and administrative logistics delay time (ALDT) do not enter into the equation.

b. Aa (Achieved Availability): Achieved availability is that ratio of the operational time to maintenance down-time experienced during test. Aa is defined as follows:

$$Aa = \frac{OT}{OT + SMT + TUM}$$

Again, standby time (ST) and administrative logistics delay time (ALDT) do not enter the equation; however, scheduled maintenance time (SMT) is considered. Ordinarily, ST and ALDT are not very useful in the developmental test environment.

c. Ao (Operational Availability): Operational availability reflects the best estimate of the true availability ratio for a test item when calculated utilizing data obtained from the real operational environment. Operational availability reflects all of the subelements for calculating availability and can be summarized as the ratio of uptime divided by uptime plus downtime. More explicitly, operational availability is defined as follows:

$$Ao = \frac{ST + OT}{ST + OT + SMT + TUM + ALDT}$$

In accordance with TECOM Supplement 1 to DARCOM Regulation 700-15[7], in cases where Ao is required and where downtime for ALDT factors is not provided in the IEP/TDP for calculating Ao, the installation/field operating activity will estimate these items based on expert judgment and military experience.

3. MR (Maintenance Ratio). The maintenance ratio is the total maintenance (scheduled (preventive), and unscheduled (corrective)) time divided by the total operating time. Again, from Figure 1, the MR is expressed as follows:

$$MR = \frac{SMT + TUM}{OT}$$

B. SPECIAL TOPICS: AMC Pamphlet 706-113[14] presents some experimental statistical techniques of special interest to the developmental tester. Chapters 15 and 16 present techniques for comparing the performance of a new product/system to that of a standard. Chapter 17 presents the treatment of outliers and Chapter 21 presents the relation between confidence intervals and tests of significance. Specific examples are provided in the AMCP to illustrate each statistical technique.

APPENDIX F - FOOTNOTE REFERENCES

1. AR 70-10, Test and Evaluation During Development and Acquisition of Materiel, dated 29 August 1975.

2. AR 200-2, w/change 1, Environmental Quality, Environmental Effects of Army Actions, dated 1 September 1981.

3. AR 385-16, System Safety and Engineering Management, dated 1 December 1980.

4. DARCOM Regulation 70-13, 16 August 192, w/TECOM Supplement 1, Test and Evaluation Incidents Disclosed During Materiel Testing, dated 16 August 1982.

5. DARCOM Regulation 70-8, 23 February 1978, w/TECOM Supplement 1, dated 27 November 1978, DARCOM Value Engineering Program.

6. FM 9-207, Operation and Maintenance of Ordnance Materiel in Cold Weather (0°F to -65°F), dated January 1978.

7. DARCOM Regulation 700-15, 26 November 1979, w/TECOM Supplement 1, Integrated Logistic Support Performance Evaluation Report, dated 20 June 1980.

8. MIL-STD-1472C, Human Engineering Design Criteria for Military Systems, Equipment and Facilities, dated 2 May 1981.

9. MIL-M-38784B, General Style and Format Requirements, dated 16 April 1983.

10. MIL-M 6300E (TM) Series, Manuals Technical: Repair Parts and Special Tools List, dated 15 March 1979.

11. TOP 1-2-609, Instructional Material Adequacy Guide and Evaluation Standard (IMAGES), dated December 1978.

12. TOP 7-3-501, Personnel Training, dated 15 March 1971.

13. TECOM Pamphlet 70-3, Project Engineers' Handbook, dated 16 June 1978.

14. AMC Pamphlet 706-113, Experimental Statistics (Sec 4), dated 16 December 1969.

15. AR 70-38, Research Development Test and Evaluation of Materiel for Extreme Climatic Conditions, dated 1 September 1979.

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