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**FINAL REPORT OF THE
ARMY SCIENTIFIC ADVISORY PANEL
AD HOC GROUP
ON
CLIMATIC TESTING**

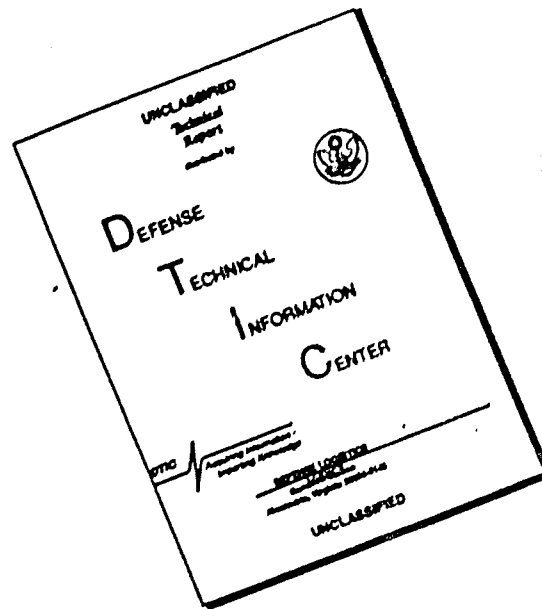
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REPORT OF
ARMY SCIENTIFIC ADVISORY PANEL
AD HOC GROUP ON CLIMATIC TESTING

JUNE 23, 1976

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SUMMARY

The ASAP Ad Hoc Group has concluded that present requirements imposed by the Army for operations, storage, and transit of general purpose equipment are reasonable and that the appropriate regulations should be strengthened to require proof through test of design integrity and equipment operability in the range of climatic conditions expected in Western Europe, the United States (for training), or the tropics. The panel concludes that climatic testing should be more clearly established as an integral part of the development process, using to the maximum extent possible simulated facilities as well as the natural environment ranges. Extensive testing, to assure operability under the normal range of expected climatic conditions, should be emphasized as contrasted to more limited testing under extreme climatic conditions. The panel recognizes that there are valid needs for extreme climatic testing; however, it believes that such testing should be accomplished in a very selective fashion.

The rationale for and focus of Arctic and Tropic testing should be very different. In particular, tropic testing is more essential to the early development process than arctic testing; arctic testing is more critical to the late development stages and to realistic operational testing. Thus, major components and subsystems should be

given tropic tests during the engineer design phases. However, testing in the arctic climate can best be done with complete systems and crews, since engineer design testing of components and subsystems can be done in climatic simulation chambers.

The Arctic Test Center is an irreplaceable asset of primary utility for operational testing. The Arctic Test Center is particularly well-suited for testing of general purpose equipment under intermediate-cold conditions, as well as the more extreme testing of specialized Arctic equipment. The workload of the range would increase to a more efficient level if emphasis were placed on operability and maintainability in temperatures down to -25°F rather than the extreme range from -35°F to -70°F and if mandatory test were required on all equipment as the group recommends.

The Ad Hoc Group concludes that the Army needs a Tropic Test Center, but that the mission of the Tropic Test Center should be modified so that TTC provides more direct and timely support to the development process as well as their more routine testing responsibilities.

Panama is the best, but not the only, site from both terrain and climate factors at which to locate the Tropic Test Center. It is under-utilized at present; staff should be reduced or changed in nature; and land usage could be reduced. TTC could co-use other required Army installations and real estate in Panama.

The Ad Hoc Group recommends a careful program of tests and simulations at several possible alternate sites to identify a satisfactory alternate location for tropic testing, should a later move be necessitated for other than technical or program reasons.

1. INTRODUCTION AND BACKGROUND

The Army Scientific Advisory Panel chartered the Ad Hoc Working Group on Testing under Extreme Natural Climatic Conditions following a request from the U.S. Army Material Command, now DARCOM. Terms of Reference presented in the letter of 19 January 1976 were used as an outline for this report (see Appendix A). The request outlined a need to examine the value of testing Army materiel under extreme natural environments and a determination whether such testing is currently being conducted most effectively and economically at the present sites. The membership of the Ad Hoc Group is listed in Appendix B.

In gathering data for the study, the Group visited the Arctic and Tropic Test Centers and Aberdeen Proving Ground. One member visited the Environmental Testing Facility at Eglin AFB, Florida. Organizations contacted included:

- * U.S. Army Materiel Development and Readiness Command (DARCOM)
- * U.S. Army Test and Evaluation Command (TECOM)
 - ** U.S. Army Arctic Test Center (ATC)
 - ** U.S. Army Tropic Test Center (TTC)
 - ** Materiel Test Directorate, Aberdeen Proving Ground (MTD)
- * U.S. Army Materiel Systems Analysis Activity (AMSAA)

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* U.S. Army Atmospheric Sciences Laboratory meteorological teams (ASL)

* U.S. Army Operational Test and Evaluation Agency (OTEA)

* Air Force Systems Command McKinley Climatic Laboratory

Numerous test plans and reports, test facility catalogs, papers and other reports were made available to the Ad Hoc Group, as well as inputs from project managers and test personnel. A bibliography will be found in Appendix C. Complete agendas for the various visits are included at Appendix D. The Trip Report for the visit to the Climatic Laboratory at Eglin AFB is at Appendix E.

2. OBSERVATIONS ON CURRENT PRACTICES

REQUIREMENTS

AR 70-10 controls test and evaluation during development and acquisition of materiel and is dated January 1, 1976. Categories of testing are defined and related to program phases. Responsibilities for testing are also defined, but in quite general terms, as also are funding responsibilities and test organizations. OTEA is identified as having responsibility for all OT and the Materiel Developer as having responsibility for all DT. However, the roles of DARCOM's major subordinate commands, PMs, TECOM, and AMSAA are not spelled out or discussed in AR 70-10 since it provides guidance to the major Army commands, nor is there a relevant DARCOM regulation to provide guidance.

AR 70-10 also addresses climatic testing at the policy level and states that climatic testing is conducted to satisfy the provisions of AR 70-38 and other appropriate user developed requirements documents. AR 70-38 defines climatic criteria and climatic categories. However, it only addresses responsibilities and requirements for climatic testing in a general way. Also, AR 70-38, dated 1969, does not address the specific roles and responsibilities

of the PM, OTEA, TECOM, and AMSAA. Examples of the generality and the permissiveness of climatic testing regulations are found in Sections 1-2, 1-3, and 1-5 of AR 70-38.

AR 70-10 states in Section 2-15, "The results of Climatic Center testing under all specified extreme climatic conditions are not required for evaluation prior to a program decision review unless identified in the CTP as a critical issue." The regulation does not state a requirement for Climatic Center testing under normal climatic conditions; the erroneous presumption being that testing in temperate CONUS facilities automatically assures design specifications will be tested for normal climates. The emphasis is on what is not required rather than on what is required; again, under an erroneous presumption that too much equipment would receive extreme climatic testing. Thus, climatic testing is "off the hook", unless specified in appropriate requirements statements and scheduled in the CTP. But the CTP is defined, in AR 70-10, as "a planning document which formalized the all-inclusive testing activities related to a development project . . . developed and maintained by the materiel developer on an item or system basis . . . coordinated with appropriate agencies prior to approval." This appears to leave decisions on climatic testing up to the materiel developer; i.e., the

program manager for the system unless such testing is specifically mandated by the requirements documents; although the independent evaluators (AMSAA, TECOM, and OTEA) have a hand in test criteria and test plan design.

The regulations regarding climatic testing appear to be overly vague and general, not specifically geared to require systems verification in realistic environments, and even confusing relative to involved organizations and organizations created after issue of AR 70-38.

TEST PLANNING AND FUNDING

AMSAA appears to do most of the test planning, test design, and test evaluation on major systems requiring ASARC's; whereas TECOM does test evaluations on a larger number of non-major systems. TECOM solicits its DT test workload annually from commodity commands--TECOM has insufficient influence on specifying climatic DT and has no funds identified for specific systems climatic testing. TECOM reviews test criteria specifications, but has no sign-off responsibility (or authority). A PM has final say on these matters for DT, although objections can be stated at TIWG meetings.

The project manager and TECOM decide what tests (DT) will be done. Sometimes OT's and DT's can be combined and this is worked out by Test Integration Working Groups (TIWG's). The CTP is the control document, developed by the program manager with inputs from all other organizations. TIWG's are now formalized and required for all major systems.

OTEA controls and manages OT's for major systems and OTEA decides whether or not certain ATC and TTC tests are required, based on inputs from TRADOC as the user representative. OTEA has a specific budget for tests considered important; TECOM doesn't. OTEA, however, has no test facilities--they task DARCOM, FORCES COMMAND or TRADOC for test support directly. TRADOC accomplishes the OT mission for most non-major systems.

ARCTIC AND TROPIC TEST CENTER USAGE

If ATC and TTC testing is required by OTEA in OT, it will generally occur only after DT-II is over, and in many cases systems go through DT-II without ATC or TTC testing. This leads to expensive "band-aiding" and performance compromises in these environments. OTEA is not obligated to use ATC--regions in Canada are sometimes preferred as being "better suited" for their OT work. Again, there is no requirement for OTEA to perform OT at ATC or TTC. OTEA performs a very limited amount of tropic and arctic testing but can influence DT and use DT data.

Contractors rarely bring materiel to ATC or TTC to test during the design or development phase. Environmental chamber tests are frequently used on programs in lieu of ATC/TTC tests, and these may be in Army facilities and/or in facilities such as the ADTC chambers at Eglin AFB. Early DT's in chambers are not generally integrated with ATC or TTC natural environment test—they appear to be almost independent design actions, and there is little data flow from chamber tests to ATC/TTC tests.

The fact that no level of climatic testing in a natural environment is required provides the basis for such tests being conducted only if convenient for a PM and if he has the funds.

There is little evidence that such testing is or is not done on the basis of a performance or operational requirement. None of the Army's "BIG 5" systems are planned for ATC and TTC testing during DT with the possible exception of UTTAS, based upon schedules available to the Ad Hoc Group.

ATC and TTC are viewed solely as extreme climatic test centers by PM's and OTEA. Hence, because extremes are not considered realistic operational environments by OTEA, and since a PM has no requirement for such testing, these facilities are severely under-utilized—despite the fact that both cover a variety of climatic ranges applicable to many temperate regions and not just the extremes.

ATC is at about 300 people and TTC at about 150 people—both essentially at or below critical mass to maintain their operations—but since their testing workload is low, they appear to be operating in an inefficient manner. In particular, ATC is not used except in the cold months. The user (PM's) are not involved in this accounting system; consequently, they feel no responsibility toward this Army inefficiency. Coordination between developer and TECOM (at ATC and TTC) is lacking even for systems tested there. The ATC and TTC people only provide services. Their arctic or tropic experience is rarely sought or used.

ATC and TTC are bulk funded from TECOM. They get no reimbursement for tests except for instrumentation that is totally unique to the system under test. The PM pays for shipping his equipment to ATC or TTC and sends TDY people to provide specialized test support in addition to using locally based troops.

ATC direct labor is about 11.5% of the indirect (bulk funding) for FY 76. We were told that it could be as much as 50% direct if they were operating at capacity and if users recognize the year-round capability at ATC. The utilization factor for TTC is higher. At TTC, only a small fraction of planned tests occur even on a delayed schedule. These statistics are not meaningful by themselves as they do not account for importance or lack thereof of tests carried out.

Work loads for ATC and TTC are no longer established in the annual TECOM conferences, but now are established piecemeal by letters that contain the list of materiel requirements (LMR). The LMR defines test objectives, test conditions, data desired, comparison or control item requirement, safety precautions, and other data deemed pertinent. But, in practice, these forecasts cannot be used for effective planning by ATC or TTC since they can and do change, fade away, or new ones appear throughout the year. No explanation or justification is required from the PM to TECOM for these variations.

Methodology studies at TECOM address such issues as how to make testing more cost effective through simulations, better field or natural environment testing, and combinations of both. But again, it is difficult to see real evidence that the results of these studies are really applied in practice.

OTEA determines operational test issues, reviews with TIWG, etc., then looks at TECOM tests and establishes new OT's to resolve remaining issues. This is good in theory, but may be too late in the development cycle in actual practice.

Extreme Climatic Testing (ECT) is done by TECOM, while Operational Climatic Testing (OCT) is done by OTEA. ECT is the full spectrum from extreme to extreme. OCT addresses the upper and lower bands (excluding the extremes) of climatic spectrum. This ranges from severe European winter to mid-east summer climates. OCT also emphasizes testing at transition points, such as freezing. TECOM does not consciously plan or execute the development phase equivalent of OCT.

ECT relates to AR 70-38, requirements documents and DT; while OCT provides estimate of operational suitability of the system under the climatic conditions it is most likely to see in use, (usually close to Categories 1, 2, 5 and 6 of AR 70-38). In practice, ECT often is not planned or conducted at all for reasons already cited and thus, when the system gets to the OT phase, OTEA will generally consider only OCT. We have an uncoupled set of practices that may lead to surprises, that yet are not contrary to the loosely established requirements.

A special category of ECT is surveillance testing. The current practice of long-term surveillance appears to be of questionable value. Little degradation occurs during cold storage, provided that the components can withstand severe cold temperatures.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The Report considers the need for testing under extreme environmental conditions. It concludes that climatic testing should be an integral part of the development process, using simulated facilities as well as natural environments. It recognizes a need to test all general-purpose equipment down to -25°F, as well as test under extreme conditions under very selective criteria. The Arctic and Tropic Test Centers are examined and refocused missions are presented. The Arctic Test Center is considered an irreplaceable asset of primary utility for operational testing, especially under intermediate conditions. The Tropic Test Center is required and should be (Cont)		

Block 20. ABSTRACT (Cont):

used for materials/component development testing. General observations of test management are presented.

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More to the point is operation at temperature transition points, which does not require the questionable realism of storage from three to five years. Component storage in tropic environments, however, can be of great value. Again, the deleterious effects of the environment usually show up after a period of time but rarely as long as three years. The practice of long-term (three to five years) surveillance should be challenged.

GENERAL

The following general observations are made:

- a. Judgments on testing are over-influenced by short-term budget considerations.
- b. Both for arctic and tropic conditions, there is a lack of a continuously updated design base.
- c. Many deficiencies cannot be found in a simulated environment; however, many that show up in a natural environment should have been found in prior simulated environment.
- d. The test data are compartmentalized - both between systems and phases of test of single systems. Interchange of test results would usually improve testing practices.
- e. There is a lack of feedback on corrective actions to test agencies and others.

- f. The Army accomplishes (or conducts) extreme climatic testing instead of limited climatic tests to determine whether equipment satisfies its design specifications and operational requirements.
- g. There are major differences in rationale, need, and timing between arctic and tropic testing. Arctic testing is most useful to validate system performance under operational conditions (late DT or OT), whereas tropic testing is essential to validate design of equipment during the early development phases (DT). Human-equipment-environment interface operability validation is the most important single value of arctic testing; component and system performance and durability determination are the most important products of tropic testing.
- h. Surveillance testing for equipment of more than 1-2 years appears to make little sense.

3. NEEDS

It is important to differentiate between testing intended to verify that equipment developed and procured by the Army can be operated through the normal range of climatic conditions and testing intended to determine the ability of equipment to operate under more extreme climatic conditions.

We shall refer to the first type of testing as Basic Climatic Testing and the second as Extreme Climatic Testing.

The Army, per AR 70-38, requires that general purpose materiel be designed for safe and effective use in the intermediate and wet climatic categories, i.e.:

Climatic Category	Operational		Storage & Transit	
	Ambient Air Temperature °F	Ambient Relative Humidity %	Induced Air Temperature °F	Induced Relative Humidity %
1 Wet-Warm	Nearly Constant 75	95 to 100	Nearly Constant 80	95 to 100
2 Wet-Hot	78 to 95	74 to 100	90 to 160	10 to 85
5 Inter- mediate Hot-Dry	70 to 110	20 to 85	70 to 145	5 to 50
6 Inter- mediate Cold	-5 to -25	Tending Toward Saturation	-10 to -30	Tending Toward Saturation

These categories include the tropic environment but not the extreme hot or cold temperature conditions. OTEA Operational Climatic Tests usually are confined within these categories.

In some cases, standard materiel may have additional climatic requirements imposed beyond Categories 1, 2, 5 and 6. In other cases, special materiel, or modification kits for standard materiel, is designed when equipment is required to operate under the more extreme climatic conditions.

The Ad Hoc Group believes that the imposed requirements are reasonable and, in fact, may not adequately anticipate desert conditions. Categories 1 and 2 of the basic requirements cover the normal range of tropic conditions. Equivalent conditions obtain for significant periods of time in other than those areas of the world designated as "tropic" on a year-round basis.

The temperature and humidity ranges of Categories 5 and 6 (Intermediate Hot-Dry and Intermediate Cold) are also experienced with significant frequency in the temperate zones of the world.

Climatic testing is essential to determine that the equipment can work effectively and can be employed by Army troops in a realistic environment. Much of the testing can be done in simulation chambers during the development period. In fact, climatic testing should be a continuous process starting with materials, processes, and components and carrying through both advanced and engineering development, as well as into the operational testing phase. A key need is to ensure early attention to minimize the risk of "surprises" entailing costly modification later.

The Group believes that the regulations should require testing of all general purpose hardware to verify the capability of operating in Category 1, 2, 5 and 6.

The Army, per AR 70-38, also specifies four additional climatic categories, i.e.

Climatic Category	Operational		Storage & Transit	
	Ambient Air Temperature °F	Ambient Relative Humidity %	Induced Air Temperature °F	Induced Relative Humidity %
3 Humid-Hot Coastal Desert	85 to 100	63 to 90	90 to 160	10 to 85
4 Hot-Dry	90 to 125	5 to 20	90 to 160	2 to 50
7 Cold	-35 to -50	Tending Toward Saturation	-35 to -50	Tending Toward Saturation
8 Extreme Cold	-60 to -70	Tending Toward Saturation	-60 to -70	Tending Toward Saturation

Testing for operability in these categories, whose temperature extremes exceed those of the earlier group, will be referred to as Extreme Climatic Testing.

Extreme climatic testing is required for specially designed equipment and for modified equipments. Extreme climatic testing is also desirable to establish the limits of capability of standard equipment. Such testing, however, is very expensive and the needs should be determined selectively. In the view of the Group, the relative priorities would be firstly, storage in Category 7; and secondly, operations in Category 3, 4, and 7; and, lowest priority, operations and storage in Category 8.

4. RECOMMENDED GUIDELINES

In the Development Test Phase (DT), Climatic Testing (Categories 1, 2, 5 and 6) should be an integral part of the developmental process. There should be maximum use of simulated environment test facilities (e.g., chambers) for component and subsystem testing prior to design freezes. Also, design processes and components should be specified in military standards. Direct access to field centers for industry, independent of TECOM surveillance, should be encouraged as simulated environments do not adequately represent either long-term tropic stresses or arctic man-machine-terrain relationships.

Climatic DT of major subsystems should be conducted at the major subsystem level for complex systems such as PATRIOT or HAWK. These tests should be funded by PMO's. AMSAA and TECOM, however, should participate in TIWG planning and have sign-off responsibility on the test plan and determination that test results meet design requirements. Such testing and evaluation should normally precede ASARC/DSARC production decisions.

DT II testing should include verification of the critical human-machine compatibility. DT III testing should verify production design equipment performance under the specified range

of climatic conditions. Climatic Testing should be confined to Categories 1, 2, 5 and 6, using prototype hardware in initial tests for military utility (OT I). Emphasis in OT II should be on system and subsystem operability and maintainability in natural environments for Categories 1, 2, 5 and 6 climatic ranges. These tests should be funded by OTEA, with TECOM in a support role. The scope of OT II Climatic Tests should not be defined earlier than essential in order that projected deployments can best be reflected in the test plan.

During DT, Extreme Climatic Testing (Categories 3, 4, 7 and 8) should be specified and funded by TECOM, and should not normally be required before ASARC/DSARC production decisions. The principal purpose of these tests would be to determine capability or shortfalls for storage and operation in Categories 3, 4, and 7 (ignoring Category 8 except in very exceptional cases). The tests should be instrumented to note and identify any unpredicted phenomena which limit performance. The test process should include fixes and retesting, if possible, or provision of simple kits or revised procedures.

During OT, the scope of tests should be governed by prospective deployment or use and such tests should emphasize operability and maintainability by troops under field simulated conditions.

5. ROLE OF THE ARCTIC TEST CENTER (ATC)

The ATC is located in an area where the longest periods of sustained cold existing in North America occur—extremes of +90°F to -64°F, with a change of from -50°F to +50°F in 24 hours. One of the climatic test centers of TECOM, it is a tenant at Ft. Greely, a FORSCOM installation. It currently has a work force, primarily military, of approximately 300 people, including 25 technical civilians and 35 officers. The testing area extends over approximately 660,000 acres. The terrain includes streams, lakes, lake beds, terraces, mountains (elevations vary between 1100 and 14000 feet). Ground conditions include tundra, muskeg, granular terraces, stream beds, and terrain with and without trees. Facilities at ATC include a good machine shop, but relatively primitive instrumentation and data reduction capabilities.

ATC has no human factors personnel. With this exception, the competence of its staff appears well matched to perform the recommended mission.

In view of the accumulated expertise of the personnel, the climatic conditions, the isolation from centers of population and the areal extent, ATC has ideal and unique capabilities to serve the following purposes:

- a. To identify operator/equipment problems through testing in the design and development cycle (e.g., ice, fog on optical weapons);
- b. To support OT of some equipment in the "cold" environment (climate Category 7) and even more importantly, to support OT of all systems to meet intermediate-cold climate (Category 6) requirements;
- c. To provide the only U.S. location to perform climate Category 8 testing, should this be required;
- d. To perform DT and OT of specialized arctic equipment;
- e. To conduct DT needed to evaluate adaptation kits or specialized arctic equipment,
- f. To provide a wide variety of trafficability conditions during the winter, break-up, summer and freeze-up seasons, coupled with many different terrain conditions to evaluate mobility characteristics of ground vehicles; and,
- g. Because of its extent and isolation, to permit brigade-size exercises in support of OT.

The mission of ATC should be modified, if necessary, to assure that no arbitrary constraints are placed on the use of ATC for these purposes. In this respect, ATC should be integrated into a broad purpose Northern region test and training center.

The capabilities of ATC would be effectively utilized, provided that mandatory DT and OT testing of major systems were required to meet climate Category 6 conditions; that emphasis were placed on +40°F to -25°F testing, and that all year use is made of this facility to perform such other testing for which ATC has the capabilities. When such testing is conducted on items already scheduled for winter testing, costs of such tests would not be substantially increased.

Whereas ATC has unique capabilities in supporting meaningful cold weather OT and is an indispensable resource for this purpose, it has a less important role for DT, much of which can be conducted in simulated environments, including test chambers.

In consideration of the foregoing comments that demonstrate the unique value of Fort Greely and ATC as an Army asset, we offer the following recommendations:

- a. Provided this workload is increased as proposed:
 1. Retain Fort Greely and ATC as a year-round Northern regions test and training center;

2. Upgrade the instrumentation to provide a real-time data processing capability;
 3. Expand the technical cadre to include human factors and instrumentation capabilities; and
 4. Strengthen the test design and planning capabilities to implement defined test requirements and also to provide an input to the definitions of these requirements and objectives.
- b. If the workload is not increased:
1. Retain Fort Greely and ATC as a year-round center but with a reduced permanent cadre; and
 2. Provide support for safari mode testing.

6. ROLE OF THE TROPIC TEST CENTER

The Tropic Test Center is currently a technically oriented organization with an enthusiastic and competent staff. The TTC has a cadre of experienced personnel. The primary orientation of this organization is to basic research or testing with little involvement with equipment until late in the development cycle.

As perceived by the Ad Hoc Group, in addition to the normal TECOM testing responsibilities, there are three other missions appropriate for TTC:

- a. The support of surveillance testing;
- b. Assistance in failure analysis; and,
- c. The support of developers outside the formal TECOM framework.

To amplify these missions, a primary thrust of TTC testing should be in support of development testing at the components, materials, and subsystems level.

The accelerated aging and deterioration of materiel in the tropics, in contrast to a more temperate environment, is well documented. TTC should be engaged to a large degree in assisting development agencies to determine what components, materiels and design

practices will lead to tropic-qualified equipment. This would be in contrast to independent research on these factors.

The TTC technical background should also be more effectively employed to support failure analysis on-the-spot, thus permitting expedited corrective actions. The current technical expertise and capability of TTC could make major contributions to development testing of a wide range of hardware. The human factors expertise could also help alleviate design limitations.

Industrial and governmental developers currently find it very difficult and expensive to obtain direct access to TTC facilities on any basis. Such testing is essential to the design process as chambers cannot effectively simulate tropic conditions. Little use is made of these valuable facilities by either commercial or other governmental agencies, apparently because of procedural problems in TECOM. Procedures should be modified to allow use of industrial funding for such activities.

A change in mission emphasis would drive significant personnel changes at TTC. Since the primary emphasis should be to support developmental testing, somewhat less emphasis may be needed on human factors and other research, and a portion of the human factors capability could be applied to the ATC where a need for more such capability exists.

In a changed role, the dedicated real estate currently available to TTC would not be required. Although live firings of short-range guns and missiles are still desirable, testing of complex systems such as HAWK or PATRIOT should be done at the subsystem level, reducing the peak manpower and instrumentation requirements. Collocation would have additional benefits, such as lower operational costs, as well as reducing real estate needs in a politically sensitive area. While the Tropic Test Center should not be satellited to another organization, it could well be a tenant upon facilities used by another. Since some firings appear desirable, an organization with access to standard firing ranges would be the most advantageous.

This change in emphasis capitalizes upon the unique capabilities of TTC. In a relatively small area, TTC presents terrain, climate and environmental factors typical of those found over a wide variety of the earth's tropic and subtropic regions. Especially noteworthy is the relatively frequent cycling of conditions, with abrupt temperature and humidity condition change several times daily. This, coupled with the year-round uniformity of test conditions, provides an accessibility and repeatability not found within the continental United States. Not only the rapid changes but the unique biota make the Canal Zone an advantageous place to accomplish development testing under extreme climatic conditions.

The history of the establishment of the TTC reflects a consensus that we need to retain tropic test expertise and testing capabilities and that the degree of this need is rarely predictable in advance. The problem, then, becomes one of recommending an approach that improves the return upon investment.

The present staff could handle a much higher active test support workload. Such a workload is potentially there, but does not materialize as tests are not mandatory in DT and are hence deferred or even not scheduled for major systems. This appears to be a dangerous omission.

Upon consideration, the Group makes the following recommendations with respect to the TTC:

- a. Retain in Panama for the present, and as long as possible, possibly co-using other Army ranges.
- b. Conduct a study to determine the extent of dedicated real estate and firing ranges required under a revised mission charter emphasizing development and subsystem testing.
- c. Identify, by means of controlled experiments, an alternate site accessible to the U.S.
- d. If workload increases, redirect the mission to emphasize more direct support of design and development testing; and, modify the staff composition.

- e. If workload does not increase, reduce the staff size, retaining test support capability.

7. SPECIFIC RECOMMENDATIONS

- a. The Army require reasonable proof through test of the design and operability of each equipment through its design climatic range. This should include major systems such as the Big 5.
- b. The appropriate regulations be clarified and strengthened to be directive rather than permissive with respect to climatic testing. The regulations should require testing of all general purpose hardware through climatic categories 1, 2, 5 and 6.
- c. AMSAA and TECOM have sign-off responsibility on test requirements and plans; and exceptions to normal climatic testing requirements.
- d. Extreme climatic testing be conducted only when specifically specified by the developer or user.
- e. Procedures be established to permit direct access by industry to Test Centers for support of early development testing, without requiring TECOM HQ planning participation.
- f. The Arctic Test Center (ATC) be used as a broad purpose Northern Region test and training center, with emphasis on testing in the Intermediate Cold (to -25°F) temperature range rather than the Cold (to -50°F) and Extreme Cold (to -70°F) ranges. In addition, increase usage of this facility for mobility tests, combined with climatic tests.

- g. If recommendations a and b and f above are accepted and implemented, resulting in an increased year-round workload at ATC; appropriately upgrade the instrumentation for real time data processing and strengthen the staff in human factors, instrumentation, and test planning and design.
- h. If the ATC workload does not increase as expected, adjust the staff size to that required to support safari testing.
- i. The Tropic Test Center (TTC) be retained in Panama as long as practical, co-using other Army required real estate.
- j. The mission of TTC be redefined to emphasize more direct support of design and development, and staff composition and size adjustment to the mission and workload requirements.
- k. DT tropic testing of major systems be conducted at the subsystem level for complex systems (such as Improved HAWK or PATRIOT).
- l. Alternate sites for the TTC should be identified and evaluated through controlled experiments.

APPENDIX A

Proposed Terms of Reference ASAP Ad Hoc Group on Extreme Natural - Environment Climatic Testing

1. Background

a. The question has arisen from time-to-time concerning the value of testing Army materiel in extreme natural climatic environments. Most of this testing has been conducted at the Arctic Test Center (ATC), Alaska, for cold-weather conditions and at the Tropic Test Center (TTC), Canal Zone, for tropical assessments.

b. Current regulations require testing in simulated environments only, prior to production. The degree of testing in extreme natural environments has been inconsistent over the course of time. While artificial environments provide much useful information, they do not truly simulate the synergetic effects of the natural cyclic events experienced at the environmental test centers.

c. Attempts to ascertain the value to the Army of extreme natural environment testing have met with differing results. A recent Army Materiel Systems Analysis Agency study finds need for more extensive testing. The US Army Audit Agency independently

has questioned the need and the suitability of the locations used for such testing. No formal philosophy has yet evolved concerning the degree of operational testing that may be desirable or necessary under such conditions within the Army.

2. Terms of Reference

a. Define the value or need for environmental testing under extreme natural conditions during the materiel life cycle.

b. Recommend general parameters or guidelines, within economic limits, wherein such testing is found to be desirable, advisable, and/or mandatory.

c. Assess the suitability of the ATC and TTC for the purpose of carrying out the recommendations of 2b, above, and furnish recommendations regarding utilization of other sites.

3. Termination

The Chairman of the Ad Hoc Group is requested to conclude his efforts at the earliest possible date. A final report should be available not later than 1 June 1976.

APPENDIX B

DEPARTMENT OF THE ARMY ARMY SCIENTIFIC ADVISORY PANEL Washington, D. C. 20310

Membership AD HOC GROUP on Extreme Natural - Environment Climatic Testing

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APPENDIX C

LIST OF REFERENCES

NOTE: This list is not, nor is it intended to be, a complete bibliography of the literature associated with testing under extreme environmental conditions. However, it does reflect a portion of the more valuable sources scanned by the Working Group.

AR 70-1	Army Research, Development, and Acquisition
AR 70-10	Test and Evaluation During Development and Acquisition of Materiel
AR 70-38	Research, Development, Test, and Evaluation of Materiel for Extreme Climatic Conditions
AR 71-3	User Testing Operational Test Instrumentation Guide, January 1974, prepared by Braddock, Dunn and McDonald, Inc., and RMC Research Corporation for USAOTEA: Vol I Summary Vol II US Army Test Facilities Vol III Non-Army DoD Test Facilities
Trip 76L04	USAMSAA Report of R&D Field Liaison Visit to 172nd Inf Bde (AK) 9 - 27 February 1976
Interim Note R-49	USAMASAA Study of Arctic/Tropic Test Centers (DRAFT)
-	TECOM Test Instrumentation Register, Jan 75
-	Index of Environmental Facilities, Materiel Test Directorate, Aberdeen Proving Ground, MD, Aug 71

Tech Rpt EP-III	Climatic Analogs of Fort Greely, Alaska, and Fort Churchill, Canada, in North America; Quartermaster Research and Engineering Center, Natick, Massachusetts, May 1959
ATC Pam 360-1	USA Arctic Test Center, Fort Greely, Alaska USA ATC Facilities Guide Various Fact Sheets prepared by USAATC Staff Various Fact Sheets prepared by USATTC Staff
Rpt 7602001	Material Testing in the Tropics, USATTC, Feb 1976
Rpt 7202001	Tropic Environmental Effects, USATTC, Feb 1974
Rpt 7307002	Laboratory versus Field Tests: A Limited Survey of Materials Deterioration Studies, USATTC, July 1973

APPENDIX D - AGENDA OF VISITS

3 - 7 March 1976

USA Arctic Test Center, Fort Greely, AK

- o USAATC
- o USAASL Meteorological Team
- o USACDAA
- o CRREL
- o NWTC
- o 172nd Inf Bde

31 March - 2 April 1976

USA Aberdeen Proving Ground, Aberdeen, MD

- o USATECOM
- o DARCOM
- o USAMSAA
- o OTEA
- o MTD, APG

23 - 29 April 1976

USA Tropic Test Center, Fort Clayton, CZ

- o USATTC
- o USAASL Meteorological Team
- o US Southern Command
- o 193rd Inf Bde (CZ)

29 April 1976

US Air Force Base, Eglin, FL

- o AFSC McKinley Climatic Laboratory

24 - 25 May 1976

Research and Development Associates,

Marina del Rey, CA

- o Ad Hoc Group Working Meeting

VISIT TO US ARMY ARCTIC TEST CENTER

Fort Greely, Alaska

3 - 7 March 1976

3 March

Arrival at Fairbanks International Airport; Enroute to
Fort Greely

4 March

Command Briefing at USAATC

Briefing and Observation of Current Tests, Weapons Test Branch

Briefing on Field and General Equipment Test Division

Tour of Bolio Lake Test Site

Briefing on Logistics/Test Support Division Operations

Tour of Ammunition Storage Sites

Briefing on Combat Developments Activity (By CDA, Alaska, Commander)

5 March

Briefing on Arctic/Subarctic Regions Environment

Briefing on Test Engineering and Analysis; Methodology; and,
Instrumentation

Tour of Photographic Branch and Computer Center

Briefing and Tour of Vehicle Test Division

Briefing and Tour of Metereological Team (By Atmospheric
Sciences Lab Met Team)

Briefing on Budget by Resources Management Branch

Briefing on Scheduling Problems

Helicopter Overflight of Test Areas, Pipeline and Gerstle
River Test Area

Briefing on Cold Regions Research and Engineering Laboratory
(CRREL Director)

Round-Table Discussion with USAATC CO and Key Staff

6 March

Individual Discussions with Staff Personnel

Review of Records

Departure for Fairbanks International Airport and CONUS

VISIT TO ABERDEEN PROVING GROUND

Aberdeen, MD

31 March - 2 April 1976

31 March

Arrival at APG; Ad Hoc Group Working Meeting

1 April

Discussion with TECOM Commanding General

Command Briefing on TECOM

Briefing on Methodology

Briefing on Human Factors Engineering

Briefing on Operational Test and Evaluation Agency

(OTEA Evaluation Div Chief)

Discussion with DARCOM and USAMSAA Representatives

2 April

Briefing on Materiel Test Directorate operations

Tour of climatic and other test facilities

Panel Discussion with key TECOM staff

Depart Aberdeen Proving Ground

VISIT TO US ARMY TROPIC TEST CENTER

Fort Clayton, Canal Zone

23 - 29 April 1976

23 April

Arrival at Tocumen International Airport

24 April

(Same as 27 April for Dean Fadum, Dr. Brock, and MAJ DeYoung.)

25 April

Arrival at Tocumen International Airport (Dr. Montgomery, Dean Clark)

26 April

Discussion with CG, 193rd Inf Bde (MG Richardson)

Briefing on Military Operations in Canal Zone (193rd Inf Bde Staff)

USATTC Command Briefing

Briefing on US military operations in tropic areas — 1776-1976
Briefing on Canal Zone climate and tropic testing with Communist
Bloc
Briefing on Foreign Military Sales and assistance to tropic
countries
Tour of Tech Library, Editing Section, ADP Room and Printing
Plant
Briefing on TTC history, personnel and technical emphasis
Briefing on Technical Division operations
Briefing on Tropic Human Factors Program
Briefings on Computerized Site Selection and Mobility
Methodology investigations
Tour of Electronic Laboratory with RF Propagation briefing
Tour of Chemical and Materials Laboratories
Briefing on Test Operations
Summary of major tropic tests; challenges to test items in
tropics

27 April

Helicopter Overflight of Firing Ranges, Test Sites and
Panama Canal Zone
Demonstration of 81-mm mortar firing test
Tour of new ranges

Briefing on meteorological support (ASL Met Team Chief)

Tour of exposure test sites

Tour of ammunition surveillance test area

Briefing on tropic effects upon ammunition, especially AMATEX

Briefing on and tour of Human Factors Jungle Test Area

Briefing on CB pod testing; MCPE tropic testing and defects

Briefing on lack of correlation between chambers and natural tropic environment

Briefing on methodology investigations, including WSMR-TTC simulation test

Tour of POL test sites, after briefing on collapsible POL tank testing

Briefing on testing and inspection of D7F dozer, with emphasis on tropic challenge

Briefing on Metrology Laboratory

Briefing on photographic instrumentation capabilities

28 April

Discussion of selected problem areas with key staff

Working Group meeting

Briefing on SOUTHCOM operations (CINCSO and Staff)

29 April

Departure from Tocumen International Airport

VISIT TO US AIR FORCE CLIMATIC TEST FACILITY (McKINLEY LABORATORY)

Eglin, FL

29 April 1976

(SEE APPENDIX E)

VISIT TO RDA

Marina del Rey, CA

24 - 25 May 1976

(Working Group Meeting -- See Report)

APPENDIX E

EGLIN AFB - CLIMATIC TEST FACILITY VISIT - 4/29/76

The undersigned visited the Eglin AFB Climatic Test Facility at the request of R. A. Montgomery for the purpose of understanding this test facility capability as it relates to the Natural Climatic Environment test facilities within the U. S. Army. The facility briefing and tour was conducted by Wayne Drake, one of two civilian project engineers assigned to the facility.

Mr. Drake presented an institutional type briefing which lasted, together with questions, about one hour. This was followed by a well-conducted tour of the entire facility. In the following, I will cover the key points regarding the facility capability and use. I have asked for a copy of the briefing; however, it is not certain at this time that they will release it.

1. This is a National Facility in that testing is performed for all of DoD and other Government organizations.

2. The facility was opened May 1947, and has been in full operation since that time, except for a 1-1/2 year period when it was down for rehabilitation-insulation repair and upgrading, automation of various elements, etc.
3. Facility initial cost was \$13M in 1947 dollars, the rehabilitation costs were \$5M in 1974 dollars, and the replacement cost in 1976 is estimated at \$48M.
4. The facility 62 man work force consists of 61 civilians and one military (safety officer). Of these there are 12 shop people (test fixtures, etc.) and 2 designers.
5. The facility utilization has been high overall, although it is not generally totally full. He estimates that the loading is somewhere around 70% of full utilization.
6. The facility consists of the main chamber which is 250' wide by 200' deep with a maximum height of 70'; has temperature capability of +165°F to -65°F; provides humidity range of 10-95% at above freezing temperatures; can produce icing, winds, snow, and desert conditions; and can produce rain soak and cold soak. This chamber uses three refrigeration units (Freon 12), takes eight hours from ambient to -40°F and a total of 24 hours to get 20-25°F lower.

7. There is also a large engine test cell where they have tested the C5A engine, plan to test the B-1 Bomber engine, and have tested various other jet engines. This cell has exhaust and air inlet capabilities and provides hot and cold chamber characteristics.

8. There are nine other chambers of smaller size that are used for component and subsystem testing. An example is the much smaller physiological chamber, that has the capability to extend from +140°F to -90°F and 80K feet in altitude. Another is the all-weather chamber which simulates arctic to jungle conditions, rain storms, winds to 25 knots, sand and dust conditions and snow conditions.

9. For each system to be tested--speaking principally of the large chamber--there is a series of planning meetings held between the Eglin people and the equipment project personnel. These meetings are held long before the actual tests start and generally they:

- o Define the test required and the test parameters desired;
- o Provide a two-way communication between Eglin Chamber personnel and the equipment personnel relative to what can be expected in the particular tests planned (based on Eglin experience);

- o Arrive at fixture designs (done by Eglin) and an understanding of who does what to whom;
 - o Lay out the program and schedule of testing from start to finish.
10. Relative to Army equipment tests, the Army generally provides test plans to Eglin, the Army Project Officers are the interface with Eglin (Not TECOM), the equipment operating people are the Army equipment folks, and the Eglin USAF people tell the Army what to expect from the tests based on the test plans and Eglin experience.
11. The Army when testing, as well as other users of the facility, reimburses Eglin for only a certain percentage of the costs as below:

Utilities - Pay about \$450 per day on average

Support - Pay for direct civilian support,
and overtime

Other - Pay for any J21 supplies; materials,
fuels, etc.

12. The Eglin people list advantage of their facility over natural environment extreme testing as principally one of cost--they say 10 times cheaper to do at Eglin than at either the ATC or TTC. They agree, however, that their testing is limited, that no one can duplicate the natural extreme environments totally, and that the real advantage is to test at Eglin early in programs in order to find problems that are readily fixed early in the programs but that are costly to fix later. They are speaking of AD, ED and other early developmental tests. They also believe that full-scale system tests are very meaningful when done at Eglin early in the cycle.

Specific merits of Eglin, as stated by W. Drake, are that the facility is cost effective, scheduling is more flexible than in the Arctic or Tropics since "weather" is controlled here, and safety is better and more readily controlled.

13. Some comments on tests that have been performed seem relevant.

- o Testing overall in the facility has averaged about 70% USAF, 18% Army, 7% Navy, and 5% other.

- o They have tested the A-10 (cold and with 30 MM gun), F-15, S3A (electronic), C5, F111, and the U-2 (which had just been tested the day before).
- o Testing of Army tanks has taken place at -65°F for several days--the tank engine was started and it was driven around in the chamber; and the big door was opened and the tank was driven out and the gun was fired immediately.
- o Helicopter tests have been performed and the "birds" have been tied down and engines fired up.
- o AWACS is planned for test in the chamber, and test planning meetings have already been initiated.
- o Most commonly, hydraulic systems really develop problems, also lubricants, cables, etc. Many problems of this type surface in these Eglin tests--cable fixes, seals, etc., that can be caught early in any program through less expensive chamber tests.

14. In general, the testing at the Eglin Chamber is carried out much the same as when testing in the Arctic and Tropics. The tests costs appear to be less, principally due to lower equipment transportation costs and lower TDY costs. Also, there generally will be less time span costs since the hot, cold, etc., can be scheduled. However, it is clear that mobility and man/machine/interface tests are not practicable in the chambers, and the chamber environment will never be equivalent to the natural climatic environment in all respects.