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APPLIED CLIMATOLOGY GUIDANCE FOR DEVELOPMENT OF ARMY MATERIEL FOR WORLD WIDE USE

Charles C. Ryerson* and Leander Page
ERDC-CRREL, Hanover, New Hampshire

Linda M. Spears
DoD Test Resource Management Center, Washington, DC

Graham Stullenbarger (ret)
Chief, Natural Environments Test Office, Yuma, Arizona

1. INTRODUCTION

The Army operates principally at and near the Earth's surface where conditions are driven by atmosphere-terrain interactions. Mission success, soldier safety, readiness, national security, and effectiveness of taxpayer investment require that Army equipment operate reliably and durably. Army Regulation 70-38 (AR70-38, 1979), *Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions*, has defined, since 1979, diurnal ranges of temperature, humidity, and solar radiation conditions, and storage and transit temperature and humidity conditions, that Army material must withstand in seven climate design types. Recent and current military operations have demonstrated, however, that diurnal atmospheric conditions alone are often inadequate standards for materiel design. The approach is inadequate to fully describe the complete environment at any location, and as a result, materiel has failed due to synergistic effects when the atmosphere and terrain interact. As a result, a new AR70-38 (AR70-38, 2008) has been drafted, entitled *Research, Development, Test and Evaluation of Materiel for World Wide Use*, to address shortcomings in the current 1979 version.

This paper explains the concepts of the overall new approach, explains how atmospheric and terrestrial conditions are combined in the new document, and provides a risk evaluation methodology identifying environment factors having the greatest impact on Army materiel by type for decision-makers. We also explain how the document is used throughout the materiel acquisition and development process.

* *Corresponding author address:* Charles C. Ryerson, ERDC-CRREL, 72 Lyme Road, Hanover, NH 03755; charles.c.ryerson@usace.army.mil

2. BACKGROUND

A fundamental purpose of Test and Evaluation (T&E) is to manage risks involved in developing, producing, operating, and sustaining systems and capabilities. T&E lowers risk through early identification of technical, operational, and system deficiencies so that appropriate and timely corrective actions can be taken prior to fielding. This reduces risk for the Soldier, wherever deployed and whatever the season by providing equipment that is fully mission capable worldwide. It reduces program risks, and lowers life cycle costs by addressing environmental challenges and potential reliability shortfalls early in the Research, Development, Test and Evaluation (RDTE) program when corrective actions have minimum impact.

Test and evaluation regulations lower risk of mission failure through assurance that each of the building blocks of an effective fighting force from the individual Soldier's weapons and equipment through transport platforms to weapon systems of systems are fully functional under worldwide conditions. Additionally, Army equipment tends to remain in the active inventory for decades and is likely to be exposed to a range of severe environmental conditions during its lifetime. Consequently durability, cost of ownership, and performance for the long term over the full range of environmental factors must be considered during RDTE.

The development of documents for describing the operating, and therefore test conditions for Army material began during World War II (Krause, 2006). The Environmental Protection Section of the Army Quartermaster Corps was started in 1942 under the direction of climatologist and Antarctic expert MAJ Paul Siple. He built a team of military and civilian climatologists, meteorologists, geologists, physical and cultural geographers, cartographers, biologists, foresters, pedologists, and agronomists that produced many reports supporting the Army's developing test programs through instrumentation of test sites and test items, and creating climatic studies and climatic analog reports (Krause, 2006). In 1947 Siple's team produced Military Standard 210 (MIL-STD-210, 1947), *Climatic Extremes for Military Equipment*, which was subsequently transferred to the Air Force in 1953 for aeronautical use. Thereafter, the Environmental Protection Section of the Quartermaster Corps began to focus on ground-based environmental design criteria because the Army is largely a ground-based force. In 1950 Special Regulation 705-70-5 (SR705-70-5, 1950), *Operation and Protection of Materiel under Adverse Conditions of Temperature*, was released providing thermal objectives for research and development of material. In 1952 AR705-15 (AR705-15, 1952), *Operation of Materiel under Extreme Conditions of Environment,* was released using tables of extremes created by Norman Sissenwine and Arnold Court. In addition to temperature, AR705-15 included non-thermal environmental conditions such as relative humidity, rainfall, snow loading, wind, pressure, blowing snow and blowing sand and dust (Krause, 2006). A revision of AR70-15 was released in 1962 providing seasonal climatic maps and more detailed design criteria, but with a de-emphasis of non-thermal conditions.

The first version of AR70-38, released in 1969 (AR70-38, 1969), entitled *Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions,* described eight climatic design types, with a primary focus on temperature and diurnal conditions within those climates. This allowed conditions to be readily duplicated within environmental chambers and was a move away from testing in natural conditions.

In 1971 responsibility for environmental characterization and for AR70-38 became the responsibility of the Army Corps of Engineers Topographic Engineering Center in Alexandria, Virginia. A revision of AR70-38 was released in 1979 under the Corps of Engineers with minor extreme maximum and minimum temperature adjustments (AR70-38, 1979). Since 1979, several attempts were made to revise AR70-38 and to make it environmentally more comprehensive. However, each attempt was rejected during the review process by such major commands as the Army Training and Doctrine Command (TRADOC) and the Army Materiel Command (AMC). As a result, the current document has not been revised in over thirty years. The Army Corps of Engineers Cold Regions Research and Engineering Laboratory is currently responsible for maintaining AR70-38.

3. A NEW APPROACH

Previous versions of AR70-38 and derivative documents have used diurnal cycles of climatic factors to describe operating environments. This approach can be easily used to define temperature and/or temperature-humidity performance ranges, for example, in acquisition specifications and verified later in chambers (MIL-STD-810G, 2008). However, this approach inadequately describes the complete environment of any actual location.

AR70-38 is the basic Army regulation that requires consideration of environmental factors during RDTE of materiel for combat use. The 1979 version does not adequately address testing for environmental factors that can affect performance of equipment and munitions other than temperature and/or temperature-humidity cycles. The 1979 document reflects the European-based strategies of the Cold War era. In addition, failure of equipment in recent years due to the synergistic effects of atmospheric and terrestrial factors suggested that changes in the document were necessary.

A major draft revision of AR70-38 was competed in December 2008 and will be shortly sent to about 70 Army commands for review and concurrence (AR70-38, 2008). The primary change to the regulation is to consider atmosphere and terrain factors in all climatic regions worldwide in which U.S. military forces may operate for all missions including disaster relief and humanitarian efforts.

The revised draft document is designed to educate and to provide a risk management methodology to decision-makers so that they can write more effective operational requirements documents and identify technical, operational, and systems deficiencies prior to fielding. The document is organized similarly to university introductory world climatology and physical geography courses - to provide an overview of world environments using a consistent classification scheme.

4. MILITARY OPERATING ENVIRONMENTS

The proposed AR70-38 subdivides the continents into areas of intrinsic similarity based upon integrated environmental characteristics (Bailey, 1983, 1996). This global classification scheme benefits the materiel RDTE process in two ways. First, the methodology provides a standardized method for directly comparing areas worldwide allowing materiel RDTE activities to be conducted at easily-accessible sites analogous to areas of potential military interest elsewhere. Secondly, the classification system considers environmental factors beyond atmospheric climatic factors.

4.1 *Classification Scheme*

At the highest level, four broad world climate regions, or Global Military Operating Environments (GMOE) are defined. These GMOEs are the most fundamental climates, and serve to educate the regulation's users about global patterns. The four GMOEs are based on Bailey's Domains (1983). Largely a function of long-term annual temperature and moisture regimes, the GMOEs are Polar, Humid Temperate, Humid Tropical, and Dry (Figure 1).

The four GMOEs are subdivided into 19 MOEs to identify environmental factors of military interest, and to demonstrate regional characteristics (Figure 2). Still based largely on climatic information, the MOEs are similar to and are based primarily upon the Köppen (1931) and Trewartha (1968) climate classifications (Bailey, 1983). Though the MOEs are differentiated based on annual and seasonal temperature and precipitation regimes, they are also tied closely to regional climax vegetation types. Since there was little readily available long-term numeric climatic information available globally when Köppen developed and demonstrated his classification system, he relied upon vegetation as a proxy for climate. Since vegetation type is driven by the energy and moisture budgets of a region, this is a reasonable approach.

Fifteen of the MOEs closely match Bailey's Divisions (1983, 1996). Four additional MOEs are used in 2008 AR70-38 revision because of their specific challenges to military equipment operation, storage, and transport (AR70-38, 2008). They are hot-humid coastal deserts, littoral (coastal) areas, mountains, and the sea environment. Only mountainous and sea areas are presented in map form in the regulation. However, characteristics of the sea environment are not presented in the regulation because it is not a traditional Army working environment even though it is used for transport. The hot, humid coastal deserts and littoral areas are not mapped because they do not cover large enough areas at the map scales used in the document.

The MOE framework provides a useful tool for understanding and comparing characteristics of potential operational areas worldwide. Areas described by the same MOE, regardless of their location, have similar atmospheric/climatic, terrain, and biological/vegetation conditions and can be directly compared. Therefore, areas available to the U.S. Army for the purpose of testing and/or training are analogous to other areas of the Earth identified as the same MOE.

4.2 *MOE Environmental Factors*

Global maps of the MOEs inform the seven Combatant Commander's about the spatial variability of natural operating environments within their Areas of Responsibility (Figure 2). But, most importantly, they inform and educate materiel developers about regional patterns and the importance of designing and testing for a wide variety of conditions.

In addition to spatial patterns provided by maps, the proposed AR70-38 also provides tabled environmental information about the MOEs. Twenty-two tabled natural environmental factors that affect Army materiel are categorized into three groups; atmospheric factors, terrain factors, and biological factors. Atmospheric factors include temperature, rain, solid precipitation, humidity, fog, wind, salt, solar radiation, and pressure (Table 1). Terrain factors include topography, soils, surface cover and hydrology. Biological factors include vegetation and macro- and micro-organisms.

Values of environmental factors that may most severely affect end-item safety, performance, and reliability/supportability are intended to be used for preparing specification documents and determining test criteria for each MOE where deployment of the materiel is expected. Additionally, materiel reliability and long term cost of ownership for worldwide use and for use in extreme environments should be considered from program initiation, to fielding and deployment.

Where information was available, and characteristics of environmental factors were amenable, extreme values were tabulated. For example, 5% extreme high and low temperatures, wind speed, and gusts are presented, as are 1% extreme precipitation rates and amounts. Some factors are presented as average annual conditions such as precipitation amounts, days of fog/ice fog/ and whiteouts, and visibility. Other factors are presented as approximate percentages of each MOE area globally, such as ice cover, dominant soil types, surface water, and potential for generating dust. Finally, some factors, such as

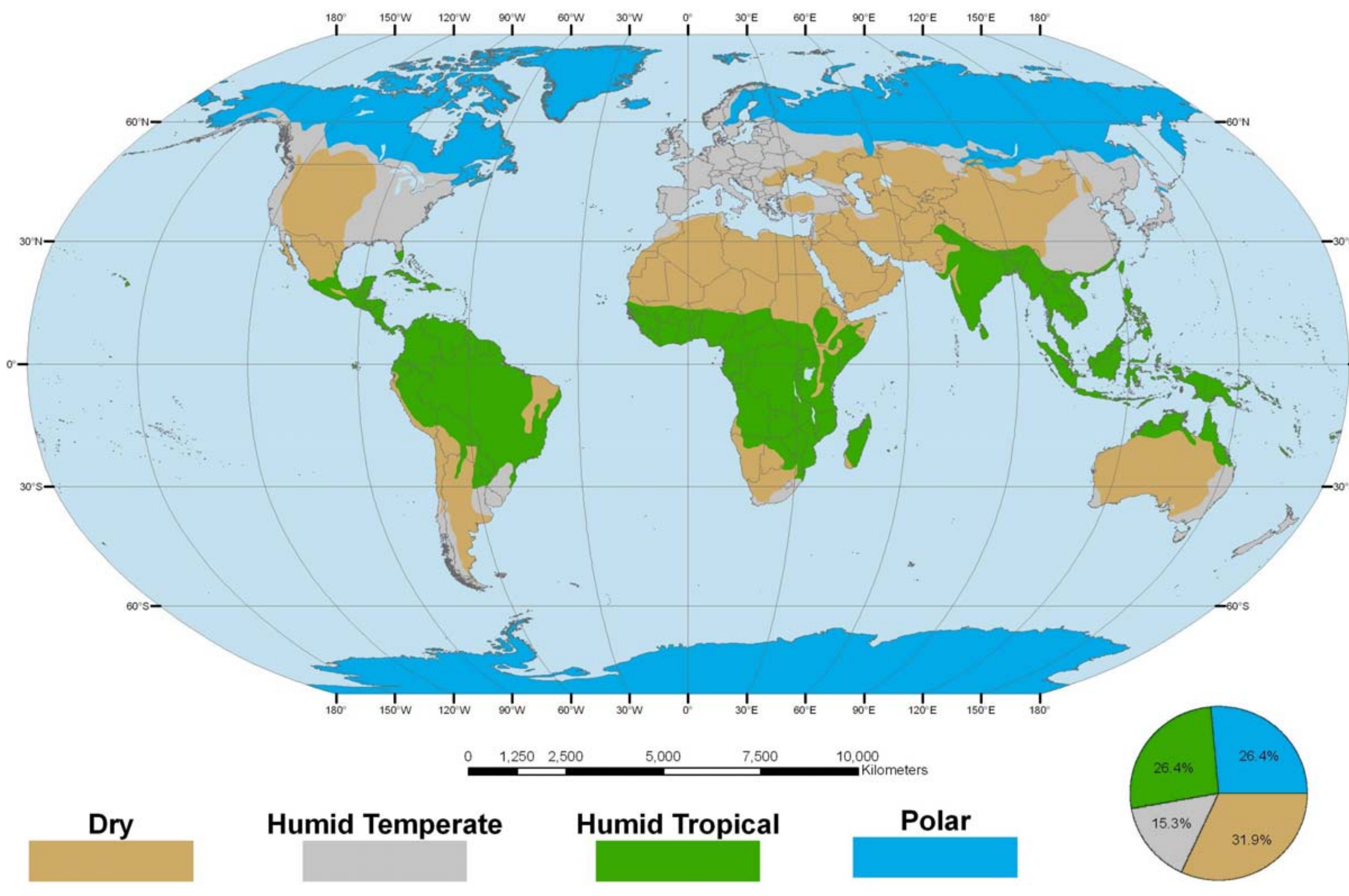

Figure 1. Global Military Operating Environments.

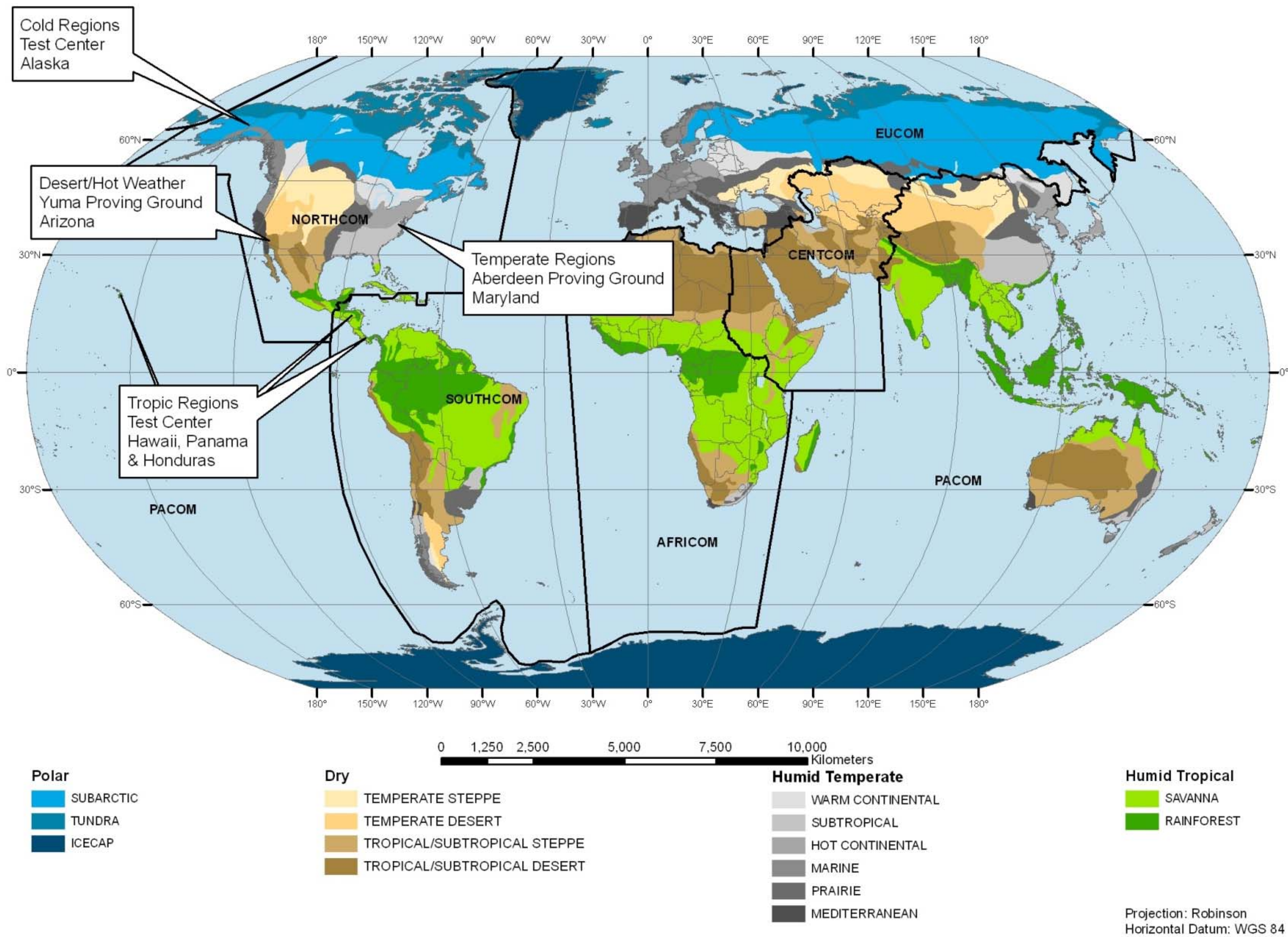

Figure 2. Military Operating Environments, Geographic Combatant Commander's Areas of Responsibility, and Army Environmental Test Centers.

Table 1. Tabulated environmental factors for the Tundra MOE.

Atmospheric Factors	
Low Temp °C (°F) (5% extreme)	-53 (-63)
High Temp °C (°F) (5% extreme)	29 (84)
Yearly avg. Precipitation mm (in)	224 (8.8)
6 hour Max(1% extreme) Precip mm (in)	25 (1.0)
Yearly avg. snow mm (in)	643 (25.3)
Mean Relative Humidity %/ Mean Dew Point °C (°F)	80% / -11 (13)
Fog/Icefog/Whiteout Mean (days)	32
Visibility Mean (miles)	13
Wind: Gusts/Max Sustained (knots) (5% extreme)	71 / 59
Terrain Factors	
Landforms (Physiography); greater than 15% total area (% area)	low interior plain (40%), coastal plain (18%), high interior plain (16%)
Predominate NRCS soil order; greater than 15% total area Soil Order (% Area)	Inceptisols (30%); Gelisols (26%)
Extensive areas of exposed bedrock, limited soil cover (High, Moderate, Low)	Moderate
Extensive areas of non-cohesive Sand and Gravel	Moderate
Extensive areas of non-cohesive Silt and Clay (mud potential)	High
Potential for generating dust; greater than 15% total area; Rating (Percent Area)	low (50%); moderate (31%); very low (19%)
Surface Water (Hydrography)[3]	Poor drainage, 50% covered in summer. Lakes, swamps, bogs
Frozen Soil	Continuous Permafrost
Snow Cover	Persistent
Surface Ice Cover	50% in winter
Biologic Factors	
Vegetation Structure	Grass, sedges, brush
Microbiology	Limited activity
Macrobiology	Abundant insects, birds seasonally

vegetation structure are identified by type, such as mixed deciduous, and factors such as macro-biology by the type of animals and their relative abundance and, if relevant, seasonal activity.

Characteristics of MOE environmental factors were compiled, in part, from military publications including Military Handbook 310 *Global Climatic Data for Developing Military Products* (MIL-HDBK-310, 1997), *Weather and Climate Extremes* (Krause and Flood, 1997), Air-Land Battlefield Environment *Environmental Factors and Standards for Atmospheric Obscurants, Climate and Terrain* (ALBE Report 1, 1987), Army Materiel Command *Engineering Design Handbook, Environmental Series* pamphlets Part 1 *Basic Environmental Concepts* (AMC-PAM 706-115, 1974), Part 2 *Natural Environmental Factors* (AMC-PAM 706-116, 1975), Part 3 *Induced Environmental Factors* (AMC-PAM 706-117,1975), Part 4 *Life Cycle Environments* (AMC-PAM 706-118, 1975), Part 5 *Glossary of Environmental Terms* (AMC-PAM 706-119, 1975), and Army Field Manual *Battlefield Weather Effects* FM34-81-1,1992).

Some environmental factors that occur naturally can also be induced by human activity. For example, the dust environment can be a combination of dust caused by wind plus that caused by military operations in dry or desert areas. Equipment and munitions stored in shelters in a dry or desert environment exposed to intense solar radiation may experience temperatures that are much higher than ambient. Induced environmental factors such as electromagnetic radiation and nuclear radiation are not addressed in the regulation. Induced environmental factors that are mechanical in nature (vibration, shock and acceleration), airborne pollutants, and acoustics are also not explicitly addressed but are included implicitly since they are coupled with natural environmental factors.

5. RISK MANAGEMENT

The purpose of AR70-38 (1969, 1979, 2008) is to reduce risk. It is critical that originators of military requirements identify the MOEs, or at least the AORs where equipment will be deployed. Developing materiel for use in specific operating environments, and testing and evaluating it in the conditions of those environments, increases the likelihood of learning and understanding strengths and weaknesses before fielding.

Risk management focuses on testing equipment so that it is exposed to the most critical factors and to the synergistic effects of all other environmental factors in analogs of the anticipated deployment environments. Testing in these realistic environmental conditions replicates the operational conditions the fielded system will experience. If relatively short duration testing in the natural environment may not expose equipment to extreme conditions, exposure to these extreme values using laboratory testing methods may be appropriate.

Program Managers (PM) are responsible for designing, planning, programming, coordinating, and executing a viable T&E program. Risk management begins with the creation of a risk matrix combining the likelihood of occurrence of each environmental factor within a defined GMOE with the vulnerability of the class of military equipment to particular environmental factors.

An impact rating is given for each environmental factor based on the likely effect the factor will have on the ability of equipment to perform its intended function. Impact ratings are based on the probability of the occurrence of severe or moderate effects, often based on historic information of the performance of similar equipment. A risk matrix based on environmental factors that affect equipment combined with the likelihood of those factors occurring in a GMOE establishes the levels of risk associated with equipment operation in the various natural environments. The risk matrix identifies to the developer and tester the high risk environmental factors that must be addressed throughout the RDTE process, and that should become an integral part of the overall Army risk management program.

Risk matrices are developed by multiplying the numerical rating for the likelihood of occurrence of each environmental factor within a GMOE (Table 2) by the numerical rating for the equipment vulnerability due to environmental factors (Table 3) for each class of materiel. Table 4 shows the example of the risk matrix for Small Arms and Automatic Weapons.

A rating of 20 to 25 indicates a high probability of encountering problems with a class of equipment in a given environment due to a particular environmental factor. A rating of 12 to 19 indicates a medium probability of encountering problems with a class of equipment in a given environment due to a particular environmental factor. A rating of 1 to 11 indicates a low probability of encountering problems with a class of equipment in a given environment due to a particular environmental factor. Items should be tested in environments that expose them to the most challenging conditions early in the T&E program so that if deficiencies exist they will be revealed for corrective action. In some cases, combinations of medium risks could result in a high risk.

Testing should provide risk mitigation of environmental effects as well as reliability relevant data for an end item or system operating in a GMOE. It is important to subject equipment to the medium and high risk terrain factors (landforms, rock, sand, mud, dust, surface water, frozen soil, surface snow/ice) for a particular equipment category since specific laboratory or simulated field tests do not always exist for terrain factors.

6. AR70-38 AND ACQUISITION

AR70-38 is intended to guide development of materiel from concept and requirements development by Training and Doctrine Command (TRADOC) and Combat Developers (CBTDEV), to assessment of capability and acceptance by the Army Test and Evaluation Command (ATEC) within the Joint Capabilities Integration & Development System (JCIDS). It may also be useful for Total Life Cycle Systems Management.

Key tasks during materiel development are to 1) develop needs documents, 2) identify missions to be accomplished, 3) identify expected deployment areas, and 4) outline typical combat missions, methods of deployment, and other operational functions so that specifications writers and testers can develop a Test and Evaluation Master Plan (TEMP) for RTDE. To support these tasks, AR70-38 would be used to develop a risk matrix.

Information developed from AR70-38 influences all stages of material development within the JCIDS process. If a capability need is identified, the JCIDS process is started to assess whether a material solution satisfies the requirement. If a material solution is needed, JCIDS provides a process for development and testing.

In the first stage, the Material Solution Analysis Phase (Figure 3), AR70-38 provides information helpful in developing an Initial Capabilities Document (ICD) stating that a material solution is required, and developing a Test and Evaluation Strategy (TES) which describes the concept for tests and evaluations throughout the program life cycle. Development of the TES requires involvement of testers and evaluators.

If a material solution is determined necessary in the Materials Solution Analysis Phase, the program transitions to the Technology Development Phase (Figure 3), and the ICD transitions to a Capability Development Document (CDD) that provides authoritative, measurable, and testable capabilities to support system development. This stage is also where the TES is used to guide development of the more specific TEMP.

Information in the ICD and CDD are used to develop Key Performance Parameters (KPP), which jointly with the CDD, guide design and prototype development in the Engineering and Manufacturing Development Phase (Figure 3). The CDD is used to create a Capability Production Document (CPD) which guides production and initial deployment.

During development of components and entire systems within JCIDS, Test Operations and Procedures (TOPS), laboratory tests, and full systems tests in relevant MOEs are developed and executed. The ICD, CDD, and CPD are the means of specifying authoritative testable

Table 2. Likelihood of Occurrence of Environmental Factors in each Global Military Operating Environment.

Environmental factor		Global Military Operating Environment			
		Polar	Humid Temperate	Dry	Humid Tropic
Atmospheric Factors	High Temperature	1	2	5	3
	Low Temperature	5	3	3	1
	Precipitation (Medium to heavy Rain)	2	4	1	5
	Precipitation (Snow, Freezing Rain, Hail)	5	4	1	1
	High Relative Humidity (Constant)	2	3	1	5
	High Relative Humidity (Cyclic)	2	4	1	4
	Low Relative Humidity	2	2	5	1
	Fog/Ice Fog/White out	3	3	1	1
	High Wind	3	3	3	3
	Salt/Salt Fog (Corrosion)	2	3	1	4
	Solar Radiation	2	3	5	3
	High Elevation (Low Pressure)	3	3	3	3
Terrain Factors	Landforms (Steep Slope, Relief, Roughness)	4	3	5	3
	Exposed Rock	3	3	5	2
	Sand	2	2	5	3
	Mud	2	3	2	4
	Dust	2	3	5	1
	Surface Water (Hydrography)	2	3	2	4
	Frozen Soil	5	3	1	1
	Surface Snow/Ice	5	3	1	1
Biological Factors	Dense Vegetation (Forest/Jungle)	3	3	1	5
	Micro/Macro Biological Organisms	2	4	3	5

Near Certainty to occur at an extreme value for prolonged periods	5
Highly Likely to occur at a near extreme value for short periods	4
Likely to occur at a near extreme value	3
Low likelihood of occurrence	2
Not Likely to Occur	1

performance capabilities for the program. And, once materiel is fielded AR70-38 information is fed into Life Cycle Sustainment which includes maintenance, down time, reliability, and ownership cost.

7. ARMY ENVIRONMENTAL TEST CENTERS

The Army Test and Evaluation Command (ATEC) operates environmental test centers in six locations (Figure 2). The Cold Regions Test Center (CRTC) is located at Ft. Greely, Alaska, 160 km southeast of Fairbanks, Alaska (Harmon et al., 2008). CRTC is located in the Subarctic MOE within the Polar GMOE.

Table 3. Numerical rating for small arms and automatic weapons environmental vulnerability.

Atmospheric Factors	
High Temp	4
Low Temp	4
Precipitation (Medium to heavy Rain)	4
Precipitation (Snow, Freezing Rain, and Hail)	4
High Relative Humidity (constant)	2
High Relative Humidity (cyclic)	2
Low Relative Humidity	1
Fog/Ice Fog/White out	1
Wind	2
Salt/Salt Fog (Corrosion)	4
Solar Radiation	2
High Elevation (Low Pressure)	1
Terrain Factors	
Landforms (Topography - Slope, Relief, Roughness)	1
Exposed rock	1
Sand	4
Mud	5
Dust	4
Surface water (Hydrography)	5
Frozen Soil	2
Surface Snow/Ice	4
Biologic Factors	
Dense Vegetation (Forest/Jungle)	5
Micro/Macro Biological Organisms	4

The Desert/Hot Weather Test Center is located in Yuma, Arizona at the Yuma Proving Ground (Figure 2) (King et al., 2004). Yuma is located in the Tropical/Subtropical Desert MOE within the Dry GMOE.

The Temperate Regions Test Center, which was the most important test center during the Cold War when AR70-38 was last approved in 1979, is located at Aberdeen Proving Ground, MD. Aberdeen is located within the Subtropical MOE within the Humid Temperate GMOE (Figure 2).

The Tropical Regions Test Center is located at three locations; Hawaii, Panama and Honduras (Figure 2) (King et al., 1999, 2006; 2007). All three locations are generally Rainforest type MOEs within the Humid Tropical GMOE.

8. CONCLUSIONS

The United States conducts military operations throughout the world, and operates bases in a large number of nations in a wide variety of MOEs. Materiel must operate reliably, efficiently, and cost effectively to assure mission success, and to protect personnel lives. Though the Army operates large numbers of manned and unmanned aircraft, it is still largely a ground-based expeditionary force. As a result, equipment and personnel experience not only atmospheric conditions found near the earth's surface, but they also experience the synergistic effects of atmosphere-terrain interaction and the resultant snow, mud, dust, biota and other natural and induced environmental conditions found near the earth-atmosphere interface. In many ways, the interface area is the harshest of environments when all environmental factors are considered.

The proposed AR70-38 is intended to capture the wide range of atmospheric, terrain, and biologic conditions not now explicitly considered in materiel development that can cause failure and loss of capability. AR70-38 is intended to educate materiel developers regarding the spatial patterns of MOEs and the characteristics of their environmental factors. And, since the Army is expected to operate in a larger range of conditions than were anticipated during the Cold War and operate effectively world wide, then materiel needs to be tested thoroughly in all environments.

As with the 1979 version of AR70-38, the new document has a climatic focus. However, rather than focusing principally on a few atmospheric variables and their diurnal ranges, responsible

Table 4. Risk Matrix for Small Arms and Automatic Weapons.

Environmental factor		Global Military Operating Environment: Polar	Humid Temperate	Dry	Humid Tropic
Atmospheric Factors	High Temp	4	8	20	12
	Low Temp	20	12	12	4
	Precipitation (Medium to heavy Rain)	8	16	4	20
	Precipitation (Snow, Freezing Rain, and Hail)	20	16	4	4
	High Relative Humidity (constant)	4	6	2	10
	High Relative Humidity (cyclic)	4	8	2	8
	Low Relative Humidity	2	2	5	1
	Fog/Ice Fog/White out	3	3	1	1
	High Wind	6	6	6	6
	Salt/Salt Fog (Corrosion)	8	12	4	16
	Solar Radiation	4	6	10	6
	High Elevation (Low Pressure)	3	3	3	3
Terrain Factors	Landforms (Steep Slope, Relief, Roughness)	4	3	5	3
	Exposed rock	3	3	5	2
	Sand	8	8	20	12
	Mud	8	15	8	20
	Dust	8	12	20	4
	Surface water (Hydrography)	8	15	8	20
	Frozen Soil	10	6	2	2
	Surface Snow/Ice	20	12	4	4
Biological Factors	Dense Vegetation (Forest/Jungle)	15	15	5	25
	Micro/Macro Biological Organisms	8	16	12	20

Note: Red areas indicate a high risk, and yellow areas indicate medium risk of equipment failure due to the specific environmental factor.

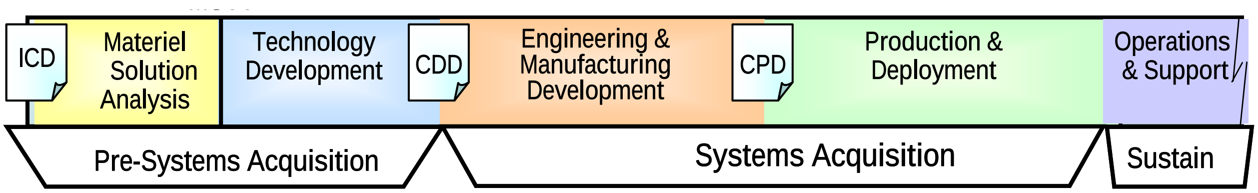

Figure 3. Joint Capabilities Integration & Development System materiel concept, design, manufacture, test, deployment and sustainment sequence with significant documents.

materiel development requires consideration of a broader range of atmospheric conditions in a true applied climatology sense, and the terrestrial and biotic factors that interactively create the Army's Military Operational Environments.

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