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NATO IMPLEMENTATION OF UNIFIED PROTECTION AGAINST ELECTROMAGNETIC ENVIRONMENTAL EFFECTS (UE^3)

Edition A, Version 1

SUSTAINMENT TEST AND EVALUATION

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NATO LETTER OF PROMULGATION

13 October 2014

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2 AEP-41 EXECUTIVE SUMMARY

There is consensus for a unified approach to the protection and hardening of all NATO military platforms, systems and equipments (hardware) against electromagnetic environmental effects (E^3) caused by the plethora of electromagnetic environments (EMEs) that these platforms, systems and equipments are subjected to during operational deployments. These E^3 can adversely impact the operational capability of military hardware resulting in their inability to accomplish their mission or even putting the crew's safety at risk. The EMEs are generated by natural, operational and hostile sources. Additionally, today's complex military operational environment is characterized by an increasingly crowded EM spectrum coupled with a reduction of spectrum allocated for exclusive military use. In combination, the military operational environment is more likely to affect the deployed hardware because of its usage of developed, non-developmental and commercial-off-the-self electronic components. The Conference of National Armaments Directors (CNAD) recognized the need for a unified E^3 (UE^3) protection (UE^3P) policy, and directed the development of an Allied Engineering Publication (AEP 41) and an associated Standardization Agreement (STANAG) 4567 to describe and define this policy. The proposed UE^3P approach can be applied to all NATO military hardware deployed operationally under the following six categories:

1) Mobile Land Systems,
2) Static Land Systems,
3) Space Systems,
4) Sea Platforms,
5) Air Platforms, and
6) Command and Information Systems.

This volume does not address NATO Space Systems, since there presently is no dedicated NATO Space System. Additionally, Command and Information Systems are treated as a logical part of the first five operational categories.

The CNAD approved the following seven AEP 41 volumes that provide the details of the different functional areas required to achieve UE^3 protection and survivability:

a) Volume I, UE^3 Philosophy and Methodology;
b) Volume II, EMEs, E^3 and Associated E^3 Risks;
c) Volume III, E^3 Coupling;
d) Volume IV, Susceptibility of Platforms, Systems and Equipment to E^3;
e) Volume V, Unified Hardening and Protection Against E^3;
f) Volume VI, Testing and Validation of E^3 Protection; and
g) Volume VII, UE^3P Sustainment Test and Evaluation.

The basic philosophy is to provide a user-controlled performance based approach to developing cost effective, verifiable, producible, maintainable and sustainable UE^3 protection for NATO military hardware. The methodology for achieving this UE^3 protection is based on use of an EM barrier protection concept which is applicable to all types of military hardware, from single or multiple barriers to unshielded distributed systems. In addition to affordable protection against multiple E^3, this methodology is both inherently accommodating and flexible for future growth and changes, as well as degradations resulting from normal usage, maintenance, and ambient environments.

2.1 Electromagnetic (EM) Barriers and Introduction to AEP-41

2.1.1 Balanced E^3 Protection. This seven volume AEP describes an approach for achieving adequate, affordable and balanced UE3 survivability in the battlespace for all classes of NATO military hardware of the six operational categories. Balance is achieved between several factors. First, the protection design is balanced for unified coverage of the EMEs encountered during operational deployment. Second, through UE3 protection, a balance between the protection provided, cost, and operational impact is achieved. Finally, the User is afforded the opportunity to balance the level of protection against risk of operational degradation when battlespace EMEs are encountered. The philosophy embodied in AEP-41 does not mandate design solutions; instead, it provides a performance based methodology that allows the designer the flexibility for deriving the final E3 design to meet performance requirements.

2.1.2 Methodology. The method of achieving this goal is through the use of the EM protection barrier to enclose Mission and Safety Critical Electronics (MSCEs). This is an existing protection concept familiar to digital, circuit, integration, and system designers; and, does not require the use of new, exotic or costly design practices. Proper implementation of this methodology results in balanced unified protection against the different EMEs and their resultant effects (E^3). Additionally, an integral part of this methodology is testing which is conducted throughout the acquisition life-cycle phases to insure that the protection design is: adequate and complete, properly implemented during production, and properly maintained and sustained during deployment. Furthermore, the EM barrier protection concept also allows testing to focus on the barrier(s) rather than individual E^3 because this methodology creates a relatively benign internal EME for the protected MSCEs. This reduction of the EMEs facilitates the wider use of Commercial-Off-the-Shelf/Non-Developmental Items (COTS/NDIs), and future upgrade and modernization programs.

2.2 AEP-41 Scope.

The general scope of this AEP is to document a philosophy and methodology for achieving adequate EM protection for all classes of NATO military hardware of the six operational categories so that affordable UE^3 survivability can be achieved, produced, maintained and sustained in today’s and tomorrow’s battlespace. This scope is addressed in all seven volumes.

2.2.1 Volume I (USA pilot nation). This volume provides the philosophy and details of the methodology for this E^3 protection approach. (See Section 4 for more details.)

2.2.2 Volume II (USA pilot nation). This volume defines and discusses the potential battlespace EMEs listed in Table 2.1 (below) that military hardware must be protected against in order to be E^3 survivable in the battlespace. These EMEs interact with military hardware causing E^3 which are defined and discussed. Finally, associated risks in achieving and sustaining E^3 survivability are discussed. The risk discussion relates to all four phases of the acquisition life-cycle, (Concept Development (Phase 1), Engineering Development (Phase 2), Production (Phase 3) and Deployment (Phase 4)), and includes potential impacts to these phases caused by other factors such as obsolescence, technology and COTS/NDIs insertions, Modernization-Through-Spares (MTS), and upgrades.

Table 0.1 **Characteristics of Battlespace Electromagnetic Environments.**

Externally Generated Electromagnetic Environments			
Environment	**Type**	**Waveform**	**Propagation**
Nearby Lightning	Natural	Pulse	Radiated and Conducted
Direct Lightning	Natural	Pulse	Conducted
High-altitude Electromagnetic Pulse (HEMP) E1, E2, E3	Hostile	Pulse	Radiated and Conducted
Source Region EMP (SREMP)	Hostile	Pulse	Radiated and Conducted
System Generated EMP (SGEMP)	Hostile	Pulse	Conducted
Electromagnetic Emissions	Electronic Operation	Pulse, CW, and Modulated CW	Radiated and Conducted
High Intensity Radiated Fields (HIRF)	Electronic Operation	CW and Modulated CW	Radiated and Conducted
Electronic Counter Measures (ECM) (backdoor)	Hostile	Modulated CW	Radiated
High Power Microwave (HPM)	Hostile	Pulse, CW, Burst of CW, Modulated CW	Radiated
Precipitation-Static (P-Static)	Natural	Pulse	Conducted
Ultra-Wideband (UWB)	Hostile	Pulse, single or multiple	Radiated
Electrostatic Discharge (ESD) – Helicopter	Natural	Pulse	Conducted

Internally Generated Electromagnetic Environments			
Environment	**Type**	**Waveform**	**Propagation**
Electromagnetic Emissions	Electronic Operation	Pulse, CW, and Modulated CW	Radiated and Conducted
Electrostatic Discharge (ESD)	Natural	Pulse	Radiated and Conducted

2.2.3 Volume III (CAN pilot nation). This volume defines and provides detailed discussion of E^3 coupling for the various classes of force or fighting platforms and systems defined in Volume I. This is a critical functional area because the EM barrier is basically an E^3 management tool to insure that the resultant residual levels from the EME generated stresses are lower than the mission and safety critical electronics (MSCEs) immunity levels by at least a 6 dB margin.

2.2.4 Volume IV (FRA/ITL pilot nation). This volume discusses E^3 susceptibilities common to the same classes of military hardware defined in Volume I. How these E^3 susceptibilities occur and how they affect these various hardware classes in the battlespace are discussed.

2.2.5 Volume V (DEU pilot nation). This volume describes how to apply the EM barrier protection concept to achieve UE^3 survivability against the susceptibilities described in Volume IV resulting from the coupling described in Volume III for the classes of force or fighting platforms and systems of the six operational categories defined in Volume I. Volume V also discusses why E^3 protection must be included early into the design of military hardware so that UE^3 survivability is achieved that is affordable, can accommodate insertions of COTS/NDIs, is readily producible, and can be maintained and preserved during operational deployment.

2.2.6 Volume VI (GBR pilot nation). This volume discusses test and validation. A crucial part of achieving, producing and sustaining UE^3 survivability is a series of E^3 tests that must be performed during various phases of the hardware's life-cycle and tailored to the requirements of the hardware. The basic test types are: engineering development, electronics immunity, barrier performance, system verification, production and deployment compliance, and surveillance. It is important that the final verification test of the implemented EM protection design be on the assembled hardware that is as near to production configuration as possible. Differences between test and production configuration must be defined and evaluated for UE^3 survivability adequacy, usually by selective testing and analysis. The test types and a brief discussion of each are provided.

2.2.7 Volume VII (USA pilot nation). This volume discusses test and evaluation procedures that support protection sustainment. These procedures generally occur in the latter phases of an equipment life-cycle, namely the Production and Deployment Phases (Phases 3 and 4, respectively) and are often referred to as production and deployment hardness maintenance and surveillance. Those in the E^3 community that address sustainment use many of the simulators and simulation techniques already discussed in Volume VI. The purpose of this document is to encourage those that do not yet embrace these techniques to do so, thus insuring overall costs can be minimized while assuring protection once included in the equipment is maintained at an acceptable level.

2.3 Requirements

Military platforms, systems and equipment must be survivable to a myriad of changing EMEs in the battlespace. This survivability must be readily achievable and affordable as well as producible, maintainable and sustainable throughout the hardware's life-cycle. These EMEs result from naturally occurring, operational, and hostile sources and are the reason for the development of the EM protection concept consistent with the hardware's survivability requirements. Table 2.1 lists these EMEs. The performance requirements critical to achieving and retaining UE^3 survivability for NATO military hardware of the six operational categories are discussed in Section 4.0 of this volume as well as Volume VI. The list of UE^3 protection requirements should specify system functional requirements for all relevant subsystems such as: no damage, no upset or the level of upset allowed, no interference or the level of interference allowed, no mission degradation or the level of degradation allowed. It is important that EMEs and the hardware's functional requirements be clearly defined early in a program, since they drive all subsequent E^3 protection activities, affordability, and flexibility of the design.

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3 AEP-41 VOLUME VII EXECUTIVE SUMMARY

3.1 Introduction

This volume addresses the final steps in a complete electromagnetic environmental effects (E^3) protection program. It outlines E^3 sustainment testing and evaluation (often referred to as hardness maintenance and hardness surveillance (HM/HS)) procedures that support unified E^3 protection against all hostile, natural, operational and integrated threats. Since E^3 sustainment testing and evaluation are a subset of test and evaluation procedures already outlined in Volume VI and Allied Engineering Conditions and Test Publication (AECTP) 500, details already covered in those volumes will be referenced or summarized rather than repeated.

Further information on the detail of testing platforms, systems and sub-systems for compliance with E^3 survivability requirements can be found in national military standards, NATO Standardization Agreements (STANAGs) and their associated Allied Engineering Publications (AEPs), and commercial standards. These standards cover the requirements of compliance demonstration for an military hardware's performance in terms of external radiated susceptibility environments, radiated emissions, conducted emissions and conducted susceptibility criteria to be met. They also address test methods to demonstrate compliance with the high energy pulsed environments of nuclear electromagnetic pulse (NEMP), lightning, electrostatic discharge (ESD), single event upset (SEU), transient radiation effects on electronics (TREE) and various transients. These should be consulted for guidance on the most suitable test methods and test levels for the various levels of testing required, namely:

a) Component level,

b) Equipment qualification level,

c) System qualification level,

d) Platform release to service (deployment) level, and

e) Platform in-service (deployment) level.

3.2 Scope

This volume provides the minimum requirements for a successful sustainment test and analysis effort. It describes the final steps in maintaining an acceptable protection level throughout the final phase (Deployment) of a typical NATO acquisition program. With some modest modification, this effort applies to all six OCs of NATO military hardware. Finally, Appendix A provides a detailed example of a sustainment test and analysis effort for a **typical** mobile ground system, such as a Main Battle Tank (MBT). It can be modified for use by nations to satisfy their particular sustainment requirements and needs. System-specific values (e.g., frequencies, voltages) are identified by the placeholder XXXX.

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4 LIFE-CYCLE SUSTAINMENT

4.1 The Sustainment Process. Life-cycle sustainment is the final step in assuring the minimum UE^3 protection designed into an military hardware is maintained until that military hardware is no longer operational. Unfortunately for most national military acquisition programs, this step is minimized or missing entirely, thus providing commanders in the field with little or no sense of military hardware survivability. Compounding this problem is the lack of NATO documentation on the subject. Even the AETCP 500 series on E^3 Test and Evaluation (T&E) does not address life-cycle sustainment, including the appropriate hardness maintenance and hardness surveillance (HM/HS) steps. The purpose of this volume is to lay out the minimum requirements for such a successful sustainment E^3 T&E plan. More specific HM/HS E^3 T&E details will be included in later editions once NATO adopts a preferred HM/HS E^3 T&E protocol.

Consider a typical military hardware acquisition program (Table 4.1). It consists of four Phases: Concept Definition (Phase 1), Engineering Development (Phase 2), Production (Phase 3), and Deployment (Phase 4). Under each phase there are several important steps, including the HM/HS E^3 T&E steps embedded in both Phases 3 and 4.

Table 0.1 Typical Life-Cycle Acquisition

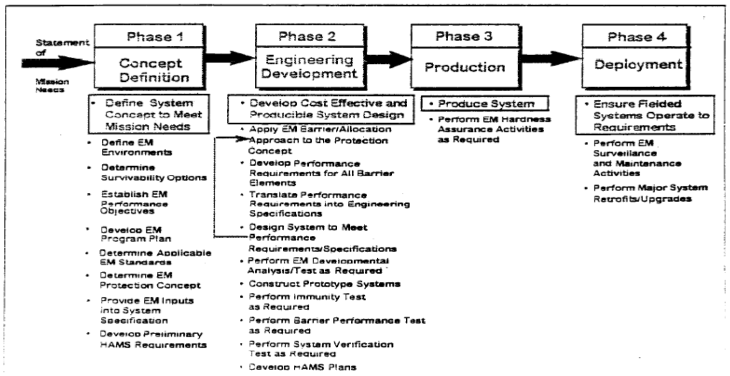

Figure 4. EME Protection Program Technical Activities Should be Coordinated with Life Cycle Acquisition Phase Activities.

Diagram.

The purpose of hardness maintenance testing is to validate the integrity of the military hardware hardening elements throughout its deployment. The purpose of hardness surveillance testing is to identify possible UE^3 protection barrier degradations. HM/HS is thus the logical consequence of the UE^{3}P steps taken in Phases 1, 2, and 3 for that military hardware acquisition. For that reason, military hardware verification test results must be preserved and documented so they serve as the HM/HS baseline. Thus, in each of the four phases there are protocols to test, evaluate, and document in a similar fashion. This section describes several national

HM/HS test and evaluation steps commonly, though not universally, used to address sustainment.

Volume VI states "The aim of testing depends on the phase in the programme where it is undertaken:

- During (engineering) development, testing reduces the overall risk that the final item will not meet its procurement EME requirements.
- At the end of (engineering) development, testing takes place to confirm that the project has met its EME specification.
- During production, testing takes place on a batch basis to ensure that there is consistency in production and design changes caused by obsolescence have not degraded its EME performance.
- Finally, during deployment, testing takes place to ensure maintenance procedures and repairs maintain the E^3 protection to the "as new" level.
- Additional to these levels of testing, proposed protection methods such as gaskets or filtering will need to be tested to confirm they will provide the required protection."

Obviously, testing first requires the identification of the appropriate EMEs. They can be actual environments or standard environments that the system is expected to experience while deployed. Alternatively, it is possible to test a military hardware by simulating the E^3 in the form of currents or voltages coupled onto the military hardware via conduction or radiation. Such simulation techniques are generally simpler to execute, but they require a thorough understanding of the coupling paths of the military hardware under test. Many of these test techniques lend themselves to performance and deployment compliance and surveillance programs.

Every successful HM/HS E^3 T&E consists of several steps (subsections 4.1.1-4.1.6). En toto, these steps are not acquisition cost drivers; rather, when properly implemented they add a small percentage to the total acquisition cost of the military hardware. In the case of mobile land systems that require random test sampling of items in a lot, HM/HS E^3 T&E adds only a few percent to the military hardware acquisition cost. Special military hardwares that require 100% E^3 T&E could add more to the total acquisition cost.

4.1.1 Pre-test Analysis Requirements

Whenever possible, pre-test analysis shall be performed to predict the current and charge densities over the military hardware surface as well as internal wiring as a function of frequency. The analysis shall also include calculations of the expected transfer functions (transfer impedance, transfer admittance, and shielding effectiveness) of each hardening element.

If some form of CW or pulse immersion test is conducted, test points shall be selected to provide measurements of representative points throughout the military hardware to best evaluate the effectiveness of the hardening subsystem and to predict the response at all interfaces to critical subsystems.

4.1.2 Test Plans and Procedures

A comprehensive military hardware-specific test plan and detailed test procedures shall be prepared for each of the CW or pulse test methods to be used. These can be individual documents or combined into a single document. As a minimum, the document shall contain:

- A statement of the test objectives.
- Military hardware identification and description.
- In particular, a description of the military hardware hardening design and hardening elements as appropriate.
- CW or pulse test apparatus description (e.g., facility used, Aperture Tester).
- CW or pulse illuminator and data acquisition equipment identification (including manufacturer, model and serial numbers, characteristics, and detailed calibration procedures).
- Detailed test procedures.
- Any deviations from the requirements of this volume.
- Data management.
- Safety, including EM radiation, electrical shock hazards, fuel safety, grounding, ingress and egress procedures, and emergencies.
- Security Plan and Procedures for both military hardware and data handling.
- Test schedule (including priority of measurements).

4.1.3 Test Report Requirements

A test report shall be prepared detailing the results of each of the CW or pulse tests. As a minimum, the test report shall contain:

- Military hardware identification and reference to the applicable test plan.
- A discussion of any deviations from the test plan and requirements of this volume.
- Copies of the measured results along with sensor calibrations and instrumentation settings required to convert the data engineering units.
- Test conclusions based on CW or pulse immersion (and Pulse Current Injection (PCI) test results) and supporting analysis.

- Test chronology, including a sequence of events and identification of failures observed and the conditions under which they occurred.

4.1.4 Post-test Analysis Requirements

Post-test data processing of the CW or pulse measurements is required to correct for sensor and instrumentation system response characteristics and to convert the measured results into the proper engineering units. Additional post test analysis of the measured data shall be performed to determine the performance of each of the hardening elements on the military hardware as well as to evaluate the overall performance of the shield system. Detailed requirements for the post-test analysis will be established by the sponsoring agency for the test. They will generally include calculations of threat responses from PCI, CW or pulse tests, and threat-level illumination test data – analysis of verification test adequacy, development of hardness conclusions, and recommendations for corrective actions, if required.

4.1.5 Data Classification

4.1.6 Test data may be classified, For Official Use Only (FOUO), or unclassified. The NATO classification guide for the specific military hardware should be consulted for guidance.

4.1.7 Alternative Test Methods

Other types of drive for the illuminator, such as Gaussian wideband noise or a repetitive pulse generator (RPG), may be used in lieu of a stepped frequency generator if it can be shown that the system has sufficient power, bandwidth and dynamic range to make the measurements. The test plan and detailed test procedures shall define the illumination approach, incident field strength, and data acquisition system characteristics (bandwidth, sensitivity, linearity, and dynamic range). The adequacy of the alternate illumination and data acquisition system for verifying the military hardware E^3 shielding subsystem shall be demonstrated.

4.2 Sustainment Testing Options

Typical sustainment testing options include those HM/HS tests that can be done in situ (in the field), at depot, or at a major threat-level simulator facility. The importance of the military hardware to critical mission completion should dictate the necessary and sufficient HM/HS test and evaluation steps. For example, the entire fleet of special aircraft executing critical Command, Control, Communication, Computers and Intelligence (C4I) might require a 100% HM/HS program, since every aircraft is deemed essential to completing the mission. On the other hand, helicopters might require only a small percentage of the entire lot to undergo a rigorous HM/HS E^3 T&E program, since they do not require 100% survivability. Table 4.2 provides a possible summary matrix for each of the operational categories.

Table 0 Typical Sustainment Tests for Military hardwares with Power On.

Military hardwares	In Situ (Field) Low-Level Tests	Depot Low-Level Tests	Threat-Level Tests (when appropriate)	Comments (military hardwares tested)
Air Platforms	Aperture,cable shield, electrical/non-electrical shield penetrations	CW (entire military hardware)	Pass/Fail	100% (special) to a few per lot

Sea Platforms	Same As Above (SAB)	SAB	SAB	100% (special) to a few per lot
Static Land Systems	SAB	SAB	SAB	100% (special) to random T&E
Mobile Land Systems	SAB	SAB	SAB	Usually a few per lot

In situ testing (also known as field expedient testing) usually consists of low-level testing on equipments, subsystems or systems, and is designed to identify those deployed military hardwares that obviously fail to meet the minimum emission and immunity levels designed into them. Depot level tests can be high-level or low-level tests, but they are more rigorous and are used to identify which specific subsystem/component failed, which must be replaced to successfully complete the critical mission, and whether the replaced protection items meet the minimum survivability criteria. For extremely critical military hardwares, such as special aircraft, it might also be required to complete the HM/HS E^3 T&E steps at one of the threat-level simulator facilities described in Volume VI.

4.2.1 In Situ Testing

In situ testing varies according to the system and platform and the importance of the military hardware. For example, if C4I military hardwares that support critical missions are few in number and are essential to survive (e.g., C4I military hardwares), in situ testing is far more rigorous than in situ testing done on a random sampling of several out of many hundreds or even thousands (e.g., Main Battle Tanks, helicopters). In those special cases, it is necessary to in situ test every military hardware.

The most likely form of in situ testing is with low-power, hand-held sensors and readily transportable equipment that test apertures, cable test shields, and electrical and non-electrical line penetrations. Typical examples are: (1) Single Point Excitation for Hardness Surveillance Aperture Tester for testing apertures; (2) Loop Resistance Tester and Cable Shield Tester for cable shield testing; and (3) Transient Protection Module Tests, and Resistance Measurement with a Bonding Meter and Resistance Test with a Loop Resistance Tester for electrical and non-electrical line penetration testing.

In certain cases, e.g., fixed facilities, low-power testing might also be complimented with threat-level testing.

4.2.2 Depot-level Testing

Depot-level E^3 T&E is more amenable to larger, more threat-level testing than in situ testing. Typical test equipment found at depot for E^3 T&E include in situ test equipment plus some form of high or low-level CW or pulse illuminator to assess military hardware shield integrity. This illuminator should be horizontally and/or vertically polarized with respect to ground in order to account for the diverse EMEs.

4.2.3 Threat-level Simulator Testing

Threat-level testing is usually associated with validation testing of military military hardwares; however, this form of testing is also associated with E^3 T&E of very special military hardwares that require a high level of survivability. Threat-level simulators include CW and/or pulse. Examples are the USA Ellipticus (CW); Horizontally Polarized Dipole and Vertically Polarized Dipole (HEMP pulse); and the Survivability Vulnerability and Analysis Lightning Facility (lightning pulse). These and other threat-level simulators are described in Volume VI.

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5 SUMMARY

The final step in the UE^{3}P process is to assure electronics that support critical missions maintain a minimum acceptable protection level. Deployed platforms and systems containing these critical electronics must therefore undergo a regularly scheduled HM/HS E^3 T&E effort. The least expensive way to do this is to include the effort in the normal HM/HS schedule. This volume provides those final UE^{3}P steps necessary to assure minimum protection levels are maintained.

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6 CONCLUSION

Sustainment testing can be characterized in terms of two means of EME propagation: radiating and conducting. Both must be considered in developing emission and immunity protection. HM/HS E^3 T&E attempts to simulate as realistically as possible the internally and externally coupled signals on the military hardware as if the military hardware were driven by the actual EMEs. The signal distribution on the military hardware shield(s) and the conducted signals passing through protection devices at deliberate and non-deliberate antennas can be monitored for all E^3 by using low-level test techniques. Such low-level test techniques are found in various national documents (e.g., USA MIL-STDs 461 (subsystem-level tests) and 464 (system-level tests) for radiated and conducted signals) as well as NATO AECTP 500.

Since VOL VI provided a thorough discussion on aircraft E^3 testing, this volume provides a similar discussion on Mobile Land System sustainment testing. A detailed test plan is also included for a typical Main Battle Tank (MBT). All numbers that might be unique to a specific MBT is omitted, but the E^3 test plan documents the minimum necessary discussion.

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APPENDIX A. MOBILE LAND SYSTEM SUSTAINMENT EXAMPLE

This appendix is provided for those nations that do not yet have their own sustainment program. The appendix example is given for **guidance** purposes only. It provides the minimum acceptable elements of a typical Mobile Land System E^3 HM/HS T&E program. Entries that might be unique to a given system are identified with XXXX.

APPENDIX A
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A.1 INTRODUCTION

A.1.1 Scope. The scope of this Mobile Land System Electromagnetic Environmental Effects (E^3) Life-Cycle Sustainment Plan is to provide a complete plan that could be used by nations that do not yet have one. It includes generic E^3 life-cycle sustainment requirements as well as a general E^3 survivability technical life-cycle sustainment philosophy and approach. It also documents E^3 analyses and testing conducted to support a viable Life-Cycle Sustainment Program. Adherence to this Appendix will result in a Mobile Land System that will have adequate compatibility and safety margins (the safety margins are to be established by the MLS program office) to ensure successful accomplishment of its required missions in an E^3 environment.

A.1.2 Purpose. The purpose of this Appendix is to establish the objectives of an adequate E^3 Life-Cycle Sustainment Program as they pertain to all phases of Mobile Land System, its suppliers, and users; to identify tasks to be performed and the party or parties responsible for their performance; to define the flow of required data; and to document E^3 life-cycle analyses and tests.

A.1.3 Applicable Mobile Land Systems Reference Documents

- XXXX
- XXXX
- XXXX

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A.2 LIFE-CYCLE PROGRAM MANAGEMENT

A.2.1 Program Roles and Responsibilities

A.2.1.1 General. For this example, the top-level E3 Life-Cycle Sustainment Program is managed by the Material Developer and the Combat Developer in conjunction with the E3/Spectrum Management Working Group (E3/SMWG). Major activities and responsibilities in common across all responsibility levels include the preparation, maintenance, and execution of E3 Life-Cycle Sustainment plans and specification updates, participation in the Engineering Change Proposal (ECP) process, participation in technical meetings, and communication and coordination of activities.

A.2.1.2 Organization

A.2.1.2.1 Combat Developer. The Combat Developer coordinates and manages the Mobile Land Systems E^3 Program. Planning, coordination and integration activities are carried out at the highest levels. Requirements and tasks are appropriately allocated and flowed down to lower levels, and specifically to the contractors/suppliers, by the Combat Developer via the Integrated Product Team (IPT) E^3 Specialty Engineering through the E^3/SMWG.

A.2.1.2.2 Electromagnetic Environmental Effects/Spectrum Management Working Group (E3/SMWG). The E^3/SMWG is established to assist the program in assuring that Mobile Land System platforms, vehicles, systems and equipment will be electro-magnetically compatible with themselves and their operational EMEs. The E^3/SMWG is comprised of Government/Army, Combat Developer, contractor and supplier personnel. The E^3/SMWG will function as a working-level IPT helping to develop recommendations regarding planning, management and monitoring of the overall E^3 program, and will assist in developing E^3 derived requirements, as well as associated test and verification activities.

A.2.1.3 Material Developer. Material Developer is responsible for the implementation of all required analysis, assessments, modelling, hardening designs, and component testing, and the development, preparation, and submittal of all required data and documentation for the Mobile Land System.

A.2.1.4 Technical Test Organization. The Technical Test Organization will provide E^3 and Directed Energy Weapons (DEW) support to the Material Developer throughout the Concept Definition Phase and the Engineering Development Phase. They will also provide personnel and facilities to support equipment E^3 consultation, life-cycle survivability assessments/analysis and to plan and conduct any required E^3 sustainment testing in the Production and Deployment Phases. This support will include:

- Support E^3 requirement interpretation
- Support E^3 design consultation
- Support Line Replaceable Unit (LRU) assessments for meeting E^3 requirements
- Support system level assessments for meeting E^3 requirements
- Support E^3 requirement interpretation

- Support LRU assessments for meeting E^3 requirements
- Support system level assessments for meeting E^3 requirements
- Support LRU assessments pertaining to Directed Energy Weapons (DEW), High Powered Microwave (HPM) and Ultra-Wide Band (UWB) threats
- Support test planning and procedure for component, LRU and system E^3 testing
- Support implementation of electrical components characterization tests to determine E^3 requirements compliance
- Support assessments and testing to assure TEMPEST requirements compliance
- Support analysis and testing to assure E^3 compatibility during EMPRS (En route Mission and Planning Rehearsal System) about transport aircraft

A.2.2 Effective Life-Cycle Program

A.2.2.1 Acquisition. Phases and Environments. An effective Mobile Land System Life-Cycle E^3 program starts in the Concept Definition Phase (Phase 1) and continues throughout the Deployment Phase (Phase 4) until the end of the System's operational life. Throughout these acquisition phases, the Material Developer in conjunction with the E3/SMWG must address hardware and design changes utilizing the Engineering Change Proposal (ECP) process to address the impact of the E^3 Survivability of the Mobile Land System. Electromagnetic Environments (EMEs) and areas of concern that must be addressed include:

- Intra-system Electromagnetic Compatibility
- Inter-system Electromagnetic Compatibility
- Subsystems and Equipment EM Interference
- Lightning
- Electromagnetic Pulse
- External RF EME/High-Intensity Radiated Fields
- Directed Energy Weapons
- Electromagnetic Radiation Hazards
    Hazards of Electromagnetic Radiation to Personnel
    Hazards of Electromagnetic Radiation to Fuel – Fuel System
    Hazards of Electromagnetic Radiation to Ordnance
- Margins

- Electrostatic Charge Control
    - Vertical Lift
    - Precipitation Static
- Ordnance Subsystems
- Personnel ESD
- Electrical Bonding
    - Mobile Land System Bonding and Grounding
    - Antenna Installation Bonding – No Transmitters
    - Mechanical Interface Bonding
    - Shock, Fault, and Ignitable Vapour Protection Bonding
- External Grounds
    - Munitions Grounds
    - Servicing and Maintenance Equipment Grounds
- High Voltage Corona
- EM Spectrum Compatibility
- TEMPEST/NONSTOP
- Signals Intelligence
- Emission Control Categorization, Separation, Routing, and Shielding Design
- Life-Cycle E^3 Hardness

A.2.2.2 Life-Cycle Tests and Verification Methodology. Life-Cycle verification of compliance with E^3 requirements will include all tasks and actions needed to evaluate progress and measure compliance with requirements. Verification methods will include testing, analysis, demonstration and inspection. Verification Plans and Procedures will be developed and documented that will lead to verification activities, data findings, results and conclusions that will be documented in the Verification Reports. The Mobile Land System's E^3 Control Plan will address the planned methodology and test locations. This methodology includes sub-system and system level integration and verification testing.

A.2.2.2.1 **Sub-System Test Requirements.** Table A.2-1 (below) outlines the minimum E^3 qualification test set for Mobile Land Systems subsystems and equipments must meet. Equipment mounted externally to the vehicle structure will have significantly higher levels of conducted and radiated susceptibility testing requirements. Unless justification has been provided and accepted by the E^3/SMWG, assume all subsystems and equipments must meet the RE XXX and RS XXX requirements (reference notes 5 and 6). Each type of subsystem or equipment will either have passed E^3 testing per the requirements of Table A.2-1, including a detailed test report, or a detailed analysis, demonstrating the ability to pass the required E^3 testing.

Table A.2-1 Typical EMI Requirements for Mobile Land System Equipment.

Conducted Emissions (CE)	Conducted Susceptibility (CS)	Radiated Emissions (RE)	Radiated Susceptibility (RS)	Applicability Notes
CE XXX	CS XXX	RE XXX	RS XXX	X, X, X & X
	CS XXX		RS XXX	
	CS XXX			
	CS XXX			
CE XXX	CS XXX	RE XXX		X
	CS XXX			
	CS XXX			
		RE XXX	RS XXX	X & X

Applicability Notes:

1) Required for All Electrical/Electronic Equipment as defined in XXXX.

2) For CS XXX, Curve X is applicable over the frequency range of XX Hz to X Hz and Curve X is applicable over the frequency range of X Hz to XXX Hz.

3) RS XXX requirement is XX V/m over the applicable frequency range of X Hz to XX Hz.

4) Applies only to antenna-connected receivers, transmitters, amplifiers, etc., as defined in XXXX.

5) RE XXX applicable where equipment is present in the installation that is potentially sensitive to magnetic induction at lower frequencies, and as defined in XXXX.

6) RS XXX applies to mobile ground equipment. The requirement is applicable to vehicles having a minesweeping or mine detection capability, and as defined in XXXX.

7) The XXX-volt power lines are allowed to use the XXX-volt limit curve to meet the CE XXX requirements as shown in XXXX, Figure CE XXX.

A.2.2.2.2 **System Test Requirements.** Once adequate sub-system E^3 performance had been achieved, the Mobile Land System shall conduct an adequate System Level E^3 test with all ECP hardware during a two-year cycle during the Production and Deployment Phases to verify and ensure that the E^3 survivability was sustained. (See A.4 for an example test plan for a system- level E^3 test and assessment.) During the Production and Deployment Phases, a representative vehicle of the Mobile Land System shall be subjected to an adequate system level E^3 test and assessment every three years to ensure that the system's E^3 survivability level is sustained. Critical area of concern during the Production and Deployment Phases is maintaining adequate grounds and bonds caused by maintenance, corrosion and high impedance interfaces of XXXX military connectors. A good E^3 maintenance practice is to measure and correct grounds and bonds on a yearly basis.

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A.3 E^3 DESIGN APPROACH

A.3.1 Control Philosophy and Test Concepts. The E^3 control philosophy of a Mobile Land System Program will be to establish the component, subsystem design immunity levels and then use engineering practices/standards to meet and exceed the design requirements. By using an analysis of the inherent electronic immunity and designed-in vehicle shielding, it can be demonstrated that internal field levels without apertures will be reduced to the level within the immunity of the most susceptible electronic circuit. External circuits and internal circuits next to apertures will use engineering practices or certified immunity levels to achieve aggregate system survivability at the required survivability level.

Internal electronic circuits will have the least severe electromagnetic environment. For internal circuits not in the vicinity of an aperture, shielding at the low frequencies will be provided by the planned vehicle's conductive shield. Data received from Mobile Lands Systems on the shielding effectiveness measurements on the crew compartment, shielded compartment, and unshielded compartment (engine compartment) are shown in Figure A.3 -1. These data was combined with the cable shielding, the average and minimum internal shielding effectiveness are summarized below:

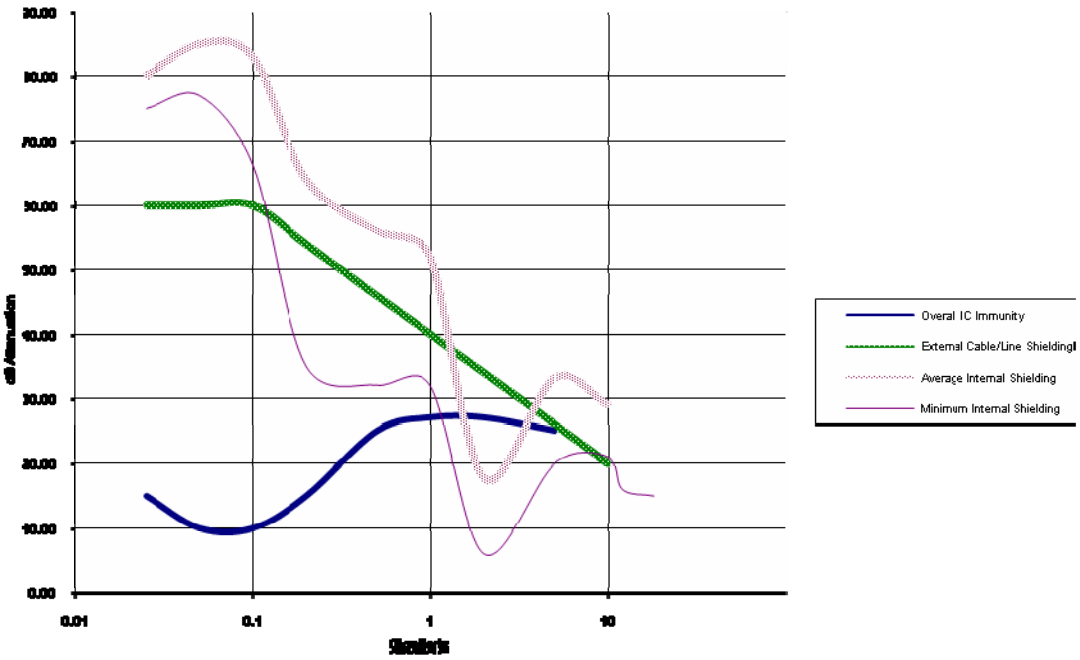

Figure A.3-1 Vehicle and Cable Shielding Versus Electronic Immunity.

The frequency band below XXX Hz is the most susceptible for sensitive modern integrated electronics. These same electronics are reasonably immune above XXX Hz. All internal cables will be shielded at XX dB up to XXX Hz, thereafter rolling off at XX dB decrease per decade of frequency up to XX Hz. Shielded enclosures will attenuate at

XX dB up to XXX Hz, thereafter rolling off at a XX dB decrease per decade of frequency up to XX Hz. This will provide an electromagnetic environment compatible with both military and commercial electronics. Based upon the types of equipment/hardware utilized in the Mobile Land System, the Peak E-field External Radio Frequency (RF) Electromagnetic Environment (EME) is not expected to be a concern.

For external electronics and internal components/subsystems near apertures, standard engineering practices will provide the same shielding that the vehicle shell does for internal electronics. All internal electronic boxes, cables/lines next to untreated apertures (<0.XX meters) will have a shielding requirement of XX dB up to XXX Hz, at which point the shielding attenuation will roll-off at a XX dB decrease per decade of frequency up to XX Hz. Shielded enclosures will attenuate at XX dB up to XXX Hz, thereafter rolling off at a XX dB decrease per decade of frequency up to XX Hz.
For electronics, which do not meet Mobile Land System requirements for average, peak, or transient electromagnetic environments, band pass filtering for average external RF EME and transient suppression for HEMP, lightning, ESD, and peak E-field, external RF EME will be implemented in the susceptible circuits.
An electronic database or spreadsheet will track the internal subsystems immunity, verifying conducted and radiated immunity in the range of XXXX level, inherent circuit immunity in the upper frequency band would allow less shielding on internal lines with adequate grounds and bonds. Numerical estimated internal E-field average levels below XXX Hz would be less than X V/m average rising to XX V/m average and XXX V/m peak at X Hz. Almost all electric circuits with any type of conductive enclosure will have adequate immunity at these frequencies.

External lines and electronics would need to demonstrate higher immunity or shield the cables (nominally double braided twisted pair shielding) and use pass-filter protection when penetrating the compartmentalized enclosure. Extremely sensitive (low immunity) external circuits or circuits with poor bond and grounds will require transient protection circuits. External munitions lines must use double braid twisted pair electric lines.
Electromagnetic compatibility will be verified by test. The contractor and each subcontractor responsible for system/subsystem/box integration will conduct electromagnetic compatibility tests on their respective boxes in accordance with XXXX. Prior to conducting the tests, an analysis of Electromagnetic Interference (EMI) data obtained from the XXXX EMI testing of component equipment items will be performed to verify that the requirements have been satisfied. The verification will be considered successful when the system/subsystem is shown to have the required safety margins on critical functions and are electro-magnetically compatible. Contractor or subcontractors responsible for system/subsystem/box integration will provide configuration data, analysis data, and test results to the Mobile Land System E^3 lead.

A.3.1.1 EMC System Level Test. To perform an Electromagnetic Compatibility (EMC) system level test, in the most meaningful operation modes, requires the Mobile Land System to be as representative of the actual tactical system as possible. Sources and loads must be included or simulated with enough fidelity to represent the appropriate grounding, bonding, impedances and cable layout of the system. An EMC system level test will be performed after integration is completed. A system level test is not currently scheduled to be performed during the necessary phases of the program, but will be up to the discretion of the Program Office. The Mobile Land System's shielding effectiveness will be determined by test and analysis.

A.3.1.2 E^3 Subsystem Level Testing. Dedicated EMC susceptibility tests particularly tailored to the specific electromagnetic environment will be performed. The bulk current injection technique will be adopted in all those cases where it is applicable; the voltage injection technique will also be adopted (when applicable) using breakout boxes. All subsystem testing specified in Table A.2.-1 will be performed and documented.

A.3.2 E^3 Predictions and Analysis

A.3.2.1 Design Concept. The basic design concept is to divide electromagnetic immunity into two categories. The first will be hardware, which is located internal to the Mobile Land System's conductive hull enclosure; the second will be hardware, which are located external to the Mobile Land System's conductive hull enclosure. The design for managing internal electronics E^3 is based on combining the inherent electronic circuit immunity to high frequencies (> XXX Hz) and shielding the low frequencies (<XXX Hz) electromagnetic energy.

The inherent immunity for the most susceptible electronics is defined using XXXX. The results are summarized by a low immunity of electronics starting at XX Hz; immunity increases as the frequency approaches X.X-X.X Hz, its highest immunity. From this, it reaches the maximum of the capability of the test equipment, which it follows to the end at XX Hz. These results are similar to those given by XXX in a similar test. Both of the test results were circuits having very little susceptibility in the X to X Hz range. It is expected that the inherent circuit immunity will become more susceptible as the electronics trend of faster and digital expands.

The shielding requirement for the hull is expected to be greater than XX dB attenuation through XXX Hz. This is based upon shielding effectiveness testing on a similar Mobile Land System's hull, which is a good baseline. The average attenuation decreases becoming XX dB at XXX Hz and maintains that level starting into the gigahertz region. Across the microwave region of the GHz frequency band, the attenuation essentially becomes zero attenuation and then returns to XX dB based upon resonances in compartments. Shielding attenuation decreases from the millimeter wave region to higher frequencies. Fortunately, circuit immunity is very high in these high frequency spectrums and inefficient coupling is predominant.

A.3.2.1.1 High Frequency Hull Shielding. The current Mobile Land System's shielding approach to address the DEW requirements and susceptibility of circuits to high frequency threats contains the following design elements:

a) Basic hull shielding design as outlined in Figure A.3-1 and detailed in Paragraph A.3.1 of this document will be implemented. Additional shielding at the hull compartment level is not planned at this time due to cost, weight, and volume penalties, and the fact that most of the internal equipment is expected not to be sensitive to high frequency electromagnetic fields. Additionally, peak E-field testing and analysis will provide adequate data on the Mobile Land System's transient response to DEW.

b) Each electrical, sensitive component, internal or external, will be individually analyzed with respect to frequency dependent sensitivity, location (to determine extent of indirect shielding), and operational requirements.

c) If it is determined that supplemental high frequency shielding (beyond the basic hull shielding and gasketing as described above) is required for any individual sensitive component, protection against damage and/or upset by high frequency DEWs will be implemented at the component level in the most cost, weight, and volume effective manner using nation-accepted standard engineering practices.

A.3.2.1.2 Electronics Immunity Analysis

1) Preliminary Electronics Immunity Analysis - Prior design and low bandwidth electronics. For the preliminary electronics immunity analysis, Organization X plans to use test results from existing technologies. Organization X expects specific technologies characteristic tendencies (including immunity to very high frequency noise) will have some relationship to other similar technology configurations. Except for those circuits technologies that are designed to react to very high frequencies (a very small number), existing circuit technology characteristics can be used for preliminary analyses. The appropriate updated data will be used for detailed analyses as needed.

2) Continuing Electronics Immunity Analysis - New design and high bandwidth electronics. The immunities of modern, high speed electronic integrated circuits, which will be used in new design and high bandwidth electronic circuits will be analyzed for electronic immunity on a case-by-case basis. A summary of any analysis performed on these types of circuits will be placed in this document.

A.3.2.1.3 External RF EME. Worst-case External RF EME for a Mobile Land System/Mobile Ground System (MGS) is shown in Tables A.3-1 and A.3-2 and Figures A.3-2 and A.3-3.

Table A.3-1 External RF EME/HIRF for Ground Systems.

Frequency Range (MHz)	Electric Field (V/m – rms)	
	Peak	Average
0.01 – 2	25	25
2 – 250	50	50
250 – 1000	1500	50
1000 – 10000	2500	50
10000 – 40000	1500	50
40000 – 45000	-	-

Table A.3-2 External RF EME/HIRF for Ship Deck Operation.

Frequency Range (MHz)	Flight Deck Electric Field (V/m – rms)		Weather Deck Electric Field (V/m – rms)	
	Peak	Average	Peak	Average
0.01 - 2	45	45	-	-
2 - 30	100	100	200	200
30 - 150	61	61	61	61
150 - 225	61	61	61	61
225 - 400	61	61	61	61
400 - 700	151	71	151	71
700 - 790	162	95	162	95
790 - 1000	1125	99	1125	99
1000 - 2000	550	112	550	180
2000 - 2700	184	158	184	158
2700 - 3600	2030	184	2030	184
3600 - 4000	290	200	290	200
4000 - 5400	290	200	290	200
5400 - 5900	345	200	345	200
5900 - 6000	345	200	345	200
6000 - 7900	345	200	345	200
7900 - 8000	345	200	345	200
8000 - 8400	345	200	345	200
8400 - 8500	483	200	483	200
8500 - 11000	510	200	510	200
11000 - 14000	310	200	310	200
14000 - 18000	310	200	310	200
18000 - 40000	200	200	200	200
40000 - 45000	200	200	200	200

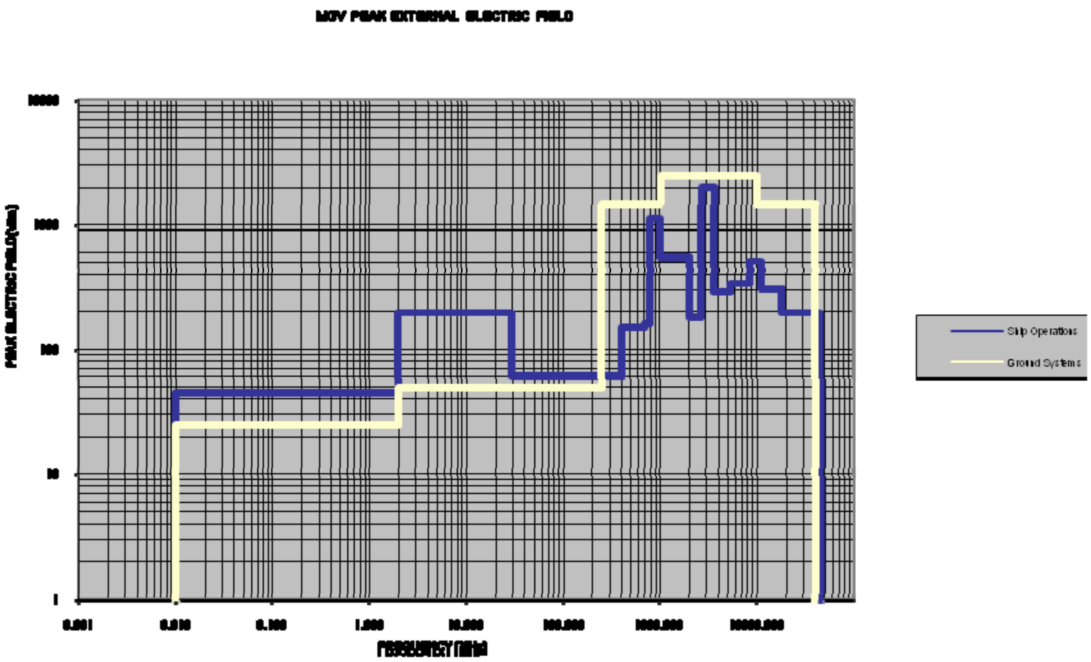

Figure A.3-2 Peak External Electric Field Requirements for the MGV.

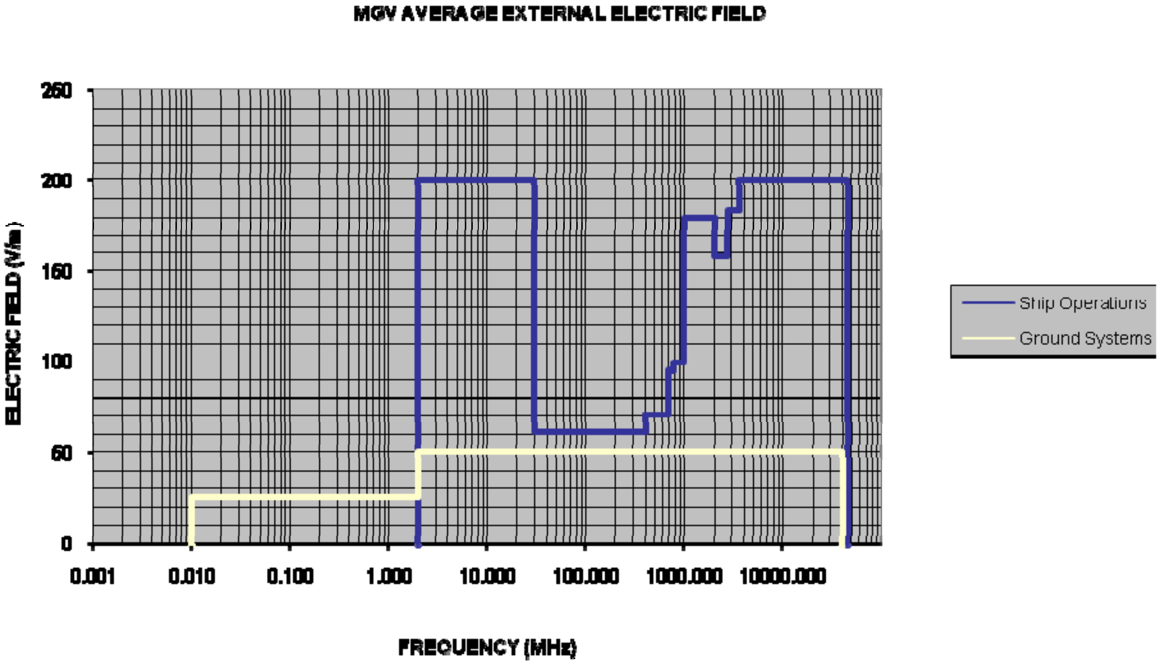

Figure A.3-3 Average External Electric Field Requirements for the MGV.

The design philosophy is that establishing the susceptibility of the circuits, the cable shielding, the enclosure shielding, the shielding of the hull and the coupling factor given above will result in adequately surviving the Mobile Land System’s E^3 system level requirements.

The cables external to the hull will have a shielding effectiveness of XX dB up to XXX Hz. The shielding effectiveness of the cables internal to the hull will be XX dB up to XXX Hz.

The cabinet shielding effectiveness either or internal to the hull must be XX dB up to XXX Hz. The hull shielding effectiveness was measured at about XX dB up to XXX Hz.

Above XXX Hz, the external field coupling is governed by the equation 0.13 λ^2 in meters. In the lower frequencies, the EME has trouble coupling onto the wires because of cable length. The shorter the cable the more difficult and inefficient it is to couple the lower frequencies. Most cable lengths in Mobile Land Systems are less than XX meters long.

The RSXXX test for all internal equipment will be XX V/m up to XX Hz.

Noise generated by the individual electronic equipment will be assessed to determine the effects on communication equipment. The range can be determined by the field intensity at the antenna. It will be determined if this range can be maintained with the radiated interference of the individual equipments as required by XXXXX. The attenuated radiated interference generated by the individual hardware and the intentional communication levels seen at the antenna will be assessed by conducting an analysis, especially in-band and harmonics of the communications equipment. As long as the radiated emission levels are less than the levels of the minimum intentional radio signals at the antenna, the system will be able to transmit and receive across the required range.

A.3.3 External RF EME / High Intensity Radiated Fields (HIRF)

The Mobile Land System's subsystems, equipments and components shall demonstrate compliance with the External RF EME / High Intensity Radiated Fields (HIRF) environment profiled in Tables A.3-1 and A.3-2, by meeting the requirements specified in Figures A.3.3-1 and A.3.3-2 (including the basic XXXX RSXXX requirements for Mobile Ground Vehicles).

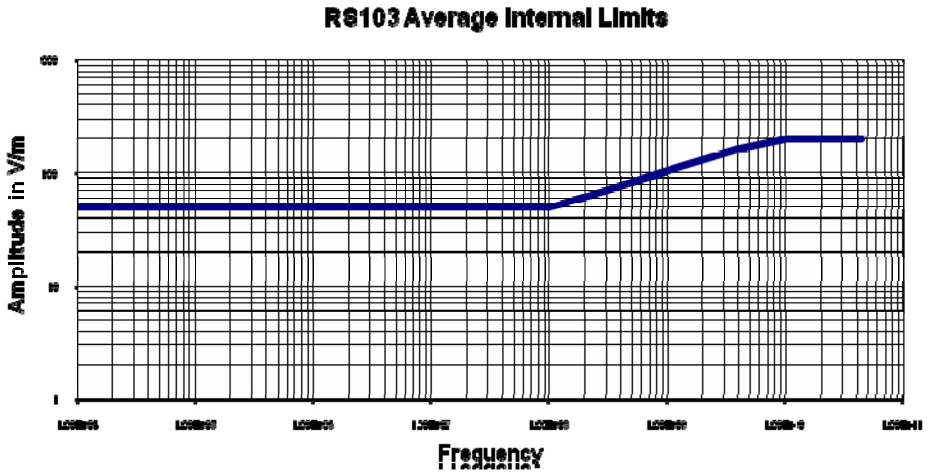

Figure A.3-4 RS103 Internal Average Limits.

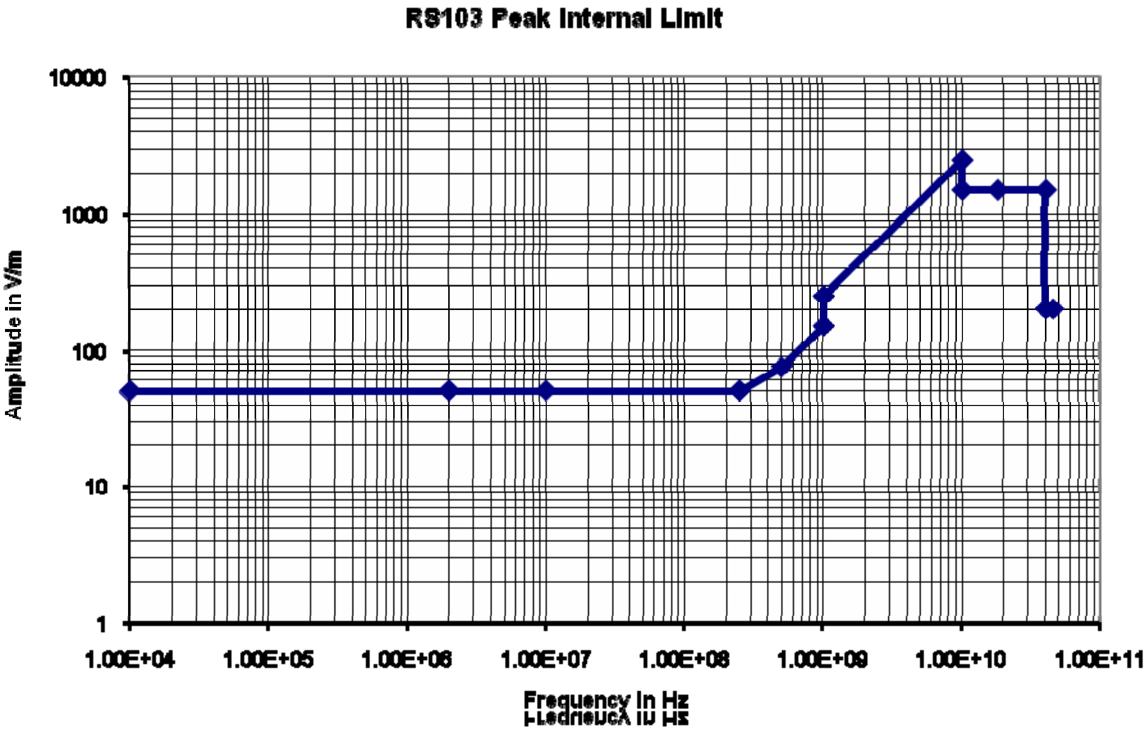

Figure A.3-5 RS103 Peak Internal Limits.

A.3.4 High Voltage Corona (HVC). The Mobile Land System, subsystems, and individual equipment will be designed and manufactured to comply with the High Voltage Corona (HVC) per requirements defined in XXXX. The HVC design will be for all subsystems, and individual equipment for altitudes up to XXXX feet and also for all required operational modes in transport aircraft. For vehicles/platforms, systems, subsystems, and individual equipment operated during En-route Mission Planning and Rehearsal System (EMPRS) aboard transport aircraft, the HVC design will address rapid decompression at the maximum cruising altitude of the transport aircraft.

A.3.5 EM Spectrum Compatibility (SC). Mobile Land Systems, subsystems, and equipment will comply with the national and international regulations for the use of the electromagnetic spectrum (such as XXXX). Each RF emitter/receiver will be mutually compatible with other spectrum dependent devices within its intended EME. RF dependent systems, subsystems, equipment and components will comply with all applicable national and international spectrum management statutes, policies and regulations, to include obtaining spectrum supportability in all host nations where deployment is expected. Spectrum compatibility/supportability with the XXX and with all host nations where the system will deploy will be determined for the life of the system through the XXXX. Preliminary Mobile Land System antenna cosite and configuration modelling should be conducted by the Material Developer and the results presented to ensure compliance and ensure compatibility throughout the System's life-cycle.

A.3.6 Emission Control (EMCON). For the Mobile Lands systems, subsystems, and individual equipment unintentional electromagnetic radiated emissions will not exceed -XXX dBm/m^2 at one nautical mile (-XXX dBm/m^2 at one kilometer) in any direction from the Vehicle/Platform/system over the frequency range of XXX Hz to XX Hz, when using the resolution bandwidths listed in Table A.3-3, below. The test bandwidth per XXXX is the same or larger than the EMCON Bandwidth so results obtained during RE XXX testing may be used to satisfy EMCON requirements.

Table A.3-3 Typical EMCON Bandwidths.

Frequency Range (X Hz)	EMCON X dB Bandwidth (X Hz)	XXXX dB BW (X Hz)
XXXX	XXXX	XXXX
XXXX	XXXX	XXXX
XXXX	XXXX	XXXX
XXXX	XXXX	XXXX

A.3.7 Life-Cycle E^3 Hardness. For the Mobile Land Systems, subsystems, and individual equipment, the operational performance and E^3 requirements will be met throughout the rated life-cycle and will include the following: modernizations, technology insertions, obsolescence solutions, usage, storage, maintenance, repair, surveillance test, and corrosion control. Maintainability, accessibility, and testability, and the ability to detect degradations will be demonstrated.

A.3.8 Power Isolation, Grounding, and Bonding. The distortion specification for the high voltage power distribution and the power line ground requirements are critical to a Mobile Land System's ability to sustain its E^3 requirements.

A.3.8.1 Power Isolation. The definitions of the various categories of power used in the Mobile Land Systems are as follows:

1) Primary Power: The primary power is the electrical power produced by generator(s) driven by the engine. The primary power consists of XXX volts and is used to drive the main drive motors and the power conditioner. This power is distributed to the primary power bus.

2) Conditioned Power: The conditioned power is XXX volts DC derived from the primary power and used to provide power to the conditioned power bus. The conditioned power is distributed to the remaining loads requiring XXX volts DC power. This power is also used to source the XX-volt power.

3) Secondary Power: The secondary power is the XX-volt vehicle power system.

4) Derived power: The derived power is power that is sourced from the XX volt secondary power, the XXX volt primary power, and/or the XXX volt conditioned power. The derived power is the power used to operate the electronics in the system. It may consist of the following DC voltages: X, ±XX, ±XX, X, XXX, etc.

A.3.8.2 Grounding. The following approaches will be adopted in the Mobile Land Systems concerning grounding (see Paragraph A.3.8.1 Power Isolation above, and Figures A.3-6, A.3-7, and A.3.-8 below):

1) Signal and power grounds, external to the equipment, will be DC isolated from each other at equipment level (equipment supplier responsibility)

2) Each derived electrical power source will be electrically connected to structure at no more than one point (system integrator responsibility). See Figure A.3-8

3) Analog and digital signal grounds external to a system, subsystem, or equipment will be electrically isolated from each other at the equipment level (equipment supplier responsibility).

4) Chassis ground connections within electrical or electronic equipment is at the discretion of the designer as long as the external power and external signal return isolation requirements are met at the equipment interface.

5) The vehicle primary power system will be single point grounded. Any primary electrical power that will enter individual pieces of equipment will be DC isolated from chassis, structure, equipment conditioned power return/reference and signal returns by a minimum of X Ω (equipment supplier / system integrator responsibility). See Figures A.3-6 and -7.

6) Secondary and derived electrical power can be single point grounded. Secondary electrical power will be DC isolated from chassis, structure, equipment conditioned power return/reference and signal circuits by a minimum of X Ω (equipment supplier / system integrator responsibility). See Figure A.3-8.

7) Signal circuit electrical power will be DC isolated from chassis, structure and equipment conditioned power return/reference by a minimum of X Ω (equipment supplier / system integrator responsibility). See Figure A.3-8.

8) Signal circuits external to the equipment and at frequencies below X Hz will be balanced and will be isolated from chassis, structure and user conditioned power return/reference by a minimum of X Ω.

9) Signal circuits with frequency components equal to or above X Hz will use controlled impedance transmission and reception media such as shielded twisted XX-Ω cable, twinax cable, and coax cable. DC isolated, single ended circuits coupled by coaxial cable with the shield terminated XXX degrees at each end and at available intermediate points will be permitted for signals with the lowest frequency component equal to or above X Hz.

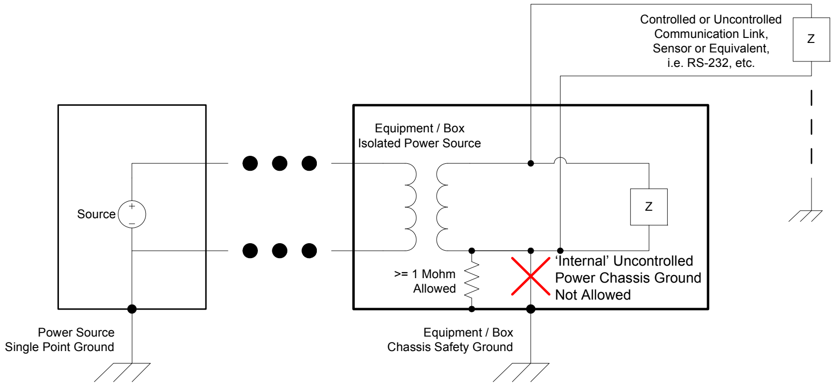

Figure A.3-6 Uncontrolled Subsystem/Equipment Internal Power Chassis Referenced

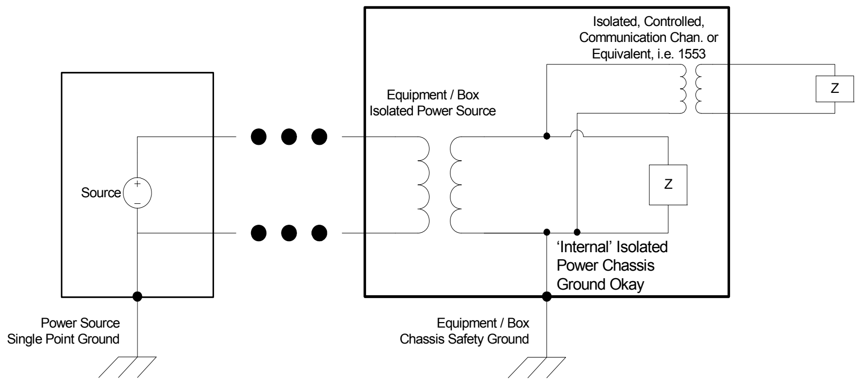

Figure A.3-7 Fully Isolated Subsystem/Equipment Secondary or Derived Power Single Point Ground (Input Power and All External Input/Output Isolated).

A.3.8.3 Bonding. The following bonding approaches should be adopted by the Mobile Land System design activity:

1) All electrical and electronic units or components that use or produce electromagnetic energy will be installed to provide a continuous low impedance path from the equipment enclosure to the vehicle conductive structure (equipment supplier/system integrator responsibility). Bonding must have a maximum DC resistance of XX mΩ between the unit enclosure and the vehicle structure even if additional in-line connections are present.

2) The supplier will demonstrate by test or analysis that the proposed bonding method results in a DC resistance of less than X.X mΩ across each faying surface in the bond path from enclosure to structure and an impedance of less than XX mΩ up to a frequency of X Hz.

3) All unit enclosures shall provide a peripheral bonding area for all electrical connectors. The connector mountings to the unit enclosure shall be provided with a conductive gasket between the connector and the enclosure. Bonding must have a maximum DC resistance of X mΩ from the connector shell to the enclosure.

4) All conductive pipes, tubes and hoses that carry fluids will have a mechanical secure conductive connection to conductive structure that will have a DCresistance value of X Ω or less.

5) Non-conductive plumbing installations, such as the fuel re-supply line, will be designed so that the static voltage generated by fluid flow will not exceed XXX V at any point outside the pipes, tubes or hoses. It is the responsibility of prime and subcontractor to implement the grounding concept to insure that a safety hazard for fuel does not develop.

6) All equipment integrated on to the Mobile Land System will be safely and efficiently grounded. In the earthing diagram, the conditioned power earth ground, the unconditioned power earth ground, the signal reference earth ground will be clearly identified with their reciprocal interconnections. However, bonding is a typical problem of the system integrator. A bonding diagram will be provided where all the points of interest are shown and where bonding measurements will be conducted during the system integration phase. As for the bonding impedance, only DC resistance measurements will be made, with approved bonding procedures by DOD, in lieu of RF bonding tests.

A.3.8.3.1 Standard MGV Interface Control Document (ICD) (Equipment Level ICD) Bonding Statement

A ground strap mounting provision shall be installed on all metal electronic equipment enclosures unless an alternate grounding implementation strategy, approved by the Mobile Land System E^3 Working Group, is used. The design of and surface finish (XXXXX, as applicable) surrounding the bonding provision shall support a X.X mΩ DC resistance across the bond junction faying surfaces from the mounting provision to the ground strap.

Bonding of the box-mounted connector shell to the equipment enclosure shall be less than or equal to X.X mΩ at the faying surface.

A.3.9 Shield Terminations. Shields may be used to reduce EMI susceptibility and emissions. To be effective, the shield must be at ground (chassis) potential. Shields will be terminated at both ends and at intermediate break points directly to structure or chassis, through connector back shells. Some low level, high impedance circuits may require double shielding with each shield terminated at alternate ends. With the exception of coaxial or triaxial cables, shields should not intentionally carry current. Radio Frequency Interference (RFI) back shells with individual shield grounding provisions will be used for multiple RF shield terminations.

A double over braid outer cable shield, in addition to internal twisted shielded pair wires, will be used in all harnesses that pass through, or are in, non-shield volume areas of the vehicle (such as the engine bay). Inside the shielded volume area, which is the crew compartment, only a single outer over braid shield, and twisted shielded inner wire pairs, will be required. In exterior exposed harnesses or in open bay areas the harnesses will be coated with an NBC environmental protection material, such as EPDM, or the equivalent.

A.3.10 E3 Safety Critical Circuits. A safety critical circuit is defined as a circuit that could result, due to EMI, in:

1) Loss of life, and/or

2) Uncommanded vehicle movement

If a critical circuit is redundant, only the worst-case path has to be evaluated. If no worst-case path can be identified, then all paths must be evaluated.

Circuits implementing critical functions must be identified and show an E^3 safety margin of X dB by test, or XX dB by analysis, below acceptable susceptibility requirements. E^3 safety margins for firing circuits of critical electrically initiated devices (EID) will demonstrate a XX.X dB safety margin by test or XX dB by analysis.

Margins will be provided based on vehicle/platform/system operational performance requirements, tolerances in vehicle/platform/system hardware, and uncertainties involved in verification of system-level design requirements. Safety critical and mission critical system functions will have a margin of at least X dB. EIDs will have a margin of at least XX.X dB of maximum no-fire stimulus (MNFS) for safety assurances and X dB of MNFS for other applications. Compliance will be verified by vehicle/platform/system level tests, analysis, or a combination thereof. Instrumentation installed in vehicle/platform/system components during testing for margins will capture the maximum system response and will not adversely affect the normal response characteristics of the component.

A.3.11 ESD, Lightning, and HEMP Protection

A.3.11.1 ESD Protection. The Mobile Land System, subsystems, and individual equipment will control and dissipate the build-up of electrostatic charge caused by precipitation static (p-static) effects, fluid flow, air flow, exhaust gas flow, personnel charging, charging of launch vehicles (including pre-launch conditions), and other charge generating mechanisms to avoid fuel ignition and ordnance hazards, to protect personnel from shock hazards, and to prevent performance degradation or damage to electronics. Compliance with the requirements specified will be accomplished by adhering to the good bonding practices. Electrostatic discharge (ESD) equal to or less than 8000 volts to the case or to any pin on external connectors will not damage un-powered electronic circuit card assembly. Handling and transportation procedures will be developed to protect static sensitive components. Test, analysis, demonstration or inspection or a combination thereof will verify item compliance with the specified ESD requirements. The verification is considered successful if the item functions normally following the verification results show that the item will not be damaged by ESD.

Electrostatic discharge shall be controlled to a level compatible with the internal circuit. The external environment is shown in Table A.3-4. The internal environment is contained in Table A.3-5. The environment for the circuit card is shown in Table A.3-6. For the ESD environment the engine is considered external environment during change out. The transport of equipment and cards shall be package to withstand a XXXX-volt static discharge.

Table A.3-4 Typical Personnel-Borne Electrostatic Discharge External Environment.

Voltage (V)	Capacitance (pf)	Series Resistance (ohm)
+XXXXX ±XXX	XXX±X%	XXX ±X%
-XXXXX ±XXX	XXX ±X%	XXX±X%
+XXXXX ±XXX	XXX ±5%	XXXX ±X%
-XXXXX ±XXX	XXX ±X%	XXXX±X%

Table A.3-5 Typical Personnel-Borne Electrostatic Discharge Internal Environment.

Contact Discharge Test Method		
Voltage (V)	Capacitance (pf)	Series Resistance (ohms)
±XXXX ±X%	XXX ±XX%	XXX ±XX%
Air Discharge Test Method		
Voltage (V)	Capacitance (pf)	Series Resistance (ohms)
±XXXXX ±X%	XXX ±XX%	XXX±XX%
Note: The source of this table is XXXXXXXXX		

Table A.3-6 Typical Personnel-Borne Electrostatic Discharge for PC Cards.

Contact Discharge Test Method		
Voltage (V)	Capacitance (pf)	Series Resistance (ohm)
±XXXX ±X%	XXX ±XX%	XXX ±XX%
Air Discharge Test Method		
Voltage (V)	Capacitance (pf)	Series Resistance (ohm)
±XXXX±X%	XXX ±XX%	XXX ±XX0%
Note: Level 1 (above) applies to Crusader circuits cards when not powered		

A.3.11.2 Lightning Protection. During and following a lightning strike, Mobile Land System, subsystems and equipments will meet operational performance requirements as specified in its requirements. This requirement includes direct and indirect effects of a lightning strike. Mobile Land System's ordnance will remain safe during and after a direct strike and will meet operational performance requirements during and after indirect effects of a lightning strike. Exposed components which are not designed to withstand direct strike lightning effects, such as whip antennas, will remain safe during and after a direct strike and will meet operational performance requirements during and after indirect effects of a lightning strike. Exposed components, which are designed to withstand direct strike lightning effects, will meet operational performance requirements during and after direct and indirect effects of a lightning strike.

The Mobile Land System's will not be required to operate during a near strike lightning event and generated EMP effects (see paragraph A.3.11.3, below) but will be required to resume operation after the lightning event such that all essential mission functions are operating within the system initialization times. The Mobile Land System will remain safe during a direct lightning strike. The vehicle subsystems, equipments, and components will meet the individual requirements of CS XXX, CS XXX and CS XXX testing under XXXX.

A.3.11.3 HEMP Protection. Mission Critical System (MCS) electrical equipment will be subjected to the high-altitude electromagnetic pulse (HEMP) environment as specified in AEP-4, VOL II. The vehicle will verify the individual subsystems requirements by CS XXX and CS XXX testing under XXXX. The MCS will not be required to operate during a HEMP event but will be required to resume operation after a HEMP event such that all essential mission functions are operating within the System's allowable downtime.

A.3.12 Cabling. Electrical cables act as antennas for both transmitting and receiving radiated EMI and as conduits for conducted EMI. Proper design and routing of cables will result in minimum EMI coupling between cables and other components/assemblies. One way of controlling EMI from cables and wiring is to separate them into similar classes of voltage, frequency, susceptibility, and TEMPEST levels. In general, cables/bundles of the same classification may be routed together. Cables of different classification should have a minimum separation of X in (X.X cm), except that high power cables, with significant low frequency (below XXX Hz) content, should be separated by at least X in (XX cm). In practice, it is not always feasible to maintain this requirement. Exceptions should be documented and assessed on a case-by-case basis. Crossing at 90 degrees is acceptable regardless of classification. An inspection of item drawings will be performed to verify that cable and wire design is in compliance with specified design and control requirements.

Cables and harnesses will have shield terminations at both ends, with a 360-degree bond at the rear of the connector. Current path elimination will be achieved by shielding, not allowing "pig tails" to extend through the shield, and wire type segregation to reduce voltage transients and eliminate common mode sinking. Power and grounds, will be evenly distributed between power returns, chassis returns and signals returns to reduce cross talk and signal coupling.

A.4 LIFE-CYCLE TEST PLAN FOR GENERIC MAIN BATTLE TANK

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A.4.1 INTRODUCTION

A.4.1.1 Test Objectives

a. Assess the ability of the Main Battle Tank (MBT) to meet the prescribed E^3 and nuclear weapons effects (NWE) survivability requirements.

b. Perform an External RF EME (Radiated Susceptibility) test on a production MBT vehicle using a subset of the frequency set developed and utilized during the MBT production assessment.

c. Perform initial nuclear radiation (INR) survivability testing on specific Line Replaceable Units (LRUs) identified by PM MBT in order to verify operational performance, survivability to the MBT NWE criteria, and verify system quality is being produced (hardness assurance).

d. Establish the and NWE system level baseline for the MBT, for use in future evaluations of system design changes, basic quality assurance tests, surveillance tests or technology and Diminishing Manufacturing Sources (DMS) changes / insertions.

e. Verify current production vehicle meets the requirements as stated in MBT specification XX-XXXXXXX.

f. Update the MBT Life-Cycle Nuclear Survivability and E^3 (LCN&ES) database.

A.4.1.2 Testing Authority

The XXX tasked the XXX located at the XXXXX to perform the Follow-On Production Test (FPT) for E^3 and NWE on the MBT. Tasking is under XXX Project Number XXXX-XX-XXXX-MBT-XXXX.

A.4.1.3 Test Concept

A.4.1.3.1 General Test Summary. The described herein MBT system level tests will be conducted by the XXX from XX through XX. The basic subtests to be performed are:

Electromagnetic Environmental Effects:
  Bonds & Grounds
  Intra-System EMC and Radiated Emissions (RE)
 External RF EME (Radiated Susceptibility - Operational (RS-O)- Stepped Frequency Methodology (141 Frequencies))
  Receiver Desensitization
  XXX Facility, XXXX
  XXXX
  XXXX

  High-altitude Electromagnetic Pulse (HEMP)
  XX Horizontally Polarized Dipole II (HPD-XX)
  XX, XXXX, XXXX. AEP-4 VOL II, XX-XXXX
  Near Strike Lightning
  XXX Lightning Test Facility
  XXX, XXXX, XX TOP X-X-XXX, XXXX

a. All subtests will be performed with a fully operational production version MBT. During functional performance checks, the tank will be operating, with the engine in tactical (TAC) idle, electrical/electronic equipments powered up, and the fire control in the COMBAT (NORMAL stabilized fire control) mode. Where necessary, the track final drives will be disconnected as a safety precaution.

b. Functional checks of the tank will consist of operating all equipment and subsystems before, during (as applicable), and after exposure to a subtest environment. The tank's responses will be documented by logging observed data from the displays, readouts and indicators, and observations of the test conductors.

c. If significant anomalies, upsets or test-induced failures occur, additional checks will be performed as time permits, to define the cause (environment, operator, equipment or anomaly), isolate the problem causing equipment(s), identify the victim(s), and to develop recommendations for corrective actions. These additional checks will include the use of the tanks extended diagnostics capability.

d. When the MBT tank is exposed to the electromagnetic environments, all hatches will be open, except the drivers hatch. The Gunner's Primary Sight (GPS) ballistic doors will be opened.

e. As in previous tests on the MBT systems, no significant impacts on the environment are anticipated as a result of this test. Vehicle operations are conducted in test areas set aside for this purpose. Air pollution from vehicle operations will be transitory and will have no long-term effects on the environment. These effects are the same as for previous MBT tank models tested at XXXX. No health hazards are anticipated.

A.4.1.3.2 Required Resources. The E^3 Survivability Assessment (E^{3}SA) and INR Survivability Assessment (INRSA) for the MBT performed by XXX will require the following test resources from the contractors and/or the PM:

a. One complete and fully operational MBT.

b. One completely operational Base Station to support communications performance checkouts – XXX Provided.

c. All necessary communications equipment properly integrated into the MBT– XXX Provided.

d. Wiring diagrams, Interconnect diagrams, and Technical Manuals (TMs).

e. Adequate Direct Support Engineering System Test Set (DSESTS) Support, Embedded Diagnostics or miscellaneous LRU Checkout Support.

f. Any contractor conducted test results and analysis.

g. Detailed test reports for Production MBT E^3 and NWE Programs.

h. On-Site Technical Support.

i. Shipping addresses and instructions to return all equipment.

j. Commonality information between MBT and other MBT tank versions.

A.4.1.3.3 Responsibility. The XXX has the responsibility for the complete MBT E^3SA and INRSA program. In addition, XXX is responsible for:

a. Preparing the detailed test plan.

b. Performing the pre-test analysis.

c. Executing the described test program.

d. Designing, setting up and operating the Data Acquisition System (DAS).

e. Collecting and processing the performance and test data.

f. Performing the analysis and survivability assessment.

g. Coordinating all activities.

h. Funding all test facilities using PM provided funds.

i. Performance of diagnostic checks.

j. Development of corrective actions for PM consideration.

k. Preparing the detailed final test report.

l. Preparing Test Incident Reports (TIRs) if applicable.

m. Updating the Life-Cycle Nuclear and E^3 Survivability (LCN&ES) database for the MBT.

n. Providing the E^3 and INR test support and test environments.

PM MBT is responsible for all the necessary test hardware, training, test support equipment, on-site expertise, and funds required to perform the E^3 SA and INR SA on the MBT.

A.4.1.4 System Description

The MBT core tank system is an upgraded version of the baseline MBT. The primary electronic assemblies to be tested are listed in Table A.4-1 below:

Table A.4-1 Typical MBT Line Replaceable Units (LRUs).

Part Description	Part Number	Comment
Cant Unit		
Computer Control Panel (CCP)		
Computer Electronics Unit (CEU)		
Control Module		
Control Monitor		
Crosswind Sensor		
Digital Electronic Control Unit		
Drivers Master Panel		
Drivers Instrument Panel		
Fire Extinguisher Amplifier		
Fire Sensor		
Fuel Sensor – Front		
Fuel Sensor – Sponsor		
Fuel Sensor – Rear		
Gunner Aux Sight (GAS)		
Gun Turret Drive (GTD)		
Hull Power Distribution Box		
Ignition Exciter		
Image Control Unit (ICU)		
Intercom Control Set		
Intercom J-Box		
Laser Range Finder		
LOS Electronics		
Power Control Module		

Part Description	Part Number	Comment
Primary Diode Box Assembly		
Pulse Control Unit		
Regulator		
RHNB Hull Networks Box		
RTNB Turret Networks Box		
Temperature Controller		
Thermal Electronic Unit (TRU)		
Upgraded Tank Commander's Control Panel (UTCP)		

A.4.1.5 Unique Test Personnel Requirements

A XXX field representative is needed to adequately support testing. XXX employees will operate the test vehicle and equipment in the required environments. XXX employees will perform the operational checks, remove and install the Line Replaceable Units (LRUs) / Shop Replaceable Units (SRUs), and perform routine maintenance. XXX personnel will setup and operate all DAS, operate test instrumentation and test facilities.

A.4.2 SUBTESTS

A.4.2.1 Bonds & Grounds

A.4.2.1.1 Objectives

a. The objective of the bonds and grounds test is verify whether the MBT has adequate electrical continuity across external mechanical interfaces on electrical and electronic equipment, and equipment to structure interface is adequate.

b. A second objective is to verify that the system's interconnects and shielding is present and installed properly. For a tactical ground system, this verifies that it has been produced correctly and is ready for electromagnetic testing.

c. A third objective is to establish a baseline for follow-on E^3 testing.

d. A final objective is to update the MBT's life-cycle E^3 database.

A.4.2.1.2 Criteria

a. Measurements of the impedance from the back-shell of a shielded cable through the electronic equipment connector to chassis ground shall not exceed 25 milliohms and measurements to chassis ground through a shielded cable shall not exceed 100 milliohms.

b. Measurements from the electronic equipment connector to chassis ground shall not exceed 50 milliohms as provided in XX-XXXX.

c. The MBT shall sustain throughout its rated life-cycle, production and deployment, the necessary electrical bonding to meet its E^3 requirements. The level of electrical bonding required to meet the MBT's E^3 requirement shall not be degraded by age, usage, maintenance, repairs, storage, upgrades, enhancements, and DMS solutions.

A.4.2.1.3 Test Procedure

a. A pretest evaluation on the MBT System-Under-Test (SUT) will be performed to determine the electrical bonding test points. Bonding data and results, and configuration information from the previous MBT assessments will be reviewed.

b. The first criterion test is performed using a Hewlett Packard 4328A which is a four wire milliohm impedance meter. The meter will be connected between the cable connector backshell of the equipment interface being measured and chassis ground. The impedance will be measured and recorded. No measurements will be made on interfaces, which require disassembly of the system.

c. If the measurement is out of tolerance (greater than 25 milliohms), the interface connector is disconnected, inspected, cleaned, repaired, reconnected, and the measurement repeated. If the measurement is still out of tolerance a measurement will be made for the equipment connector and then the cable shield to determine which impedance path is the problem.

d. The second criterion test (XX-XXXX) will be performed with the interface cables disconnected and the impedance measured between the electronic equipment connector and chassis ground. This measurement will be recorded.

e. To meet the life-cycle requirements, pertinent data, results and information will be collected and archived into the MBT life-cycle E^3 survivability database.

A.4.2.1.4 Data Required

a. Visual inspections, logs, test conductor notes, and photographs of out-of tolerance bonding test points.

b. Baseline check data from MBT checks.

c. Go/no-go log of tank checks from the Operators manuals, i.e., self-test (ST), and as needed, diagnostics tests with descriptions of discrepancies.

d. Calibration status of the milliohm meter.

e. Record of all measurements taken.

f. Description of corrective actions.

g. TIRs, if applicable.

A.4.2.1.5 Data Analysis / Procedure

A.4.2.1.5.1 Data. Results from the MBT pre-test analysis and the contractor's test and analytical programs will be evaluated and incorporated into the test planning and pre-test analysis of the XXX bonds and grounds program for the MBT. The incorporation of all test data will be used to enhance and reduce the scope of testing. Pertinent data will be placed into a tabular form presenting the impedance measurement for each measured equipment interface. A data table will be provided for the interfaces, which were out of tolerance and the corrective actions performed.

A.4.2.1.5.2 Criteria Compliance. Data from the bonds and grounds measurements will be evaluated against the MBT requirements. Non-compliant differences will be identified and discussed with regards to potential impacts on the operational performance and E^3 requirements.

A.4.2.1.5.3 System Configuration Compliance. The SUT configuration will be evaluated against both the production and previous MBT configuration and differences identified, discussed and documented.

A.4.2.1.5.4 System Performance Compliance. Measured electrical bonding deficiencies will be discussed with respect to the effects on the MBT production tank's operational performance and E^3 requirements.

A.4.2.1.5.5 LCN&ES. Pertinent pre-test and post-test data and results, compliance data and results, information, and assessments will be archived to update the MBT life-cycle database.

A.4.2.2 Intra-System Electromagnetic Compatibility (EMC) and Radiated Emissions (RE)

A.4.2.2.1 Objectives

a. To measure the electromagnetic emissions generated by the MBT during operational missions; which could be a source of interference for itself (intra-system EMC), future device, component and equipment additions (intra-system EMC), and any nearby military equipment (RE).

b. To perform radiated emissions testing using XXXXX methodology for systems and MBT system specification XX-XXXXXXXX.

c. To expand and update the existing MBT E^3 life-cycle database to include pertinent data, results and information from this MBT RE subtest.

A.4.2.2.2 Criteria. The fully equipped MBT shall meet XX-XXXX, which indicates that XXXX shall be used as the baseline for the system radiated emissions (RE). For XXXX, the following (Figure A.4-1) will be used (Intentional emissions such as those from a radio transmission are exempt):

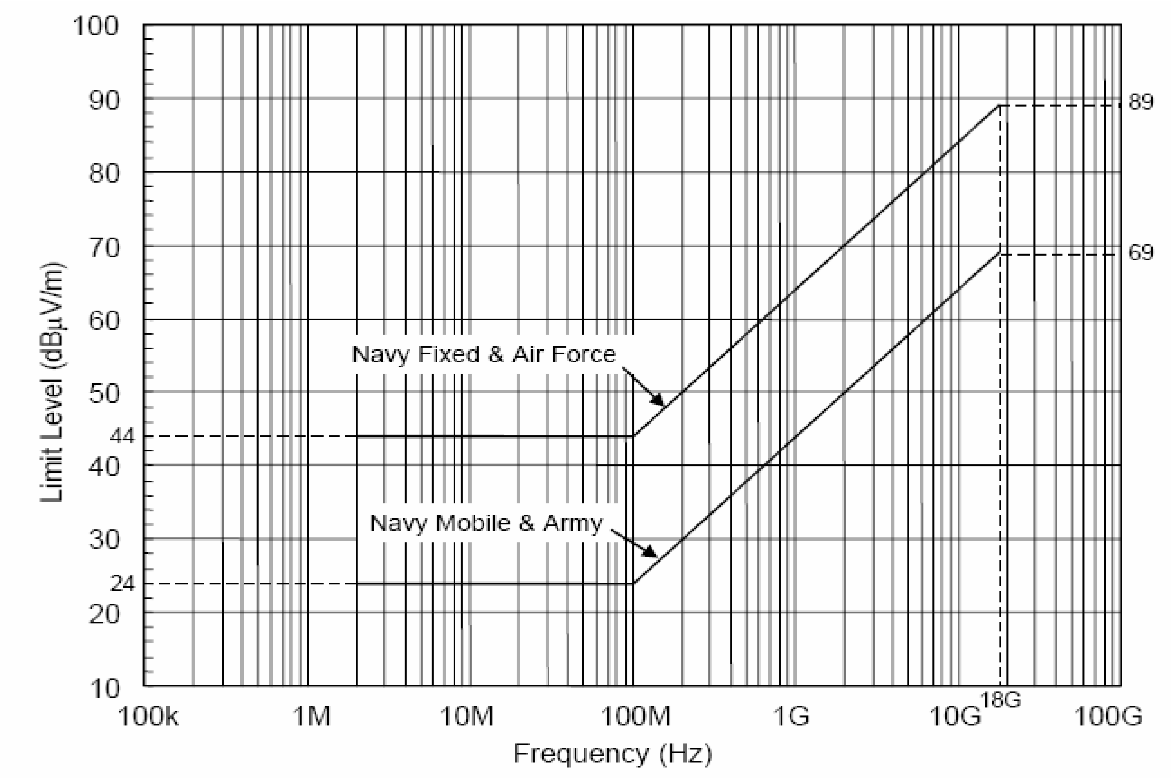


Figure A.4-1 MBT Baseline RE.

a. As in previous MBT RE tests, the driver's hatch shall be closed and the loader and commander's hatches shall be open during testing. (System Spec, XXX)

b. The MBT system shall be electro-magnetically compatible with itself such that system operational performance requirements are met.

A.4.2.2.3 Test Procedure

a. The RE from the MBT will be measured in a large, electro-magnetically shielded enclosure designed for these types of measurements using the basic procedures of MIL-STD-461E. The first test configuration-orientation will consist of the main gun pointing over the front of the hull. The tank's engine will be operating in tactical idle, and the fire control system will be operating in the NORMAL mode. All equipment will be powered and operating. The MBT radios and intercom system will be ON and operating in the receive mode during RE measurements. As the emission data are being recorded, the gun and turret will be slewed through small angles.

b. The MBT SUT RE will be measured at eight positions around the MBT as indicated in Table A.4-2 in the engine powered configuration. For positions 1 through 8, the emission measurement antennas will be placed X.X meters above the floor level and X meter from the MBT. The recorded data will be extrapolated from X meter to X and X meters as indicated in the system specification. This extrapolation technique was performed on all previous MBT RE tests. Table A.4-2 shows the RE antenna locations, with respect to the front and rear edge of the MBT.

Table A.4-2 Typical Antenna Placement Locations for Radiated Emissions Subtest.

Position	Antenna Placement Relative to MBT
1	Center front of MBT
2	Curbside, X meters from front of MBT
3	Curbside, X.X meters from front of MBT
4	Curbside, X meters from front of MBT
5	Center rear of MBT
6	Roadside, X meters from front of MBT
7	Roadside, X.X meters from front of MBT
8	Roadside, X meters from rear of MBT

c. With the MBT and antennas in place, the ambient RE background will be measured and recorded. The MBT will then be powered ON and operated as described above while RE are recorded. The ambient RE background will be periodically measured and recorded. By subtracting the ambient RE measurements from the SUT RE measurements, the actual RE values for each antenna position will be determined. The results will be provided in tabular form. This procedure will be repeated for each test configuration-orientation position. Plots will be generated of worst-case RE, showing amplitude versus frequency.

d. If excessive SUT RE is measured, the two hatches will be closed and the ambient RE and SUT measurement repeated. If closing the hatch results in a significant difference in the RE level, the plots and data will be recorded. If the hatches are closed and the RE level is still excessive, then source identification procedures will be performed. This consists of turning individual equipments OFF one at a time while the RE is being recorded. These procedures are continued until the excessive RE cease.

e. The Intra-system EMC data will be collected throughout all subtests, while the SUT is operating and during checkouts. Operators will record any intra-system compatibility problems. As necessary, these will be diagnosed to determine victim-source. Pertinent data from the bonds and grounds subtest will be included. These operational data and measurements will be the basis for determining compliance for intra-system EMC.

A.4.2.2.4 Data Required

a. Visual inspections, logs, test conductor notes, and photographs of the test setup to include antenna positions.

b. Baseline check data from MBT checks and intra-system compatibility observations.

c. Go/no-go log of MBT checks from the operator manuals, i.e., self-test (ST), and as needed, diagnostic tests with descriptions of discrepancies.

d. Location and type of receiving antennas relative to the MBT (x, y, z, coordinates in meters ± 0.1 m).

e. MBT setup and operating conditions for test.

f. Measurements from the radio desensitization subtest.

g. Plots of radiated emission amplitude (V/m ± 2) versus frequency (Hz ± 2%) over the specified test band for background RE noise and background RE noise plus SUT RE.

h. Radiated emissions diagnostic procedures (if necessary) and results.

i. Identification of any excessive RE sources.

j. Description of conditions where excessive radiated emissions are generated.

k. Corresponding RE results from previous MBT tests.

l. TIRs if applicable.

m. Test conductor/engineer data of any intra-system incompatibility during any subtest.

n. Electromagnetic Interference (EMI) diagnostic measurements.

o. Model and serial numbers of the RE measuring antennas and recording instrumentation.

A.4.2.2.5 Data Analysis / Procedure

A.4.2.2.5.1 *Data*

a. Results from the previous MBT test programs and the contractor's test and analytical programs will be evaluated and incorporated into the test planning and pre-test analysis of the XXX RE program for the MBT. The incorporation of all test data will be used to enhance and where possible reduce the scope testing. Pertinent data will be included in the XXX pre-test analysis, failure diagnostics, post-test analysis / assessment and be documented in the detailed test report to support the test results. A table will be created which indicates the frequencies at which the emissions are above the limit and the corresponding delta. The MBT RE plots will be compared with corresponding plots from the previous RE tests. Significant differences will be discussed with respect to cause(s) and impacts on performance.

b. Intra-system EMC results from the previous MBT production test programs, the contractor’s test and analytical programs, and the bonds and grounds subtest will be evaluated and incorporated into the test planning and pre-test analysis of the XXX intra-system EMC program for the MBT.

A.4.2.2.5.2 Criteria Compliance. Data from the RE test environment measurements will be scored against the criteria levels set forth in XXXX and XXXX, to determine the extent to which the test environment criteria were met. Excessive RE will be identified, discussed and documented with respect to criteria compliance and effects on the test results.

A.4.2.2.5.3 System Configuration Compliance. The test system's configuration will be evaluated against the previous MBT test configuration, the baseline configuration and the expected production configuration. All differences will be identified, discussed and documented.

A.4.2.2.5.4 Effects Analysis. Intra-system EM incompatibilities will be identified, victim and sources will be identified, and impact(s) on the MBT's operational performance requirements will be discussed. A comparison will be made of the excessive RE from the previous MBT tests. Excessive RE and sources will be identified and discussed. Potential impacts on co-located system (both like and different) will be discussed, in particular, to the MBT becoming a potential RS emitter.

A.4.2.2.5.5 Survivability Assessment. A RE survivability assessment will be performed on the production or baseline configuration against the XXXX and XXXX criteria using the results of paragraphs. 2.2.5.2 through 2.2.5.5. Excessive RE will be discussed with respect to the source(s) and reduction options will be presented**.**

A.4.2.2.5.6 LCEMS. Both the configurations for the test system and proposed baseline production system will be stored for LCES' configuration (survivability) control and future analyses. In addition, the pertinent test data and results, extrapolated results, and information will be archived in the MBT life-cycle database.

A.4.2.3 External RF EME (Radiated Susceptibility (RS))

A.4.2.3.1 Objectives

a. To assess whether the MBT is electro-magnetically compatible with its defined external EME, such that its system operational performance requirements are met. This subtest subjects the MBT to the electromagnetic environments produced by external transmitters, both friendly and hostile. This test is being performed over the full/extended frequency range, for use as a baseline for the MBT, to determine primary frequencies for future evaluations, and compare these primary frequencies with those established in XXXX and used for all follow-on MBT RS tests.

b. To establish MBT E^3 life-cycle database to include RS data.

A.4.2.3.2 Criteria

a. The MBT system shall be capable of meeting its operational performance requirements while being immersed in an electromagnetic environment (Table A.4-3 Radiated Susceptibility Environment) specified from MIL-STD-464A (TABLE 1D. external EME for ground systems), with Amplitude Modulation (AM) of XX% at XXXX Hz. This is based upon the EME and modulation agreed upon and used in other MBT External RF EME tests.

Table A.4-3 Typical External RF EME Environment.

Frequency	Volts/ Meter	Modulation

Table A.4-3 Typical External RF EME Environment.

Frequency	Volts/ Meter	Modulation

b. The test modulation presented in Table A.4-3 above was extracted from XXXX and were used in previous MBT External RF EME test programs.

c. MIL-STD 464A allows for the calculation of the required system test frequencies based on physical geometry. Performing these calculations and a review of previous test results, allows the conservative use of X.0 XHz as the lower bound frequency. The polarization will be vertical between X and XX XHz and will be both vertical and horizontal above XX XHz.

d. The MBT will be exposed to the EM environmental frequencies and field intensity levels listed in Table A.4-4. The range of frequencies being used is based upon external transmitters that can be co-located with MBTs, or friendly and hostile emitters.

Table A.4-4 Typical External RF EME Frequency List.

Frequency #	Frequency (xHz)	Polarity	Mod	Field Intensity
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
XX				
XX				
XX				

A.4.2.3.3 Test Procedure

a. The test will be conducted in accordance with (IAW) XXXXX. The EME frequencies, intensities and modulation are specified in Table #4 above.

b. The MBT SUT operational performance status will be established prior to RS testing. Problems will be identified, documented, and corrected if deemed detrimental to the test.

c. The MBT will be positioned in the center of each EME test area on a XX-ton turntable, which will be used to rotate the system. Three XX-kW high power transmitters are used in conjunction with the three turntables to provide whole body illumination between X – XXX XHz IAW XXXX guidelines. Two additional sets of high power transmitters provide the remainder of the required frequency range, e.g., XXX MHz to XX GHz. The system will be exposed in a total of four orientations. This results in two iterations per frequency. The four test orientations are presented in Table A.4-5 on the following page.

Table A.4-5 Typical Orientations.

0 degrees is toward the antenna

Angular rotation is clockwise

Orientation Number	**HULL (degrees)**	**TURRET (degrees)**
1	0	Rotate xx
2	xx	Rotate xx

d. The MBT test irradiation will be done at each frequency using one modulation and each polarization for a duration of thee minute. During each irradiation the MBT operators will perform mission functions while monitoring the SUT for EM induced responses, and document such responses.

e. In the event of system malfunction or performance degradation during exposure to the EM field, the frequency, orientation, and polarization will be noted and stored by the transmitter control software. The center frequency of the effect response band will be repeated by gradually increasing the field intensity until the maximum intensity, which allows proper operation is established. This will be recorded as the threshold field intensity for the effect band and used later for direct comparison to XXXX.

A.4.2.3.4 Data Required

a. Visual inspection, logs, test conductor/operator notes, and photographs of the test setups.

b. Baseline check data from MBT SUT checks.

c. External test environment frequency, modulation, antenna polarization, and field intensity to include:

   1) Frequency (Hz ± X %).

   2) Modulation (percent ± 0.X%).

   3) Polarization (vertical or horizontal, degrees ± X°).

   4) Maximum field intensity [V/m ± X].

   5) Threshold field intensity (V/m ± X).

d. Go/no-go log of MBT checks from the operator manuals, i.e., self-test (ST), and as needed diagnostics tests with descriptions of discrepancies.

e. MBT physical and operating configuration during each subtest run.

f. Log sheets of test run to include induced responses, frequency, modulation, orientation, configuration, and if necessary threshold amplitude.

g. Internal field data measured in [V/m].

h. TIRs if applicable.

A.4.2.3.5 Data Analysis / Procedure

A.4.2.3.5.1 Data. Results from the MBT pre-test analysis and the contractor's test and analytical programs will be evaluated and incorporated into the test planning and pre-test analysis of the XXX RS program for the MBT. The incorporation of all test data will be used to enhance and reduce the scope of testing. Pertinent data will be included in the XXX failure diagnostics, post-test analysis / assessment and documented into the detailed test report to support the test results. Significant MBT responses to the EM conditions will be discussed with respect to frequency, threshold field intensity, previous MBT test results, and impact on mission performance. The MBT RS data will be compared with the data obtained from RS tests on previous MBTs to determine if the primary response frequencies have remained the same and to reduce the frequency set for future testing.

A.4.2.3.5.2 Criteria Compliance. The pre-exposure, during exposure, and post-exposure MBT’s configuration operational and system check data, along with the environmental exposure data and specification requirements, will form the basis of the analysis to assess the effects of the EM environment on MBT’s mission combat operations. By evaluating the EM effect and the level to which it occurred, criteria compliance will be developed.

A.4.2.3.5.3 System Configuration Compliance. The test system's configuration will be evaluated against the previous MBT test configuration, the baseline configuration and the expected production configuration. All differences will be identified, discussed and documented.

A.4.2.3.5.4 Effects Analysis. Effects will be scored at the test level of occurrence, cause(s) will be identified, and impact(s) on the MBT operational performance requirements will be discussed. A comparison will be made to the RS susceptibilities from the previous MBT tests. RS effects and sources will be identified and discussed. Potential impacts on co-located system (both like and different) will be discussed, in particular, to the MBT becoming susceptible to potential RS sources.

A.4.2.3.5.5 Survivability Assessment. A RS survivability assessment will be performed on the production or baseline configuration against the MIL-STD 464A and TOP 1-2-511 criteria using the results of paragraphs A.4.2.3.5.2 through A.4.2.3.5.5. RS susceptibilities will be discussed with respect to the source(s) and Techniques, Tactics and Procedures (TTPs) options will be presented.

A.4.2.3.5.6 LCEMS. Both the configuration for the test system and proposed baseline production system will be stored for Life-Cycle Electromagnetic Survivability (LCEMS)’ configuration (survivability) control and future analyses. In addition, the pertinent test data and results, extrapolated results, and information will be archived in the MBT's life-cycle database.

A.4.2.4 High Power Microwave (HPM) / Ultra-Wide Band (UWB)

A.4.2.4.1 Objective

a. To assess the survivability of the MBT to the HPM / UWB environment, as specified in the XXXX.

b. To update the MBT life-cycle E^3 database by entering pertinent data, results and information from the HPM / UWB test.

A.4.2.4.2 Criteria

a. The MBT shall remain combat effective without component replacement.

b. The MBT will be exposed to requirements that were extracted from XXXX.

c. The MBT shall sustain HPM / UWB survivability throughout its rated life-cycle, production and deployment. The HPM / UWB survivability shall not be lost or significantly degraded by age, usage, maintenance, repairs, storage, upgrades enhancements, and DMS solutions.

A.4.2.4.3 Test Procedures

A.4.2.4.3.1 General Procedures. The HPM / UWB survivability program for the MBT will include testing at XXXX. The survivability of the MBT to its HPM/UWB criteria level will be assessed by:

a. Performing a pre-test analysis.

b. Establishing its complete performance baseline prior to HPM/UWB testing, using baseline self test checks.

c. Performing detailed bulk current measurements on cables identified in the pretest analysis (external cables, Ports Of Entry (POE) and internal cables).

d. The MBT will be tested in two hull orientations with respect to the electric field vector, i.e., longitudinal axis parallel to electric field vector, and 90 degrees clockwise or perpendicular to the electric field vector. For each hull orientation, the turret will be oriented in two positions, 1) XXXX and 2) XXXX. In each of these four hull-turret orientations, the MBT will be illuminated by a series of HPM/UWB pulses. If no failures occur, the MBT will be illuminated, at a minimum, twice more per each hull-turret orientation configuration or until all data acquisition has been completed.

e. Illuminating the SUT to 75% of the criterion level, followed by 100% and then 125%.

f. Illuminating the SUT in a fully operational mode with engine idling, fire control in the Normal, and NBC, communications, POS/NAV, etc., turned

ON. The final drive will be disconnected as deemed necessary. All hatches except the drivers will be opened during exposures.

g. Repeating the necessary pre-test baseline checks on the SUT after each illumination.

h. The actual number of HPM/UWB test illuminations performed will depend on how many MBT harness shields are monitored for HPM/UWB induced currents. It is planned to measure all accessible cables; no physical changes will be made to access data points.

i. Most HPM/UWB responses are manifested as system upsets. In the event of an upset the system power will be cycled OFF/ON to determine if normal operation can be restored. If normal operation is restored the illumination will be repeated on the same hull-turret orientation to verify the effect. If system operation is not restored further investigation will be performed to determine the affected victim(s).

j. Documenting upsets, failures, downtime, and corrective actions.

k. Identifying and classifying all failures to the electronic piece-parts/component level.

A.4.2.4.3.2 Test Facility. The HPM/UWB testing performed on the MBT will utilize the XXXX's XXXX facility, which generates a high power HPM/UWB source connected to their Impulse Radiating Antenna (IRA). The provided test data will consist of one channel to capture the HPM/UWB source and three channels to measure induced currents.

A.4.2.4.3.3 Pre-test Analysis. A pre-test analysis will be conducted to:

a. Evaluate and incorporate previous test data and results.

b. Analyze drawings and circuits to identify potentially harmful energy paths.

c. Identify test system's internal configuration.

d. Identify and determine all energy coupling POEs.

e. Analyze grounding schemes and shielded cables to include connectors / backshells.

f. Evaluate deliberate hardening devices and techniques.

g. Define DAS requirements.

h. Identify cables for measurements.

i. Identify test levels, orientations, configurations, and operational modes based on the results of the hardening determination.

A.4.2.4.3.4 System Setup

a. Prior to testing, the MBT will be functionally checked to establish its operational status. Problems will be documented, reported, and corrected if detrimental to the HPM/UWB survivability assessment program on the MBT.

b. The MBT SUT will be placed in its first test hull-turret configuration at the HPM/UWB facility near the center of the test volume for the desired test level. A second functional check will be performed.

c. A bulk current probe will be placed near (but not attached to) the longest cable run in the SUT and a noise measurement taken to establish the data collection base line. This type of base line measurement will be made for all of the current probes.

d. Bulk current measurements will be obtained on cables identified in the pre-test analysis as being potential paths for harmful levels of HPM/UWB induced energy. Pin current measurements will only be collected if a failure is identified and the data will be utilized in a failure analysis and/or to perform corrective actions.

A.4.2.4.3.5 System Test. The MBT configuration will be illuminated by a HPM/UWB source EME that is characterized by an E-Field having a magnitude of approximately XX% of the HPM/UWB criterion value. After illumination, the MBT SUT will again be checked to establish the functional status of the system. At the completion of each successful test series (all cables measured and effects/anomalies diagnosed), the MBT will be placed in the next orientation to account for energy coupling into different cable layouts and tested. This procedure will be repeated two additional times for the remaining two orientations. Once the series of four hull-turret orientations have been completed, then the E-field magnitude of the HPM/UWB pulse will be increased to the next test level and the test procedures described above repeated. This will be repeated for the remaining HPM/UWB test level.

A.4.2.4.3.6 Effects Procedure. If an effect/anomaly occurs, it will be documented and diagnosed. Testing will not be continued until the problem is understood, and its effect on the MBT SUT has been assessed as well as potential impacts on the MBT SUT and SUT results if testing is continued. If an upset occurs, the MBT power will be cycled OFF/ON. If the SUT fully recovers, testing will be repeated at the same level and test orientation to determine whether the problem was EME induced or an anomaly. Borderline cases may require an additional test exposure or Current Injection (CI) testing to explicitly establish whether the effect was environmentally induced. If the SUT does not recover, then follow-up checks, measurement review, and review of the pre-test analysis will be used to identify the energy path and the affected electronic piece-part/component. If the effect is a failure, diagnostic checks will be performed to determine energy path and victim(s). If the operational status of the SUT can be restored, an engineering judgment will be made of potential risk to the SUT if testing is continued. Again, every effort will be made to complete testing.

A.4.2.4.3.7 Environment Measurements. Measurements of each illumination will be made using an Electric Flux Density per unit time (D-dot) probes, so that the magnitude of the E-field and pulse shape can be determined. This information will be digitized, reviewed, and stored for later environment compliance analysis. Injected current signals will be measured using a calibrated bulk current probe, reviewed and then stored for later stress level compliance analysis and upset/problem evaluations.

A.4.2.4.4 Data Required

a. Detailed description of each HPM/UWB environment to include photographs of the test facility setup showing test system position relative to the HPM/UWB antenna array.

b. Complete set of pre-test mapping data of each HPM/UWB illumination level with the electric field (E-field) expressed in volts/meter (V/m) (±X%), rise time and pulse width expressed in nanoseconds (nsec) (±X%), frequency bandwidth expressed in Hertz (Hz)(±X%), repetition rate in pulses per second (±X%), and modulation of pulse.

c. Detailed description of the MBT functional checks used to baseline the MBT SUT to determine its pre- and post-illumination capabilities.

d. Visual inspection, logs, test conductor notes, and photographs.

e. Detailed description, serial numbers, and dimensions of the MBT SUT equipments.

f. Detailed description and recording of all inspections, downtime and recovery time (sec) (±XX%), and checkout data.

g. Go/no-go log of tank checks from the operator manuals, i.e., self-test (ST), with descriptions of discrepancies.

h. SUT physical and operating configuration during each subtest illumination.

i. Log sheets of test illumination to include induced upsets or failures.

j. Description and calibration of current / voltage measuring probes and the Data Acquisition System (DAS). In addition, probe locations used on the MBT SUT during testing are required.

k. Results of all facility environment measurements expressed in the same units as listed in Para 2.4.4.b above.

l. Results of all current and voltage measurements, and Fast Fourier Transforms (FFTs) data obtained from the DAS.

m. Results of previous HPM/UWB and CI tests performed by the contractor or another government agency on the MBT.

n. Detailed description of all deliberate HPM/UWB hardening devices and/or techniques employed on the MBT.

o. Detailed description of the utilized DAS.

p. Percent error incorporated into the DAS.

q. TIRs if applicable.

A.4.2.4.5 Data Analysis/Procedure

A.4.2.4.5.1 Data. The pre-test analysis will consist of evaluating results from the previous MBT HPM/UWB program, review of the test system's configuration. Pertinent data, results and information will be incorporated into the test planning of the XXX

HPM/UWB program for the MBT. The incorporation of all test data will be used to enhance and reduce the scope of testing. Pertinent data will be included in the XXX failure diagnostics, post-test analysis / assessment, and documented in the detailed test report to support the test results.

A.4.2.4.5.2 Criteria Compliance. The HPM/UWB environmental data from the test facility will be corrected to account for the percent error associated with the DAS:

a. A mean and standard deviation will be established from the error corrected test facility E-field parameters.

b. A mean and standard deviation rise time will be established from the test facility E-field data.

c. The test facility E-field data, test point current data and test point FFTs will be examined using XXXXXX to determine the primary coupling frequency or coupling frequency range, critical damping factor, and energy content.

d. The data in paragraphs A.4.2.4.5.2 a through A.4.2.4.5.2 c will be compared and evaluated against the HPM/UWB criteria, and criteria compliance will be performed.

A.4.2.4.5.3 System Configuration Compliance. The test system's configuration will be evaluated against the expected production configuration and all differences will be identified and documented.

A.4.2.4.5.4 Effects Analysis. Effects will be scored at the test level of occurrence, cause(s) and victim(s) will be identified, and impact(s) on the MBT mission will be discussed. Failures or operational performance degradation occurring at levels above criteria will be classified as system shortcomings, unless verified by additional data and/or energy coupling analysis to be valid as a result of manufacturing variations or assembly. This information will be used primarily to provide the needed level of confidence in the survivability assessment of the MBT to meet its defined criteria.

A.4.2.4.5.5 System Performance. Comparison of pre- and post-illumination functional checkout data for the MBT test system will be used to determine the effects of the HPM/UWB test environment on the MBT. Degradation resulting in system performance outside specifications, or total failure(s), will be addressed with regards to cause(s), victim(s), test level at which they occurred, allowable downtime, and mission impact.

A.4.2.4.5.6 Survivability Assessment. A HPM/UWB survivability assessment will be performed on the production or baseline configuration against the HPM/UWB criteria using the results of paragraphs A.4.2.4.5.2 through A.4.2.4.5.5. This assessment may produce results different than obtained during the testing phase due to corrections for manufacturing variations and/or test environment deficiencies.

A.4.2.4.5.7 LCEMS. Both the configurations for the test system and proposed baseline production system will be stored for LCEMS' configuration (survivability) control and future analyses. In addition, the pertinent test data and results, extrapolated results, and information will be archived in the MBT life-cycle database.

A.4.2.5 Radio Desensitization

A.4.2.5.1 Objective. To assess the loss in radio transmission distance caused by the MBT system electromagnetic noise.

A.4.2.5.2 Criteria. No criterion exists for this subtest. The resulting data will be added to the MBT database and compared to previous MBT radio desensitization tests.

A.4.2.5.3 Test Procedures. This test is performed using two XXXX radios. One is used for a transmission source, while the MBT radio is used as a receiver.

a. A spectrum analyzer will be connected in series with the XXXXXXX antenna cable in order to measure the frequencies, which are being coupled to the antenna. The major frequencies recorded and frequency hop mode will be used in performing the radio desensitization measurements.

b. The transmit radio (Radio A) will be set for low power output and a variable attenuator installed on the output. XX BIT and XX BIT pattern generators will provide the data input.

c. The MBT receive radio (Radio B) will be operated with all MBT electronics turned off (under XXXX or external battery power). The output of the receive radio will be connected to a XXXX XXXX data analyzer measuring bit error rate.

d. Radio A will transmit the bit patterns to Radio B. The output attenuator will be adjusted until a fixed data error rate is achieved (X or XX %) or loss of sinc-up and the dB attenuation ($\text{ATTEN}_{\text{OFF}}$) setting recorded.

e. ALL MBT electronic systems will then be powered. The attenuator will have XX dB of attenuation initially removed so that the radios will sinc-up. The attenuator will then be adjusted until the same data error rate is achieved. The attenuator (ATTEN_{ON}) setting will be recorded.

f. The difference between the two settings is the loss in sensitivity of the receiving radio as a result of system-generated noise.

A.4.2.5.4 Data Required

a. Visual inspections, logs, test conductor notes, and photographs of the test setup.

b. Baseline check data from MBT checks.

c. Attenuation readings.

d. Bit error rate readings.

A.4.2.5.5 Data Analysis/Procedure. The difference in the two-attenuator settings provides the change in sensitivity as a result of system noise. This will be correlated to a loss in operating distance at high power (with power amplifier) as a percent change and as a loss in ideal distance. The advertised sensitivity of a XXXX radio is –XXX dBm and the ideal range is XX m. The ideal (Friis) transmission equation and data reduction equations are provided below:

$$P_R = \frac{P_T\, G_T\, A_\varepsilon}{4\pi\, R^2}$$

where:

P_r = power received this is defined as radio sensitivity
P_t = power transmitted
G_t = gain of the transmitter
A_ε = effective area of the receiver
R = range in meters

Solving for R^2

$$R^2 = \frac{P_T\, G_T\, A\varepsilon}{4\pi\, P_R}$$

Applying attenuator reading with the MBT powered OFF

$$R_{off}^2 = \frac{P_T\, G_T\, A\varepsilon\;\; ATTEN_{off}}{4\pi\, P_R}$$

R_{OFF} = assigned as a nominal XX m
Applying attenuator reading with the MBT powered ON

$$R_{on}^2 = \frac{P_T\, G_T\, A\varepsilon\;\; ATTEN_{on}}{4\pi\, P_R}$$

Solving the two equations as a ratio to eliminate constant terms

$$\frac{R_{on}^2}{R_{off}^2} = \left[\frac{P_T G_T A\varepsilon\;\; ATTEN_{ON}}{4\pi P_R}\right] X \left[\frac{4\pi P_R}{P_T G_T A\varepsilon\;\; ATTEN_{OFF}}\right] = \frac{ATTEN_{ON}}{ATTEN_{OFF}}$$

$$\frac{R_{on}}{R_{off}} = \sqrt{\frac{ATTEN_{ON}}{ATTEN_{OFF}}}$$

$$R_{ON} = R_{OFF}\sqrt{\frac{ATTEN_{ON}}{ATTEN_{OFF}}}$$

Converting the attenuator settings to dB

$$\frac{R_{ON}}{R_{OFF}} = \sqrt{10^{\left(\frac{ATTENdB_{ON} - ATTENdB_{OFF}}{10}\right)}}$$

$$\frac{R_{ON}}{R_{OFF}} = 10^{\left(\frac{ATTENdB_{ON} - ATTENdB_{OFF}}{20}\right)}$$

$$R_{ON} = R_{OFF} 10^{\left(\frac{ATTENdB_{ON} - ATTENdB_{OFF}}{20}\right)}$$

Finally solving for percent change in nominal distance

$$\%CHANGE = \left(\frac{R_{ON}}{R_{OFF}} - 1\right) X\ 100\%$$

A.4.2.6 High Altitude Electromagnetic Pulse (HEMP)

A.4.2.6.1 Objectives

a. To assess the survivability of the MBT when exposed to a HEMP environment as specified in AEP-4 VOL II and MIL-STD 464A E-field parameters.

b. To update the MBT life-cycle E^3 database and identify the baseline configuration of the MBT for the LCEMS management and control specified in XXXX. This will be accomplished by entering pertinent data, results and information from this HEMP test.

A.4.2.6.2 Criteria

A.4.2.6.2.1 HEMP Levels. The MBT shall perform all its mission essential operational functions following exposure to the HEMP environment specified in XXXX. The MBT shall remain combat effective without component replacement. The tank will be subjected to Early-time (E1) peak electric field intensity from AEP-4 VOL II using the timing parameters of environment E1 of AEP-4 VOL II. The MBT does not have an operate-through requirement; instead, it is allowed to experience upsets that can be re-set by the crew to achieve full operational capability within the allowable downtime of XXXX minutes after the HEMP event. The HEMP criteria levels for the MBT are:

E-field = XXXX [volts/meter]

H-field = XXXX [amp-turns/meter]

Rise Time = XXXX [seconds]

A.4.2.6.2.2 Omission. The HEMP levels are extracted from the AEP-4 VOL II, which is classified NATO SECRET. The HEMP criteria are, therefore, omitted from this document in order to maintain its UNCLASSIFIED status. The criteria are available by contacting XXXX, or by obtaining a copy from the XXXX. The E1 HEMP criterion levels will be provided in the classified Detailed Test Report (DPT).

A.4.2.6.2.3 LCEMS. IAW XXXX and XXXX, a life-cycle program shall be established and implemented for mission critical systems such as the MBT. The production, operation, maturity, maintenance, storage, upgrades, enhancements, ambient environment, and DMS solutions and technology insertions, must not introduce any HEMP susceptibilities or unacceptable levels of degradation into the MBT.

A.4.2.6.3 Test Procedures

A.4.2.6.3.1 General Procedures. The HEMP survivability program for the MBT will include testing at XXX HEMP simulator, the XXXX. The survivability of the MBT to its HEMP criteria level will be assessed by:

a. Performing a pre-test analysis.

b. Establishing its complete performance baseline prior to HEMP testing, using baseline self test checks, Diagnostic tests.

c. Performing detailed bulk current measurements on cables identified in the pretest analysis (external cables, Ports Of Entry (POE) and internal cables).

d. The MBT will be tested in two hull orientations with respect to the electric field vector, i.e., longitudinal axis parallel to electric field vector, and 90 degrees clockwise or perpendicular to the electric field vector. For each hull orientation, the turret will be oriented in two positions, 1) XXXX, and 2) XXXX. In each of these four hull-turret orientations, the tank will be illuminated by a series of HEMP pulses. If no failures occur, the MBT will be illuminated, at a minimum, twice more per each hull-turret orientation configuration or until all data acquisition has been completed.

e. Illuminating the MBT configuration in two orientations, the perpendicular and parallel to the E-field at XX%, XXX% and XXX% of its E-field criterion level depending on the facility and time resources.

f. Illuminating the MBT in a fully operational mode the tank will be fully operational with engine idling, fire control in the Normal mode, and communications, etc., turned ON. The final drive will be disconnected as deemed necessary. All hatches except the drivers will be opened during exposures.

g. Repeating the necessary pre-test baseline checks on the MBT after each illumination.

h. The number of test pulses performed will depend on how many MBT harness shields are monitored for HEMP induced currents. It is planned to measure all accessible cables; no physical changes will be made to access data points. Unacceptable effects will be investigated to quantify, determine the cause, and identify fixes.

i. Most HEMP responses are manifested as system upsets. In the event of an upset the system power will be cycled to determine if normal operation can be restored. If normal operation is restored the illumination will be repeated to verify the effect. If system operation is not restored further investigation will be performed to determine the affected LRU.

j. Documenting upsets, failures, downtime, and corrective actions; most problems induced will be transient upsets and will be correctable by cycling power OFF/ON.

k. Identifying and classifying all failures to the electronic piece-parts/component *level.*

A.4.2.6.3.2 Test Facility. The HEMP testing performed on the MBT SUT will utilize the XXX XXX facility, which generates the E-1 (AEP-4 VOL II) horizontally polarized EM Environment (EME). (A test at a vertically polarized EME facility is recommended.)

A.4.2.6.3.3 Pre-test Analysis. A pre-test analysis will be conducted to:

a. Evaluate and incorporate previous test data and results.

b. Analyze drawings and circuits to identify potentially harmful energy paths.

c. Identify test system's internal configuration.

d. Identify and determine all energy coupling POEs.

e. Analyze grounding schemes and shielded cables to include connectors / backshells.

f. Evaluate deliberate hardening devices and techniques.

g. Define DAS requirements.

h. Identify cables for measurements.

i. Identify test levels, orientations, configurations, and operational modes based on the results of the hardening determination.

A.4.2.6.3.4 System Setup

a. Prior to testing, the MBT configuration will be functionally checked to ensure proper operation. Problems will be documented, reported, and corrected if detrimental to the HEMP survivability assessment program on the MBT.

b. The MBT configuration in a pre-test analysis selected configuration will be placed in the HEMP facility near the center of the test volume for the desired test level. The MBT will then be powered and a functional check performed.

c. A bulk current probe will be placed near (but not attached to) the longest cable run in the unit and a noise measurement taken to establish the data collection base line. This type of base line measurement will be made for all of the current probes.

d. Bulk current measurements will be obtained on cables identified in the pre-test analysis as being potential paths for harmful levels of HEMP induced energy. Pin current measurements will only be collected if a failure is identified and the data will be utilized in a failure analysis and/or to perform corrective actions.

A.4.2.6.3.5 System Test The MBT configuration will be illuminated by a transverse electromagnetic wave whose E-field magnitude is approximately XX% of the HEMP criterion value. After illumination, the MBT will again be checked to establish the functional status of the system. At the completion of each successful test series (all cables measured), the MBT configuration/orientation will be changed to account for energy coupling into different cable layouts and functions in the system. Once the series of orientations, configurations and modes described in Para 2.6.3.1.d have been completed, then the E-field magnitude will be increased to the next E-field criterion level and the test procedures repeated.

A.4.2.6.3.6 Effects Procedure. If an effect/anomaly occurs, it will be documented and diagnosed. Testing will not be continued until the problem is understood, and its effect on the MBT SUT has been assessed as well as potential impacts on the MBT SUT results if testing is continued. If an upset occurs, the MBT power will be cycled OFF/ON. If the SUT fully recovers, testing will be repeated at the same level and test orientation to determine whether the problem was EME induced or an anomaly. Borderline cases may require an additional test exposure or Current Injection (CI) testing to explicitly establish whether the effect was environmentally induced. If the SUT does not recover, then follow-up checks, measurement review, and review of the pre-test analysis will be used to identify the energy path and the affected electronic piece-part/component. If the effect is a failure, diagnostic checks will be performed to determine energy path and victim(s). If the operational status of the SUT can be re-stored, an engineering judgment will be made of potential risk to the SUT if testing is continued. Again, every effort will be made to complete testing.

A.4.2.6.3.7 Environment Measurements. Measurements of each illumination will be made using Electric Flux Density per unit time (D-dot) probes, so that the magnitude of the E-field and pulse shape can be determined. This information will be digitized, reviewed, and stored for later environment compliance analysis. Injected current signals will be measured using a calibrated bulk current probe, reviewed and then stored for later stress level compliance analysis and upset/problem evaluations.

A.4.2.6.4 Data Required

a. Detailed description of each HEMP environment to include photographs of the test facility setup showing test system position relative to the HEMP antenna array.

b. Complete set of pre-test mapping data of each HEMP illumination level with the electric field (E-field) expressed in volts/meter (V/m) (±X%), rise time and pulse width expressed in nanoseconds (nsec) (±X%), frequency expressed in Hertz (Hz)(±X%), and magnetic field (H-field) amplitude expressed in amp-turns/meter (±X%).

c. Detailed description of the MBT functional checks used to baseline the MBT to determine its post-illumination capabilities.

d. Visual inspection, logs, test conductor notes, and photographs.

e. Detailed description and serial numbers of the MBT subsystems.

f. Detailed description and recording of all inspections, downtime and recovery time (sec) (±XX%), and checkout data.

g. Go/no-go log of tank checks from the operator manuals, i.e., self-test (ST), and as needed diagnostic tests with descriptions of discrepancies.

h. Tank physical and operating configuration during each subtest illumination.

i. Log sheets of test illumination to include induced upsets or failures.

j. Description and calibration of current/voltage measuring probes and the Data Acquisition System (DAS). In addition, probe locations used on the MBT during testing are required.

k. Results of all facility environment measurements expressed in the same units as listed in Para A.4.2.6.4.b above.

l. Results of all current and voltage measurements, and Fast Fourier Transforms (FFTs) data obtained from the DAS.

m. Results of previous HEMP and CI tests performed by the contractor or another government agency on the MBT.

n. Detailed description of all deliberate HEMP hardening devices and/or techniques employed on the MBT.

o. Detailed description of the utilized DAS.

p. Percent error incorporated into the DAS.

q. TIRs if applicable.

A.4.2.6.5 Data Analysis/Procedure

A.4.2.6.5.1 Data. The pre-test analysis will consist of evaluating results from the previous MBT HEMP program and reviewing the test system's configuration. Pertinent data, results and information will be incorporated into the test planning of the XXX HEMP program for the MBT. The incorporation of all test data will be used to enhance and reduce the scope of testing. Pertinent data will be included in the XXX failure diagnostics, post-test analysis / assessment, and documented in the detailed test report to support the test results.

A.4.2.6.5.2 Criteria Compliance. The HEMP environmental data from the XXXX facility will be corrected to account for the percent error associated with the DAS:

a. A mean and standard deviation will be established from the error corrected XXX E-field parameters.

b. The H-field parameter will be derived by dividing this mean error corrected XXX E-field parameter by XXX ohms.

c. A mean and standard deviation rise time will be established from the XXX E-field data.

d. The XXX E-field data, test point current data and test point FFTs will be examined using XXXXXX to determine the primary coupling frequency or coupling frequency range, critical damping factor, and energy content.

e. The data in paragraphs A.4.2.6.5.2 a through A.4.2.6.5.2 d will be compared and evaluated against the AEP-4 VOL II E1 HEMP criteria, and criteria compliance will be performed.

A.4.2.6.5.3 System Configuration Compliance. The test system configuration will be evaluated against the expected production configuration and all differences will be identified and documented.

A.4.2.6.5.4 Effects Analysis. Effects will be scored at the test level of occurrence, cause(s) and victim(s) will be identified, and impact(s) on the MBT mission will be discussed. Failures or operational performance degradation occurring at levels above criteria will be classified as system shortcomings, unless verified by additional data and/or energy coupling analysis to be valid as a result of manufacturing variations or assembly. This information will be used primarily to provide the needed level of confidence in the survivability assessment of the MBT to meet its defined criteria.

A.4.2.6.5.5 System Performance. Comparison of pre- and post-illumination functional checkout data for the MBT test system will be used to determine the effects of the HEMP test environment on the MBT. Degradation resulting in system performance outside specifications, or total failure(s), will be addressed with regards to cause(s), victim(s), test level at which they occurred, allowable downtime, and mission impact.

A.4.2.6.5.6 Survivability Assessment. A HEMP survivability assessment will be performed on the production or baseline configuration against the HEMP criteria using the results of paragraphs A.4.2.6.5.2 through A.4.2.6.5.5. This assessment may produce results different than obtained during the testing phase due to corrections for manufacturing variations and/or test environment deficiencies.

A.4.2.6.5.7 LCEMS. Both the configurations for the test system and proposed baseline production system will be stored for LCEMS' configuration (survivability) control and future analyses. In addition, the pertinent test data and results, extrapolated results, and information will be archived in the MBT life-cycle database.

A.4.2.7 Near Strike Lightning (NSL)

A.4.2.7.1 Objectives

a. To assess the survivability of the MBT when exposed to a NSL environment as specified in XXXX and its requirements.

b. To establish the technical database and identify the baseline configuration of the MBT for the LCEMS management and control specified in XXXX.

A.4.2.7.2 Criteria

A.4.2.7.2.1 NSL Levels. The MBT must be able to perform all its mission essential functions following exposure to the XXXX NSL levels. The MBT is allowed to reset if upset with an allowable downtime to be operational within 7 minutes after the NSL event. The NSL criteria levels for the MBT are shown below in Table A.4-6:

Table A.4-6 Typical Indirect Lightning Effects Criteria. (Cloud to Ground)

Near Strike Lightning	
Magnetic Field Rate of Change at XXm	XX A/m/s
Electric Field Rate of Change at XXm	XX V/m/s
Maximum Electric Field at XXm	XX V/m

a. The MBT shall survive and remain combat effective without component replacement.

b. The MBT will be subjected to a peak electric field intensity of XXX kV/m (polarized vertically). This represents a XXX kAmpere lightning stroke (XX percentile) occurring at a distance of XXX meters.

A.4.2.7.2.2 LCEMS. IAW AEP-4 VOL II, a life-cycle program shall be established and implemented for mission critical systems such as the MBT. The production, operation, maturity, maintenance, storage, upgrades, enhancements, ambient environment, and DMS solutions and technology insertions, must not introduce any NSL susceptibilities or unacceptable levels of degradation into the MBT.

A.4.2.7.3 Test Procedures

A.4.2.7.3.1 General Procedures. The NSL survivability program for the MBT will include testing at XXX XXXX lightning simulator. The survivability of the MBT to its NSL criteria level will be assessed by:

a. Performing a pre-test analysis.

b. Establishing its complete performance baseline prior to NSL testing, using baseline self test checks, Diagnostic tests.

c. Performing detailed bulk current measurements on cables identified in the pretest analysis (external cables, Ports Of Entry (POE) and internal cables).

d. The MBT will be tested in two hull orientations with respect to the electric field vector, i.e., longitudinal axis parallel to electric field vector, and 90 degrees clockwise or perpendicular to the electric field vector. For each hull orientation, the turret will be oriented in two positions, 1) XXXX, and 2) XXXX. In each of these four hull-turret orientations, the tank will be illuminated by a series of NSL pulses. If no failures occur, the AIM will be illuminated, at a minimum, twice more per each hull-turret orientation configuration or until all data acquisition has been completed.

e. Illuminating the MBT configuration in two orientations, the perpendicular, parallel to the E-field at XX% and XXX% of its E-field criterion level depending on the facility and time resources.

f. Illuminating the MBT in a fully operational mode the MBT will be fully operational with engine idling, fire control in the Normal mode, and communications, etc., turned ON. The final drive will be disconnected as deemed necessary. All hatches except the drivers will be opened during exposures.

g. Repeating the necessary pre-test baseline checks on the MBT after each illumination.

h. The number of test pulses performed will depend on how many tank harness shields are monitored for NSL induced currents. It is planned to measure all accessible cables; no physical changes will be made to access data points. Unacceptable effects will be investigated to quantify, determine the cause, and identify fixes.

i. Most NSL responses are manifested as system upsets. In the event of an upset the system power will be cycled to determine if normal operation can be restored. If normal operation is restored the illumination will be repeated to verify the effect. If system operation is not restored further investigation will be performed to determine the affected LRU.

j. Documenting upsets, failures, downtime, and corrective actions; most problems induced will be transient upsets and will be correctable by cycling power OFF/ON.

k. Identifying and classifying all failures to the electronic piece-parts/component level.

A.4.2.7.3.2 Test Facility. The lightning facility is capable of generating up to X.X million volts or XXX kA. The facility to be utilized for the MBT is the lightning facility at XXXX. The XXX lightning facility is nominally XX m by XX m in area and is capable of generating a XX % lightning strike.

A.4.2.7.3.3 Pre-test Analysis. A pre-test analysis will be conducted to:

a. Incorporate previous test data and results.

b. Analyze drawings and circuits to determine potentially harmful energy paths.

c. Identify test system's internal configuration.

d. Identify and determine all energy coupling POEs.

e. Analyze grounding schemes and shielded cables to include connectors / backshells.

f. Evaluate deliberate hardening devices and techniques.

g. Define DAS requirements.

h. Identify cables for measurements.

i. Identify test levels, orientations, configurations, and operational modes based on the results of the hardening evaluation.

A.4.2.7.3.4 System Setup

a. Prior to testing, the MBT configuration will be functionally checked to ensure proper operation. Problems will be documented, reported, and corrected if detrimental to the NSL survivability assessment program.

b. A MBT configuration will be placed in the lightning facility test volume to obtain the desired first test level. Once the desired orientation/configuration has been established, the MBT will be powered and a functional check will be performed.

c. A bulk current probe will be placed near (but not attached to) the longest cable run in the unit and a noise measurement will be taken to establish the data collection base line. This type of base line measurement will be made all of the current probes.

d. Bulk current measurements will be collected on those cables identified in the pre-test analysis as being potential paths for harmful levels of NSL induced energy. Pin current measurements will only be collected if a failure is identified and the data will be utilized in a failure analysis and/or to perform corrective actions.

A.4.2.7.3.5 System Test. The MBT will be illuminated by an electromagnetic wave generated by the simulated lightning strike whose peak E-field magnitude is approximately XX% of the XXX kAmperes E-field level (XX% strike). After illumination, the MBT will again be checked to establish the functional status of the system. At the completion of each successful test, the MBT configuration/orientation will be changed to account for the different cable layouts and functions in the system. Once the series of configurations described in Para A.4.2.7.3.1.d has been completed, then the E-field magnitude will then be increased to XXX% the E-field criterion level and, at each of these levels, the procedure repeated.

A.4.2.7.3.6 Effects Procedure. If an effect/anomaly occurs, it will be documented and diagnosed. Testing will not be continued until the problem is understood, and its effect on the MBT SUT has been assessed as well as potential impacts on the MBT SUT and SUT results if testing is continued. If an upset occurs, the MBT power will be cycled OFF/ON. If the SUT fully recovers, testing will be repeated at the same level and test orientation to determine whether the problem was EME induced or an anomaly. Borderline cases may require an additional test exposure or Current Injection (CI) testing to explicitly establish whether the effect was environmentally induced. If the SUT does not recover, then follow-up checks, measurement review, and review of the pre-test analysis will be used to identify the energy path and the affected electronic piece-part/component. If the effect is a failure, diagnostic checks will be performed to determine energy path and victim(s). If the operational status of the SUT can be restored, an engineering judgment will be made of potential risk to the SUT if testing is continued. Every effort will be made to complete testing.

A.4.2.7.3.7 Environment Measurements. Measurements of each illumination will be made using an Electric Flux Density per unit time (D-dot) probe, so that the magnitude of the E-field and pulse shape can be determined. This information will be digitized, reviewed, and stored for later environment compliance analysis.

A.4.2.7.4 Data Required

a. Detailed description of each NSL environment to include photographs of the test facility setup showing test system position relative to the lightning strike.

b. Complete set of pre-test mapping data of each lightning strike level with the E-field expressed in volts/meter (V/m) (±X%), rise time and pulse width expressed in microseconds (μsec) (±X%), frequency expressed in Hertz (Hz)(±X%), and H-field amplitude expressed in amp-turns/meter (±X%).

c. Detailed description of the MBT functional checks used to baseline the MBT to determine its post-illumination capabilities.

d. Complete set of electrical schematics, wiring diagrams, and interconnect diagrams of the MBT.

e. Detailed description, serial numbers, and dimensions of the MBT test subsystems.

f. Visual inspection, logs, test conductor notes, and photographs.

g. Go/no-go log of tank checks from the operator manuals, i.e., self-test (ST), and as needed diagnostic tests with descriptions of discrepancies.

h. Tank physical and operating configuration during each subtest illumination.

i. Log sheets of test illumination to include induced upsets or failures.

j. Detailed description and recording of all inspections, downtime and recovery time (sec) (±XX%) and checkout data.

k. Description and calibration of current / voltage measuring probes and the DAS. In addition, probe locations used on the MBT during testing are required.

l. Results of all facility environment measurements expressed in the same units as listed in Para A.4.2.7.4.b above.

m. Results of all current and voltage measurements, and FFT data obtained from the DAS.

n. Results of previous NSL tests and analysis performed by the contractor or another government agency on the MBT.

o. Detailed description of all deliberate NSL hardening devices and/or techniques employed on the MBT.

p. Detailed description of the utilized DAS.

q. Percent error incorporated into the DAS.

r. TIRs if applicable.

A.4.2.7.5 Data Analysis/Procedure

A.4.2.7.5.1 Data. The pretest analysis will consist of evaluating results from the previous MBT NSL program and reviewing the test system's configuration. Pertinent data, results and information will be incorporated into the test planning of the XXX NSL program for the MBT. The incorporation of all test data will be used to enhance and reduce the scope of testing. Pertinent data will be included in the SVA failure diagnostics, post-test analysis / assessment, and documented in the detailed test report to support the test results.

A.4.2.7.5.2 Criteria Compliance. The NSL environmental data obtained from the Lightning facility will be corrected to account for the percent error associated with the DAS:

a. A mean and standard deviation will be established from the error corrected Lightning E-field parameters.

b. The H-field parameter will be derived by dividing this mean error corrected Lightning E-Field parameter by XXX ohms.

c. The Lightning E-Field data, test point current data, and test point FFTs will be examined using XXXXXX to determine the primary coupling frequency or coupling frequency range, critical damping factor, and energy content.

d. The data in paragraphs A.4.2.7.5.2a through A.4.2.7.5.2c will be compared and evaluated against the MIL-STD 464A NSL criteria and criteria compliance will be performed.

A.4.2.7.5.3 System Configuration Compliance. The test system's configuration will be evaluated against the expected production configuration and all differences will be identified and documented.

A.4.2.7.5.4 Effects Analysis. Effects will be scored at the test level of occurrence, cause(s) and victim(s) will be identified, and impact(s) on the MBT mission will be discussed. Failures or operational performance degradation occurring at levels above criteria will be classified as system shortcomings, unless verified by additional data and/or energy coupling analysis to be valid as a result of manufacturing variations or assembly. This information will be used primarily to provide the needed level of confidence in the survivability assessment of the MBT to meet its defined criteria.

A.4.2.7.5.5 System Performance. Comparison of pre- and post-illumination functional checkout data for the MBT test system will be used to determine the effects of the NSL test environment on the MBT SUT. Degradation resulting in system performance outside specifications, or total failure(s), will be addressed with regards to cause(s), victim(s), test level at which they occurred, allowable downtime, and mission impact.

A.4.2.7.5.6 Survivability Assessment. A NSL survivability assessment will be performed on the production or baseline configuration against the NSL criteria using the results of paragraphs A.4.2.7.5.2 through A.4.2.7.5.5. This assessment may produce results different than obtained during the testing phase due to corrections for manufacturing variations and/or test environment deficiencies.

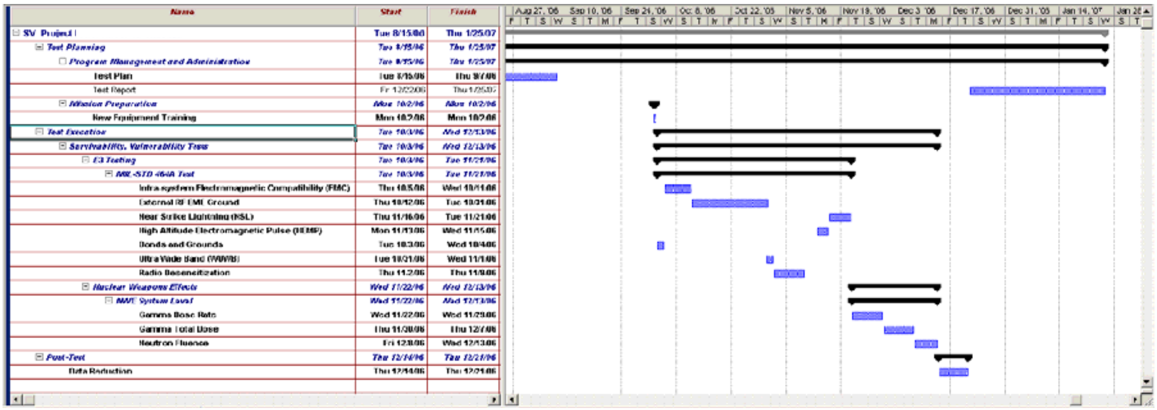
A.4.2.7.5.7 LCEMS. Both the configurations for the test system and the proposed baseline production system will be stored for LCES' configuration (survivability) control and future analyses. In addition, the pertinent test data and results, extrapolated results, and information will be archived in the MBT life-cycle database.

A.4.3 APPENDICES

APPENDIX A.4.A TEST CRITERIA

A classified Appendix A.4.A for the specific MBT, which contains the classified sources and material, is available upon request; if it is not classified, the information is contained herein.

APPENDIX A.4.B TEST SCHEDULE



Name	Start	Finish
SV Project I	Tue 8/15/06	Thu 1/25/07
Test Planning	Tue 8/15/06	Thu 1/25/07
Program Management and Administration	Tue 8/15/06	Thu 1/25/07
Test Plan	Tue 8/15/06	Thu 9/7/06
Test Report	Fri 12/22/06	Thu 1/25/07
Mission Preparation	Mon 10/2/06	Mon 10/2/06
New Equipment Training	Mon 10/2/06	Mon 10/2/06
Test Execution	Tue 10/3/06	Wed 12/13/06
Survivability, Vulnerability Tests	Tue 10/3/06	Wed 12/13/06
E3 Testing	Tue 10/3/06	Tue 11/21/06
MIL-STD 464A Test	Tue 10/3/06	Tue 11/21/06
Intra-system Electromagnetic Compatibility (EMC)	Thu 10/5/06	Wed 10/11/06
External RF EME Ground	Thu 10/12/06	Tue 10/31/06
Near Strike Lightning (NSL)	Thu 11/16/06	Tue 11/21/06
High Altitude Electromagnetic Pulse (HEMP)	Mon 11/13/06	Wed 11/15/06
Bonds and Grounds	Tue 10/3/06	Wed 10/4/06
Ultra Wide Band (UWB)	Tue 10/31/06	Wed 11/1/06
Radio Desensitization	Thu 11/2/06	Thu 11/9/06
Nuclear Weapons Effects	Wed 11/22/06	Wed 12/13/06
NWE System Level	Wed 11/22/06	Wed 12/13/06
Gamma Dose Rate	Wed 11/22/06	Wed 11/29/06
Gamma Total Dose	Thu 11/30/06	Thu 12/7/06
Neutron Fluence	Fri 12/8/06	Wed 12/13/06
Post-Test	Thu 12/14/06	Thu 12/21/06
Data Reduction	Thu 12/14/06	Thu 12/21/06

APPENDIX A.4.C INFORMAL COORDINATION

This test plan was coordinated with the following personnel:

1. XXX
   Telephone # XXX

2. XXX
   Telephone # XXX

3. XXX
   Telephone # XXX

4. XXX
   Telephone # XXX

5. XXX
   Telephone # XXX

APPENDIX A.4.D REFERENCES

1. XXXX.

2. XXXX.

3. XXXX.

4. XXXX.

5. XXXX.

6. XXXX.

7. XXXX.

8. XXXX.

APPENDIX A.4.E ABBREVIATIONS

XXX - XXX XXXX XXXXXX
XXX - XXX XXXX XXXXXX
XXX - XXX XXXX XXXXXX
XXX - XXX XXXX XXXXXX

APPENDIX A.4.F DISTRIBUTION LIST

ADDRESS	**NUMBER OF COPIES**
XXX XXXXXXXXXXX XXXXXXXX	X
XXX XXXXXXXXXXX XXXXXXXX	X
XXX XXXXXXXXXXX XXXXXXXX	X
	Total = X

APPENDIX B. TERMINOLOGY AND REFERENCES

B.1 Definitions

Significant confusion exists in documentation as to the differences between military hardware, platform, system, equipment and components. For the purpose of this Design Guide the following terminology will be used throughout:

Military hardware:	A generic term referring to the platform complete with all its systems or a collection of platforms such as a Brigade HQ.
Platform:	A platform is a structure into which systems are to be installed (e.g., building, aircraft, tank). It can be the bare shell or a platform plus "standard fit" systems into which another system is to be installed.
System/Sub-system:	A set of equipment/modules interconnected to provide a function.
Equipment:	Normally a single electrical/electronic box. However in the new modular electronics concept, the modules forming the equipment may not be located in the same box.
Module:	A sub-unit of a piece of equipment, which is reliant on the equipment for functionality.
Circuit:	The means by which components are electrically connected together.
Component:	The smallest element from which equipment is built – e.g., semiconductor, connector, gasket, filter, or cable.

Figure B.1 shows an illustration of the terminology as applied to an aircraft.

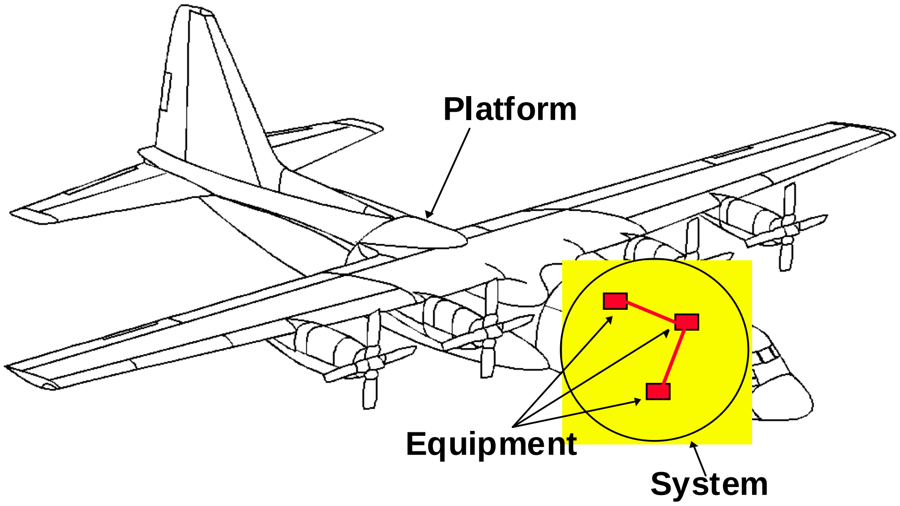


Figure B.1-1 Illustration of Platform/System/Equipment Definition.

B.2 Glossary of Terms

AECTP	Allied Engineering Conditions and Test Publication
AEP	Allied Engineering Publication
C4I	Command, Control, Communications, Computers and Intelligence
COTS	Commercial-Off-The-Shelf

CS	Conducted Susceptibility
CW	Continuous (or carrier) Wave
DCI	Direct Current Injection
E^3	Electromagnetic Environmental Effects
ECM	Electronic Countermeasures
EED	Electro-Explosive Device
EIRP	Equivalent Isotropic Radiated Power
EMC	Electromagnetic Compatibility
EMP	EM Pulse
ESD	Electrostatic Discharge
EM	Electromagnetic
EMH	EM Hazards
EME	EM Environment
EMI	EM Interference
ERP	Effective Radiated Power
EUT	Equipment Under Test
FOUO	For Official Use Only
GFE	Government Furnished Equipment
HARM	Hardness Assurance, Reliability and Maintenance
HEMP	High-altitude EM Pulse
HERO	Hazardous EM Radiation to Ordnance
HIRF	High Intensity Radiated Field
HME	Hazard Monitoring Equipment
HM/HS	Hardness Maintenance/Hardness Surveillance
HPM	High Power Microwaves
IC	Integrated Circuit
IMI	Inter-modulation Interference
INR	Initial Nuclear Radiation
LAN	Local Area Network
LLC	Low Level Coupling
LLSC	LL Swept Current
LLSF	LL Swept Field
LEMP	Lightning EMP
LRP	Loop Resistance Tester
LRU	Line Replaceable Unit
MGV	Mobile Ground Vehicle
MIL-STD	Military Standard
MSCEs	Mission and Safety Critical Electronics
MTS	Modernization-Through-Spares
NDI	Non-developmental Items
NEMP	Nuclear EMP
N^2EMP	Non-Nuclear EMP
PCI	Pulse Current Injection
PRF	Pulse Repetition Frequency
RADSEC	Radiation Security
RF	Radio Frequency
RFW	RF Weapons
RPG	Repetitive Pulse Generator
SAE	Society of Automotive Engineers
SEU	Single Event Upset
SREMP	Source-region EMP
SGEMP	System Generated EMP
TPD	Transient Protection Device
TREE	Transient Radiation Effects in Electronics
UE^3	Unified Electromagnetic Environmental Effects

UE^{3}P	UE^3 Protection
UEME	Unified EME
UWB	Ultra-wideband
WAN	Wide Area Network

B.3 REFERENCES

Allied Engineering Conditions and Test Publication (AECTP) 250, Edition 1, Electrical and Electromagnetic Environmental Conditions, 2009.

AECTP 500, Edition 1, Electrical/Electromagnetic Environmental Effects Test and Verification, 2009.

MIL-STD-461F, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, 10 December 2007.

MIL-STD-464, Electromagnetic Environmental Effects Requirements for Systems, 18 March 1997.

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