ATPD 2407 - ELECTROMAGNETIC ENVIRONMENTAL EFFECTS (E3) FOR US ARMY TANK AND AUTOMOTIVE VEHICLE SYSTEMS TAILORED FROM MIL-STD-464C

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FOREWORD

1. This ATPD has been prepared by the TACOM LCMC Electromagnetic Environmental Effects Requirements Board (E3RB) and is for use in the acquisition of tracked and wheeled tank and automotive vehicle systems.

2. Disclaimer: Reference herein to any specific commercial company, product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the Department of the Army (DoA). The opinions of the authors expressed herein do not necessarily state or reflect those of the United States Government or the DoA, and shall not be used for advertising or product endorsement purposes.

3. Comments, suggestions, or questions on this document should be addressed to U.S. Army Tank automotive and Armaments Command, ATTN: RDTA-EN/STND/TRANS, MS# 268, 6501 E. 11 Mile Road, Warren, MI 48397 5000 or emailed to usarmy.detroit.rdecom.mbx.tardec-standardization@mail.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at http://assist.daps.dla.mil.

1 SCOPE

1.1 Scope.

This Army-Tank Purchase Description (ATPD) tailors MIL-STD-464C, "Electromagnetic Environmental Effects (E3) Requirements for Systems." It establishes requirements and verification criteria for tanks and automotive systems based on the applicable ground system requirements of MIL-STD-464C.

The requirements and verification criteria of this document apply to ordnance only as integrated to Army tank and automotive platforms; not individual items of ordnance.

1.2 Application.

This ATPD is applicable for complete Army tank and automotive systems, both new and modified.

2 APPLICABLE DOCUMENTS

2.1 General.

The documents listed in this section are referenced in sections 3, 4, and 5 of the main body of this document. This section does not include documents referenced in other sections of this document or recommended for additional information or examples. While every effort has been made to ensure completeness of this list, document users are cautioned that applicable systems must meet all specified requirements of documents cited in sections 3, 4, and 5 of this document, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards and handbooks.

The following specifications, standards and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract (see 6.2).

INTERNATIONAL STANDARDIZATION AGREEMENTS

NATO AECTP-500 - Electromagnetic Environmental Effects Test and Verification

(Copies of this document are available from http://nsa.nato.int/nsa/ or NATO Standardization Agency, North Atlantic Treaty Organization HQ, 1110 Brussels, Belgium, or as directed by the contracting officer.)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-188-141	-	Interoperability and Performance Standards for Medium and High Frequency Radio Systems
MIL-STD-188-181	-	Interoperability Standard for Access to 5-kHz and 25-kHz UHF Satellite Communications Channels
MIL-STD-188-182	-	Interoperability Standard for UHF SATCOM DAMA Orderwire Messages and Protocols
MIL-STD-188-183	-	Interoperability Standard for Multiple-Access 5-kHz and 25-kHz UHF Satellite Communications Channels
MIL-STD-331	-	Fuze and Fuze Components, Environmental and Performance Tests for
MIL-STD-461	-	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-464	-	Electromagnetic Environmental Effects (E3) Requirements for Systems
MIL-STD-1472	-	Human Engineering
MIL-STD-2169	-	High-Altitude Electromagnetic Pulse (HEMP) Environment

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-235-1	-	Military Operational Electromagnetic Environment Profiles, Part 1, General Guidance
MIL-HDBK-235-4	-	External Electromagnetic Levels for Ground Systems
MIL-HDBK-235-8	-	External Electromagnetic Levels for High Power Microwave Systems
MIL-HDBK-240	-	Hazards of Electromagnetic Radiation to Ordnance (HERO) Test Guide

(Copies of these documents are available from https://assist.dla.mil/quicksearch/ or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094. MIL-STD-2169 is classified and requests for this document shall be referred to the Defense Threat Reduction Agency, 8725 John J. Kingman Road, Stop 6201, Ft. Belvoir, VA 22060. See MIL-HDBK-235-1 for instructions on requesting copies of MIL-HDBK-235-4 and MIL-HDBK-235-8.)

2.2.2 Other Government documents, drawings, and publications.
The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract (see 6.2).

DEPARTMENT OF DEFENSE

DoDD 3222.3	-	DoD Electromagnetic Environmental Effects (E3) Program
DoDI 6055.11	-	Protecting Personnel from Electromagnetic Fields
DoD 4145.26-M	-	DOD Contractor's Safety Manual for Ammunition and Explosives

(Copies of these documents are available from http://www.dtic.mil/whs/directives/index.html.)

NSTISSAM

CNSS TEMPEST 01-02	-	Advisory Memorandum, NONSTOP Evaluation Standard
NSTISSAM TEMPEST/1-92	-	Compromising Emanations Laboratory Test Requirements, Electromagnetics
NSTISSAM TEMPEST/2-95A	-	RED/BLACK Installation Guide

(Copies of CNSS and NSTISSAM documents are classified and available only through the procuring activity.)

2.3 Non-Government publications.
The following publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those sited in the solicitation or contract (see 6.2).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C63.14	-	American National Standard Dictionary of Electromagnetic Compatibility (EMC) including Electromagnetic Environmental Effects (E3)

(Copies of these documents are available from www.ansi.org or ANSI Customer Service Department, 25 W. 43rd Street, 4th Floor, New York, NY 10036.)

EUROPEAN UNION COMMISSION DIRECTIVE

2004/104/EC	-	Official Journal of the European Union Commission Directive

(Copies of these documents are available from http://eur-lex.europa.eu/)

SAE INTERNATIONAL

SAE-J1645 - Society of Automotive Engineers (SAE) Fuel Systems and Components-Electrostatic Charge Mitigation

(Copies of these documents are available from www.sae.org or SAE Customer Service, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

2.4 Order of precedence.
In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been established.

3 DEFINITIONS.

The terms used in this ATPD are defined in MIL-STD-464C and ANSI Standard C63.14. In addition, the following definitions are applicable for the purpose of this ATPD.

3.1 Electromagnetic Environment (EME).
The official DoD definition of EME is "the resulting product of the power and time distribution, in various frequency ranges, of the radiated or conducted electromagnetic emission levels that may be encountered by a military force, system, or platform when performing its assigned mission in its intended operational environment." (DoDD 3222.3)

For the purpose of clarification, the EME includes emitters of electromagnetic radiation both external to the system as well as integral to the system.

3.2 Platform.
For the purposes of this ATPD, a platform is a tracked or wheeled vehicle, and is considered a system.

3.3 Instrumented Electrically Initiated Device (EID).
The laser and ordnance firing mechanisms, fire extinguishers, training pyrotechnics, and airbag igniters instrumented to include instrumented dummy/inert EID ordnance placed in the breech and in the ammunition storage.

4 GENERAL REQUIREMENTS

4.1 General.
General requirements shall be in accordance with MIL-STD-464C.

4.2 Verification.
This ATPD, in conjunction with the guidance presented in MIL-STD-464C Appendix A, provides the information necessary to successfully verify compliance of Army tank and

automotive systems with the tailored requirements of MIL-STD-464C as described in this document.

4.3 System operation during E3 testing.

Validation of system operation during E3 testing requires a disciplined, consistent, and repeatable approach to ensure system performance requirements are met. Identify the step-by-step procedures necessary to operate and exercise the system during testing and post-test inspection for pass/fail or "go/no go" criteria. These procedures shall be consistent with the applicable performance specification(s), operational doctrine, etc. and be repeatable during E3 testing. Procedures may need to consider different modes of system operation.

These procedures shall address system aspects as applicable. This includes safety critical functions, mission essential functions, ordnance firing mechanisms, communication busses and all life cycle aspects of the platform, including (as applicable) production, normal in-service operation, communications at maximum output power, checkout, upgrades/modernization, training, maintenance and repairs, obsolescence and technology insertions, storage, transportation, handling, packaging, loading, unloading, launch, and the normal operating procedures associated with each aspect.

System functions exercised as part of the step-by-step procedures shall be monitored to determine system response(s) to test stimulus. This monitoring may include real-time observation of system instruments by personnel or automated data acquisition systems.

Where applicable, dwell or exposure times to test stimulus shall be equal to or greater than the slowest cycle time of the system and installed subsystems. This is necessary to ensure the exposure time to a test stimulus is sufficient to elicit a response based on known system time constants or latencies. Dwell times may need to be reduced to limit personnel exposure to RF energy (Section 4.4).

All procedures developed to exercise the system shall be validated for suitability and fitness of purpose prior to their use during E3 testing.

4.4 Protection of personnel from electromagnetic fields.

Limit electromagnetic radiation exposure of personnel during testing to meet the requirements of hazards of electromagnetic radiation to personnel (HERP) for personnel safety in accordance with DoD Instruction 6055.11. This is applicable to all tests contained in this document where radio frequency (RF) is generated external to or by subsystems as installed on the platform.

5 DETAILED REQUIREMENTS

This section specifies the E3 requirements for tanks and automotive systems. Each system requirement includes verification methods that determine the effectiveness of the EMC design and support the E3 system tests that are typically performed by a DoD test facility. An overall

assessment shall be performed, such as systems engineering analysis, of the applicability and sequence of each requirement and verification.

5.1 Margins.

5.1.1 Requirement.
The requirements for margins shall be in accordance with MIL-STD-464C.

5.1.2 Verification.
Compliance shall be verified through test and analysis.

Margins can be applied to the stimulus field and can sometimes be applied to the system response. Often the stimulus test device cannot produce the required field strengths with margin and the system response must be extrapolated to simulate the required levels. The margin measurements shall be performed without extrapolation whenever possible. Instrumentation installed in system components during testing for margins shall capture the maximum system response and shall not adversely affect the normal response characteristics of the component. When environment simulations below specified levels are used, instrumentation responses may be extrapolated to the full environment for components with linear responses (such as hot bridgewire EIDs). When the response is below instrumentation sensitivity, the instrumentation sensitivity shall be used as the basis for extrapolation. For components with non-linear responses (such as semiconductor bridge EIDs), no extrapolation is permitted.

5.2 Intra-system electromagnetic compatibility (EMC).

5.2.1 Requirement.
The requirements for intra-system electromagnetic compatibility shall be in accordance with MIL-STD-464C.

5.2.2 Verification.
Compliance shall be verified through analysis, inspection, and test.

The intra-system test should be performed in an electromagnetically quiet environment.

Prior to intra-system EMC testing:

a) Verify the test vehicle/system and all subsystems are functional and parameters to be monitored during the test are within their nominal operating ranges by using the procedures developed in accordance with Section 4.3.
b) Verify the bonds and grounds tests (see Section 5.11.2) have been successfully completed on the test vehicle.
c) Inspect all antennas to verify proper installation.

d) Verify the output power and receiver sensitivity of the radios installed in the test platforms comply with their specified requirements. Emitters shall transmit at typical power levels.

Analysis shall determine the source and victim subsystems.

Compliance shall verify that:

a) Each victim operates as specified with worst case emissions from each separate source.
b) All victims operate as specified with worst case emissions from all sources combined.

5.2.3 Hull generated intermodulation interference (IMI).
This requirement of MIL-STD-464C is not applicable.

5.2.4 Shipboard internal electromagnetic environment (EME).
This requirement of MIL-STD-464C is not applicable.

5.2.5 Multipaction.
This requirement of MIL-STD-464C is not applicable.

5.2.6 Induced levels at antenna ports of antenna-connected receivers.

5.2.6.1 Requirement.
The requirements for induced levels at antenna ports of antenna-connected receivers shall be in accordance with MIL-STD-464C.

For each antenna/receiver system mounted to the vehicle, and with the Minimum Received Signal (MRS) set to the value of TABLE I, the voice quality shall not degrade below a modified rhyme test (MRT) score of 91% in accordance with MIL-STD-1472. The data throughput shall not degrade to a level below the acceptable level of TABLE I.

TABLE I. Minimum received signal.

Communication Standard or Frequency Range (MHz)	Minimum Received Signal (dBm)	Error Rate	Throughput (Kbps)
MIL-STD-188-141 2.0-29.9999	-111[1)]	N/A	N/A
30-87.975	-86	5.0E-2 (Data)	0.6-2.4 4.8 6.0
MIL-STD-188-181, 182, and 183	Satellite[1)]	1.0E-3	2.4
1575.42 (L1) 1227.60 (L2)	-131.5[1)] -134.5[1)]	FOM<3	N/A
420-450	-92	1.0E-1 (Data)	155

1) These specifications are taken from the associated standard or Interface Control Document. Verification/validation of performance of these devices as installed on the system will require the use of the actual radio set.

5.2.6.2 Verification.
Compliance shall be verified through analysis and test.

Analysis shall identify the antenna connected receivers, antennas and the antenna placement for the system. The criterion of TABLE I shall be determined for any platform mounted communication systems that are not identified in TABLE I.

The vehicle under test shall be operated with all subsystems on and in modes found by analysis to be of greatest potential to degrade antenna connected receiver performance. More than one mode may be required. These modes of operation shall be consistent with the procedures developed in accordance with Section 4.3.

Verify the test vehicle/system and all subsystems are functional and parameters to be monitored during the test are within their nominal operating ranges by using the procedures developed in accordance with Section 4.3.

Analysis shall determine the worst-case frequencies and hop sets. Electromagnetic spectrum plots will be generated to determine electromagnetic noise levels at all vehicle mounted antennas.

The intra-system pre-test requirements of Section 5.2.2 shall be applicable. The test shall be performed in two phases. Data from the first phase shall be analyzed and used to determine the frequencies that pose the greatest risk of receiver degradation for testing in the second phase. Select the frequency bands that indicate the highest level of interference from the internal EME.

1) Phase 1 – Spectrum Measurements
This test shall include the entire frequency band of each antenna-connected receiver for all potential sources of unintentional RF emissions, including potential spurious emissions from out-of-band transmitters. The induced levels at each antenna port for antenna-connected receivers shall be evaluated as follows:

a) The ambient emissions levels at the antenna port of the receiver under test shall be measured. Measurements shall be performed with a spectrum analyzer (or an equivalent type of frequency selective equipment) at the antenna port of the receiver.
b) The emission levels at the antenna port of the receiver under test shall be measured while the system is operated in each applicable mode using the procedures developed in accordance with Section 4.3. Transmitters outside the frequency band of interest for the antenna port under test shall be actively radiating signals, the engine shall be running and the electrical subsystems shall be operating while the measurements are performed.
c) Compare the measured emissions levels to the ambient noise level at the receivers to determine the frequency bands where it may be susceptible to potential degradation.

2) Phase 2
This test shall be performed to determine the impact of unintentional RF emissions on communications as follows:

a) A radio link shall be established between a fixed transmitter external to the system and the receiver installed on the system. The transmitting signal shall be attenuated to measure the worst case Minimum Received Signal of TABLE I at the receiving antenna.
b) Evaluate the performance of each communication system using the criteria specified in Section 5.2.6.1 over the frequency bands determined in Phase 1. The performance shall comply with the system's operational voice, throughput or data rate requirements.
c) The modified rhyme test (MRT) as specified in MIL-STD-1472 shall be used to measure the speech intelligibility of voice communication systems. A data traffic generator modulation source and a Bit Error Rate (BER) analyzer should be used to measure the BER of the data communication systems.

5.3 External RF EME.

5.3.1 Requirement.
The system shall be electromagnetically compatible with its defined external RF EME such that its system operational performance requirements are met.

EME requirements for tank and automotive systems shall comply with TABLE II. A minimum of 3 dB margin shall be added to the maximum EME values in TABLE II. Margins for EIDs, safety critical and mission critical functions shall be in accordance with MIL-STD-464C.

TABLE II Maximum external EME for tank and automotive systems.

Frequency Range (MHz)		Electric Field (V/m RMS)	
		Peak	Average
0.01	2	50	50
2	30	103	103
30	150	57	57
150	225	50	50
225	400	58	58
400	700	98	98
700	790	50	50
790	1000	284	50
1000	2000	2452	134
2000	2700	489	50
2700	3600	1148	191
3600	4000	489	50
4000	5400	645	129
5400	5900	6146	155
5900	6000	549	55
6000	7900	549	55
7900	8000	549	97
8000	8400	1095	110
8400	8500	1095	110
8500	11000	1943	139
11000	14000	3454	103
14000	18000	7897	243
18000	50000	2793	73

The EME shall be emitted at discrete frequencies in steps. A minimum of 350 discrete frequencies between 10 kHz and 50 GHz is recommended for each vehicle orientation. This should include a mix of average power (275 frequencies) and peak power (75 frequencies), the exact mixture of which is platform dependent. These test frequencies shall encompass the representative HERO test frequencies of MIL-HDBK-240 as shown in TABLE III of this document, and the number of test steps within the associated frequency bands defined in TABLE IV of this document.

TABLE III HERO EME test frequencies.

Frequency (MHz)								
2.00	8.00	32	57	100	400	1000	3672	9300
2.30	9.19	34	60	115	438	1155	4243	10098
2.64	10.56	36	63	132	480	1335	4902	11668
3.03	12.13	38	67	152	527	1543	5665	13482
3.48	13.93	40	71	174	577	1783	5950	15578
4.00	16.00	43	75	200	632	2060	6545	18000
4.59	18.38	45	80	230	693	2380	7563	26500
5.28	21.11	48	84	264	760	2750	7950	33000
6.06	24.25	50	89	303	833	2950	8200	39000
6.96	27.86	53	94	348	912	3178	8500	

TABLE IV Number of required discrete emitter frequencies for external RF EME.

Frequency Band(s) (MHz)	Minimum Number of Steps Required within the Frequency Band(s)
2 – 30	30
30 – 60, 60 -88	10 (within each band)
225 – 290, 290 – 320, 320 - 400	4 (within each band)
406 – 420, 450 – 549	4 (within each band)
420 – 450	5
755 – 985	10
1307.5 +/- 0.5	1 (include specified frequency)
3249.9 +/- 0.5	1 (include specified frequency)
4400 – 5000	8
5637.5 +/- 0.5	1 (include specified frequency)
5650 +/- 0.5	1 (include specified frequency)
7900 – 8400	3
9100 +/- 0.5	1 (include specified frequency)
13080 +/- 0.5	1 (include specified frequency)
14900 +/- 0.5	1 (include specified frequency)
16600 +/- 0.5	1 (include specified frequency)

The remaining frequencies shall be chosen based on known electromagnetic vulnerabilities (EMV) of the vehicle. Smaller, roughly proportional steps shall be used at lower frequencies between 0.01MHz and 1GHz (approximately 75% of the steps should be below 1GHz). Larger, roughly proportional steps shall be used at higher frequencies greater than 1GHz. Pulse

modulation parameters specified in MIL-HDBK-235-4 (classified) should be utilized as needed. Modulation types defined in TABLE V shall be used for non-pulse modulations when specific emitter characteristics are not available.

Analysis shall identify frequencies that have the potential to damage the front-end circuitry of platform-installed receivers and cause receiver burnout. The receivers shall be protected from damage at these frequencies during EME testing.

TABLE V Non-pulse waveform modulation type.

Frequency (MHz)	Modulation Type
0.01 – 1.99	CW, AM
2 – 19.9	CW, AM
20 – 149.9	CW, AM, FM
150 – 249.9	AM, FM
250 – 499.9	AM, FM
500 – 999.9	AM, FM
1000 – 1999.9	AM, FM
2000 – 3999.9	AM, FM
4000 – 7999.9	AM, FM
8000 – 9999.9	AM, FM
10000 – 50000	CW, FM
NOTES: CW = Continuous Wave FM = Frequency Modulation. Below 1 GHz use a 20 kHz deviation, modulated by 1 kHz tone. Above 1 GHz use 1 MHz deviation, modulated by a 10 kHz square wave AM = Amplitude Modulation. Modulated by a 1 kHz, 50% modulation	

The EME simulator should radiate sequentially in both vertical and horizontal polarization. Vertically polarized illuminations should be performed below 30MHz and both horizontal and vertical polarizations should be performed above 30MHz.

Continuous sweep EME illumination and more aggressive margins should be used for supplemental testing critical and safety critical subsystems. MIL-STD-461 susceptibility tests of a critical subsystem hot mockup, like fire control, should be considered to determine additional potential vulnerability frequencies. Note that system-level tests tests may be less rigorous (e.g.: exposed to fewer discrete test frequencies) as compared to MIL-STD-461 susceptibility tests performed on the subsystems.

An assessment shall be developed to determine which system functions may be allowed to exhibit degraded performance, but return to normal operation after the external EME is removed. If there are operational performance issues with the absolute need for a subsystem to be totally functional in a particular environment, measures (such as external filters) shall be implemented in the system design and the definition of the appropriate methods to verify the subsystem performance shall be provided.

An EMV assessment shall be performed to determine the impact of the observed susceptibility (during test) on system operational performance (post test analysis).

5.3.2 Verification.
Compliance shall be verified through test and analysis.

Prior to External RF EME testing:

a) Verify the test vehicle/system and all subsystems are functional and parameters to be monitored during the test are within their nominal operating ranges by using the procedures developed in accordance with Section 4.3.
b) Verify the bonds and grounds tests (see Section 5.11.2) have been successfully completed on the test vehicle.
c) Verify the intra-system EMC verification (see Section 5.2.2) has been successfully completed on the test vehicle.
d) Identify the procedure(s) as developed in accordance with Section 4.3 to be performed by the vehicle crew which exercise and monitor the functions that may be susceptible to degradation caused by external RF EME.

During External RF EME testing, the system shall be powered and operational. The system shall be tested with vehicle hatches, doors and windows open. Operate and monitor the system using the procedures developed in accordance with Section 4.3.

The external EME tests should be performed in an open area test site. Where feasible, the main 3dB beamwidth of the antenna used to expose the platform to the EME shall be wider than the maximum dimension of the system. Use both vertical and horizontal polarization for frequencies above 30 MHz; only vertical polarization is necessary below 30 MHz.

System orientations that exhibit the worst-case coupling of EME into the system and subsystems based on analysis shall be tested. Consideration shall be given to HERF and HERO requirements when determining the system orientations to be tested; spot illumination of specific areas should be considered.

The EME as defined in paragraph 5.3.1 (peak and average) shall be used as stimulus for the test.

The laser and ordnance firing mechanisms, fire extinguishers, training pyrotechnics, and airbag igniters shall be instrumented, and instrumented dummy EID ordnance shall be placed in the

breech and in the ammunition storage. The instrumented EID circuit shall be monitored during all EME test frequencies and demonstrated that any RF-induced energy in an EID circuit will not exceed a level expressed as a margin in dB below the maximum no-fire threshold sensitivity for the EID concerned. Refer to MIL-HDBK-240 for guidance on instrumentation of EIDs. A 16.5 dB MNFS margin shall be used for safety concerns and a 6dB MNFS margin for reliability concerns.

5.4 High-power microwave (HPM) sources.

5.4.1 Requirement.
The system shall meet its operational performance requirements after being subjected to the wideband HPM environments. Safety critical and mission critical functions, including mobility, shall not be degraded while being subjected to the HPM environment. The system shall meet its operational performance requirements after being subjected to the wideband HPM environments. TABLE VI, the HPM environment derived using guidance from MIL-STD-464C Appendix A, shall be used to demonstrate compliance with the HPM requirements for tank and automotive systems.

TABLE VI Wideband HPM for tank and automotive systems.

Frequency Range (MHz)		Broad-Band Electric Field Distribution (mV/m/MHz@100m)
150	225	234000
225	400	234000

5.4.2 Verification.
Compliance shall be verified through test and analysis. The safety critical, mission critical and mobility functions shall be monitored while the system is being illuminated to verify that these systems do not degrade during illumination.

Prior to HPM testing:

a) Verify the test vehicle/system and all subsystems are functional and parameters to be monitored during the test are within their nominal operating ranges by using the procedures developed in accordance with Section 4.3.
b) Verify the bonds and grounds tests (see Section 5.11.2) have been successfully completed on the test vehicle.
c) Verify that the intra-system EMC verification (see Section 5.2.2) has been successfully completed on the test vehicle.
d) Identify the procedure(s) as developed in accordance with Section 4.3 to be performed by the vehicle crew which exercise and monitor the functions that may be susceptible to HPM degradation. The functional modes more susceptible to HPM or while operational

shall be identified so the system can be placed in these modes during the test. At a minimum, the engine shall be running, and all subsystems shall be powered. These procedures shall be used to verify a good system and detect any system degradation after the HPM transient.

e) Evaluate the need (with suggested probe placement) for making internal field measurements (crew compartment, ordnance storage, power lines, cables etc.) during the test. A procedure to monitor the system functions required to operate during test illumination shall be defined. Ordnance firing mechanisms, ammunition compartments, training pyrotechnics, safety and mission critical functions shall be a priority in this analysis.

During HPM testing, use the exact threat waveforms or as close as technically feasible to the exact waveforms that are defined for each threat in MIL-HDBK-235-8 (Classified) for red force HPM. A wideband waveform such as double exponentials that cover the Broad-Band Electric Field Distribution can also be used.

The tests shall be performed in an open area test site. The HPM environment shall illuminate the system for a duration determined by analysis to expose any system vulnerabilities. The critical incidence(s) of illumination shall be determined through a coupling analysis of the system.

The system shall be operating and the vehicle hatches and windows shall be open when illuminated by the HPM environment. Operate and monitor the system using the procedures developed in accordance with Section 4.3. Additional testing may be performed with the vehicle in various operating modes and conditions (hatches closed, windows closed etc.). System degradations, latch-up and permanent degradation shall be considered potential failures that shall be evaluated and reported to the procuring activity for a pass/fail disposition.

Some subsystems may require test personnel in the vehicle operating the subsystems, such as the stabilization and fire control, and to verify that the safety critical, mission critical and mobility functions are not degraded during the test illumination. Refer to Section 4.4 of this document for additional details on the protection of test personnel. The operational verification procedure shall be performed before and after each test.

The laser and ordnance firing mechanisms, fire extinguisher, training pyrotechnics, airbag igniters and other EIDs shall be instrumented. Instrumented dummy EID ordnance shall be placed in the breech, launcher and all ordnance storage locations. The instrumented circuits shall be monitored during the transient field test and demonstrated that any RF-induced energy in the circuit will not exceed a level expressed as a margin in dB below the maximum no-fire threshold sensitivity for the EID or cause other safety/reliability concerns. Refer to MIL-HDBK-240 for guidance on instrumentation of EIDs. A 16.5 dB MNFS margin shall be used for subsystems with safety concerns and a 6dB MNFS margin shall be used for reliability concerns.

5.5 Lightning.

5.5.1 Requirement.
The system shall remain safe during the direct effects of lightning. Ordnance that is integrated to the system shall meet its operational performance requirements after experiencing a direct strike in a stored condition. Ordnance that is integrated to the system shall remain safe during and after experiencing a direct strike in an exposed condition. Stored ordnance is defined as being within the systems ammunition storage compartment with all access doors closed; otherwise the ordnance is considered exposed.

The system shall meet its operational performance requirements after the indirect effects of lightning and remain safe during the indirect effects of lightning. Ordnance that is integrated to the system shall meet its operational performance requirements after experiencing a near strike in an exposed condition. The distance for the near strike lightning shall be ten (10) meters.

5.5.2 Direct Strike Verification.
Compliance shall be verified through test and analysis.

A direct strike lightning test environment as defined in accordance with MIL-STD-464 shall be performed on the vehicle and subsequently be visually inspected for induced damage. Instrumentation shall monitor the safety critical functions during the direct strike. The test instrumentation shall be evaluated and the operational verification procedures developed in accordance with Section 4.3 shall be performed before and after each lightning discharge.

Prior to Direct Strike Lightning testing:

a) Verify the test vehicle/system and all subsystems are functional and parameters to be monitored during the test are within their nominal operating ranges by using the procedures developed in accordance with Section 4.3.
b) Verify the bonds and grounds tests (see Section 5.11.2) have been successfully completed on the test vehicle.
c) Verify the intra-system EMC verification (see Section 5.2.2) has been successfully completed on the test vehicle.
d) Identify the procedure(s) as developed in accordance with Section 4.3 to be performed which exercise and monitor the functions that may be susceptible to degradation after the Direct Strike Lightning transient. These procedures shall be used to verify a good system and detect any system degradation after the Direct Strike Lightning transient.

Analysis shall determine the most probable strike points on the system. The strike points shall include those which would be most susceptible to damage or most likely to cause safety problems or operational reliability problems. Safety and vulnerability analysis shall determine the number/types/locations of dummy ordnance EID to employ for direct strike tests. Ordnance firing mechanisms, ammunition compartments, turret movement and safety critical functions shall be considered in the analysis.

Ordnance, devices with EIDs, laser firing mechanisms, fire extinguisher, training pyrotechnics and airbag igniters shall be instrumented. Instrumented dummy ordnance shall be placed in the breech, launcher and in ordnance storage locations as determined by the analysis. The instrumented circuit shall be monitored during the transient field test and demonstrated that RF-induced energy in the circuit, induced by the lightning simulator, will not exceed a level expressed as a margin in dB below the maximum no-fire threshold sensitivity for the EID or other safety concerns. Refer to MIL-HDBK-240 for guidance on instrumentation of EIDs. A 16.5 dB margin shall be used for safety concerns and a 6dB margin for reliability concerns.

5.5.3 Near Strike Verification.
Compliance shall be verified through test and analysis.

An indirect strike lightning test environment as defined in accordance with MIL-STD-464C shall be performed on the vehicle and subsequently be visually inspected for induced damage.

Prior to Near Strike Lightning testing:

a) Verify the test vehicle/system and all subsystems are functional and parameters to be monitored during the test are within their nominal operating ranges by using the procedures developed in accordance with Section 4.3.
b) Verify the bonds and grounds tests (see Section 5.11.2) have been successfully completed on the test vehicle.
c) Verify the intra-system EMC verification (see Section 5.2.2) has been successfully completed on the test vehicle.
d) Identify the procedure(s) as developed in accordance with Section 4.3 to be performed which exercise and monitor the functions that may be susceptible to degradation after the Near Strike Lightning transient. At a minimum, the engine shall be running and all subsystems shall be powered. These procedures shall be used to verify a good system and detect any system degradation after the Near Strike Lightning transient.

Analysis of the coupling effects shall predict susceptible circuits, identify susceptible apertures and predict where high energy may penetrate the system. The critical system test orientation and added test methods (such as using seam leakage sniffers prior to system test) will be determined based on the coupling analysis.

Safety and vulnerability analysis shall determine the number/types/locations of dummy ordnance EID to employ for direct strike tests. Ordnance firing mechanisms, ammunition compartments, turret movement and safety critical functions shall be considered in the analysis. The system shall be placed in the operating mode defined by the coupling analysis and operated using the procedures developed in accordance with Section 4.3.

Current injection tests (with suggested probe placement) on power lines and cables shall be performed if system vulnerabilities are suspected. The functional modes more susceptible to E3 shall be identified so the system can be placed in these modes during the test. A procedure to

monitor the system functions that are required to operate during test illumination shall be defined. Ordnance firing mechanisms, ammunition compartments, training pyrotechnics, turret movement, air bag igniters, safety and mission critical functions shall be a priority in this analysis.

Vehicle hatches, doors, and windows shall be open when illuminated by the test transient. Additional testing can be performed with the vehicle in various operating modes and conditions (hatches closed, windows closed, etc.).

The tests shall be performed in an open area test site. A bounded wave simulator that provides a uniform field over the entire system will be utilized. The test orientations shall include head, lateral and other critical incidence as determined by the coupling analysis. The transient shall illuminate the system not less than three (3) times for each orientation.

Some subsystems may require test crew in the vehicle operating the subsystems, such as the stabilization and fire control subsystems, during the test illumination. Refer to Section 4.4 of this document for additional details on the protection of test personnel.

The operational verification procedure shall be performed before and after each test. System degradations, latch-up and permanent degradation shall be considered potential failures that shall be evaluated and reported to the procuring activity for a pass/fail disposition.

The laser and ordnance firing mechanisms, fire extinguisher, training pyrotechnics, airbag igniters and other EIDs shall be instrumented. Instrumented dummy EID ordnance shall be placed in the breech, launcher and all ordnance storage locations. The instrumented circuits shall be monitored during the transient field test to demonstrate that any RF-induced energy in the circuit will not exceed a level expressed as a margin in dB below the maximum no-fire threshold sensitivity for the EID or cause other safety/reliability concerns. Refer to MIL-HDBK-240 for guidance on instrumentation of EIDs. A 16.5 dB MNFS margin shall be used for subsystems with safety concerns and a 6dB MNFS margin shall be used for reliability concerns.

5.6 Electromagnetic pulse (EMP).

5.6.1 Requirement.
The requirements for EMP shall be in accordance with MIL-STD-464C. After exposure to the EMP environment and after recycling the vehicle master power all functions shall be operational with no degradation.

5.6.2 Verification.
The system shall be tested with vehicle hatches and windows open. The EMP tests shall be performed in an open area test site. The EMP transient shall be defined by MIL-STD-2169 (classified). The EMP shall illuminate the entire vehicle. The verification methods of paragraph 5.5.3 shall be used for the EMP verification.

5.7 Subsystems and equipment electromagnetic interference (EMI).

5.7.1 Requirement.
Individual electronic, electrical, and electromechanical subsystems and equipment shall conform to requirements as specified for Army ground platforms by MIL-STD-461.

5.7.2 Verification.
Compliance shall be verified through subsystem and equipment testing in accordance with MIL-STD-461. Test results shall be reviewed to verify compliance to the MIL-STD-461 requirements. Test results which show a passing result, but fall within the uncertainty of the applied measurement system, shall be identified. The system function(s) supported by the identified subsystem(s) and equipment shall be considered when developing the test plan for system-level E3 tests.

5.7.3 Non-developmental items (NDI) and commercial items.

5.7.3.1 Requirement.
NDI and commercial items shall meet the requirements as specified for ground systems by MIL-STD-461.

5.7.3.2 Verification.
Compliance shall be verified as in Section 5.7.2.

5.7.4 Shipboard DC magnetic field environment.
This requirement of MIL-STD-464C is not applicable.

5.8 Electrostatic charge control.

5.8.1 Requirement.
The system shall safely control and dissipate the build-up of electrostatic charges caused by fluid flow, air flow, exhaust gas flow, personnel charging, track static and other charge generating mechanisms to avoid fuel ignition, inadvertent detonation or dudding of ordnance hazards, to protect personnel from shock hazards, and to prevent performance degradation or damage to electronics.

The resistance from the system ground to all surfaces of the fuel system components shall be less than 100 kilohms (10^5 ohms). The resistance from the system ground to the track pads shall be less than 100 kilohms (10^5 ohms).

5.8.2 Verification.
Compliance shall be verified through test and inspection. Verify that the bonds and grounds inspection has been completed successfully on the test vehicle prior to system level ESD tests.

Inspect the fuel carrying system to verify compliance with Society of Automotive Engineers (SAE) J1645, "Fuel System—Electrostatic Charge".

Inspect the track pads (if applicable) to verify compliance with the system design requirements. Measure the resistance from the system ground to the track pads.

5.8.3 Vertical lift electrostatic discharge (ESD).

5.8.3.1 Requirement.
The system shall meet its operational performance requirements after being subjected to a ±300 kilovolt discharge. This requirement is applicable to systems which may be transported through external lift by aircraft.

5.8.3.2 Verification.
Compliance shall be verified through test, analysis, inspections, or a combination thereof.

Prior to Vertical Lift ESD testing:

a) Verify the test vehicle/system and all subsystems are functional and parameters to be monitored during the test are within their nominal operating ranges by using the procedures developed in accordance with Section 4.3.
b) Verify the bonds and grounds tests (see Section 5.11.2) have been successfully completed on the test vehicle.
c) Verify the intra-system EMC verification (see Section 5.2.2) has been successfully completed on the test vehicle.
d) Identify the procedure(s) as developed in accordance with Section 4.3 to be performed which exercise and monitor the functions that may be susceptible to degradation after the Vertical Lift ESD transient. These procedures shall be used to verify a good system and detect any system degradation.

Analysis shall determine the most probable locations on the system where ESD may occur during the vertical lift process.

Apply the test discharges to the locations as determined by analysis to simulate the vertical lift scenario. Testing of the system shall require a minimum of three (3) discharges per test point directly to the system depending upon the configuration used in transport. Apply both positive and negative polarity discharges using a simulated aircraft capacitance of 1000 picofarads through a maximum of one (1) ohm resistance with a circuit inductance not to exceed 20 microhenries. The system should have discharges applied to several locations around the system. After each discharge, verify proper operation of the system using the procedures developed in accordance with Section 4.3.

5.8.4 Precipitation static (p-static).
This requirement of MIL-STD-464C is not applicable.

5.8.5 Electrostatic discharge, ordnance and EID-based subsystems.

5.8.5.1 Requirement.
Subsystems that interface with ordnance or EID-based subsystems shall not inadvertently initiate, dud, or disable the ordnance or EID when subjected to a ±25 kilovolt electrostatic discharge (ESD).

5.8.5.2 Verification.
Compliance shall be verified through test and analysis.

Prior to ESD testing of ordnance and EID-based subsystems:

a) Verify the test vehicle/system and all subsystems are functional and parameters to be monitored during the test are within their nominal operating ranges by using the procedures developed in accordance with Section 4.3.
b) Verify the bonds and grounds tests (see Section 5.11.2) have been successfully completed on the test vehicle.
c) Verify the intra-system EMC verification (see Section 5.2.2) has been successfully completed on the test vehicle.
d) Identify the procedure(s) as developed in accordance with Section 4.3 to be performed which exercise and monitor the functions that may be susceptible to degradation after the ESD transient. These procedures shall be used to verify a good system and detect any system degradation.

Analysis shall predict the ordnance locations within the system that may susceptible to ESD and the ordnance types to be instrumented throughout the system.

The ordnance firing mechanisms, fire extinguisher, training pyrotechnics and airbag igniters shall be instrumented and instrumented dummy ammunition ordnance shall be placed in the breech and in the ammunition storage.

Compliance shall be verified by test (such as MIL-STD-331 or AECTP 500, Category 508 Leaflet 2). Apply both positive and negative polarity discharges, using a network consisting of a 500 picofarad capacitor discharging through a 500 ohm resistor with a circuit inductance not to exceed 5μH, to the ordnance subsystem (such as electrical interfaces, enclosures, and handling points), airbags, and fire extinguisher subsystems including, but not limited to the predicted worst case points.

The effects from a personnel static charge applied to any electrical interface, enclosure, and handling point of the ordnance, airbags, training pyrotechnics (such as the Hoffman Device), Main Gun Signature Simulators and fire extinguisher subsystems shall evaluated.

The instrumented EID circuit shall be monitored during the ESD event and demonstrated that any induced energy in an EID circuit will not exceed a level expressed as a margin in dB below the

maximum no-fire threshold sensitivity for the EID concerned. A 16.5 dB MNFS margin shall be used for safety concerns and a 6dB MNFS margin for reliability concerns.

5.8.6 Electrostatic discharge, electrical, electronic, and electromechanical subsystems.

5.8.6.1 Requirement.
Electrical, electronic, and electromechanical subsystems that do not interface with or control ordnance items shall not be damaged by a maximum ±8 kV contact discharge or ±15 kV air discharge during normal installation, handling, operation, and maintenance.

5.8.6.2 Verification.
Compliance shall be verified through test and analysis.

Prior to ESD testing:

a) Verify the subsystem to be tested is functional and the parameters to be monitored during the test are within their nominal operating ranges by using the procedures developed in accordance with Section 4.3.
b) Verify the bonds and grounds tests (see Section 5.11.2) have been successfully completed on the test vehicle.
c) Verify the intra-system EMC verification (see Section 5.2.2) has been successfully completed on the test vehicle.
d) Identify the procedure(s) as developed in accordance with Section 4.3 to be performed which exercise and monitor the subsystem functions that may be susceptible to degradation after the ESD transient. These procedures shall also be used to verify a good subsystem and detect any subsystem degradation after application of the ESD transient.

Analysis shall determine the most probable points on the subsystem that may be contacted by the crew during operation or other personnel during operations such as transport, assembly, loading/unloading and maintenance. Include all of the subassemblies that are bonded to the subsystem.

Apply a minimum of five (5) discharges of positive polarity and five (5) discharges of negative polarity to each discharge point. An ESD network consisting of a 150 pF capacitor and a 330 ohm resistor with a circuit inductance not to exceed five (5) μH shall be used to simulate a human discharge ESD transient represented by a double exponential waveform with a rise time of 2-10 nanoseconds and pulse duration of approximately 150 nanoseconds. The contact discharges shall be applied at levels of ±4 kV, ±6 kV, and ±8 kV. The air discharges shall be applied at levels of ±4 kV, ±6 kV, ±8 kV, and ±15 kV.

In the unpowered mode, the discharges shall be applied to points including the case, connectors, seams, and any other locations on the subsystem accessible by personnel during operations such as transport, assembly, loading/unloading and maintenance where ESD is likely to penetrate

internal circuitry. Individual pins within connectors shall be tested if the design of the connector does not prevent direct contact to the pins by personnel handling the subsystem.

In the powered mode, the discharges shall be applied to points including the case, displays, connectors, switches, and any other locations on the subsystem accessible to the crew during operation and maintenance of the system.

After each ESD test level and polarity, the subsystem shall be checked for proper operation using the procedures developed in accordance with Section 4.3. If damage occurs or if the ESD test transient causes system degradation (subsystem resets, etc.) it shall be documented and assessed.

5.9 Electromagnetic Radiation Hazards (EMRADHAZ).

5.9.1 Requirement.
The system design shall mitigate the hazardous effects of electromagnetic radiation to personnel (HERP), fuels (HERF), and ordnance (HERO). The EMRADHAZ requirements are specified in paragraphs 5.9.3, 5.9.4 and 5.9.5. The sources of electromagnetic radiation shall include the onboard emitters and external RF EME.

5.9.2 Verification.
Compliance shall be verified through test and analysis.

Prior to EMRADHAZ testing:

a) Verify the test vehicle/system and subsystems to be tested are functional and the parameters to be monitored during the test are within their nominal operating ranges by using the procedures developed in accordance with Section 4.3.
b) Verify the bonds and grounds tests (see Section 5.11.2) have been successfully completed on the test vehicle.
c) Verify the intra-system EMC verification (see Section 5.2.2) has been successfully completed on the test vehicle.
d) Identify the procedure(s) as developed in accordance with Section 4.3 to be performed which exercise and monitor the subsystem functions that may be susceptible to EMRADHAZ. These procedures shall also be used to verify a good system/subsystem and detect any degradation.

The system shall be tested with all interior and exterior antennas transmitting at typical power (note any margins) and with vehicle hatches, doors and windows open.

5.9.3 Hazards of electromagnetic radiation to personnel (HERP).

5.9.3.1 Requirement.
The requirements for HERP shall be in accordance with MIL-STD-464C.

5.9.3.2 Verification.
Compliance shall be verified through a combination of inspection, analysis, and test. Evaluate and measure the HERP in accordance with DoDI 6055.11.

5.9.4 Hazards of electromagnetic radiation to fuel (HERF).

5.9.4.1 Requirement.
The effects of electromagnetic radiation shall not inadvertently ignite fuels. Margins of at least 6 dB shall be used for HERF.

5.9.4.2 Verification.
Compliance shall be verified through test and analysis. The primary fuel type in use shall be evaluated to determine if special precautions and methods are required. Special attention should be given to fuel system components. Testing may be performed in conjunction with external RF EME testing (see Section 5.3).

5.9.5 Hazards of electromagnetic radiation to ordnance (HERO).

5.9.5.1 Requirement.
The effects of electromagnetic radiation shall not inadvertently actuate electrically initiated devices (EIDs) in ordnance and other subsystems/components. The effects of electromagnetic radiation shall not degrade the performance characteristics of EIDs in ordnance and other subsystems/components. The external RF EME as defined in the Tank and Automotive EME columns of TABLE VII and maximum field intensities generated by onboard emitters shall define the electromagnetic radiation environment.

This requirement applies to both direct RF induced actuation of the EID and inadvertent activation of an electrically powered firing circuit. This requirement applies to all EIDs expected to interface with the system throughout its entire life cycle. This requirement is applicable to the following stockpile-to-safe separation sequence phases:

1) Handling/Loading (Restricted Environment)
2) Platform-Loaded (Unrestricted Environment)
3) Immediate post-launch (Unrestricted Environment)

This ATPD does not apply to the HERO requirements for the Transportation/Storage, Assembly/Disassembly and Staged stockpile-to-safe separation sequence phases. The HERO requirements for these phases are outside the scope of this document and shall be in accordance with applicable ordnance specifications.

TABLE VII Comparison of EME levels for EIDs.

Frequency Range		Field Intensity (V/m - rms)					
(MHz)	(MHz)	Unrestricted		Restricted /1		Tank and Automotive EME	
		Peak	Avg	Peak	Avg	Peak	Avg
0.01	2	200	200	80	80	50	50
2	30	200	200	100	100	103	103
30	150	200	200	80	80	57	57
150	225	200	200	70	70	50	50
225	400	200	200	100	100	58	58
400	700	2200	410	450	100	98	98
700	790	700	410	270	270	50	50
790	1000	2600	490	1400	270	284	50
1000	2000	6100	600	2500	160	2452	134
2000	2700	6000	500	490	160	489	50
2700	3600	12667	1533	2500	220	1148	191
3600	4000	8600	280	1900	200	489	50
4000	5400	9200	660	650	200	645	129
5400	5900	9200	660	6200	240	6146	155
5900	6000	9200	270	550	240	549	55
6000	7900	4100	400	4100	240	549	55
7900	8000	550	400	550	200	549	97
8000	8400	7500	400	1100	200	1095	110
8400	8500	7500	400	1100	200	1095	110
8500	11000	7500	910	2000	300	1943	139
11000	14000	7500	680	3500	220	3454	103
14000	18000	8700	680	8700	250	7897	243
18000	50000	2900	580	2800	200	2793	73

/1 In some of the frequency ranges for the “Restricted Average” column, limiting the exposure of personnel through time averaging will be required. Refer to Section 4.4 of this document regarding personnel safety.

The pass/fail criteria for tank and automotive systems shall be determined using the Tank and Automotive peak and average EME, of TABLE VII, with a 16.5 dB MNFS margin for safety and a 6 dB MNFS margin for reliability.

5.9.5.2 Verification.
Compliance shall be verified through a combination of inspection, analysis, and test. Refer to MIL-HDBK-240 for guidance. Analysis shall determine the following for the ordnance that could be stored in or fired from the system:

a. Type of EID
b. Subcomponent containing the EID
c. Firing sensitivity
d. Bridgewire resistance
e. Response time
f. Function within the ordnance
g. Firing consequence (safety/ reliability)
h. The HERO classification

In addition, evaluate the need to install and instrument training pyrotechnics during the test.

Analysis shall determine the post-launch characteristics of the ordnance and the electromagnetic radiation that the ordnance may be exposed to as it is launched from the system and this information shall be incorporated into the verification testing. Internal detonation devices and electronic guidance subsystems of the ordnance that can actuate early or become unreliable when exposed to the post-launch electromagnetic radiation shall be evaluated. Analysis shall determine the post-launch test requirements for the ordnance and the need for live fire tests, bench tests, or both.

Analysis shall determine the RF coupling paths (including wires, cables, and apertures), and ordnance to emitter orientations, configurations, and conditions for the system where RF coupling may occur. The inherent system RF frequencies shall be evaluated. These shall include at a minimum; the system frequencies of transmission as well as associated modulation parameters, frequencies associated with data rates, computer processors and power subsystems. The exposed EID test condition may be assumed to be worst-case for energy transfer to the ordnance itself due to lack of shielding from the system.

Verification methods shall show that electro-explosive subsystems will not inadvertently operate and EIDs will not inadvertently initiate or be dudded during handling, storage, or while installed in the system. Assessment of the immunity of an EID is based upon its no-fire threshold.

Testing shall demonstrate that any RF-induced energy in an EID circuit does not exceed a 16.5 dB MNFS margin for safety and a 6 dB MNFS margin for reliability. Refer to MIL-HDBK-240 for test guidance.

The EME test levels of TABLE VII with margins applied are greater than 200 V/m. If the test levels with margins cannot be achieved, then a minimum field level of 200 V/m shall be used during testing and the instrumentation responses extrapolated to the criteria level. The HERO instrumentation installed in the test system for margins data collection shall capture the maximum system response and shall not adversely affect the normal response characteristics of the system. The measurement results will be evaluated by the HERO community to determine ordnance classification.

The safety of all EIDs integrated as part of the system, and ordnance/EIDs utilized by and stored in the system, shall be verified during the testing of the following requirements as specified herein:

a) External RF EME (see Section 5.3)
b) High Powered Microwave (see Section 5.4)
c) Lightning (see Section 5.5)
d) Electromagnetic Pulse (see Section 5.6)
e) Electrostatic charge control (see Section 5.8.5)

The specified safety and reliability margins may be relaxed if they are unachievable for live fire post launch HERO verifications.

5.10 Life Cycle, E3 hardness.

5.10.1 Requirement.
The system shall meet the E3 requirements of this document throughout its rated life cycle. The life cycle shall include, but not be limited to, engineering changes, maintenance, repair, surveillance, and corrosion control.

5.10.2 Verification.
Compliance shall be verified through test and inspection. The ability to detect degraded features shall be demonstrated. The bonds and grounds inspection shall be performed throughout the life cycle phases i.e., development, production, and sustainment; in combination with other ongoing tests with the purpose of evaluating and comparing platforms before and after accumulation of high mileage/hours of operation. The bonds and grounds inspection shall be in accordance with Section 5.11.5.

5.11 Electrical Bonding.

5.11.1 Requirement.
The requirements for electrical bonding shall be in accordance with MIL-STD-464C.

5.11.2 Verification.
Compliance shall be verified through test, analysis, and inspection according to the applicable verification subsections for current return paths (5.11.3), antenna installations (5.11.4),

mechanical interfaces (5.11.5), shock, fault, and ignitable vapor protection (5.11.6), and electrical bonding for protection of ordnance from electrostatic discharge (5.11.7).

5.11.3 Electrical bonding, current return paths.

5.11.3.1 Requirement.
The use of system structure for return current paths shall be minimized. Low-level signal current return paths shall be routed as close as physically possible to the respective source path, through a combination of parallel routing and twisting the source and return wires together.

For systems using structure for power return currents, bonding provisions shall be provided for current return paths for the electrical power sources such that the total voltage drops between the point of regulation for the power system and the electrical loads are within the tolerances of the applicable power quality standard.

5.11.3.2 Verification.
Compliance shall be verified through test and analysis.

Analyze the characteristics of the current return paths that use the system structure. Inspect the physical dimensions, fastener torque and bonding surfaces for all ground straps, wires, and other conductors in the current return paths.

Activate the high current circuits using conditions that exhibit the worst case switching and highest current loading. Exercise all functions to determine if any degradation exists indicative of EMI from switching transients. Observe the response(s) of sensors as the functions are exercised and note any deviations from expected values.

For each power system load drawing a current equal to or greater than one (1) Ampere, measure and assess the voltage between the load's power terminal(s) and associated reference point of the power system for excessive drop which has the potential to adversely affect the operation of the load. Measure the voltage drop between the negative (-) terminal of the load and the negative (-) reference terminal of the power system. If it is not physically possible to make this measurement, measure the voltage across the load and the voltage drop between the positive (+) terminal of the power system and the positive (+) reference terminal of the load.

5.11.4 Electrical bonding, antenna installations.

5.11.4.1 Requirement.
The requirements for electrical bonding of antenna installations shall be in accordance with MIL-STD-464C.

5.11.4.2 Verification.
Compliance shall be verified through test. Measure the impedance of the counterpoise or ground plane at the mounting point(s) of each antenna in the frequency range of operation to determine compliance with the design specifications of each respective antenna.

5.11.5 Electrical bonding, mechanical interfaces.

5.11.5.1 Requirement.
The system mechanical interfaces used as electrical bonds shall provide electrical continuity across mechanical interfaces on electrical and electronic equipment, both within the equipment and between the equipment and other system elements, for control of E3 such that the system operational performance requirements are met.

The resistance across each mechanical interface utilized as an electrical bond shall be controlled in order to limit the voltage potential across the mechanical interface to the value(s) necessary to meet system performance requirements.

5.11.5.2 Verification.
Compliance shall be verified through test, analysis, and inspection.

Analysis shall determine the upper limit on the DC resistance for each electrical bond path based on the greatest operational voltage potential allowed across the bond between conductors (such as radio frequency energy or during near strike lightning) which does not adversely affect system performance.

Inspect each mechanical interface used as an electrical bond for missing/incomplete connections, unnecessary multiple terminations, quality of workmanship, painted surfaces, untreated surfaces, improper movement of the hardware used to create the mechanical interface associated with each electrical bond, use of inappropriate hardware, whether bonding straps are sheathed or unsheathed, inappropriately sized bonding straps, etc.

Measure the DC resistance of each mechanical interface used as an electrical bond to verify the measured values of the bond as implemented are consistent with the analysis.

5.11.6 Electrical bonding for shock, fault, and ignitable vapor protection.

5.11.6.1 Requirement.
The requirements for electrical bonding for shock, fault, and ignitable vapor protection shall be in accordance with MIL-STD-464C.

5.11.6.2 Verification.
Compliance shall be verified through test, analysis, and inspection.

Analysis shall identify the electrical bond(s) between system elements where potentially hazardous voltages may appear and the associated fault condition(s).

Inspect each circuit protection device to ensure it is installed in accordance with the associated manufacturer's specifications.

Test electrical bonds in fuel or flammable vapor areas to eliminate potential sources of ignition caused by electrical arcing, sparking or resistive heating of the electrical bond. Measure the voltage(s) across each electrical bond identified above to verify the voltage is below the specified shock hazard voltage level(s).

5.11.7 Electrical bonding for protection of ordnance from ESD

5.11.7.1 Requirement
Bonding for protection of ordnance from ESD shall be in accordance with DoD 4145.26-M.

5.11.7.2 Verification
Compliance shall be verified through test and inspection.

Measure the DC resistance of each mechanical interface used as an electrical bond for charge dissipation from ordnance in order to verify the measured values of the bond as implemented are consistent with the requirement.

5.12 External Grounds.

5.12.1 Requirement.
The requirements for external grounds shall be in accordance with MIL-STD-464C.

5.12.2 Verification.
Compliance shall be verified through analysis and inspection.

Analysis shall identify the location(s) where external grounding provisions are required.

Inspect and test the external grounding provisions according to Section 5.11 to verify proper electrical bonding of the external grounding provisions to the system structure.

5.12.3 Aircraft grounding jacks.
This requirement of MIL-STD-464C is not applicable.

5.12.4 Servicing and maintenance equipment grounds.
This requirement of MIL-STD-464C is not applicable.

5.13 TEMPEST.

5.13.1 Requirement.
The requirements for TEMPEST shall be in accordance with MIL-STD-464C. The system shall comply with NSTISSAM TEMPEST/1-92 level II electromagnetic radiation requirements, NSTISSAM TEMPEST/1-92 level I power line conduction requirements and CNSS TEMPEST 01-02 NONSTOP requirements. NSTISSAM TEMPEST/2-95A shall be used for design guidance. The specifics of TEMPEST-related system requirements are classified.

5.13.2 Verification.

Analysis shall identify mitigation for all potential TEMPEST vulnerabilities. Testing, when necessary, shall be performed at a CTTA-approved TEMPEST test facility. Compliance will be verified by the Army Certified TEMPEST Technical Authority (CTTA); see Section 6.5.

5.14 System radiated emissions.

5.14.1 Requirement.
The system shall meet requirements for broadband and narrowband electromagnetic radiation from vehicles as specified in the Official Journal of the European Union Commission Directive 2004/104/EC.

5.14.2 Verification.
Compliance shall be verified through test.

Measure the system radiated emissions over the frequency range as required by 2004/104/EC. Additional measurements of the system radiated emissions beyond the frequency range as specified by 2004/104/EC should be performed following a similar methodology for informational purposes.

The engine of the system under test shall be running at its typical idle speed with the transmission in park during the broadband test. The radios shall be on and receiving, but not transmitting during the narrowband and broadband tests.

5.14.3 Emission control.
This requirement of MIL-STD-464C is not applicable.

5.14.4 Inter-system EMC.

5.14.4.1 Requirement.
The requirements for inter-system EMC shall be in accordance with MIL-STD-464C. This includes radio receivers, antennas and waveforms that characterize the communication systems installed on Army platforms as specified by the procuring activity.

The system's unintentional radiated emissions shall not degrade the performance of each receiver/antenna/waveform combination installed on the system while communicating using the specified waveform(s) when the external antenna is located at a minimum standoff distance of five (5) meters from the system. The voice quality shall not degrade below a modified rhyme test (MRT) score of 91% in accordance with MIL-STD-1472. The data throughput shall not degrade to a level below the acceptable level of TABLE I.

A receiver/waveform combination that is used on the system and complies with the requirements of Section 5.2 is not required to be verified for Inter-system EMC in order to avoid redundant verifications.

5.14.4.2 Verification.
Compliance shall be verified through test and analysis.

Analysis shall compare the frequency bands of operation of the installed radios with the measurements obtained in Section 5.14.2 in order to determine potential sources of interference from unintended radiated emissions.

For each receiver/antenna/waveform combination, place the antenna at the distance from the platform as specified in Section 5.14.4.1. Using a spectrum analyzer or equivalent, measure the radiated emissions received by the antenna external to the system as the subsystems are activated using the step-by-step procedure developed in 5.2.6.2.

Test the performance of each communication system at the specified standoff distance over the susceptible frequency bands as determined by the spectrum analyzer measurements. Verify the performance of each receiver/antenna/waveform combination complies with the operational voice, throughput and data rate requirements as specified in Section 5.14.4.1.

5.15 EM Spectrum Supportability.

5.15.1 Requirement.
Spectrum Dependent (SD) electronic subsystems integrated as part of tank and automotive systems shall comply with existing Army Regulations regarding Spectrum Certification and Supportability. Tanks and automotive platforms are not considered SD, but electronic systems and subsystems integrated into the platforms may be SD.

5.15.2 Verification.
Analysis shall identify the Spectrum Certification Characteristics of all SD electronic subsystems integrated into the system design.

6 NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use.

This ATPD contains electromagnetic environmental effects requirements for tanks and automotive systems.

6.2 Acquisition requirements.

Acquisition documents should specify the following:

a. Title, number, and date of this document.
b. If required, the specific issue of individual documents referenced.

6.3 MIL-STD-464C Data Item Descriptions (DIDs).

MIL-STD-464 has been assigned an Acquisition Management Systems Control (AMSC) number authorizing it as the source document for the following DIDs. When it is necessary to obtain data, the applicable DIDs must be listed on the Contract Data Requirements List (DD Form 1423).

DID Number	DID Title
DI-EMCS-81540B	Electromagnetic Environmental Effects (E3) Integration and Analysis Report
DI-EMCS-81541B	Electromagnetic Environmental Effects (E3) Verification Procedures
DI-EMCS-81542B	Electromagnetic Environmental Effects (E3) Verification Report
DI-EMCS-81827	Spectrum Certification Spectral Characteristics Data

The above DIDs were current as of the date of MIL-STD-464C. The ASSIST database should be researched at https://assist.daps.dla.mil/quicksearch/ to ensure that only current and approved DIDs are cited on the DD Form 1423.

6.4 Tailoring guidance for contractual application.

Application specific criteria may be derived from operational and engineering analyses on the system being procured for use in specific environments. When analyses reveal that a requirement in this document is not appropriate or adequate for that procurement, the requirement should be tailored and incorporated into the appropriate documentation.

6.5 Technical points of contact.

6.5.1 Certified TEMPEST Technical Authority (CTTA).
The Army CTTA point of contact for tank and automotive systems is:

Army TEMPEST Program Manager
310th Military Intelligence Battalion, IAMG-C-TMP
4552 Pike Road
Fort George G. Meade, MD 20755
Telephone: (301) 677-4440
E-mail: 902d310thTEMPEST@mi.army.mil

6.6 Subject term (key word) listing.

E3
Electrical bonding
EMC
EMCON
EMI
EMP
ESD
Electromagnetic compatibility
Electromagnetic environment
Electromagnetic emission
Electromagnetic interference
Electromagnetic radiation hazards
Electromagnetic susceptibility
Grounding
HERF
HERO
HERP
HPM
Inter-system electromagnetic compatibility
Intra-system electromagnetic compatibility
Lightning
RADHAZ
System
TEMPEST

6.7 Acronyms.

TABLE VIII Acronyms.

Acronym	Acronym Definition
DAMA	Demand Assignment Multiple Access
DA PAM	Department of the Army Pamphlet
DOD	Department of Defense
DODD	Department of Defense Directive
DODI	Department of Defense Instruction
E3	Electromagnetic Environmental Effects
EID	Electrically Initiated Device
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EMCON	Emission Control
EME	Electromagnetic Environment
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
EMR	Electromagnetic Radiation
EMRADHAZ	Electromagnetic Radiation Hazards
EMV	Electromagnetic Vulnerability
ESD	Electrostatic Discharge
HBCT	Heavy Brigade Combat Team
HPM	High-Power Microwave
HERF	Hazards of Electromagnetic Radiation to Fuel
HERO	Hazards of Electromagnetic Radiation to Ordnance
HERP	Hazards of Electromagnetic Radiation to Personnel
HF	High Frequency
JTRS	Joint Tactical Radio System
MNFS	Maximum No-Fire Stimulus
NDI	Non-Developmental Items
RF	Radio Frequency
SD	Spectrum Dependent

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Custodian:
Army - AT

Preparing Activity:
Army - AT

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.