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DEPARTMENT OF DEFENSE HANDBOOK

ELECTROMAGNETIC ENVIRONMENTAL EFFECTS AND SPECTRUM SUPPORTABILITY GUIDANCE FOR THE ACQUISITION PROCESS

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Foreword

1. This handbook is approved for use by all Departments and Agencies of the Department of Defense.

2. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

3. This handbook provides guidance for establishing effective electromagnetic environmental effects (E3) and spectrum supportability (SS) programs throughout the life cycle of platforms, systems, subsystems, and equipment.

4. Comments, recommendations, additions, or deletions and any other pertinent data that may improve this document should be emailed to J5@jsc.mil or addressed to:

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1. SCOPE

1.1 Purpose

This handbook provides guidance for establishing and implementing effective electromagnetic environmental effects (E3) control and spectrum supportability (SS) for the design, development, and procurement of Department of Defense (DoD) platforms, systems, subsystems, or equipment. This handbook is intended for DoD personnel responsible for requirements generation and acquisition life cycle processes, including test and evaluation of these end items.

This handbook is consistent with the policies, responsibilities, and procedures of DoD Directives (DoDD) 5000.1, 3222.3, and 4650.1, DoD Instruction (DoDI) 5000.2, and the latest Chairman, Joint Chiefs of Staff Instructions (CJCSI) 3170.01 and 6212.01 and Chairman, Joint Chiefs of Staff Manual (CJCSM) 3170.01. Provisions of this handbook apply to research, development and acquisition activities for any electrical or electronic device which emits or which can be susceptible to electromagnetic (EM) energy either through intentional antenna coupling or through unintentional EM coupling mechanisms such as radiation penetration through the case and cable. Most electrical and electronic devices procured by DoD fall into these categories. The handbook may be used either to assure visibility, accountability, and control of the E3/SS effort, as well as its integration into the overall program, or to assure management awareness and cost effective tailoring of applicable E3 and SS interface and performance standards.

This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

1.2 Background

The E3 and spectrum management (SM) disciplines are often represented by different organizations in military agencies; however, there is substantial commonality between the concerns of the two disciplines. E3, as defined in paragraph 3.2.2, is concerned with minimizing the impact of the electromagnetic environment (EME) on equipment, subsystems, systems, and platforms. The complex military EME is composed of radiated and conducted emissions from intentional and unintentional sources, including high-powered transmitters from military forces and the civilian infrastructure, lightning, electromagnetic pulse (EMP), precipitation static (p-static), electrostatic discharge (ESD), and so forth. SM, as defined in paragraph 3.2.4, is involved with planning, coordinating, and managing Joint use of the EM spectrum by subsystems and equipment that radiate or receive EM energy. SM includes operational, engineering, and administrative procedures to accomplish electromagnetic compatibility (EMC) and preclude electromagnetic interference (EMI). The relationship between E3 and SS is depicted in Figure 1. SS is defined in 3.2.5. As shown, an overlap occurs, primarily, in the equipment spectrum certification (ESC) area, which is concerned with assuring the EMC and preventing EMI with spectrum-dependent equipment.

The increase in operational E3 and SS issues made it necessary for the Director, Operational Test and Evaluation (DOT&E) to place greater emphasis on these requirements during Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) events of oversight

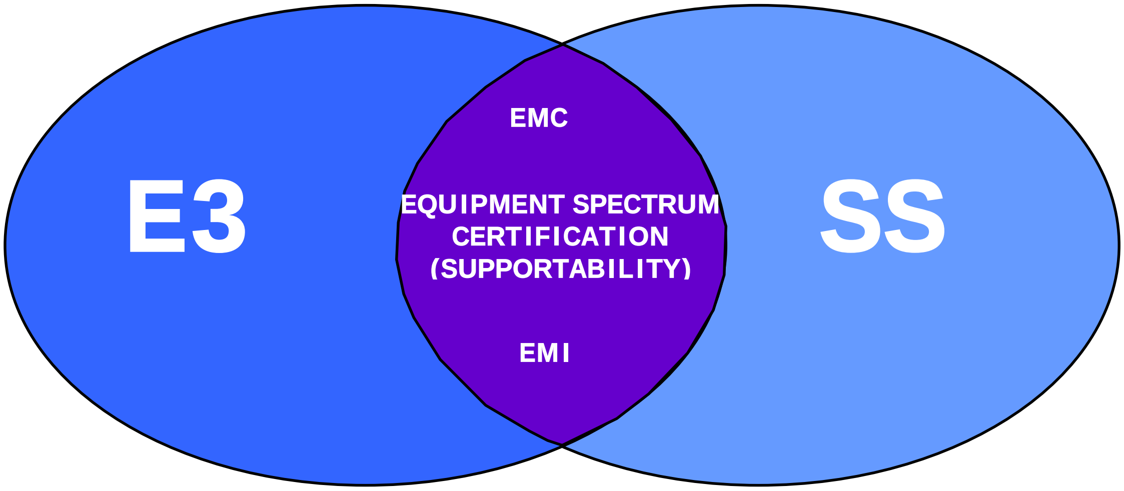

FIGURE 1. The Overlap Between E3 and SS.

programs. Joint and Allied operations have encountered E3 problems and spectrum conflicts between forces that have reduced mission effectiveness and increased operational restrictions. Furthermore, deployments of United States (U.S.) military command, control, communications, computers, and intelligence (C4I) assets to foreign nations have resulted in the denial to operate these assets and even confiscation due to lack of SS, including Host Nation Approval (HNA). Operational impact assessments of E3 and SS issues need to be accomplished during all life cycle phases of the acquisition process and reviewed at each milestone decision point. The DoD can reduce this negative impact to military operations by ensuring that platform, system, subsystem, and equipment limitations and vulnerabilities are mitigated and sufficiently documented for the warfighter.

1.3 Structure

This handbook is structured for both the Program Manager (PM) and E3/SM engineers. Sections 4 and 5 provide the PM with general overviews of E3 and SM concepts, requirements, and concerns. Section 6 provides the PM with guidance for incorporating E3 and SS requirements and considerations into the acquisition within the framework of the acquisition program. E3/SM engineers are provided in Appendix C general information on the acquisition process so that their requirements can be incorporated into the PM's tasks and associated documents at appropriate points during the acquisition life cycle. Descriptions of E3 test and analysis capabilities and facilities are provided in Appendix D. Guidance on the use of commercial standards is included in Appendix E.

2. APPLICABLE DOCUMENTS

2.1 General

The documents listed below are not necessarily all of the documents referenced herein, but are those needed to understand the information provided by this handbook. A detailed bibliography is presented in Appendix A and in the Engineering Practice Study (EPS) report referenced herein.

2.2 Government Documents

2.2.1 Specifications, Standards, and Handbooks

The following standards form a part of this document to the extent specified herein.

Department of Defense

MIL-STD-461	Interface Standard, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-464	Interface Standard, Electromagnetic Environmental Effects Requirements for Systems
MIL-STD-469	Interface Standard, Radar Engineering Design Requirements, Electromagnetic Compatibility

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government Documents and Publications

The following other Government documents and publications form a part of this document to the extent specified herein. They are referenced solely to provide supplemental data and are for informational purposes only.

Department of Defense

DoDD 3222.3	DoD Electromagnetic Environmental Effects (E3) Program
DoDD 4630.5	Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)
DoDI 4630.8	Procedures for Interoperability and Supportability of Information Technology and National Security Systems

DoDD 4650.1	Policy for the Management and Use of the Electromagnetic Spectrum
DoDD 5000.1	The Defense Acquisition System
DoDI 5000.2	Operation of the Defense Acquisition System
DoDI 6055.11	Protection of DoD Personnel from Exposure to Radio Frequency Radiation and Military Exempt Lasers
Chairman Joint Chiefs of Staff Instruction (CJCSI) 3170.01	Joint Capabilities Integration and Development System
CJCSI 6212.01	Interoperability and Supportability of Information Technology and National Security Systems
CJCSM 3170.01	Operation of the Joint Capabilities Integration and Development System
DOT&E E3 Policy Memorandum	Policy on Operational Test and Evaluation of Electro-magnetic Environmental Effects and Spectrum Management, dated 25 October 1999
EPS-0178	Results of Detailed Comparisons of Individual EMC Requirements and Test Procedures Delineated in Major National and International Commercial Standards with Military Standard MIL-STD-461E
Joint Chiefs of Staff (JCS) Pub. No. 1-02	Department of Defense Dictionary of Military and Associated Terms

National Telecommunications and Information Administration (NTIA)

NTIA Manual	Manual of Regulations and Procedures for Federal Radio Frequency Management

(Copies of DoD Directives and Instructions are available from the Document Automation and Production Service, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094. If you have any questions, please contact the appropriate ASSIST-Help Desk team: Account/Password Issues: 215-697-6257 [DSN: 442-6257]). CJCSM 3170.01 can also be found at www.dau.mil. Copies of the NTIA Manual are available from the U.S. Government Printing Office, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954 or it may be downloaded from www.ntia.doc.gov/osmhome/redbook/redbook.html. Copies of the EPS are available on the Joint Spectrum Center (JSC) web site: http://www.jsc.mil).

2.3 Non-Government Publications

The following document forms a part of this guide to the extent specified herein.

American National Standards Institute (ANSI)

ANSI/IEEE C63.14	Standard Dictionary for Technologies of Electromagnetic Compatibility (EMC), Electromagnetic Pulse (EMP), and Electrostatic Discharge (ESD)

(Copies of this document are available from Institute of Electrical and Electronics Engineers (IEEE) on www.ieee.org or IEEE Service Center, 445 Hoes Lane, Piscataway, NJ 08854-1331.)

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3. DEFINITIONS

3.1 General

A glossary of acronyms and abbreviations used in this handbook, including the appendices, is contained in Appendix B of this handbook.

3.2 Definitions

Many terms used in this handbook are defined in ANSI/IEEE C63.14, JCS Pub. 1-02, DoDD 3222.3, DoDD 4650.1, or the DoD 5000 series of documents. The following definitions are repeated herein for ready reference. Additional terms unique to a specific section of this handbook are defined in that section.

3.2.1 Electromagnetic Environment (EME)

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.

3.2.2 Electromagnetic Environmental Effects (E3)

E3 is the impact of the EME upon the operational capability of military forces, equipment, systems, and platforms. It encompasses all electromagnetic disciplines, including electromagnetic compatibility (EMC); electromagnetic interference (EMI); electromagnetic vulnerability (EMV); electromagnetic pulse (EMP); electrostatic discharge (ESD); hazards of electromagnetic radiation to personnel (HERP), ordnance (HERO), and volatile materials such as fuel (HERF); and natural phenomena effects of lightning and precipitation static (p-static). (JCS Pub 1-02)

3.2.3 Equipment Spectrum Certification (ESC)

ESC is the statement(s) of adequacy received from authorities of sovereign nations after their review of the technical characteristics of a spectrum-dependent equipment or system regarding compliance with their national spectrum management policy, allocations, regulations, and technical standards. Equipment Spectrum Certification is alternately called “spectrum certification.”

3.2.4 Spectrum Management (SM)

SM is the planning, coordinating, and managing Joint use of the electromagnetic spectrum through operational, engineering, and administrative procedures, with the objective of enabling electronic systems to perform their functions in the intended EME without causing or suffering unacceptable EMI. (JCS Pub 1-02)

3.2.5 Spectrum Supportability (SS)

SS is the assurance that the necessary frequencies and bandwidth are available to military systems in order to maintain effective interoperability in the operational EME. The assessment of an equipment or system as having “spectrum supportability is based upon, as a minimum, receipt of equipment spectrum certification (ESC), reasonable assurance of the availability of sufficient frequencies for operation, Host Nation Approval (HNA), and consideration of EMC.

4. OVERVIEW OF E3

4.1 EME

4.1.1 General

The EME, as defined earlier in 3.2.1, is the resulting product of the power and time distribution, within various frequency ranges, and includes the radiated and conducted EM emission levels that may be encountered. It is the totality of EM energy, from man made and natural sources, to which a platform, system, subsystem, or equipment (hereby collectively referred to as items) will be exposed within any domain (that is, land, air, space, sea) while performing its intended mission throughout its operational life cycle. When defined, the EME will be for a particular time and place. Specific equipment characteristics (such as emitter power levels, operating frequencies, and receiver sensitivity), operational factors (such as distances between platforms, systems, and force structure), and frequency coordination all contribute to the EME. In addition, transient emissions and their associated rise and fall times (such as from EMP, lightning, and p-static) also contribute to the EME.

EMC and SS, which are basic tenets to ensure interoperability, are critical to maximizing mission operational effectiveness in the intended EME for all military items. Undesired EM energy may degrade the performance of an item temporarily, in which case the item may operate in a degraded mode when sufficient EM energy is present. Alternatively, the EM energy may cause permanent damage, in which case the item will not operate until it is either repaired or replaced and the E3 problem has been resolved. Examples of the effects that can be caused by undesired EM energy, depending on the victim, are:

- Burnout or voltage breakdown of components, antennas, and so forth,
- Performance degradation of receiver signal processing circuits,
- Erroneous or inadvertent operation of electromechanical equipment, electronic circuits, components, ordnance, and so forth,
- Unintentional detonation or ignition of ordnance and flammable materials, and
- Personnel injuries.

4.1.2 EME Effects

The effects of undesired EM energy on an item that operates in a specific environment are dependent upon the item's susceptibility (or immunity) characteristics, and the amplitude, frequency, and time-dependent characteristics of the EME. To prevent E3 problems from occurring, the possible effects of undesired EM energy should be considered for each item when operating in its intended EME. Furthermore, compliance with the National Environmental Policy Act requires Environmental Impact assessments for many types of systems and installations. These assessments must address the potential impact of the EME on personnel, ordnance and fueling areas. As we will see later in this handbook, a requirement to demonstrate satisfactory performance in a defined EME should be included in all acquisition documents, including the test and evaluation master plan (TEMP).

4.1.3 Contributors to the EME

The EME in which military platforms, systems, subsystems, and equipment must operate is comprised of a multitude of natural and manmade sources. Natural sources consist of:

– Galactic noise,
– Atmospheric noise,
– Solar noise,
– P-static,
– Lightning, and
– ESD.

Manmade sources consist of friendly and hostile emitters, both intentional and unintentional, and spurious emissions such as motor noise and intermodulation products. Intentional emitters include, but are not limited to the following types of subsystems/equipment:

– Communications,
– Navigation,
– Meteorology,
– Radar,
– Weapon, and
– Electronic Warfare (EW).

Unintentional emitters encompass subsystems and equipment that uses, transforms, or generates undesired EM energy as a by-product of performing its mission. Therefore, any electrical, electronic, electromechanical, or electro-optic device can be an unintentional emitter. Examples of unintentional emitters include the following:

– Intentional radiators emitting other than the intended emission,
– Computers and associated peripherals,
– Televisions, cameras, and video equipment,
– Microwave ovens,
– Radio and radar receivers,
– Power supplies and frequency converters,
– Motors and generators, and
– Electrical hand tools.

Power levels and source locations relative to the item are the two main considerations used for determining which sources are the dominant contributors to the operational EME. For example, during normal, non-combat operations the primary sources of EM energy would be primarily from intentional and spurious emissions from own, co-located equipment. In a combat scenario, enemy transmissions could be another major contributor. Hence, the EME within which an item must operate and survive is both mission-dependent and scenario-dependent.

4.1.4 Defining the EME

The EME in which the item is most likely to operate must be defined early in the acquisition process. The initial step is to identify the major geographic regions in which the system will operate, that is, the U.S., Atlantic, Pacific, Europe, Middle East, or possibly, worldwide. The next step is to identify the specific countries in each major region in which the item is likely to be deployed, since obtaining host nation approval to operate may be more challenging in some countries. Once that is done, the theater and missions must be defined. Then, individual host platforms and systems on or near the item to be deployed must be identified. Following this, the types and characteristics of any spectrum-dependent item present or planned that could possibly interact with the proposed item should be identified. This identification addresses both items affected by and those that affect the item. The identification must address both the military and commercial EME alike. The information on interacting items will be used as an initial input for frequency allocation and E3 analyses.

Although the EME is defined early in the program, continuous update of the EME is necessary throughout the entire life cycle because the environment is not static. Other entities (friendly and hostile) will be simultaneously developing or fielding items that will operate within the same EME. Data concerning these "new" items must be sought out and added to the EME definitions. In addition, the original mission of the proposed item may be changed, forcing additional geographic regions, countries, host platforms, and nearby equipment to be considered. As EME definitions are updated, they should be used to refine E3 analyses and frequency allocation requests. MIL-HDBK-235 and MIL-STD-464 describe land-based, ship-based, airborne, and battle space EME levels, including friendly and hostile levels that may be encountered by an item during its life cycle. One of the difficulties encountered when specifying the performance requirements of an item is that the quantitative characteristics of the intended operational EME may be unknown.

Each item, in all likelihood, will be exposed to several different EME levels during its life cycle. MIL-HDBK-235 and MIL-STD-464 provide general information on the EME. Referring to these publications can be useful when defining the power levels of the EME to which an item may be exposed. However, the tables should be tailored for specific applications. Specifying an EME level that is too stringent may result in additional costs that are unnecessary. Each distinctive EME that an item will be exposed to during its life cycle should be defined before specifying its performance requirements. For example, a missile will be exposed to different EME levels during shipment, storage, checkout, launch, and the approach to a target. The specified E3 control performance requirements should ensure the item's performance is not adversely affected by any of the EME levels that will be encountered.

The physical configuration of an item may vary depending on its intended location. An item's immunity or susceptibility to the EME may also vary depending on its physical configuration and location relative to the intended operational EME. Therefore, when developing E3 performance requirements, both the physical configuration and the location of the item within each of its intended operational EME should be considered.

4.1.4.1 Specifying the Intended EME

There is usually a significant difference between the levels of EM energy that will temporarily degrade or limit the effective performance of an item (operational) and those levels that will permanently damage an item (survivability). The requirement to control any effects from the EME under all circumstances should be, by necessity, more stringent than just to ensure that the item will not be permanently damaged. When specifying E3 control requirements, the item's function and how critical it is to the intended mission should be taken into account. There are also precautions that can be taken to protect equipment from being permanently damaged by EM energy when not in use that cannot be implemented when they are in an operational mode.

The susceptibility characteristics of an item depend on its design characteristics. For example, the item may respond to a broad frequency range or be frequency selective. Also, some victims have response times in microseconds and are affected by the peak power levels of short-term signals, whereas other victims are affected by heating and respond more slowly to the average power levels of signals. The design characteristics of an item, as well as the shielding integrity, choice of components, and use of filtering should be considered when evaluating EM effects on an item.

Possible changes in the intended operational EME and future applications of an item also should be considered when defining the EME that an item may encounter. An item designed to operate in a specific EME may, in the future, be required to operate in another, or used to perform functions and missions that were not planned for when the item was originally designed. Although the cost of an item may increase when designed for an EME that is more severe than the EME that is currently being predicted to be encountered by the item, the increase in cost may be justified in terms of adaptability for future applications. This is particularly true for items designed by a Service that may, ultimately, be used in a Joint operation.

When defining the operational EME that an item will be required to operate or survive in during its life cycle, operational and installation conditions that can preclude or reduce exposure to the EME and any added information that may affect an item's exposure to the EME should be considered. For example, the complement of emitters on a platform or site will determine the frequency bands within which high levels of EM energy will probably be encountered. Dimensional restrictions and intervening structures may exist that cause an item to operate in the near or induction field region of an antenna. Other factors that should be considered are the platform on which an item is installed and its operational use.

4.2 EMC

EMC is the ability of a system, equipment, and devices that use the spectrum to operate in their intended operational EME without experiencing unintentional degradation from co-located systems or causing unintentional degradation because of EM radiation or response. It involves the application of sound EM principles; SM; system, equipment, and device design configuration that ensures interference-free operation; and clear concepts and doctrines that maximizes operational effectiveness. It is apparent, then, that the lack of EMC due to the presence of EMI is the concern. Increased multi-National military operations, proliferation of both friendly and hostile weapons systems, and the expanded use of the spectrum worldwide have resulted in an operational EME not previously encountered. The growing presence of intentional emitters worldwide poses significant challenges for the military. Therefore, it is essential that the EME created by these emitters be defined and used to establish system E3 requirements. Documents such as MIL-HDBK-235 and MIL-STD-464 list various land, ship, airborne, and battle force EME levels. The EM fields, which may illuminate platforms or systems, are very high and can degrade overall performance if they are not properly addressed. Operational problems resulting from the adverse effects of EM energy on systems or platforms are well documented. Problems include premature detonation of ordnance, loss of communications, loss of guidance and tracking radar, component failure, and unreliable built-in-test indications. These problems underscore the importance of designing platforms and systems that are compatible with their intended operational EME. Joint operations further increase the potential for safety and reliability problems since the system is likely to be exposed to an operational EME different from that for which they were designed.

4.3 EMI

EMI is any EM disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronics and electrical equipment. It can be induced intentionally, as in some forms of EW, or unintentionally, as a result of spurious emissions and responses, intermodulation products, and the like. Related to EMI is "susceptibility" which is the inability of an item to perform its function without degradation while in the presence of an EM disturbance. EM disturbances can be in the form of either radiated or conducted emissions. The EMI characteristics (emission and susceptibility) of individual equipment and subsystems must be controlled to obtain a high degree of assurance that these items will function in their intended installations without unintentional EM interactions with other equipment, subsystems, or the external EME. The EME within a system is complex and variable depending upon the operating modes and frequencies of the onboard equipment. Also, configurations are continuously changing as new or upgraded equipment is installed. Furthermore, items developed for one platform may be used for other platforms. MIL-STD-461 provides a standardized set of EMI control and test requirements that form a common basis for assessing the EMI characteristics of subsystems and equipment. Adherence to these EMI requirements will afford a high degree of confidence that the item will operate compatibly upon integration and would minimize potential cost impact and scheduling delays. A further concern is the need for equipment using power to control transients to levels that will not cause upset or damage to other power users. Related to EMI is EMV. (See 4.6)

4.4 EMP

EMP, as used herein, is the non-ionizing EM radiation (EMR) from a nuclear explosion caused by Compton-recoil electrons and photoelectrons from photons scattered in the materials of the nuclear device or in a surrounding medium. The resulting electric and magnetic fields may couple with electrical or electronic systems and associated interfaces to produce damaging current and voltage surges. A nuclear burst above the atmosphere that produces coverage over a large area is called a high-altitude EMP, or HEMP. In a nuclear conflict, it is possible that many military systems will be exposed to an EMP. The resultant EM field is characterized by high amplitude, short duration, and short rise time pulse for a very brief time. There are two types of EMP, each distinguished by the height of the burst. One type is exo-atmospheric where the detonation is outside of the atmosphere but which can produce coverage over large geographical areas; and the other is endo-atmospheric which results from a low altitude detonation. In either case, the effects can be detrimental to the performance of many electrical and electronic items. MIL-STD-2169 describes the predicted EMP waveforms. EMP waveform criteria are also provided in MIL-STD-461 and 464. EMP may also be caused by non-nuclear means. EME levels generated by the normal operation of systems, subsystems, or equipment (such as from EM launchers or guns) are not currently addressed in these standards.

4.5 Electromagnetic Radiation (EMR) Hazards (RADHAZ)

EMR can have harmful effects on personnel, fuels, and ordnance if uncontrolled. These effects are discussed below.

4.5.1 HERP

HERP is the potential hazard that exists when personnel are exposed to an EM field of sufficient intensity to heat the human body. The fact that heating is associated with absorption of radio frequency (RF) power by humans was known nearly 50 years ago and led to the introduction of RF diathermy for medical and surgical purposes. The heat resulting from RF field interactions simply adds to the metabolic heat load of the human. If the body's heat gain exceeds its ability to rid itself of excess heat, the body temperature rises. Therefore, if significant power is absorbed, an increase in body temperature can occur that could have a competing effect on metabolic processes, with potentially deleterious effects. Radar and EW systems present the greatest potential for personnel hazard due to their high transmitter output powers and antenna characteristics. Personnel assigned to repair, maintenance, and test facilities have a higher potential for being overexposed due to their tasks, the proximity to radiating elements, and the pressures for rapid maintenance response. Safety tolerance levels for personnel exposure to EMR are defined in MIL-STD-464 and DoDI 6055.11.

4.5.2 HERF

HERF is the potential hazard that is created when volatile combustibles, such as fuel, are exposed to EM fields of sufficient energy to cause ignition. For fuel vapors to ignite, a flammable fuel-air mixture must be present, in addition to an intense EM field. EMR can induce currents into any metal object. The amount of current, and thus the strength of a spark across a gap between two conductors, depends on the field intensity of the energy and how well the conductors act as a receiving antenna. Many parts of a system, a refueling vehicle, or a static grounding conductor can act as receiving antennas. The induced current depends, mainly, on the conductor length in relation to the wavelength of the RF energy and the orientation of the field. It is neither feasible to predict nor control these factors. The hazard criteria must then be based on the assumption that an ideal receiving antenna could be inadvertently created with the required spark gap. The existence and extent of a fuel hazard are determined by comparing the actual RF power density to an established safety criterion. Requirements to control EMR hazards to fuels are in MIL-STD-464. T.O. 31Z-10-4 and OP 3565 provide procedures for establishing safe operating distances.

4.5.3 HERO

HERO is the potential hazard that exists when ordnance that contains electrically initiated devices (EIDs) is adversely impacted by the EME. Ordnance includes weapons, rockets, explosives, EIDs themselves, squibs, flares, igniters, explosive bolts, electric primed cartridges, destructive devices, and jet-assisted take-off bottles. Modern transmitters can produce a high EME that can be hazardous to ordnance. These EME levels can cause premature actuation of ordnance. RF energy of sufficient magnitude to fire or dud EIDs can be coupled from the external EME, either by explosive subsystem wiring or by capacitive coupling from nearby radiated objects. Possible consequences include both hazards to safety and performance degradation. EIDs should be selected to be the least sensitive that will meet system requirements. Each EID must be categorized as to whether its inadvertent ignition would lead to either safety or performance degradation problems. The PM should determine this categorization. HERO requirements and evaluation guidance are in MIL-STD-464 and MIL-HDBK-240. Additional guidance can be found in OP-3565 and OD 30393. MIL-STD-1576 provides guidance on the use and test of ordnance devices in space and launch vehicles.

4.6 EMV

EMV is the characteristic of an item that causes it to suffer degraded performance, or the inability to perform its specified task, as a result of the operational EME. An item is said to be vulnerable if its performance is degraded below a satisfactory level because of exposure to the stress of an operational EME or transient. There are many different EME levels that an item will be exposed to during its life cycle. Many threats will be seen only infrequently. However, if the item encounters an operational EME corresponding to its susceptibility characteristics as observed in a laboratory test, it may suffer degradation in performance, or not be able to perform its specified task at all in that operational environment. An EMV analysis is usually required to determine the impact of a laboratory-observed susceptibility on actual operational performance. The results of the EMV analysis guide the possible need for hardware modification, additional analyses, or testing.

4.7 Lightning

Lightning is an electric discharge that occurs in the atmosphere between clouds or between clouds and grounds. The EM radiation associated with a lightning discharge produces electric and magnetic fields that may couple with electrical or electronic items to produce damaging current and voltage surges. Lightning effects can be divided into direct (physical) and indirect (EM) effects; both effects may occur to the same component.

- Direct effects of lightning are any physical damage to the system structure or equipment due to the direct attachment of the lightning channel. These effects include tearing, bending, burning, vaporization, or blasting of hardware, as well as the high-pressure shock waves and magnetic forces produced by the associated high currents.

- Indirect effects are those resulting from electrical transients induced in electrical circuits due to coupling of the EM fields associated with lightning and the interaction of these fields with equipment in the system.

For example, a lightning strike to an antenna could cause physical damage and send damaging voltages into the transmitter or receiver connected to that antenna. Also, currents and voltages conducted by cables or wiring in aircraft may cause serious electrical shock. Lightning pulse characteristics and additional guidance are contained in MIL-STD-464.

4.8 Precipitation Static

P-static is an EM disturbance caused by a random ESD buildup as a result of the flow of air, moisture, or airborne particles over the structure or components of a vehicle moving in the atmosphere, such as an aircraft or spacecraft. As systems in motion encounter dust, rain, snow, and ice, an electrostatic charge builds up. This buildup of static electricity causes significant voltages to be present which can result in interference to equipment and constitute a shock hazard to personnel. For aircraft applications, air crew personnel may be affected during flight, and ground personnel may be affected after landing. P-static deserves special emphasis because of increased sensitivity of electronic equipment, wider frequency spectrum for new communications systems, and increased use of composite materials.

4.9 ESD

ESD occurs when the static electric field between two objects exceeds the dielectric strength of the air between them. The discharge is a complex event involving a localized transfer of charge at the point of discharge, EM near field coupling between the objects involved, induced current flow in the object receiving the discharge, and radiated EM energy from the charged object as well as from the arc of the discharge. All of these phenomena are capable of causing malfunctions and, in some cases, damage in electronic equipment. Examples of sensitive components that can be damaged are microcircuits, discrete semiconductors, thick film resistors, hybrid devices, and piezo-electric crystals. ESD can cause intermittent or upset (transient) failures as well as hard failures. Intermittent failures occur when the equipment is in operation and is usually characterized by a loss of information or temporary distortion of its functions. No apparent hardware damage occurs and proper operation resumes automatically after the ESD exposure or in the case of some digital equipment, after re-entry of the information by re-sequencing the equipment. Catastrophic (hard) ESD failures can be the result of electrical overstress of electronic parts caused by a discharge from a person or object, an electrostatic field, or a high voltage spark discharge. ESD can also cause hazardous conditions in fuels and ordnance, as well as presenting a shock hazard to personnel.

- Sloshing fuel in tanks and fuel flowing in lines can both create a charge buildup resulting in a possible fuel hazard due to sparking. Any other fluid or gas flowing in the system (such as cooling fluid or air) can likewise deposit a charge with potentially hazardous consequences.

- Ordnance is potentially susceptible to inadvertent ignition from ESD. The primary concern is discharge through the bridgewire of the EID used to initiate the explosive.

- During maintenance, personnel contact with the structure and various materials can create an electrostatic charge buildup on both the personnel and structure (particularly on non-conductive surfaces). This buildup can constitute a safety hazard to personnel or fuel or may damage electronics.

Requirements and guidance are contained in MIL-STD-464 and 1686 and MIL-HDBK-263. ANSI/ESD-S20.20 provides guidance for establishing an ESD control program to minimize ESD hazards to sensitive devices. ESD TR 20.20 provides guidance for applying ANSI/ESD-S20.20.

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5. OVERVIEW OF SPECTRUM MANAGEMENT

5.1 General

Use of the EM spectrum by DoD is expanding based on emerging advanced technologies and Joint warfighting strategies. The DoD employs a large number of weapon systems in executing military missions, and most, if not all, depend upon the EM spectrum. Loss of spectrum access, however, has the potential to derail efforts to exploit available technology. DoD is provided access to spectrum by the Federal Government and shares spectrum with other Federal Agencies, local Governments and private Industry. Consequently, the DoD must demonstrate critical needs to maintain specific portions of the spectrum for exclusive use. This is truer now more than ever before considering the wide use of wireless technologies in the market-place. Expanding commercial access to spectrum is a reality. Spectrum use is governed by International agreements and national laws since DoD operations are conducted worldwide, bringing new challenges to efforts involved in planning and coordinating Joint missions. Relocation of systems to new bands is difficult and costly because an equipment may interact with many other equipment. In addition to the increased likelihood of operational EMI because of overcrowding in the remaining spectrum, equipment redesign, additional testing, re-certification for spectrum use, and training all may be necessary. Further domino effects are also likely, forcing changes to other parts of the integrated military system. Many frequencies used by DoD are those that work best for the intended purpose, dictated by the laws of physics. DoD efforts to safeguard needed spectrum access depend on the capability to demonstrate the criticality of targeted frequencies. The acquisition community plays a key role since the data generated during the ESC process provides much of the information needed to substantiate DoD positions.

The availability of adequate spectrum to support military electronic systems and equipment is critical to maximizing mission effectiveness. Spectrum planning and management must be given appropriate and timely consideration during the development, procurement, and deployment of military assets that utilize the EM spectrum. To ensure maximum EMC among the various worldwide users of the spectrum, it is essential that spectrum-dependent equipment and other intentional radiators, including identification devices and stock control micro strips, comply with spectrum usage and management requirements. Elements of spectrum management are:

- Frequency Allocation. The designation of frequency bands for use by one or more radio communication service, for example, fixed, land mobile, air-to-ground, or commercial broadcast. (based on National and International agreements).

- Frequency Assignment. The authorization for a spectrum-dependent system to use a frequency under specified conditions or restrictions. (license to operate).

- Equipment Spectrum Certification (ESC). The statement(s) of adequacy received from authorities of sovereign nations after their review of the technical characteristics of a spectrum-dependent equipment or system regarding compliance with their national spectrum management policy, allocations, regulations, and technical standards. ESC is alternately called “spectrum certification.”

- Spectrum Supportability (SS). SS is the assurance that the necessary frequencies and bandwidth are available to military systems in order to maintain effective interoperability in the operational EME. The assessment of an equipment or system as having "spectrum supportability is based upon, as a minimum, receipt of ESC, reasonable assurance of the availability of sufficient frequencies for operation, Host Nation Approval (HNA), and consideration of EMC.

5.2 Spectrum Supportability (SS)

SS must be given appropriate and timely consideration in acquisition planning, development, procurement, and deployment of spectrum-dependent systems or equipment. SS must be addressed early in the conceptual phase of system development and be periodically reviewed and updated throughout the system design. OMB Circular A-11 requires that spectrum support be obtained before submitting funding estimates for the development or procurement of systems or equipment. In addition, certification is required before funds are obligated for spectrum-dependent systems or equipment. To accomplish this, a DD Form 1494 must be submitted to the appropriate Service Frequency Management Office (FMO) in accordance with policies and procedures of DoDD 4650.1, DoDI 5000.2, and the form itself. The data required, and provided on the DD Form 1494 is maintained at the JSC and benefits that portion of the DoD SM community involved in mission planning and training operations. The data enables:

- Frequency assignments for DoD operations, exercises, and training, including coordination with foreign (host) nations for use of DoD systems overseas,
- Mitigation or resolution of EMI problems,
- Siting of new DoD or commercial systems on ships, aircraft, in space, and at shore sites,
- Integration of CI into the intense EME found on military platforms and installations, and
- Establishment of mutually beneficial parameters for spectrum sharing with Industry.

5.2.1 Joint Missions and Host Nation Agreements

The International Telecommunication Union (ITU), an approximately 200-nation member organization, regulates the spectrum worldwide and promotes International cooperation in the efficient use of the spectrum. In ever-increasing competition for limited frequency spectrum, the DoD must provide for mutual compatibility and agreement regarding its use in the International community. Spectrum is a national resource managed by each country. Approval to transmit within a country is at the sole discretion of that country, based on the perceived potential for EMI to local receivers. Use of military or commercial C4I systems in host nations requires coordination and negotiation including approvals and certifications. Host nations have denied frequency assignments to DoD systems because of EMI caused to in-country systems, such as cellular and other mobile phones, civil aviation, civil defense, other civil and Government systems, sensors, radar, military systems, and satellite communications. The military conducts operations in territories of nations other than the U.S. In such situations, use of the spectrum for U.S. operations is by permission of the host Government and is formalized in an agreement between the U.S. and that nation. To ensure EMC, the host nation, in most cases, requires the U.S. to supply data concerning the equipment characteristics from a spectrum usage standpoint. The data required in most of these situations are the same data elements required in DD Form 1494. Failure to obtain HNA can result in action as severe as confiscation of the equipment. As a minimum, such equipment will not be allowed to operate. As indicated in 5.2.2, use of commercial items (CI) in DoD operations overseas must also be coordinated through these negotiations.

5.2.2 Equipment Spectrum Certification of CI

Procurement and use of CI by DoD is encouraged as an alternative to the costly in-house development process. However, the civilian spectrum is generally not authorized for military use. When contracting for the acquisition of spectrum-dependent CI, particularly those that utilize civilian frequencies, it is essential that ESC be addressed, in addition to the E3 issues discussed in this handbook. DoD directives and instructions require acquisition personnel to obtain ESC approval for all spectrum-dependent equipment, including CI emitters and receivers, particularly where the Government relies on commercially provided services or secondary allocations, that is, permission to use on a not-to-interfere basis for military purposes. This requirement extends to CI used for military purposes, whether operating in Government exclusive bands, shared bands, or non-Government exclusive frequency bands. Government requirements for use of the spectrum in exclusive non-Government bands can be accommodated either by becoming a user of a commercial service, such as cellular telephone, or by obtaining a secondary allocation.

When using a commercial service, a Government user may buy or lease CI equipment that has been “Type-Accepted” in accordance with Federal Communications Commission (FCC) rules. As a practical matter, and as discussed earlier, the limitations of CI and their potential for EMI problems should be recognized. FCC requirements differ markedly from those imposed by the DoD and, generally, do not provide the necessary data on equipment technical characteristics or system performance. This data is important to the SM community, and is used for frequency planning of Joint missions and training, EMI resolution efforts, HNA, and other related tasks. Secondary allocations can be even more of a problem for the Government user who, in this case, is afforded no protection at all from EMI. Furthermore, regulatory policy stipulates that primary allocation operations will receive no EMI from secondary users. Consequently, operational EMI can be expected in the absence of appropriate ESC considerations applied during acquisition. CI generally enters the ESC process prior to Milestone C (see 6.8.1) since the development has already taken place. In these cases, equipment manufacturers must supply the requisite technical characteristics and performance data needed to complete the process for the following reasons:

- The potential for EMI is increased, because most CI are not designed or tested for operation in the extremely dense, high power EME found on DoD platforms and in mission battle space situations. Conversely, the resolution of such problems is more difficult when ESC data is not available for use in developing potential fixes.

- Site planning, for installing CI systems in DoD platforms or land facilities, while maintaining mutual compatibility between installed systems, becomes extremely difficult, if not impossible to do efficiently in the absence of specific, spectrum performance data.

- CI with unknown, out-of-band emission characteristics can inadvertently cause severe EMI to critical C4I systems in the environment, requiring costly corrective action programs and probably reducing operational effectiveness.

– Spectrum planners, who develop frequency plans for DoD missions, are responsible for assigning frequencies to preclude EMI among the multitude of emitters and receivers that will operate in the battle space or in training exercises. Non-certified emitters and receivers constitute unknown quantities that present a hazard to spectrum planning and overall mission success, regardless of their operational frequencies.

5.3 Regulatory Organizations

The major organizations that work individually and collectively to maintain and implement spectrum policy are discussed below. Their functions and responsibilities cover all aspects of SM, from the regulatory aspects of spectrum use rules, to the specific procedural aspects of certifying equipment and obtaining assigned operational frequencies. Figure 2 depicts the SM structure.

5.3.1 International Telecommunication Union (ITU)

The first regulations governing wireless telegraphy were adopted in 1906 by the International Telegraph Convention after a widely recognized need to coordinate and control use of the spectrum. This organization later became the ITU, currently with approximately 200-member nations. The regulations, now known as the Radio Regulations, allocate the frequencies between 3 kHz and 300 GHz into bands for use by radio services worldwide. These regulations have been amended and revised over the years at World Radio Conferences (WRCs). The ITU comprises the following:

– The Plenipotentiary Conference is the supreme authority of the union and meets every four years to adopt the strategic plan and fundamental policies of the organization.

– The Council is composed of 46 members of the union and acts on behalf of the plenipotentiary conference to consider broad telecommunication policy issues.

– The World Conferences on International Telecommunications meet according to needs, generally every 2-4 years, to establish the general principles related to the operation of International telecommunication services.

– The Radio Communication Sector ensures rational, equitable, efficient and economical use of the spectrum by all radio communication services.

– The Standardization Sector studies the technical, operating, and tariff questions and issues recommendations for standardizing telecommunications on a worldwide basis.

– The Development Sector facilitates and enhances telecommunications development by offering, organizing and coordinating technical cooperation and assistance activities.

– The General Secretariat handles all administrative and financial aspects of the ITU.

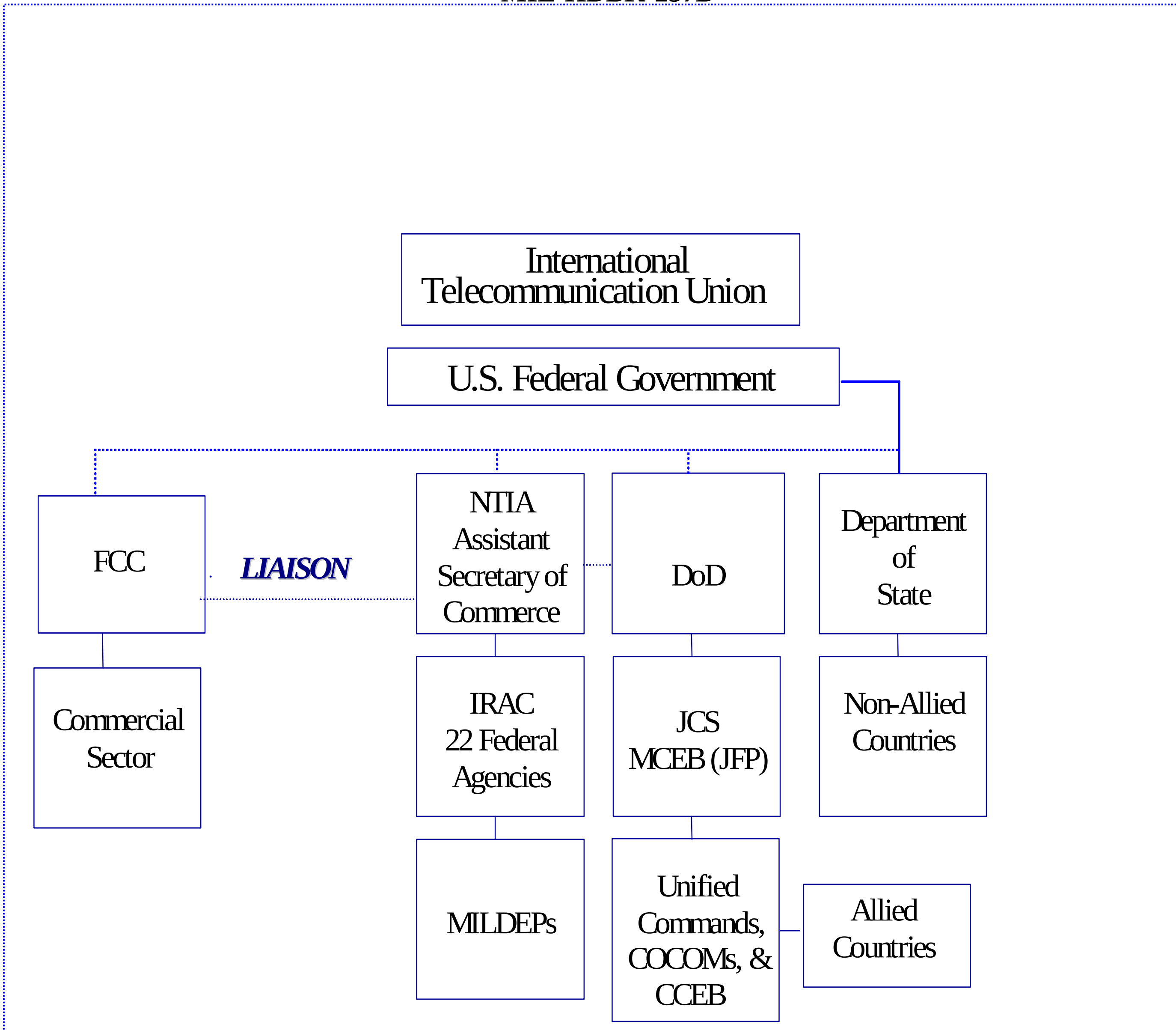

FIGURE 2. Spectrum Management Organizations.

5.3.2 National

5.3.2.1 Federal Communications Commission (FCC)

Congress has authority over civil portions of the spectrum. The Communications Act of 1934 established the FCC as an independent Government agency to control and manage civilian use of the spectrum. (See Figure 3) The FCC is directly responsible to Congress for regulating civilian use of the spectrum by radio, television, wire, satellite, and cable. Their jurisdiction covers the 50 states, the District of Columbia, and U.S. and its possessions. There are seven operating Bureaus: Cable Services, Common Carrier, Consumer Information, Enforcement, International, Mass Media, and Wireless Telecommunications. These Bureaus are responsible for developing and

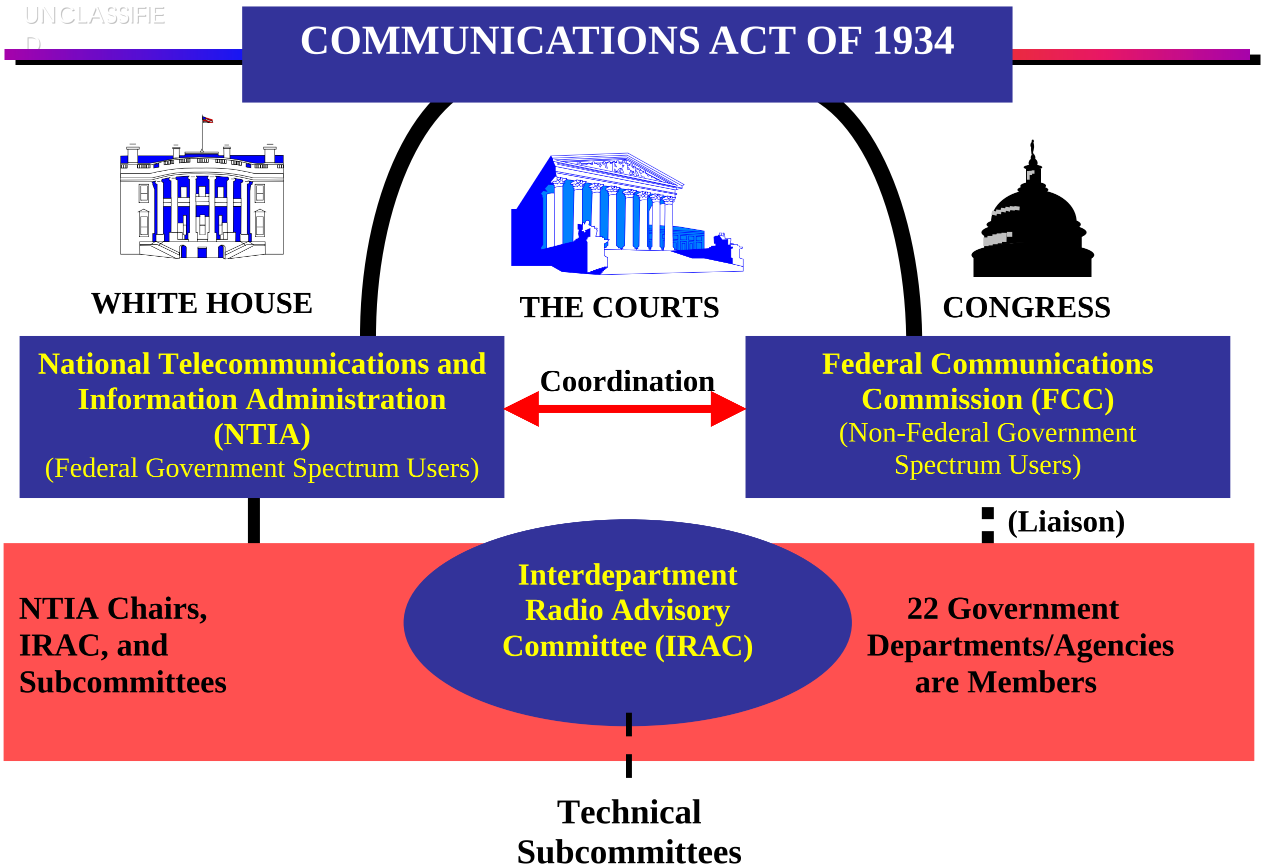

FIGURE 3. Communications Act of 1934

implementing regulatory programs, processing applications for licenses or other filings, analyzing complaints, conducting investigations, and taking part in FCC hearings.

5.3.2.2 National Telecommunication & Information Administration (NTIA)

The NTIA was established in 1978 under the Secretary of Commerce as the President's principal advisor on telecommunications policy. The Assistant Secretary acts as Administrator. Spectrum management within the organization is under the direction of its Associate Administrator, the Office of Spectrum Management. Among NTIA SM responsibilities are the following:

- Serve as the President's principal advisor on telecommunications policies pertaining to regulation of the telecommunications Industry,
- Advise the Director, OMB on the development of policies for procurement and management of Federal telecommunications systems,

– Conduct research and analysis of EM propagation, radio system characteristics and operating techniques affecting spectrum use,

– Establish policies concerning frequency allocations and assignments for telecommunication systems owned and operated by the Government and provide guidance to various Agencies to ensure their compliance with policy,

– Develop, in cooperation with the FCC, a comprehensive long-range plan for improved management of all EM spectrum resources, including jointly determining the National Table of Frequency Allocations (TOA), and

– Continues operation of the Interdepartment Radio Advisory Committee (IRAC) to serve in an advisory capacity to the Assistant Secretary.

5.3.2.3 Interdepartment Radio Advisory Committee (IRAC)

The IRAC, now under jurisdiction of the NTIA, was originally formed in 1922 to manage the Government's portion of the spectrum when Federal Departments and Agencies banded together under the Secretary of Commerce to coordinate their use. The Assistant Secretary of Commerce, under Executive Order 12046 of 1978 and the NTIA Organization Act, continued this relationship. The basic functions of the IRAC are to support the Assistant Secretary in assigning frequencies to U.S. Government radio stations and in developing and executing policies, programs, procedures, and technical criteria pertaining to the allocation, management, and use of the spectrum. The permanent substructure of the IRAC consists of the following:

– Frequency Assignment Subcommittee that carries out those functions related to the assignment and coordination of radio frequencies and the development and execution of related procedures.

– Spectrum Planning Subcommittee (SPS) that plans for use of the spectrum in the National interest, to include the apportionment of spectrum space for the support of established or anticipated radio services, as well as the apportionment of spectrum between or among Government and non-Government activities.

– Technical Subcommittee that carries out those functions related to technical aspects of use of the EM spectrum, and such other matters as the IRAC may direct. This committee evaluates and makes recommendations regarding EMC capabilities and the needs of the Government in support of SM. They also develop and update recommended standards and pertaining to spectrum use. These are published in the NTIA Manual.

– Radio Conference Subcommittee that carries out functions related to preparing for ITU conferences, including the development of recommended U.S. proposals and positions.

– International Notification Group that prepares responses to the ITU concerning questionnaires and other correspondence related to U.S. frequency assignments.

- Secretariat that consists of the Executive Secretary, who is the principal officer, the Assistant Executive Secretary, and the Secretaries of the Subcommittees. They, together with the requisite technical and clerical personnel, carry out the work of the IRAC.

The IRAC has an active membership comprised of 22 Government Departments and Agencies, including each military Department, effectively representing all Federal users. A representative appointed by the FCC acts as liaison between the IRAC Subcommittees and the Commission, thereby creating a forum for addressing civil and Federal spectrum use interests.

5.3.3 Department of Defense

5.3.3.1 Assistant Secretary of Defense for Networks and Information Integration (ASD(NII))

The ASD(NII) oversees SM within the DoD, including the following:

- Provides capabilities to generate, use, and share information among DoD forces,
- Provide direction and guidance for the development of DoD positions for, and DoD participation in, international and regional spectrum forums, including all related national, regional, and international preparatory activities for the ITU WRCs,
- Provides direction and guidance within the DoD for managing and using the EM spectrum,
- When appropriate, issue specific authorization for acquisitions and acquisition programs to proceed without spectrum supportability,
- For Major Defense Acquisition Programs and Major Automated Information Systems provide SS assessments to the milestone decision authority (MDA) at acquisition milestones,
- Direct the establishment and maintenance of a capability to analyze and make recommendations concerning whether spectrum-dependent systems, either being acquired or procured, have, or will have, SS,
- Directs the establishment and maintenance of a capability to document and manage existing spectrum assets and to perform required EMC analyses and studies to support effective use of spectrum-dependent systems in EMEs.

5.3.3.2 Joint Chiefs of Staff (JCS)

The rapid growth in sophisticated weapons systems, as well as intelligence, operations, and information systems, has increased demand for spectrum that, if not carefully coordinated and managed, will have an adverse effect upon Joint operations. The Joint Staff represents the interests of the Combatant Commands (COCOMs) related to operational SM matters. They also identify, assess, and recommend measures to ensure that EM spectrum use is mutually supporting and effective in Joint and Combined operations. At the heart is Joint Vision 2020, which promotes achieving the ultimate goal of our military forces through Full Spectrum Dominance across the full range of operations. The Directorate for Command, Control, Communications, and Computer Systems (J-6) ensures adequate support to the COCOMs and all warfighters for DoD and Joint operations, provides a permanent Military Communications Electronics Board (MCEB) Secretariat, and serves as chairman of the MCEB.

5.3.3.2.1 Military Communications Electronics Board (MCEB)

Although each of the Departments is represented in IRAC and its subcommittees, development of common procedures for inter Service coordination is the responsibility of the MCEB. The MCEB reports to the Secretary of Defense through the JCS and consists of the Chairman, senior Communications-Electronics officers of the Army, Navy, Air Force, Marine Corps, and Coast Guard, and Directors or senior representatives of Defense Information Systems Agency (DISA) and National Security Agency. The MCEB is responsible for developing and promoting the DoD position in negotiations with other host nations on matters for which it is responsible. The Joint Frequency Panel (JFP) reviews, develops, and coordinates studies, reports, and DoD positions regarding RF engineering and SM for MCEB consideration, with duties divided among eight working groups. The Equipment Spectrum Guidance Permanent Working Group (ESGPWG) reviews newly submitted DD Form 1494s for the JFP or submit them to the JFP for other actions.

5.3.3.3 Defense Spectrum Office (DSO)

The DSO, an office in DISA, in support of ASD(NII) determines DoD's future spectrum requirements, supports the WRC and coordinates analytical support, and positions for the DoD to ensure spectrum access in the 21st century.

5.3.3.4 Joint Spectrum Center (JSC)

The JSC provides technical guidance and assists the DoD in effective use of the EM spectrum in support of National security and military objectives. It provides a National repository for spectrum usage data and SM support to the DSO, the Joint Staff (J-6), ASD(NII), the Military Departments, COCOMs, and Joint and Component Commands. In addition, the JSC:

- Reviews DD Form 1494 frequency allocation applications for the Services,
- Maintains spectrum use databases for planning and analysis, and
- Provides interference prediction and analysis modeling and simulation support.

5.3.3.5 U.S. Army Spectrum Management Office

The U.S. Army Spectrum Management Office performs SM activities on behalf of the Army Spectrum Manager. It is the focal point for acquisition personnel, Major Army Commands, Major Subordinate and System Commands, and Materiel Support Commands who develop, purchase, or lease telecommunications equipment for U.S. Army use. It exercises technical control over the following Area Frequency Coordinators (AFC): Army FMO – Continental United States, DoD AFC Arizona, and DoD AFC White Sands Missile Range (WSMR). The Office is also responsible for the following ESC functions:

- Prepares, reviews, and distributes completed applications to the MCEB, the SPS, and the COCOMs, as appropriate,
- Coordinates applications with interested Army and other activities, and
- Forwards applications to the MCEB ESGPWG for approval.

5.3.3.6 Air Force Frequency Management Agency (AFFMA)

AFFMA secures and protects access to the spectrum for all Air Force requirements, nationally and internationally. With regard to ESC, the AFFMA:

- Reviews DD Form 1494s for Air Force procurements,
- Assigns J/F-12 numbers and forwards Air Force DD Form 1494s to the MCEB Secretariat for distribution to all J/F-12 holders,
- Coordinates applications with interested Air Force directorates and other designated activities for review and comment, and
- Coordinates responses and drafts and forwards approval memos to the MCEB ESGPWG.

5.3.3.7 Navy and Marine Corps Spectrum Center

The Chief of Naval Operations (CNO N71) has frequency approval authority for all Navy and Marine Corps systems. The Navy and Marine Corps Spectrum Center is CNO's agent for managing the Navy's EM spectrum resources. Navy and Marine Corps Spectrum Center personnel represent the Navy on the MCEB ESGPWG and IRAC SPS. With regard to ESC, the Center:

- Coordinates the Navy's spectrum resource usage,
- Reviews, coordinates, and processes ESC applications, and
- Provides guidance, training, and procedures for SM.

5.3.3.8 Combined Communications Electronics Board (CCEB)

The CCEB is a five-nation military communications-electronics (C-E) organization committed to maximizing the effectiveness of combined operations, with regard to communication and information systems. Their mission is to ensure interoperability among member nations through the formulation of combined C-E policy and coordination of C-E issues. The current CCEB includes the U.S., the United Kingdom, Canada, Australia, and New Zealand. Within the organization, the Frequency Planners Meeting is one of the principal activities. This forum is directed towards ensuring adequate spectrum support for forces of the CCEB nations. While the CCEB does not control national procurement initiatives, or mandate the use of particular standards, it is expected that future equipment acquisition will be strongly influenced by the standards, policies, and procedures that the organization develops.

6. INCORPORATING E3/SS IN THE ACQUISITION PROCESS

6.1 General

The military faces increasingly more complex and challenging problems in developing and fielding platforms, systems, subsystems, and equipment. Evolutionary acquisitions, including spiral and incremental developments, are the preferred approach to satisfying operational needs; however, an appropriate balance is required among key factors, such as operational needs, interoperability, supportability, and affordability of alternative acquisition solutions.

DoD policy requires all electrical and electronic systems, subsystems, and equipment, including ordnance containing EIDs, to be mutually compatible in their intended EME without causing or suffering unacceptable mission degradation due to E3. Accordingly, appropriate E3 requirements must be imposed to ensure a desired level of compatibility with other co-located equipment (intra-system) and within the applicable external EME (inter-system, RF, lightning, EMP, and p-static) and to address safety of personnel, ordnance, and fuel in these environments. In addition, national, international, and DoD policies and procedures for the management and use of the EM spectrum direct PMs developing spectrum-dependent systems or equipment to consider SS requirements and E3 control early in the development process and throughout the acquisition life cycle. Mandatory E3 and SS policies are discussed in Appendix A. In addition, Sections 4 and 5 provide overviews of E3 and SM, including SS, concerns, respectively, Section 7 provides guidance on E3 and SS testing, including analysis and prediction, and Appendix C describes the acquisition system. Managers should take the following actions to obtain SS for spectrum-dependent equipment, and minimize E3 on all equipment, systems, and platforms (both spectrum-dependent and non spectrum-dependent). Detailed guidance is provided in subsequent portions of this handbook.

6.1.1 Prior to Milestone A

- Develop SS and E3 control requirements and perform initial risk assessments to ensure issues are addressed early in the program acquisition.
- Complete and submit an initial Stage 1 (Conceptual) DD Form 1494 for coordination.

6.1.2 Before Milestone B (or before the first Milestone that authorizes contract award)

- If the system or equipment is spectrum-dependent and has not yet obtained Certification of Spectrum Support from NTIA or the MCEB to proceed into the System Development and Demonstration (SDD) Phase, the PM must develop a justification and a proposed plan to obtain SS. DoDD 4650.1 requires Milestone Decision Authorities (MDAs) and DoD Component Acquisition Executives (CAEs) to provide such a justification and proposed plan to the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD (AT&L)), the ASD(NII)/DoD Chief Information Officer (CIO), the Director, Operational Test and Evaluation (DOT&E), and the Chair, MCEB.

- Ensure E3 and SS requirements are addressed in the Joint Capabilities Integration and

Development System (JCIDS) documents (Mission Area Initial Capabilities Document (ICD), Capability Development Document (CDD), and Capability Production Document (CPD))

- Address SS and E3 control requirements in the Statement of Work (SOW), Contract Data Requirements List (CDRL), and Performance Specifications.

- Ensure completion/update and submission of the DD Form 1494. If previously submitted, ensure information is current.

- Define E3 and SS requirements in the Information Support Plan (ISP).

- Define in the Test and Evaluation Master Plan (TEMP), SS and E3 control requirements to be tested during DT&E and the SS and E3 assessments to be performed during OT&E.

6.1.3 Prior to Milestone C

- Review and update SS and E3 control requirements in the CPD, the ISP, and TEMP.

- If the system is spectrum-dependent and has not yet obtained the SS required allowing it to proceed into the Production and Deployment phase, the PM must develop a justification and a proposed plan to obtain SS. DoDD 4650.1 requires MDAs and CAEs to provide such a justification and proposed plan to the USD (AT&L), ASD(NII)/DoD(CIO), the DOT&E, and the Chairman, MCEB.

6.1.4 After Milestone C

- Monitor system changes to determine their impact on requirements for SS and E3 control. Changes to operational parameters (such as, tuning range, emission characteristics, antenna gain and height, bandwidth, or output power) or proposed operational locations may require additional ESC actions through an updated DD Form 1494 or additional E3 analyses or tests.

6.2 Pre-Acquisition Technology Projects

As noted in Appendix C, paragraph C.2.1, pre-acquisition projects include Joint Warfighting Experiments, such as the warfighting experiments conduced by the military services and the Joint Forces Command; Advanced Technology Demonstrations (ATDs); and Advanced Concept Technology Demonstrations (ACTDs). The following concerns should be addressed early in these projects:

- Does the project address E3?
- Does the project address a requirement for SS?
- Does the project address the safety issues regarding HERO, if applicable?

6.3 Incorporating E3 Control and SS Requirements in JCIDS Documents

JCIDS documents are discussed in Section C.3 of this handbook. Both CJCSM 3170.01 and CJCSI 6212.01 require the Mission Area ICD, the CDD, and the CPD to address SS and E3 control. The Joint Staff will employ the following assessment criteria when reviewing these documents.

6.3.1 Mission Area ICD

The Mission Area ICD is discussed in C.3.2. Mission Area ICDs typically address broad capability gaps in joint warfighting functions that, in most cases, do not directly translate into EM spectrum concerns such as E3 and SS functionality. However, it is appropriate to address E3 and SS functionality in the ICD when the operational capabilities, gaps, or shortcomings involve EM spectrum usage, access, or support areas such as cognitive radios that employ emerging spectrum technology waveforms, ultra-wideband systems, frequency management issues, and so forth.

When addressing E3 and SS in the ICD, shortcomings or technology gaps of existing capabilities that impact these requirements should be addressed. The ICD should explain how the deficiencies noted will be resolved or mitigated by the planned capability or technology. The ICD should also address regulatory compliance issues as applicable. For example, the Joint Tactical Radio System bridges a technology gap but at the same time it presents numerous SS concerns from EMI to HNA. These issues, in order to be effectively addressed, must be presented to decision-makers within the DoD, National, and International regulatory structure early in the requirement generation and acquisition process.

The following questions should be addressed when addressing E3 and SS in the ICD:

- Will the capability comply with the DoD, National, and International SM policies and regulations?
- Can sufficient HNA be obtained?
- Can operational frequency assignments be made when the capability is deployed?
- Will the capability be compatible with existing systems?
- Does the capability need to be hardened to withstand the EME?

6.3.2 CDD

The CDD is discussed in C.3.4. CJCSM 3170.01 requires the CDD to address both E3 and SS. The following requirements are excerpted from the CDD format template contained in Appendix A, Enclosure E of the manual:

> "10. <u>Electromagnetic Environmental Effects (E3) and Spectrum Supportability</u>. Describe the electromagnetic environment in which the system must operate and coexist with other US, allied, coalition, government and non-government systems. Identify potential issues regarding E3 interference from threat emitters. For systems that communicate via electromagnetic energy, spectrum certification is necessary to ensure adequate access to the electromagnetic spectrum."

"14. Other System Attributes. As appropriate…. Address safety issues regarding hazards of electromagnetic radiation to ordnance (HERO). Define the expected mission capability (e.g., full, percent degraded) in the various environments. Include applicable safety parameters, such as those related to system, nuclear, explosive and flight safety."

In addition, the "Threat Summary" paragraph of the CDD, Section 4, should include a definition of the EME, both friendly and hostile forces that the device may encounter such as specific high-power emitters, EMP, directed energy weapons, and so forth. Further descriptions of some of these threats can be found in MIL-STD-464 and 461.

CJCSI 6212.01 establishes the assessment criteria for evaluating the CDD that will be employed during the Joint Staff review. The following criteria should be addressed when preparing the CDD:

- Does the CDD address E3?
- Does the CDD identify a requirement for SS?

In addition, CJCSI 6212.01 requires the Net-Ready Key Performance Parameter (NR-KPP) assessment to address the following:

- SS
- E3
- HNA

DoDI 5000.2 defines SC compliance as a statutory information requirement that must be addressed during all program milestones and phases. The following is an excerpt from the Statutory Compliance Table.

Spectrum Certification Compliance (DD Form 1494) (applicable to all systems/equipment that require utilization of the electromagnetic spectrum)	47 U.S.C. 305, reference Pub. L. 102-538, 104, reference 47 U.S.C. 901-904, reference DoD Directive 4650.1, reference OMB Circular A-11, Part 2, reference	MS B MS C (if no MS B)

Typical, E3 and SS statements for the CDD to ensure compliance with these requirements follow.

"Electromagnetic Environmental Effects. The XXX system (or equipment) shall be mutually compatible and operate compatibly in the electromagnetic environment. It shall not be operationally degraded or fail due to exposure to electromagnetic environmental effects, including high intensity radio frequency (HIRF) transmissions or high-altitude electromagnetic pulse (HEMP). Ordnance systems will be integrated into the platform to preclude unintentional detonation. (THRESHOLD)"

"Equipment Spectrum Certification. The XXX equipment will comply with the applicable DoD, National, and International spectrum management policies and regulations and will obtain spectrum certification prior to operational deployment. DD Form 1494 will be submitted to the Military Communications Electronics Board Joint Frequency Panel via the service/component E3/SM office. (THRESHOLD)"

"Hazards of Electromagnetic Radiation to Ordnance. All ordnance items shall be integrated into the system in such a manner as to preclude all safety problems and performance degradation when exposed to its operational EME. (THRESHOLD)"

6.3.3 CPD

The CPD is discussed in C.3.5. CJCSM 3170.01 requires the CPD to address both E3 and SS. The following requirements are excerpted from the CPD format template contained in Appendix A, Enclosure F of the manual:

"10. Electromagnetic Environmental Effects (E3) and Spectrum Supportability. Describe the electromagnetic environment in which the system must operate and coexist with other US, allied, coalition, government and non-government systems. Identify potential issues regarding E3 interference from threat emitters. For systems that communicate via electromagnetic energy, spectrum certification is necessary to ensure adequate access to the electromagnetic spectrum."

"14. Other System Attributes. As appropriate…. Address safety issues regarding hazards of electromagnetic radiation to ordnance (HERO). Define the expected mission capability (e.g., full, percent degraded) in the various environments. Include applicable safety parameters, such as those related to system, nuclear, explosive and flight safety."

In addition, the "Threat Summary" paragraph of the CPD, Section 4, should include a definition of the EME, both friendly and hostile forces that the device may encounter such as specific high-power emitters, EMP, directed energy weapons, and so forth. Further descriptions of some of these threats can be found in MIL-STD-464 and 461.

CJCSI 6212.01 establishes the assessment criteria for evaluating the CPD that will be employed during the Joint Staff review. The following criteria should be addressed when preparing the CPD:

– Does the CPD address E3?
– Does the CPD identify a requirement for SS?
– Does the CPD address HNA?

In addition, CJCSI 6212.01 requires the NR-KPP assessment to address the following:

– SS
– E3
– HNA

As noted in 6.3.2, the Statutory Compliance Table in DoDI 5000.2 defines SC compliance as a statutory information requirement that must be addressed during all program milestones and phases. Typical, E3 and SS statements for the CPD to ensure compliance with these requirements are as follows:

"Electromagnetic Environmental Effects. The XXX system (or equipment) shall be mutually compatible and operate compatibly in the electromagnetic environment. It shall not be operationally degraded or fail due to exposure to electromagnetic environmental effects, including high intensity radio frequency (HIRF) transmissions or high-altitude electromagnetic pulse (HEMP). Ordnance systems will be integrated into the platform to preclude unintentional detonation. (THRESHOLD)"

"Equipment Spectrum Certification. The XXX equipment will comply with the applicable DoD, National, and International spectrum management policies and regulations and will obtain spectrum certification prior to operational deployment. DD Form 1494 will be submitted to the Military Communications Electronics Board Joint Frequency Panel via the service or component E3/SM office. (THRESHOLD)"

"Hazards of Electromagnetic Radiation to Ordnance. All ordnance items shall be integrated into the system in such a manner as to preclude all safety problems and performance degradation when exposed to its operational EME. (THRESHOLD)"

6.4 ISP

The ISP is discussed in Section C.3.6 of this handbook. According to DoDI 4630.8 and CJCSI 6212.01, the ISP must address SS, including ESC, reasonable assurance of the availability of operational frequencies, and consideration of E3 control. Enclosure (4) of DoDI 4630.8 stipulates that when preparing the ISP, DoD Components shall ensure that SS requirements are addressed through:

- Submission of a DD Form 1494 by the acquiring activity.
- Consideration of supportability comments provided by the ESGPWG
- On-going reviews and assessments of ISPs within the SM community.

DoDI 4630.8 and CJCSI 6212.01 define the steps in the ISP information needs discovery and analysis process. The following is an excerpt from these instructions:

Step 9	Discuss RF Spectrum needs.

The ISP should identify and address implementation issues related to E3 and SS support needs, dependencies, and interfaces related to net-readiness, interoperability, information supportability, and information sufficiency concerns. The ISP must also discuss actions, plans, or techniques to mitigate or resolve these issues. Specifically, the ISP should address the following EM spectrum issues:

- ESC problems
- Status of HNA
- Mitigation of known EMI problems

As noted in CJCSI 6212.01, in the Joint Staff's review of the ISP, the following will be assessed:

– Under Chapter 2, has a requirement for SS and a status of the ESC process been provided?
– Has a separate Appendix that addresses E3, including the intended operational EME, SS, and HNA been prepared? For platforms that employ RF emitters developed by a separate acquisition program, spectrum documentation for those emitters may be cited here as evidence of compliance with SS regulations. In addition, if applicable, there should be a discussion of the impact of the loss of a planned spectrum-dependent command, control, or communication link as a result of an unresolved spectrum supportability issue.

6.5 TEMP

6.5.1 General

The overall goals of the E3/SS portion of the test program, as discussed in Section 7 of this handbook, are to ensure that E3 and SS evaluations are conducted during DT&E, and that these assessments are performed during OT&E that define, for the MDA, performance and operational limitations and vulnerabilities. As noted in Section C.3.8.1 of this handbook, the TEMP identifies a tailored program of T&E tasks to demonstrate that the applicable KPPs, critical issues, and technical parameters are met and that the platform, system, subsystem, or equipment demonstrates effective performance in its intended environment. Test limitations such as platform availability, test equipment, and personnel may lead towards the use of modeling and simulation (M&S) for the required verification effort. The Service E3 offices and the JSC can be consulted to determine the availability of such capabilities. Appendix D of this handbook describes the Services' test facilities and capabilities.

Recent reallocation of the EM spectrum from DoD and Government use to the private sector may preclude operation of a system or equipment on specific frequencies. Approved frequency allocations must be obtained for the development and procurement of the item, whereas the Service Operational Test Agency (OTA) is responsible for obtaining frequency assignments for equipment operated during operational testing.

E3/SS considerations for the TEMP are discussed in the following paragraphs.

6.5.2 Content

As noted in C.3.8.1, content requirements for the TEMP are defined in the Acquisition Guidebook (Appendix 2). In preparing and reviewing the TEMP, the following issues should be addressed:

– Under "System Introduction":

  - Are measures of effectiveness and suitability established for E3/SS requirements that are addressed in the CDD or CPD?
  - Is E3 identified as a critical operational effectiveness and suitability parameter?
  - Are Measures of Effectiveness (MOEs) and Measures of Performance (MOPs) stated and evaluation criteria and data requirements defined that includes E3/SS considerations?

– Under "Integrated Test Program Summary"

- Is the schedule for E3 verification events identified?
- Is T&E responsibility for E3 verification established by organization?

– Under "Developmental Test and Evaluation Outline"

- Has emission and susceptibility testing been planned for the subsystems or equipment in accordance with MIL-STD-461 or commercial EMI standards, as appropriate?
- Are E3 tests planned for Commercial Items or Non-Developmental Items (CI/NDI)?
- Have platform/system E3 verifications been planned in accordance with MIL-STD-464? (Note that EMI, EMC, and EMV testing should be required for all platforms or systems, whereas special E3 T&E efforts such as HERO, HERF, HERP, EMP, lightning, and p-static may be required on a case-by-case basis, as noted in the CDD, CPD, TEMP, or contract documents.)

– Under "Operational Test and Evaluation Outline"

- Are E3/SS issues addressed?
- Have intra- and inter-subsystem and equipment E3 verifications been planned?
- Have intra-and inter-platform and system E3 verifications been planned?
- Are special E3 verifications required, depending on the results of DT&E?

– Under "Test and Evaluation Resource Summary"

- Have adequate resources, including M&S, been identified for the following efforts?

  * Subsystem and equipment emission and susceptibility testing,
  * Testing of CI/NDI,
  * MIL-STD-464 verifications,
  * Operational Intra-platform and system EMI evaluations, and
  * Operational Inter-platform and system EMI evaluations.

6.6 Incorporating E3 Control and SS Requirements in Program Office Tasks and Products

6.6.1 General

This section provides general guidance for establishing a workable and effective E3/SS program to ensure that an end-item will operate in its intended EME without causing or suffering unacceptable performance degradation due to E3. Guidance is provided to ensure appropriate E3 and SS requirements and considerations are addressed.

6.6.2 E3/SS Considerations in Integrated Product Teams (IPTs)

An E3/SS Working Level IPT (WIPT) should be established for each program that is either designated as, or meets the criteria for, Acquisition Category (ACAT) I or II, or for any acquisition when the end-item may affect, or be affected by its intended operational EME. It may also be established for programs with complex, multi-discipline EM issues. An E3/SS WIPT is an advisory body that may be established by the PM to assist him in assuring that the platform, system, subsystem, or equipment under development has spectrum support and will be electromagnetically compatible with itself and with the external EME. The E3/SS WIPT monitors the E3/SS program associated with a project, provides assistance in formulating and implementing solutions for E3/SS problems, and establishes high-level channels of coordination. It functions as a major resource for review, advice, and technical consultation on program E3 or SS issues. The E3/SS WIPT should be organized early in a program so that it can contribute to the trade-off studies of alternate concepts and to assess the impact of design, budgetary, and scheduling decisions related to E3/SS considerations. The E3/SS WIPT is usually comprised of Government and contractor personnel empowered with the authority to make most decisions within their discipline while being held accountable for meeting performance and cost requirements. The team is expected to make decisions in a cooperative manner as compared to the adversarial relationships between Government and contractor personnel that often existed in the past.

6.6.2.1 Members

The chairman of the E3/SS WIPT operates under the authority of the PM. Often, Government and prime contractor personnel will co-chair the WIPT. Membership may often vary over time depending on the status and phase of the development and the various E3-related disciplines that are deemed appropriate for a particular acquisition. E3 and SS specialists from various organizations, such as acquisition offices, modeling or test areas, and subcontractors, may be involved. Specialists in other disciplines may also need to participate such as those with contracts, safety, or system integration backgrounds. The total number of members is usually dependent upon the complexity of the program. Industry participation must be consistent with the contract.

6.6.2.2 Responsibilities

Responsibilities of an E3/SS WIPT should be defined in a charter and may include the following:

- Establishing E3 performance requirements for the system or equipment, by drawing from and tailoring existing military and commercial standards,
- Defining the flow of E3/SS requirements down to elements of the system,
- Defining and updating the various aspects of the external EME,
- Defining E3/SS requirements, verification methodology, such as analysis, M&S, and T&E,
- Preparing and updating the DD Form 1494 for spectrum-dependent systems and equipment,
- Defining E3/SS budget requirements,
- Providing E3/SS inputs to acquisition documents and reviewing program documentation and contract deliverables,
- Assessing HERO, HERP, and HERF safety issues,
- Performing E3 analyses and tests to identify potential E3/SS problems and solutions,
- Identifying operational limitations for E3 problems not corrected, and
- Evaluating the E3 impact of using CI/NDI on the overall performance of the end item.

6.6.2.3 Charter

The charter should delineate the responsibilities, objectives, membership, and operation of the E3/SS WIPT, program authority, and relationships among participants for Joint procurements. It should provide guidance for the WIPT to ensure that all pertinent E3/SS considerations are being implemented and to establish confidence that the platform, system, subsystem, or equipment being developed can operate compatibly in its intended EME. The charter should include a purpose and scope, a description of the item being procured, its functions, intended uses, and installations. It should also identify the E3 disciplines that are to be addressed during the program. The charter should describe the responsibilities and role of the WIPT and its members and how its recommendations will be handled, within the overall program. If there is more than one E3/SS WIPT involved in an overall program, such as for individual subsystems or equipment and for the overall platform or system, the relationship between the WIPTs should be clearly delineated. Specific categories of representatives, such as Chairman, Vice-Chairman, Secretary, and Members, should be defined and each of their individual responsibilities and functions should be detailed. Technical specialists, contractors, and consulting members who are technical support individuals that attend only when requested should also be identified. The charter should describe in detail the activities and required schedules and milestones that should be formulated for these activities. It should delineate all of the documentation requirements to be provided by the WIPT. Finally, the charter should state that the WIPT will document all decisions which may later have an impact, identify essential E3 features or qualities such as special components and specialized installation techniques, and identify, as appropriate, any E3/SS deficiencies and the risks associated with them.

6.6.3 Specifying Requirements in Solicitation Documents

6.6.3.1 General

As discussed in C.3.9 of this handbook, performance specifications, SOWs, CDRLs, and Data Item Descriptions (DIDs) are documents used in solicitations that become part of a contract. It is essential that requirements be clearly articulated during the preparation of these documents. As detailed below, E3 and SS requirements are to be included in each of these documents

6.6.3.2 Performance Specifications

6.6.3.2.1 General

This section discusses the applicable military standards that are to be invoked in the performance specification. It also contains guidance for tailoring the requirements in the standards. (See Appendix A of this handbook for additional applicable E3 and SS documents).

6.6.3.2.2 Subsystem/Equipment Military E3 Standards

Subsystems and equipment should not be susceptible to conducted or radiated EM emissions that could degrade or render them ineffective. Likewise, they should not be sources of EMI to other equipment within the platform or system. Developmental EMI requirements for subsystems and equipment, that is, conducted and radiated, emission and susceptibility (immunity) requirements are defined in MIL-STD-461. Many of the requirements in the standard are universally applicable to all subsystems and equipment, regardless of end use, whereas a limited number of requirements are structured to address specific concerns associated with the end platform or system. Tables in the standard define the applicability of the requirements. The requirements contained therein are not to be applied to subassemblies of equipment such as modules or circuit cards, nor are they intended for platforms. The requirements in the standard are to be used as a baseline and should be tailored to the specific item being procured. Verification of the EMI requirements is demonstrated by tests based on those also in MIL-STD-461. The Appendix of the standard provides rationale and guidance for implementing and tailoring the requirements contained therein. In addition, the Appendix should be consulted for detailed guidance on tailoring and performing the required tests. Compliance with the equipment or subsystem EMI requirements does not relieve the developing or integrating activity of the responsibility for providing overall platform or system compatibility.

6.6.3.2.3 Platform/System Military E3 Standards

Developmental E3 requirements for airborne, sea, space, and ground platforms and systems, including associated ordnance, are defined in MIL-STD-464. Ordnance includes weapons, rockets, explosives, EIDs, EEDs, squibs, flares, igniters, explosive bolts, electric primed cartridges, destructive devices, and jet-assisted take-off bottles. The standard applies to complete platforms or systems, both new and modified. The platform or system E3 specification, although based on MIL-STD-464, must be tailored for the specific acquisition and to the expected operational environment. Verification of the tailored E3 requirements is done by test, analysis, inspection, or some combination thereof, depending upon the degree of confidence in the particular method, the technical appropriateness, associated costs, and availability of assets. The Appendix to the standard provides rationale and guidance for implementing the requirements and verification procedures contained therein. The basic requirements in MIL-STD-464 are at the platform or system level and deal with both the integration and operation of subsystems and equipment in the platform or system and with the operation of the platform or system in its operational EME. The requirements for intra-platform/system EMC, inter-subsystem/equipment EMC, and EMV are universally applicable. Additional, specialized E3 assessments, such as lightning, p-static, HERP, HERF, HERO, and EMP, may also be required, depending on the type of item being procured, its mission, and its intended operational EME. Appendix A of this handbook lists other documents that could be referenced for an acquisition.

6.6.3.2.4 Tailoring

E3 requirements should be tailored to the specific needs of the mission and should be considered in conjunction with program risks and costs when related to performance trade-offs. Tailoring is the process by which the requirements of a standard are adapted to the characteristics or operational requirements of an item under development. Since each platform, system, subsystem, or equipment has its own requirements and characteristics, the general E3 performance requirements in MIL-STD -461 or 464, for example, may not be adequate. Quite often the requirements for items that operate in critical EME need to be made more stringent.

Tailoring involves modifying, deleting, or adding to the requirements in a basic military standard.

Tailoring the requirements of a standard should either result in improved performance of the item or reduce the item's development or life cycle costs without compromising the item's operational capabilities. Tailoring the requirements of a standard does not constitute a waiver or deviation from the document. Tailored E3 performance requirements should be reflected in the solicitation documents. The depth of detail, level of effort required, and the data expected should be defined when tailoring the requirements. Subsequent tailoring of performance requirements may be requested or recommended by a contractor but should be subject to Government approval.

Tailoring is an important step in preparing the SOW, CDRLs, and the requirement documents. First, there should be an orderly process of reviewing all of the available specifications and standards and selecting those that are considered pertinent to the particular item. Then, the individual requirements from the sections and paragraphs of the selected standards, specifications, or related documents should be evaluated to determine their suitability for an item's acquisition. As required, individual requirements should be tailored for the specific application and use of the item to ensure an optimal balance between the item's operational needs and acquisition costs.

The following two paragraphs are examples of how to address E3 performance requirements in a subsystem or equipment specification:

> "EMI Control. The equipment shall comply with the applicable requirements of MIL-STD-461."
> "EMI Test. The equipment shall be tested in accordance with the applicable test procedures of MIL-STD-461."

As an alternative, the specific, applicable MIL-STD-461 conducted emission, radiated emission, conducted susceptibility, and radiated susceptibility requirements may be specified, along with modifications to the limits or applicable frequency ranges, as appropriate. Acceptable, equivalent commercial standards may also be invoked.

A system or platform specification will call out the specific, applicable, E3 requirements of MIL-STD-464 in a similar manner.

6.6.3.3 Statement of Work (SOW)

The SOW is described in C.3.9.2. Sample wording addressing the E3/SS area that might be included in a contract for a system follows:

> "The contractor shall design, develop, integrate, and qualify the system such that it meets the E3/SS performance requirements of the system specification. The contractor shall perform analyses, studies, and testing to establish E3/SS controls and features to be implemented in the design of the item. The contractor shall perform inspections, analyses, and tests, as necessary, to verify that the system meets its E3/SS performance requirements. The contractor shall prepare and update the DD Form 1494 throughout the development of the system for spectrum-dependent equipment and shall perform analysis and testing to characterize the equipment, where necessary. The contractor shall establish and support an E3/SS WIPT to accomplish these tasks. MIL-HDBK-237 may be used for guidance."

6.6.3.4 Contract Data Requirements List (CDRL)

The CDRL and its relationship to the SOW and the Data Item Descriptions (DIDs) are discussed in C.3.9.3. See 6.6.3.4.1 for applicable DIDs.

6.6.3.4.1 Applicable E3 Data Item Descriptions (DIDs)

DIDs are used for ordering data products associated with hardware development. The most frequently ordered DIDs in subsystem or equipment procurements are associated with MIL-STD-461. These DIDs are:

- EMI Control Procedures — DID No. DI-EMCS-80199B
- EMI Test Procedures — DID No. DI-EMCS-80201B
- EMI Test Report — DID No. DI-EMCS-80200B

The DIDs associated with platform or system procurements implementing MIL-STD-464 are:

- E3 Integration and Analysis Report — DID No. DI-EMCS-81540A
- E3 Verification Procedures — DID No. DI-EMCS-81541A
- E3 Verification Report — DID No. DI-EMCS-81542A

Appendix A of this handbook lists other possible data that may be ordered.

6.7 Commercial Items and Non-Developmental Items (CI/NDI)

While the use of CI/NDI provides a cost-effective alternative to what can be a costly and time consuming design process and takes advantage of the latest technology, there needs to be an increased awareness of the limits associated with the use of these items in the military EME. CI/NDI should meet the basic operational requirements and function in the intended operational EME. CI/NDI, like developmental acquisition programs, should address logistics support, T&E, reliability, maintainability, E3, SS, and safety issues.

6.7.1 SS Concerns

Evidence of SS and approval to operate in its intended environment, including overseas theaters, is required for CI. From a SS standpoint, there may be a potential problem with the military using commercial equipment, particularly on commercial frequencies. A DD Form 1494 must be submitted by the Program Office, in coordination with the organization's E3/SM office, to the military Service's frequency manager for approval. The commercial equipment procured by the military may only be operated after approval has been granted by the MCEB. On the other hand, the rules for the operation of leased CI operated by the military are different.

6.7.2 E3 Concerns

The use of CI/NDI presents a dilemma between the need for imposing E3 controls and the desire to take advantage of existing designs, which may have unknown or undesirable EMI characteristics. Blindly using CI/NDI carries a risk of E3 problems within the platform, system, subsystem, or equipment. CI/NDI should meet the operational performance requirements for that equipment in the proposed installation. As a practical matter, the limitations of CI should be recognized. For example, CI are generally not designed to operate in the harsh military EME and in many instances lack sufficient emission control or susceptibility (immunity) protection such that severe EMI can result from co-located C4I systems, other onboard electronic and electrical subsystems and equipment, or emitters on other platforms. Experience has shown that efforts to resolve these EMI problems may be time consuming, difficult to implement in the field and expensive for the Government, often with marginal results. Also, NDI may be designed for one environment but selected for use in another. Each potential use of CI/NDI needs to be reviewed for the actual intended usage, and a determination needs to be made of appropriate requirements for that application.

6.7.2.1 Assessment of CI/NDI

Since CI/NDI is already designed, it is essential that the intended EME and required E3 performance characteristics of each candidate item be assessed. Modifications required to correct E3 problems in an operational CI can be time consuming and very costly. E3 problems can present a potentially hazardous situation resulting in loss of life, damage to hardware, or degradation of mission performance capability. To mitigate the risk, an assessment should be performed to evaluate the planned EME and the equipment's EMI characteristics. This can be accomplished by reviewing existing test data, reviewing the equipment design, or with limited EMI testing. If the item was designed to a commercial standard, or to one from another Government agency, there may be existing EMI test data. That data, if available, should be reviewed to determine if the item is suitable for the particular application or intended installation. If data is non-existent, or does not allow comparison with the applicable MIL-STD-461 requirements, limited laboratory EMI testing should be performed to provide the data necessary to do the comparison. If, after evaluation of the EMI data, it is determined that the equipment would not satisfactorily operate in the intended EME, then it is the responsibility of the procuring activity to implement modifications to, or select, equipment with adequate characteristics. CI/NDI avionics qualified to RTCA DO-160D are considered acceptable for use on military land-based avionics systems since the tests and the limits in DO-160 are similar to those in MIL-STD-461. There is no commercial standard equivalent to MIL-STD-464.

6.7.2.1.1 Commercial Specifications and Standards

Not all CI/NDI will function properly in the military EME. Most commercial E3 standards are inadequate for military platforms (that is, they do not adequately stipulate susceptibility or immunity performance requirements, do not address the concern of common-mode EMI, and so forth). Comparing military and commercial EMC performance requirement is a first step in determining if:

- Use of CI/NDI is practical,
- More testing is required, or
- Whether the equipment must be hardened.

6.7.2.1.2 Comparisons

Items successfully tested to commercial E3 requirements may meet a portion of the military E3 requirements in MIL-STD-461 or 464, as appropriate. Being able to compare military and commercial specifications and standards can save an appreciable amount of effort and money when qualifying CI/NDI for military applications. In order to make useful comparisons, the minimal E3 performance requirements essential for mission effectiveness should first be established by tailoring MIL-STD-461 or 464 to the specific application. These E3 performance requirements should then be compared to the E3 requirements of the specifications/standards that were used to develop the CI/NDI that is being considered for procurement. When a commercial E3 requirement is equivalent to, or more stringent than, a MIL-STD-461 or 464 tailored requirement, it can be assumed the CI/NDI satisfies the military E3 performance requirement. If there is no equivalent commercial E3 requirement, testing in accordance with MIL-STD-461 or 464 should be conducted to demonstrate whether the CI/NDI E3 performance complies with the established performance requirements. Information to assist in comparing major National and International commercial EMC standards with MIL-STD-461E is provided as Appendix E of this handbook and in report EPS-0178.

6.7.2.1.3 Alternatives

Several alternatives exist when E3 assessments or the testing of CI/NDI demonstrates that the equipment or system cannot meet its E3 performance requirements. These include:

- Shielding or isolation of the item,
- Frequency management,
- Filtering,
- Blanking,
- Reassessing mission profiles to determine if the CI/NDI E3 performance is acceptable, or
- Abandoning the CI/NDI acquisition strategy when the E3 parameters of available CI/NDI are far inferior to the requirement.

6.8 The Equipment Spectrum Certification Process

6.8.1 General

The purpose of the ESC process is to ensure that DoD equipment and subsystems are designed and verified to conform to requirements of applicable International and National TOAs and other spectrum policies. The methodology involves review of the technical and performance characteristics of an item during the procurement to determine compliance with requirements and provide guidance to the developer. The process:

- Provides authorization to develop or procure items that utilize a defined frequency band(s) or frequencies for the accommodation of a specific electronic function,
- Ensures compliance with the policies and tables concerning the use of the spectrum, and
- Ensures spectrum availability to support the item in its intended operational environment.

As required by DoDI 5000.2, SS must be addressed at Milestone B and C reviews. The relationship between the acquisition process and the ESC process is depicted on Figure 4. A DD Form 1494 must be submitted in a timely and accurate manner. It is submitted up to 4 times (or stages) during the acquisition process. CI generally enters the ESC process prior to Milestone C as a Stage 4 DD Form 1494. Processing time depends on the quality of the data and is often delayed due to incomplete or erroneous information. Nominal time to complete the process is 3 - 9 months. A critical factor is the coordination period associated with HNA. Some countries may take years to complete coordination, whereas others may be as quick as 60 to 90 days for non-controversial systems. The process should be initiated once:

– Sufficient information becomes available on the intended use and feasible frequency limits of a proposed item to warrant consideration of a specific allocation,
– An equipment is being considered for development, or
– Procurement of CI or leasing of a commercial service for military use is being considered.

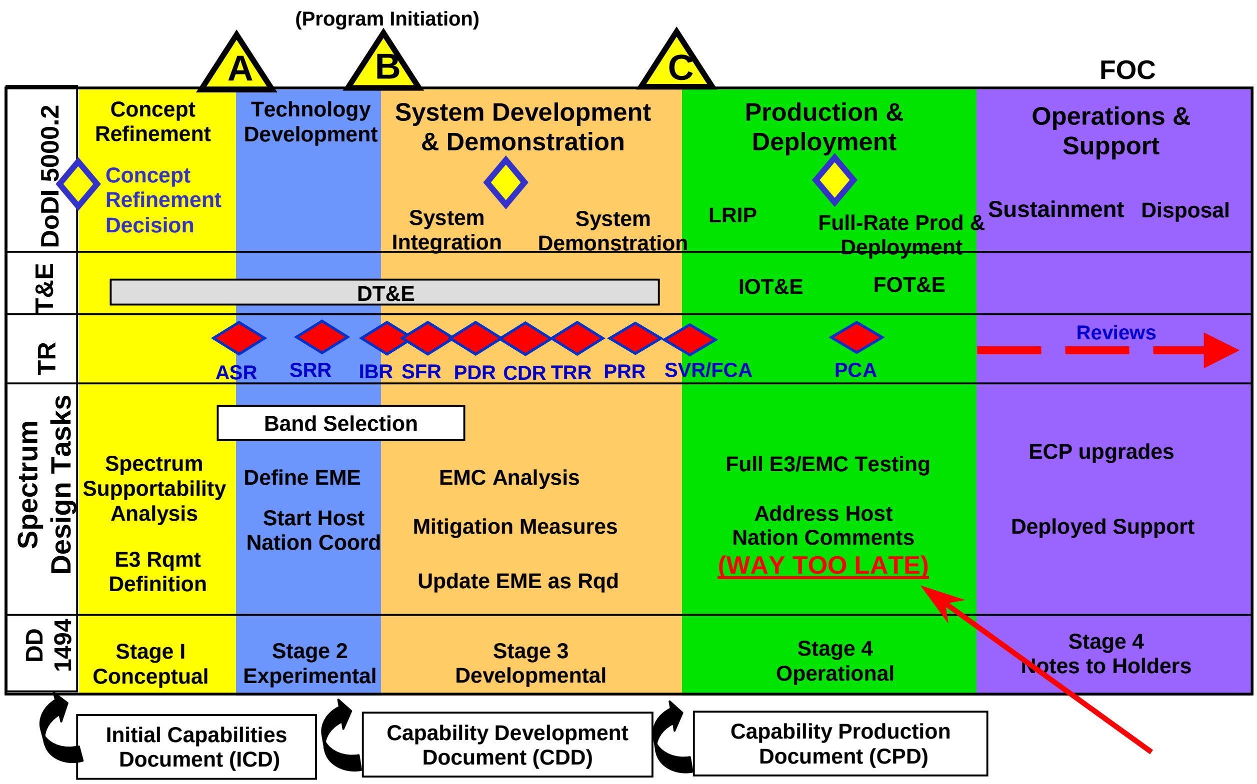

FIGURE 4. Relationship Between the Acquisition Process and the ESC Process

6.8.2 Overview of the Process

An overview of the DoD ESC process is shown in Figure 5. Contractors may supply the technical equipment characteristics data required by DD Form 1494 to the Program Office, who, in turn, provides a completed DD Form 1494 along with any applicable releasability instructions to the organization's E3/SM office. It is then forwarded to the sponsoring Military Departmental FMO for review and comment. Once complete, the sponsoring Department then submits the application to the ESGPWG for review and comment. At the same time, copies may be sent to the NTIA SPS for U.S. National approval. Releasable DD Form 1494s are sent to the MCEB and subsequently to the COCOMs and CCEB for coordination of HNA. All comments flow back to the sponsoring Department who drafts the MCEB guidance for review by the ESGPWG. A J/F-12 number is assigned upon approval of the allocation application. Once approval is obtained from the MCEB, the JSC places pertinent data about the item and its allocation into the Spectrum Certification System (SCS) database. The SCS is updated within one or two days of receipt of the information from the sponsoring department. Updates of the SCS are distributed worldwide on a semi-annual basis to DoD organizations and Military Departments. Submission of the DD Form 1494 is the key to obtaining HNA. This form is forwarded to the COCOMs where the system will be deployed overseas. Each Command's Joint FMO then reviews, coordinates, and obtains HNA of specified frequencies for the system. Once approval has been obtained, the COCOM must request assignment of a specific frequency, or frequencies, from the host nation to operate the equipment. As indicated earlier, use of CI in DoD operations overseas must also be coordinated through these negotiations.

6.8.3 Submission of DD Form 1494

The data required, and provided, on the DD Form 1494 includes identification of the item, requested spectrum support (operational frequency band(s)), planned deployment information, equipment technical characteristics, and performance data. The DD Form 1494 is submitted at times (stages) commensurate with an acquisition item's procurement cycle. These times are defined in DoDI 5000.2 and the DD Form 1494 itself. The forms must be submitted in sufficient time to allow for processing. With each submission, data requirements with respect to equipment technical characteristics and performance progressively increase. With the final submission, all data blocks requiring technical data should be completed with measured data. Calculated data generally is not acceptable.

6.8.3.1 Selection of Frequency Band

All major DoD acquisition programs are based on identified, documented, and validated mission needs. Definition of the mission provides a means for deriving the telecommunication needs of the system and, therefore, serves as a meaningful basis for preliminary preparation of spectrum support requirements. The International and National TOAs define the usable spectrum for specific radio services in accordance with International treaties. This is a preliminary source for identifying potential frequency band requirements based on the intended radio service, that is, communications, navigation, radiolocation, and so forth. Next, the requirement should be assessed in conjunction with state-of-the-art technology to determine whether certain technical factors might lead to the selection of specific frequency bands that are ideally suited. A determination should be made as to

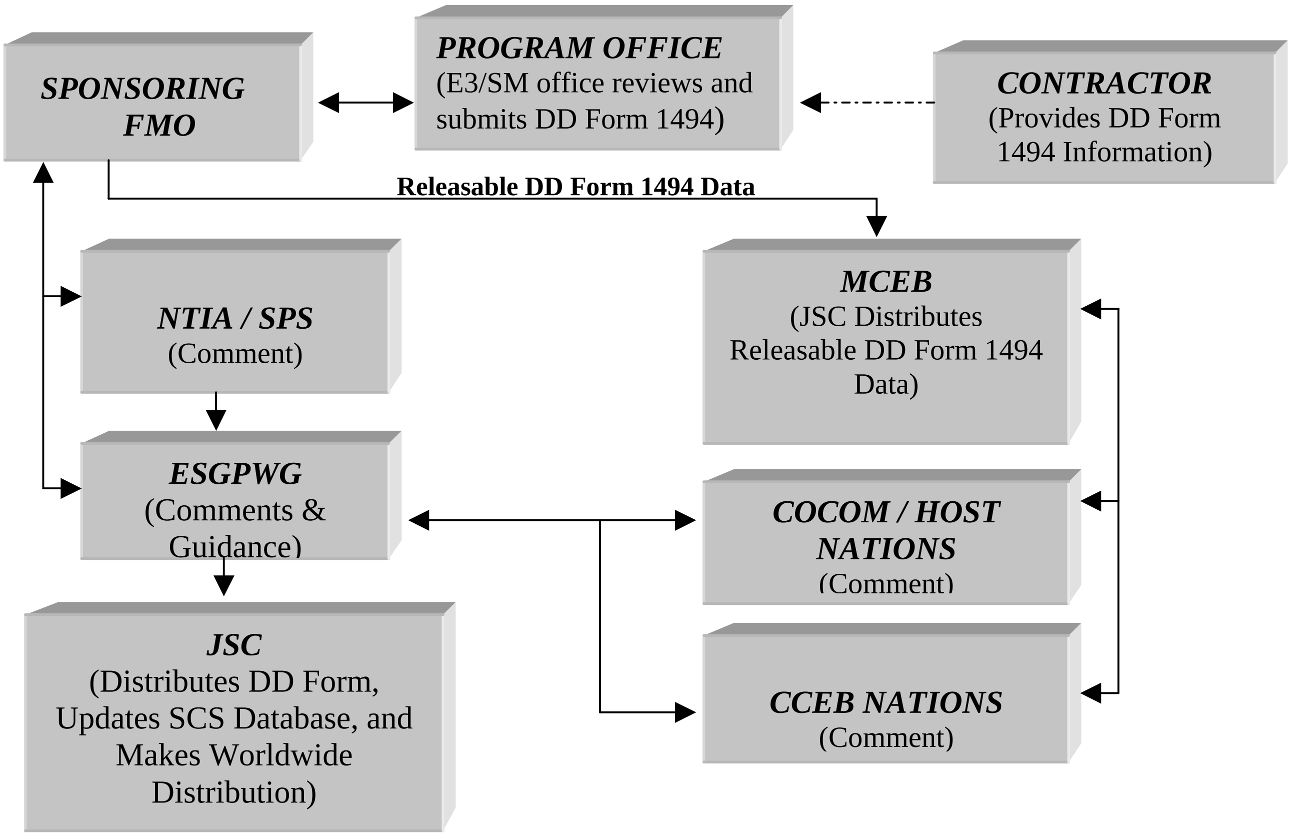

FIGURE 5. Overview of the Equipment Spectrum Certification Process

whether some bands ideally suited from a technical standpoint might be impractical for other reasons and should be rejected. Overcrowding might be one such reason, as might operating restrictions imposed by DoD, Federal, and International rules and regulations that govern the selected bands. It is also very important to consider where the system will be installed during the testing and operational phases of its life cycle.

Before finalizing the band selection process, a review should be made of existing frequency assignments that are authorized for equipment operating in the area(s) intended for location of the system. In addition, a survey should be conducted of the number of items in the DoD inventory that may be impacted by the new or modified equipment. Once completed, the survey will provide insight on potential impacts to other equipment in the intended environment that could result in rejection, or long, costly delay of approval of the frequency allocation application. The survey will additionally provide insight as to whether the proposed equipment may be adversely impacted by other items in the environment, which could lead to selection of another band option. Normally, the frequency band selected will be one of those allocated to the radio service in question, as specified in the NTIA TOA. Bands other than those identified in the TOA, however, may be proposed if operational, technical, and economic justifications are provided. Upon identification of the appropriate operational frequency band, the DD Form 1494 can be initiated.

6.8.3.2 Completing the Form

The JSC has developed the SCS Data Maintenance and Retrieval (SCS DMR) software application to automate portions of the ESC process by organizing and compiling the information required by DD Form 1494. The SCS DMR software application and user manual can be downloaded from the Internet by completing a registration form at www.jsc.mil. The SCS DMR application provides the following capabilities:

- Aids in simplifying the entry and maintenance of ESC data in a structured database,
- Provides a database retrieval capability,
- Generates and prints the completed application, and
- Outputs records for transfer to other users.

The DD Form 1494 is a multi-page document used to coordinate applications for equipment frequency allocations, both nationally and internationally. The form, composed of the eight pages, described below may be assembled in different order depending on the forum to which it is being submitted for evaluation. The back of each page contains instructions for completing each block.

- DoD General Information Page. The first page of the application contains general information concerning the nomenclature, use, number of equipment types that make up the system, and the frequency requirements.

- Transmitter Equipment Characteristics Page. The second page documents transmitter equipment characteristics. All technical characteristics required here, such as the tuning range, output power, RF channeling capability, emission bandwidth, and so forth, are evaluated in accordance with DoD requirements to determine suitability of the equipment for operation in the intended EME.

- Receiver Equipment Characteristics Page. This page consists of information related to receiver characteristics. The required data items are evaluated against performance requirements to determine the ability of the equipment to discern and process desired signals in the intended operational environment. With a multi-receiver equipment, a copy of the receiver page should be submitted for each different receiver.

- Antenna Equipment Characteristics Page. It is very common for separate receiver and transmitter antennas to be employed or for several different antennas to be associated with the same transmitter. No attempt should be made to describe several antennas on the same page. Use the “Remarks” block to describe any unusual characteristics of the antenna, particularly as they relate to the assessment of EMC, and to clarify any other antenna information provided.

- Line Diagram Page. This is one of two blank pages that the DD Form 1494 provides to allow for further description of the item. This page provides space for a line diagram to provide graphical illustration of the equipment.

– Continuation Page. The Remarks Continuation page is provided to continue any remarks needed in reference to any of the other six pages. Continuation pages are allowed.

– NTIA General Information Page. This page requires much of the same information required by the DoD General Information page, however, it provides a format acceptable to the IRAC SPS along with other specific required information. The DoD General Information page is removed prior to submission of the application to the SPS. The NTIA page is used to begin U.S. National coordination with other Government Agencies via the SPS review process. Any Agency that is a member of the SPS can impact approval of an application based on the information provided, or not provided. Use of the continuation and line diagram sheets is strongly recommended to ensure that application information is clear when submitted. Completeness is a critical factor is obtaining timely approval.

– Foreign Coordination General Information Page. This page should be completed only for equipment that will be operated outside the U.S, and Possessions. Foreign disclosure authority is required for coordination to obtain spectrum support from countries where the equipment may operate. Consequently, the release of technical information contained in DD Form 1494 to these countries is necessary. Such information, however, may not be released without first obtaining foreign disclosure approval. Action must be initiated to obtain foreign disclosure authority in accordance with Military Department regulations and policies for the release of appropriate data to the proposed host nations. A foreign coordination version of DD Form 1494 is treated as a completely separate document from a U.S. coordination version.

6.8.4 Frequency Assignments

Frequency assignments are issued by designated authorities of sovereign nations, such as telecommunications agencies within foreign countries, and the NTIA for the U.S. and Its Possessions. Under certain conditions, other designated authorities, such as DoD Area Frequency Coordinators or Unified and Specified Commanders may grant frequency assignments. Equipment that has not been previously granted some level of spectrum certification will normally not receive a frequency assignment. Procedures for obtaining frequency assignments, once the equipment, sub-system, or equipment has become operational, are delineated in regulations issued by the Unified and Specified Commands and Military Services. In most cases, operational frequency assignments are requested and received after a program has been fielded. However, if the PM has implemented guidance received in response to the submission of a DD Form 1494 during program development and designed the system as described in the DD Form 1494, system operators have not historically encountered problems in obtaining operational frequency assignments. Spectrum congestion, competing systems, and interoperability, all may contribute to the operator encountering some operational limitations such as geographical restrictions or limitations to transmitted power, antenna height and gain, bandwidth or total number of frequencies made available, and so forth. Certification to operate in a particular frequency band does not guarantee that the requested frequency(ies) will be available to satisfy the system's operational spectrum requirements over its life cycle. Procedures for obtaining frequency assignments are delineated in the Service regulations. (See Appendix A). A request for a frequency assignment should be submitted in a timely manner. It can be initiated by contacting the appropriate local installation FMO.

6.8.5 Note-To-Holders

A "Note-to-Holders" is a mechanism provided by the ESC process to permit minor changes to an existing frequency allocation in lieu of generating a new, separate allocation. The types of modifications permitted include:

- Adding the nomenclatures(s) of equipment which have essentially identical technical and operating characteristics as a currently allocated item,
- Adding comments that have been provided by the NTIA or host nations,
- Documenting minor modifications, or improvements to equipment that do not essentially alter its operating characteristics (transmission, reception, frequency response), or
- Announcing the cancellation or reinstatement of a frequency allocation.

A Note-to-Holders must be submitted in a timely manner and can be initiated by contacting the appropriate local installation FMO.

6.9 Systems Engineering Technical Reviews with Recommended E3/SS Actions

6.9.1 Initial Technical Review (ITR)

The ITR is a multi-disciplined technical review to support a program's initial Program Objective Memorandum submission. This review is intended to ensure that a program's technical baseline is of sufficient rigor to support a valid cost estimate with an acceptable cost risk, and enable independent E3/SS assessments of that estimate by cost, technical, and program management subject matter experts. Recommended E3/SS actions and focus areas are as follows:

- Develop E3/SS inputs to the Mission Area ICD
- Familiarize PM with E3/SS Requirements such as the E3 requirements in MIL-STD-461 and 464 and the National, International, and Host Nation SS Rules and Regulations
- Submit Stage 1 (Conceptual) DD Form 1494 for any new spectrum-dependent equipment
- Ensure cost estimates for all E3/SS tasks and related activities, such as system/platform antenna design, if required
- Obtain SS approval for MS A from DoD or Component CIO, CAE, or MDA, as appropriate

6.9.2 Alternative Systems Review (ASR)

The ASR is a review conducted to demonstrate the preferred system concept(s) to take forward into the Technology Development, formerly the Component Advanced Development phase. During this phase, program cost, schedule, and performance for the purpose of supporting MS approvals are validated. A tailored version of the ITR checklist should be used. Recommended E3/SS actions and focus areas are as follows:

- Establish an E3/SS WIPT or participate in System Engineering (SE) IPT
- Budget for E3 documentation (see 6.6.3.4.1 for applicable DIDs)
- Prepare and submit Stage 1 (Conceptual) DD Form 1494 request for any new spectrum-

dependent equipment
- Obtain SS approval for MS A from DoD or Component CIO, CAE, or MDA, as appropriate
- Incorporate all "Lessons Learned"
- Refine cost estimates for all E3/SS tasks, and related activities, such as system/platform antenna design, if required
- Ensure E3/SS analyses and predictions (see 7.4) are programmed, including those to assess the addition of new antennas or apertures on a platform or system

6.9.3 System Requirements Review (SRR)

The SRR is a system-level review conducted to ensure that system requirements have been completely and properly identified and that there is a mutual understanding between the Government and contractor. It captures systems requirements that go with the Concept Exploration and Technical Development phases, and is generally conducted just prior to MS B. This review validates program cost, schedule, and performance for the purpose of supporting MS approvals. Recommended E3/SS actions and focus areas are as follows:

- Continue the E3/SS WIPT and support the SE IPT
- Prepare applicable E3 documentation (see 6.6.3.4.1 for applicable DIDs), including testing requirements
- Develop E3/SS inputs to the CDD
- Update budget for applicable E3 documentation
- Define operational EME
- Establish initial E3 design requirements
- Develop and include E3/SS requirements in SOW, CDRLs, specification, and TEMP, as needed
- Prepare and submit Stage 2 DD Form 1494 request
- Include E3/SS DT/OT test requirements in TEMP
- Ensure E3/SS analyses and predictions (see 7.4) are programmed, including those to assess the addition of new antennas or apertures on a platform or system
- Refine cost estimates for all E3/SS tasks and related activities, such as system/platform antenna design, if required
- Obtain SS approval for MS B from DoD or Component CIO, CAE, or MDA, as appropriate

6.9.4 System Functional Review (SFR)

The SFR is a review of the conceptual design of the system to establish its capability to satisfy requirements. It establishes the functional baseline as the governing technical description, which is required before proceeding with further technical development. During this review program cost, schedule, and performance for the purpose of supporting MS approvals are validated. Recommended E3/SS actions and focus areas are as follows:

- Continue E3/SS WIPT and support to SE IPT
- Update applicable E3 documentation (see 6.6.3.4.1 for applicable DIDs), including testing requirements

- Develop E3/SS inputs to the CPD
- Update Operational EME
- Ensure E3/SS requirements are addressed in the SOW, CDRLs, specifications and TEMP, as needed
- Prepare and submit Stage 3 DD Form 1494 request
- Include E3/SS DT/OT test requirements in TEMP
- Ensure E3/SS analyses and predictions (see 7.4) are programmed, including those to assess the addition of new antennas or apertures on a platform or system
- Refine cost estimates for all E3/SS tasks and related activities, such as system/platform antenna design, if required
- Obtain SS approval for MS B from DoD or Component CIO, CAE, or MDA, as appropriate

6.9.5 Preliminary Design Review (PDR)

The PDR is a review that confirms that the preliminary design logically follows the SFR findings and meets the requirements. It normally includes emphasis on software specifications, and results in approval to begin detailed design. This review establishes the allocated baseline and validates program cost, schedule, and performance to support MS approvals. Recommended E3/SS actions and focus areas are as follows:

- Continue E3/SS WIPT and support SE IPT
- Update applicable E3 documentation (see 6.6.3.4.1 for applicable DIDs), including testing requirements
- Prepare applicable E3 test procedures
- Ensure E3/SS requirements are addressed in the SOW, CDRLs, specifications, and TEMP, as needed
- Include E3/SS DT/OT test requirements in TEMP
- Develop E3/SS inputs to the CPD
- Update Operational EME
- Prepare and submit Stage 3 DD Form 1494 request
- Submit frequency assignment request(s) for specific test frequencies and locations
- Ensure Host Nation Coordination has been initiated for use of spectrum-dependent equipment overseas and in foreign countries
- Refine cost estimates for all E3/SS tasks and related activities, such as system/platform antenna design, if required
- Obtain SS approval for MS C from DoD or Component CIO, CAE, or MDA, as appropriate
- Ensure E3/SS analyses and predictions (see 7.4) are initiated, including those to assess the addition of new antennas or apertures on a platform or system
- Review Engineering Change Proposals and requests for waivers

6.9.6 Critical Design Review (CDR)

The CDR is a review conducted to evaluate the completeness of the design, its interfaces, and its suitability to start initial manufacturing. This review establishes the product baseline and validates program cost, schedule, and performance to support MS approvals. Recommended E3/SS actions and focus areas are as follows:

- Continue E3/SS WIPT and support to SE IPT
- Update applicable E3 documentation (see 6.6.3.4.1 for applicable DIDs), including testing requirements
- Update applicable E3 test procedures
- Ensure E3/SS requirements are addressed in the SOW, CDRLs, specifications, and TEMP, as needed
- Include E3/SS DT/OT test requirements in TEMP
- Develop E3/SS inputs to the CPD
- Update Operational EME
- Update and submit Stage 3 DD Form 1494 request
- Submit frequency assignment request(s) for specific test frequencies and locations
- Refine cost estimates for all E3/SS tasks and related activities, such as system/platform antenna design, if required
- Obtain SS approval for MS C from DoD or Component CIO, CAE, or MDA, as appropriate
- Ensure E3/SS analyses and predictions (see 7.4) are implemented and completed, or nearly completed, including those to assess the addition of new antennas or apertures on a platform or system
- Review Engineering Change Proposals and requests for waivers
- Review status of Host Nation Coordination efforts for authorization of spectrum-dependent equipment overseas and in foreign countries
- Ensure the design has taken into account any limitations or restrictions on its use contained in the approved MCEB DD Form 1494 guidance recommendations

6.9.7 Test Readiness Review (TRR)

The TRR is a review of the program's readiness to begin testing at any level, either by the contractor or Government. This review determines the completeness of test procedures and their compliance with test plans and descriptions. Recommended E3/SS actions and focus areas are as follows:

- Continue E3/SS WIPT and support to SE IPT
- Update applicable E3 documentation (see 6.6.3.4.1 for applicable DIDs), including testing requirements
- Ensure completeness of applicable E3/SS test procedures and compliance thereto
- Ensure E3/SS requirements are addressed in the SOW, CDRLs, specifications, and TEMP, as needed
- Include E3/SS DT/OT test requirements in TEMP
- Ensure that E3/SS inputs to the CPD have been submitted
- Update Operational EME
- Update and submit Stage 3 DD Form 1494 request
- Submit frequency assignment request(s) for specific test frequencies and locations

- Refine cost estimates for all E3/SS tasks and related activities, such as system/platform antenna design, if required
- Obtain SS approval for MS C from DoD or Component CIO, CAE, or MDA, as appropriate
- Ensure E3/SS analyses and predictions (see 7.4) are implemented and completed, or nearly completed, including those to assess the addition of new antennas or apertures on a platform or system
- Review Engineering Change Proposals and requests for waivers
- Review status of Host Nation Coordination efforts for authorization of spectrum-dependent equipment overseas and in foreign countries
- Ensure the design has taken into account any limitations or restrictions on its use contained in the approved MCEB DD Form 1494 guidance recommendations
- Ensure DT&E Yellow Sheets are provided to the program office for entering and tracking in a problem management system.

6.9.8 Readiness Reviews (RR)

6.9.8.1 Flight RR

The Flight RR is a review to ensure the proper people, planning, equipment, materials, training, configuration, flight clearance (or defined flight clearance process, with plans to get an initial flight clearance), ranges, instrumentation, safety controls, and risk assessments/mitigations are in place prior to flight. Recommended E3/SS actions and focus areas are as follows:

- Continue E3/SS WIPT and support to SE IPT
- Update applicable E3 documentation (see 6.6.3.4.1 for applicable DIDs), including testing requirements
- Ensure completeness of applicable E3/SS test procedures and compliance thereto
- Ensure E3/SS requirements are addressed in the SOW, CDRLs, specifications, and TEMP, as needed
- Include E3/SS DT/OT test requirements in TEMP
- Ensure that E3/SS inputs to the CPD have been submitted
- Update Operational EME
- Update and submit Stage 3 DD Form 1494 request
- Submit frequency assignment request(s) for specific test frequencies and locations
- Refine cost estimates for all E3/SS tasks and related activities, such as system/platform antenna design, if required
- Obtain SS approval for MS C from DoD or Component CIO, CAE, or MDA, as appropriate
- Review Engineering Change Proposals and requests for waivers
- Ensure that the E3 development (Flight Worthiness) testing and the EMI qualification demonstration (EMC SOFT) have been successfully completed in accordance with applicable instructions and directives

6.9.8.2 Fleet RR

The Fleet RR is a review to verify proper coordination between the developing agency and all applicable Fleet E3/SS disciplines. The developing agency and the Fleet need to understand and approve the scope of the E3/SS test effort, how it will be executed, the test results, and actions to correct deficiencies. Recommended E3/SS actions and focus areas are as follows:

- Continue E3/SS WIPT and support to SE IPT
- Update applicable E3 documentation (see 6.6.3.4.1 for applicable DIDs), including testing requirements
- Ensure completeness of applicable E3/SS test procedures and compliance thereto
- Ensure E3/SS requirements are addressed in the SOW, CDRLs, specifications, and TEMP, as needed
- Include E3/SS DT/OT test requirements in TEMP
- Ensure that E3/SS inputs to the CPD have been submitted
- Update Operational EME
- Update and submit Stage 3 DD Form 1494 request
- Submit frequency assignment request(s) for specific test frequencies and locations
- Refine cost estimates for all E3/SS tasks and related activities, such as system/platform antenna design, if required
- Obtain SS approval for MS C from DoD or Component CIO, CAE, or MDA, as appropriate
- Review Engineering Change Proposals and requests for waivers

6.9.8.3 Operational Test Readiness Review (OTRR)

The OTRR is a review to determine readiness for test in the actual EME. Recommended E3/SS actions and focus areas are as follows:

- Request requisite frequency assignment(s)
- Verify the E3/SS operational test plan and test scenarios
- Review the E3/SS operational effectiveness and suitability thresholds in the TEMP
- Validate all corrections to E3/SS deficiencies discovered during previous testing
- Ensure adequate organic support is in place

6.9.8.4 Technical Evaluation

Recommended E3/SS actions and focus areas are as follows:

- Request requisite frequency assignment(s)
- Verify attainment of E3/SS performance specifications and objectives
- Demonstrate that E3/SS risks have been minimized
- Evaluate compatibility and interoperability with existing or planned equipment and systems
- Provide assurance the equipment or system is ready for testing in the operational EME

6.9.8.5 Operational Evaluation

Recommended E3/SS actions and focus areas are as follows:

- Request requisite frequency assignment(s)
- Estimate the equipment or system E3/SS operational effectiveness and operational suitability
- Test in the operational EME
- Identify needed E3/SS modifications
- Provide information of the equipment or system E3/SS operational performance, including tactics, doctrine, organizational, and personnel requirements
- Verify the adequacy of supporting E3/SS documentation, such as manuals, handbooks, support plans, and so forth
- Correct and retest all significant E3/SS deficiencies

6.9.9 System Verification Review/Production Readiness Review (SVR/PRR)

The SVR is a review conducted to verify that the production configuration complies with the performance specification. The PRR is a review conducted incrementally prior to any rate production decision to validate design readiness, resolution of production engineering problems, and accomplishment of production phase planning. These reviews validate program cost, schedule, and performance in support of MS approvals. Recommended E3/SS actions and focus areas are as follows:

- Continue E3/SS WIPT and support to SE IPT
- Update applicable E3 documentation (see 6.6.3.4.1 for applicable DIDs), including testing requirements
- Ensure completeness of applicable E3/SS test procedures and compliance thereto
- Ensure E3/SS requirements are addressed in the SOW, CDRLs, specifications, and TEMP, as needed
- Include E3/SS DT/OT test requirements in TEMP
- Ensure that E3/SS inputs to the CPD have been submitted
- Update Operational EME
- Update and submit Stage 4 DD Form 1494 request
- Submit frequency assignment request(s) for specific test frequencies and locations
- Refine cost estimates for all E3/SS tasks and related activities, such as system/platform antenna design, if required
- Obtain SS approval for MS C from DoD or Component CIO, CAE, or MDA, as appropriate
- Ensure E3/SS analyses and predictions (see 7.4) are completed, including those to assess the addition of new antennas or apertures on a platform or system, and necessary certifications are in work or in place
- Review Engineering Change Proposals and requests for waivers
- Review status of Host Nation Coordination efforts for authorization of spectrum-dependent equipment overseas and in foreign countries
- Ensure the design has taken into account any limitations or restrictions on its use contained in the approved MCEB DD Form 1494 guidance recommendations
- Validate all corrections to E3/SS deficiencies discovered during previous testing
- Review and approve E3/SS test reports

- Ensure that subsequent procurements and replacement parts meet original E3 program requirements

6.9.10 Physical Configuration Review (PCR)

The PCR formalizes the product baseline, including specifications and the Technical Data Package, so that future changes can only be made through full Configuration Management procedures. Recommended E3/SS actions and focus areas are as follows:

- Continue E3/SS WIPT and support to SE IPT
- Update applicable E3 documentation (see 6.6.3.4.1 for applicable DIDs), including testing requirements
- Update Operational EME
- Update and submit Stage 4 DD Form 1494 request
- Refine cost estimates for all E3/SS tasks and related activities
- Ensure E3/SS analyses and predictions (see 7.4) are completed, including those to assess the addition of new antennas or apertures on a platform or system, and necessary certifications are in work or in place
- Review Engineering Change Proposals and requests for waivers
- Ensure the design has taken into account any limitations or restrictions on its use contained in the approved MCEB DD Form 1494 guidance recommendations
- Validate all corrections to E3/SS deficiencies discovered during previous testing
- Review and approve E3/SS test reports
- Ensure that subsequent procurements and replacement parts meet original E3 program requirements

6.9.11 Engineering Change Proposal Review

This is a review of proposed engineering changes to the fielded system. Recommended E3/SS actions and focus areas are as follows:

- Review program E3/SS history, lessons learned, and Frequency Allocation and Host Nation Coordination status (DD Form 1494)
- Develop E3 documentation for ECPs
- Update Operational EME
- Update/Submit Stage 4 Frequency Allocation (DD Form 1494) request, as required, based on proposed engineering changes
- Ensure the design has taken into account any limitations or restrictions on its use contained in the approved MCEB DD Form 1494 guidance recommendations
- Validate all corrections to E3/SS deficiencies discovered during previous testing
- Review ECPs and requests for waivers
- Ensure that subsequent procurements and replacement parts meet original E3 program requirements
- Refine cost estimates for all E3/SS tasks and related activities

6.10 Summary Matrices of E3/SS Tasks and Applicable Documents

Table 1 shows the checkpoints during the acquisition life cycle where E3/SS requirements and issues can be reviewed.

Tables 2 through 4 provide guidance and checklists to ensure that E3/SS are adequately considered as the program progresses through the acquisition process. A checklist is presented for each milestone decision point. If the source document does not provide the necessary information, the issues should be raised at appropriate forums, such as IPT meetings, to obtain the required information.

Table 5 contains a list of tasks normally required for most acquisitions and a list of applicable documents that address each task. Additional Service-unique publications may also be consulted. See Appendix A for a list of other such publications.

Acquisition Phases	Concept and Technology Development	System Development and Demonstration	Production and Deployment	Operations and Support
Decision Points	◆ MS A	◆ MS B	◆ MS C	
Documents Requiring E3/SS Input				
Mission Area ICD	▽ (MS A)	▽ (MS B)		
CDD, CPD, CRD, ISP		▽ (MS B)	▽ (MS C)	
TEMP		▽ (MS B)	▽ (MS C)	
Minimum DD Form 1494 Submittals; others, as specified on form itself		▽ (MS B)	▽ (MS C)	
E3/SS Testing Opportunities				
DT&E		▽ Prototype	▽ EDM ▽ FAAT ▽ LRIP	
OT&E		▽ Prototype	▽ EDM	▽ LRIP ▽ As required

↑ Commercial Item ⟶

TABLE 1. E3/ESC Checkpoints

Legend:

EDM: Engineering Development Model
FAAT: First Article Acceptance Test
LRIP: Low Rate Initial Production
MS: Milestone

TABLE 2. Milestone A (Concept and Technology Development Approval) Data Requirement Checklist

Objective: To ensure that E3 and SS are addressed in requirement documents, ACTDs/ATDs, Joint Warfighting Experiments, Concept Refinements, and Technology Developments

Required Information:

1. DD Form 1494 submitted to Service Frequency Management Office indicating intent to comply with applicable DoD, National, and International SM policies and regulations.

2. Requirements documents, demonstrations, and experiments that addresses the following:

   a. Does the project address E3?

   b. Does the project address the requirement for SS?

   c. Does the project address the safety issues regarding HERO, if applicable?

TABLE 3. Milestone B (System Development and Demonstration Approval) Data Requirements Checklist

Objective: To ensure that E3 and SS issues are identified and adequately addressed.

Required Information:

1. DD Form 1494 submitted to Service Frequency Management Office

2. Status of HNA efforts

3. CDD/CPD that addresses the following:

   a. Description of operational EME (that is, the operational environment, theater, mission in the Operations Plan, and so forth),

   b. Compliance with applicable DoD, National, and International SM policies and regulations,

   c. Intra- and inter-platform/system EMC, and

   d. E3 specialty issues (HERO, HERP, HERF, EMP, lightning, ESD, and p-static, as appropriate).

4. TEMP, with a NR-KPP, a list of verification efforts that addresses effectiveness/suitability/ survivability of the platform, system, subsystem, or equipment in the intended operational EME, and provisions for testing CI/NDI

5. E3 and SS potential risks identified and tests and analyses performed to date which identify and define operational limitations and vulnerabilities

NOTE: All acquisition documents should contain requirements for E3 and SS tests and analyses.

TABLE 4. Milestone C (Production and Deployment Approval) Data Requirements/OT&E E3/SS Assessment Checklist

Objective: To identify to the best extent possible E3/SS limitations and vulnerabilities of the subject system, subsystem, or equipment.

Required Information, as appropriate:

1. DD Form 1494 submitted to Service Frequency Management Office

2. Status of HNA effort

3. Description of operational EME (that is, the operational environment, theater, mission in the Operations Plan, and so forth)

4. Latest program documentation (Mission Area ICD, CDD, CPD, CRD, ISP, performance specification, and SOW.)

5. TEMP that contains:

   a. A NR-KPP and

   b. A list of tests and analyses used to determine the item's effectiveness/suitability/survivability in the operational EME

6. Copies of the following verification results, including T&E data:

   a. Intra-platform/system data, including:

      (1) Antenna coupling and blockage analyses and test data,
      (2) Subsystem/equipment EMC analyses and test data, and
      (3) CI/NDI EMC analyses and test data

   b. Inter-platform/system EMC verification results and test data for spectrum-dependent (Joint E3 Evaluation Tool (JEET) model) and non-spectrum-dependent equipment

   c. Special E3 analyses and test data (HERO, HERP, HERF, EMP, lightning, ESD, and p-static) if required by the CDD, CPD, TEMP, or contractual documents

7. E3 and SM impact assessments which identify and define operational limitations and vulnerabilities, including lessons learned

8. DT&E test plans and results/reports

9. Initial OT&E test plans and results/reports

10. User initiated test results

TABLE 5. E3/SS Tasks and Applicable Documents.

E3/SS TASKS	DoDD 4630.5	DoDI 4630.8	DoDD 4650.1	Acquisition Guide	DoDD 3222.3	CJCSI 3170.01	CJCSM 3170.01	CJCSI 6212.01	MIL-STD-461	MIL-STD-464	MIL-STD-469	MIL-HDBK-235	MIL-HDBK-237	NTIA Manual
Prepare E3/ESC inputs to Mission Area ICD, CDD, CPD, CRD, ISP, and TEMP, as applicable	X	X		X	X	X	X	X					X	
Organize E3/SS WIPT				X	X								X	
Determine spectrum requirements and submit requests for frequency allocation (DD Form 1494) at appropriate times			X	X	X					X	X		X	X
Define EME which may be encountered during life cycle and update					X				X	X		X	X	
Determine feasibility and evaluate possible use of CI/NDI				X	X				X	X			X	
Verify if performance of proposed item is compatible in its intended operational EME	X	X		X	X				X	X	X	X	X	
Define acceptable performance criteria, including the NR-KPP	X	X		X				X	X	X	X		X	X
Evaluate E3 standards, predicted EME, and acceptable performance criteria to determine if item will meet general E3 and SS criteria	X	X							X	X	X	X	X	X
Establish initial E3 requirements for inclusion in performance specification, SOW, CDRL									X	X	X	X	X	X
Specify DT&E and OT&E requirements to demonstrate the item will perform its mission in the intended EME; include in TEMP		X		X	X				X	X	X		X	X
Review all contractor data items									X	X	X		X	
Perform special E3 tests or analyses as specified in TEMP				X	X				X	X	X		X	
Define vulnerabilities and limitations due to E3/ESC issues				X	X				X	X	X		X	
Request assignment of test frequencies			X	X	X								X	X
Monitor and review waiver requests and modifications					X				X	X			X	X
Investigate and fix operational E3 problems					X								X	

7. E3/SS TEST STRATEGY

7.1 General

Information is required to make risk assessments, to validate M&S, to determine compliance with performance specifications, and to determine whether an item is operationally effective, suitable, and survivable for its intended use. A program must be structured to integrate all applicable verification activities, including T&E and M&S, which will be conducted during an item's life cycle. Objectives for each phase of a program are to be designed to allow assessment of performance appropriate to each phase and milestone. However, until an item is actually tested, there is no assurance that it possesses the desired characteristics. The following verification efforts usually occur during a program:

- Stage 1. Subsystem/equipment qualification testing (including EMI) usually performed in a factory, laboratory, or Open Area Test Site (OATS)

- Stage 2. Subsystem/equipment installation inspection (visual) to determine if an item was installed properly (that is, grounding, bonding, cable separation, and so forth)

- Stage 3. Functional tests to determine whether subsystems and equipment meet their performance specifications after installation

- Stage 4. Intra-subsystem tests to show that equipment comprising a functional subsystem (that is, radar, fire control, machinery control, communications, and so forth) satisfactorily operate together. This will also show that the subsystem is free from self-generated, or internal, EMI.

- Stage 5. Inter-subsystem/equipment (or intra-platform/system) testing and analysis to demonstrate whether the items on the platform or system are functioning so that the platform/ system can perform its mission(s). This will also verify that all subsystems and equipment within the platform/system effectively operate without degrading each other's performance due to E3.

- Stage 6. Total platform or system test and analysis to verify that all subsystems and equipment satisfactorily demonstrate their operational performance with all items operating in an EME representative of a battle space scenario. These operational tests or analyses assess intra-platform/system and inter-platform/system interactions that can occur between radar, communications subsystems, weapons subsystems, ordnance, and so forth. Tests are not one-on-one interactions but, rather, a full operational test of all sensors and radiators operating in the EME whether from own platforms or systems or others in the vicinity.

Stages 1-4 are usually performed by the developing or integrating activity, whereas Stage 6 is usually performed by the OTA. Stage 5 may be performed by either or both the integrating activity or the OTA. Developmental and operational E3 testing and evaluations are performed during the stages described above and should be conducted on all Defense acquisition items. In addition, verification of specialized E3 requirements, such as for p-static, lightning, EMP, HERP, HERF, and HERO may be required on a case-by-case basis, as discussed in 7.2.4 of this handbook. It is intended that limitations of operational capabilities caused by E3 be minimized and that the limitations and vulnerabilities remaining after deployment are documented. Plans must be formulated as early as possible to ensure that during T&E potentially adverse E3 and SS problems are identified. Both developmental and operational testers must be involved early to ensure that the test program can support the acquisition strategy, the harmonization of objectives, thresholds, and MOEs/MOPs with appropriate quantitative criteria, and effective performance in the operational EME is demonstrated.

7.2 Developmental Test & Evaluation (DT&E)

7.2.1 General

Developmental testing will demonstrate that the engineering design and development process is complete, that E3 risks have been minimized, and that the item will be in compliance with its contractual E3 specifications, based on tailored military standards (such as MIL-STD-461 or 464) or commercial standards. Developmental testing will usually be planned and conducted by the developer in a factory, laboratory, or OATS. These tests include Production Acceptance Tests and Evaluation and First Article E3 testing after an item has been approved for full-rate production. A final step in a successful developmental test program is certification that the item is ready for OT&E.

7.2.2 Subsystems and Equipment

Developmental EMI requirements for subsystems and equipment, that is, conducted and radiated, emission and susceptibility (immunity) requirements are defined in MIL-STD-461. The standard is discussed in detail in paragraph 6.6.3.2.2 of this handbook. Verification of these requirements is also demonstrated by tests that are based on MIL-STD-461. The standard's Appendix should be consulted for detailed guidance on tailoring and performing the required tests. Compliance with the equipment-level EMI requirements does not relieve the developing or integrating activity of the responsibility for providing overall platform or system compatibility. Furthermore, if CI/NDI is involved, sufficient testing must be done on the CI/NDI to ensure performance, operational effectiveness, and operational suitability for the military application. Testing of CI/NDI is discussed in paragraph 6.7.2 of this document.

7.2.3 Platforms and Systems

Developmental E3 requirements for airborne, sea, space, and ground platforms and systems, including associated ordnance, are defined in MIL-STD-464. The standard applies to complete platforms and systems, both new and modified. Verification of the tailored E3 requirements is done by test, analysis, inspection, or some combination thereof, depending on the degree of confidence in the particular method, technical appropriateness, associated costs, and availability of assets. The standard's Appendix provides rationale and guidance for implementing the requirements and verification procedures contained therein. The standard is discussed in further detail in paragraph 6.6.3.2.3 of this handbook. Testing or analyses for intra-and inter-platform/ system EMI, and EMV are universally applicable and are discussed below. Additional specialized

E3 assessments, such as p-static, EMP, lightning, HERP, HERF, and HERO may also be required and are also discussed below.

7.2.3.1 Intra-Platform/System EMI Testing

The limits specified in MIL-STD-461 for subsystems and equipment is empirically derived to cover most configurations and environments. The limits have a proven record of success demonstrated by the relatively low incidence of problems at the platform/system level. Compliance with the EMI requirements assures a high degree of confidence of achieving platform/system compatibility; however, it does not guarantee it. Although tailoring may have been done, it may not have accounted for all of the peculiarities of the intended installation. Non-compliance with the EMI requirements often leads to operational problems. The greater the non-compliance, the higher the probability that a problem will develop. Since EMI requirements are a risk reduction initiative, adherence to them will afford a higher degree of confidence that the platform or system and its associated subsystems and equipment will operate compatibly upon integration. It is essential that within a platform or system, subsystems and equipment be capable of providing full performance along with others that are operating concurrently. EMI generated by a subsystem or equipment must not degrade the overall platform or system effectiveness. Intra-platform/system EMI is one of the basic elements of concern and is addressed in detail in MIL-STD-464.

7.2.3.2 Inter-Platform/System EMI Evaluations

Operational problems resulting from the adverse effects of EM energy from one platform or system to another are well documented. These problems underscore the importance of providing the warfighter with items that are compatible with their intended operational EME. Joint operations further increase the potential for safety and reliability problems, particularly if the platforms or systems are exposed to operational EMEs different from those for which they were designed and tested. For example, Army systems, if designed to operate in a land EME, may be adversely affected by exposure to the Navy's shipboard EME as may be encountered in a Joint operation.

In addition, the threat presented by RF emitters around the world is becoming increasingly more serious. Increased multi-National military operations, proliferation of both friendly and hostile weapons, and the expanded use of the spectrum, worldwide, have resulted in an operational EME not previously encountered. It is therefore essential that the EME be defined and used to evaluate inter-platform/system performance. Tools such as the JSC's JEET described in Appendix D are available to support the required analyses. The EME in which military platforms and systems and their associated subsystems and equipment must operate is created by a multitude of sources. The contribution of each emitter may be described in terms of its individual characteristics, such as: power level, modulation, frequency, bandwidth, antenna gain (main beam, side lobe, and backlobe), antenna scanning, and so forth. These characteristics are important in determining the potential impact on performance. Many threats may be seen only infrequently. For example, a high-powered emitter may illuminate a platform or system or one of its subsystems or equipment for only a short time due to its search pattern. And too, it may operate at a frequency where effects are minimized. There are many different EME levels that can be encountered during an item's life cycle. MIL-STD-464 describes airborne, land-based, ship-based, air, and battle space EME levels and addresses the requirement for inter-platform/system EMI in detail. In addition, MIL-HDBK-235 contains friendly and hostile EME levels, as well as emitter characteristics.

7.2.3.3 EMV

Some inter-platform/system EMI testing may be performed under laboratory conditions where the item under test and the simulated EME are controlled. Detection of undesired responses during routine EMI testing might necessitate an EMV analysis to determine the impact of the laboratory observed susceptibility on operational performance. Operational testing in the actual EME rarely is effective in the investigation or verification of susceptibilities because there is much less control on variable conditions, fewer functions can generally be exercised, and expenses can be high. The results of EMV analyses and tests guide the possible need for modifications, additional analyses, or testing. The inter-platform/system environment is evaluated to determine which frequencies are of interest from the possible emitters to be encountered when deployed, optimum coupling frequencies, susceptibility of the subsystem and equipment, available simulators, and authorized test frequencies that can be radiated. The evaluations require descriptions of the EME, both friendly and hostile, which the item may encounter during its life cycle. Based on these considerations and other unique factors, a finite list of test emitters is derived. For each test emitter, the item is illuminated and evaluated for susceptibilities. These tests are usually carried out in specialized test chambers, that is, reverberation chambers, anechoic chambers, shielded or anechoic hangars, and so forth, depending on the size of the item being tested.

7.2.4 Verification of Special E3 Requirements

Verification of these special E3 requirements are described in MIL-STD-464 and are to be applied on a case-by-case basis, as noted in the CDD, CPD, TEMP, or contractual documents.

7.2.4.1 P-Static

The control of static charge accumulation is accomplished during the design and construction of the aircraft and its associated subsystems/equipment. An aircraft must be verified to not pose a hazard when exposed to p-static charging. Conductive coating resistance must be verified to fall within the required range to prevent excessive accumulation of charge. In addition, the metallic and composite structural members should be inspected to verify that they are adequately bonded and that electrically conductive hardware and finishes are used.

7.2.4.2 Lightning

Verification of lightning requirements is essential to demonstrate that the platform or system is protected from the lightning threat environment. During development, numerous tests and analyses are normally conducted to sort out the optimum design. These evaluations may be considered part of the verification process and must be properly documented. For example, flight testing of aircraft may occur prior to verification of lightning protection control. Under this circumstance, the flight test program should include restrictions to prohibit flights within a specified distance from thunder storms, usually 25 miles. Lightning flashes sometimes occur large distances from thunderstorm clouds and can occur up to an hour after the storm appears to have left the area. There are many documents that describe analysis and test approaches for lightning.

These include MIL-STD-464, MIL-STD-1542, RTCA DO-160, Federal Aviation Administration (FAA) Advisory Circulars AC 20-53 and 20-136, and the Society of Automotive Engineers (SAE) Aerospace Recommended Practices 5412, 5413, 5414, 5415, 5416, 5417, and 5577.

7.2.4.3 EMP

For items with a nuclear EMP requirement, verification is necessary to demonstrate that the control measures that have been implemented provide sufficient protection to demonstrate that the platform or system meets the EMP requirements in MIL-STD-464. This is accomplished by demonstrating that the transient levels at the subsystem or equipment interfaces of mission critical subsystems or equipment do not exceed the MIL-STD-461, or other tailored hardness levels, and that the required design margins have been met. Mission critical items are those for which proper operation is critical or essential to the operation of the platform or system.

A combination of analysis and test is usually required to verify performance after being subjected to EMP. Analyses or models are necessary to determine the EMP field that can be coupled into the platform or system without causing damage. Existing coupling data on similar platforms or systems may be used to estimate the voltages and currents generated by the EMP at each interface of each mission critical subsystem or equipment. However, the complex geometry of a final platform or system design may be so different from that which was modeled that the EM behavior can be substantially altered. There are a number of ways to obtain platform or system excitation for purposes such as quality control or hardening evaluation. EMP testing may be done using an injection method where a pulse current is injected into the penetrating conductors at points outside the platform or system EM shielding barrier. Residual responses are measured and the operation of the mission critical subsystems or equipment is monitored for upset or damage. For example, in the case of an aircraft, single point excitation such as electrical connection of a signal source to a physical point on the external structure of the aircraft, can be done in a hangar and can reveal any obvious problems in the airframe shielding. Alternatively, a platform or system level test can be performed using a high-level EMP simulator in a controlled test site. DoD has a number of such sites available for EMP testing, as described in Appendix D of this handbook.

The operational performance requirements for the platform or system must be met after exposure to the EMP field. At the instant of the EMP event, the electrical transients may cause some disruption of performance. However, immediately after the event, or within some specified time frame driven by the platform or system operational performance requirements, the item must function properly. EMP poses a threat only to electrical and electronic subsystems and equipment. There are no structural damage mechanisms; however, EMP-induced arcing of insulators on antenna systems can permanently damage the insulator, disabling the antenna.

7.2.4.4 EMR Hazards

7.2.4.4.1 HERP

A HERP evaluation should be performed to determine safe distances for personnel from RF emitters. Safe distances can be determined from calculations based on RF emitter characteristics or by measurement. Once a distance has been determined, an inspection is required of the areas where personnel have access together with the antenna's pointing characteristics. If personnel have access to hazardous areas, appropriate measures must be taken such as warning signs and precautions in servicing publications, guidance manuals, operating manuals, and the like. The safety tolerance levels for EMR to personnel are defined in DoDI 6055.11.

Before a measurement survey is performed, calculations should be made to determine distances for starting measurements to avoid hazardous exposures to survey personnel and to prevent damage to instruments. Safe distance calculations are often based on the assumption that far-field conditions exist for the antenna. Consult your applicable Service publication in Appendix A of this handbook for techniques to calculate safe distances and for calculating the gains of certain types of antennas. Since hazard criteria are primarily based on average power density and field strength levels, caution needs to be exercised with the probes used for measurements because they have peak power limits above which burnout of probe sensing elements may occur. When multiple emitters are present and the emitters are not phase coherent, as is usually the case, the resultant power density is additive. This effect needs to be considered for both calculation and measurement approaches. In addition to the main beam hazard, localized hot spots may be produced by reflections of the transmitted energy from any metal structure. T.O. 31Z-10-4 and OP 3565 provide procedures for determining safe operating distances.

7.2.4.4.2 HERF

The existence and extent of a fuel hazard is determined by comparing the actual power density to an established safety standard. The volatility and flash points of particular fuels will influence whether there is a hazard under varying EME conditions. The amount of current and, thus, the strength of a spark across a gap between two conductors depend on both the field intensity of the energy and how well the conductors act as a receiving antenna. Verification by inspection and analysis is usually done, with testing limited to special circumstances. T.O. 31Z-10-4 and OP 3565 provide procedures for determining safe operating distances. An important issue is that fuel hazard criteria are based on peak power, while personnel hazard criteria are based, primarily, on average power. Any area on a platform or system where fuel vapors may be present needs to be evaluated. Restrictions on the use of some transmitters may be necessary to ensure safety under certain operational conditions, such as refueling operations.

7.2.4.4.3 HERO

Adequate measures must be taken to protect ordnance from EM energy and their effectiveness must be verified to ensure safe and effective operation. HERO testing should include exposure of the ordnance to the test EME in all life-cycle configurations, including packaging, handling, storage, transportation, checkout, loading, unloading, and launch from the host platform/system to determine its susceptibility characteristics. Verification methods must show that the ordnance device will not inadvertently operate, initiate, or be dudded. Methods used to determine HERO susceptibility characteristics require instrumenting the device using any number of possible techniques such as thermocouple and fiber optic temperature sensors, RF voltage or current detectors, temperature sensitive waxes, or substitution of more sensitive elements. Such instrumentation must not alter the overall sensitivity or response characteristics of the ordnance. The test EME should simulate the operational EME to the maximum extent possible. This requires appropriate representation of the EME with respect to frequency, field strength or power density, field polarization, and illumination angle. For radar EME, representative pulse widths, pulse repetition frequencies, and beam dwell periods should be chosen to maximize response by the ordnance. In the high frequency range, transmitting antennas should be the same type used to produce the fields in operation. Determining resonance frequencies is a fundamental aspect of HERO testing. Whenever possible, swept frequency testing is the preferred means of determining resonance frequencies. Reverberation chambers can be used effectively for creating a contained, swept frequency EME. Follow-on testing at a discrete, high level EME is recommended to determine actual susceptibility thresholds. After the susceptibility characteristics of the ordnance are ascertained, the platform or system operational EME must be determined to ensure that potentially hazardous EME levels are not present where ordnance may be stored, handled, or used.

Appendix A of MIL-STD-464 and MIL-HDBK-240 should be consulted for detailed rationale, guidance, and procedures to conduct HERO evaluations, as well as the JSC Ordnance E3 Risk Assessment Database (JOERAD). (See D.5.2)

7.3 Operational Test and Evaluation (OT&E)

7.3.1 General

Historically, failure to adequately verify platform, system, subsystem, or equipment performance in an operational EME has resulted in costly delays, mission aborts, and reduced operational effectiveness. Therefore, in addition to the DT&E assessments described in paragraph 7.2, operational evaluations for E3/SS should be performed to determine if the item is operationally effective and suitable for the intended use. The user community or Services T&E Commands perform these evaluations. OT&E will demonstrate operational performance in the presence of other operating items and compliance with KPPs described in the TEMP. It will also identify any resulting limitations and vulnerabilities. These evaluations, which may include both tests and analyses, may also be used to formulate operational procedures and tactics for the item. OT&E should be accomplished in as realistic an operational EME as possible. It is important that resources and assets required for verification of E3 requirements be identified early in the program to ensure their availability when needed. The following guidance applies to operational E3 testing:

- Items used for verification should be production configuration, preferably the first article.
- The item should be up-to-date with respect to all approved engineering change proposals and modifications (both hardware and software).
- EMI qualification testing to either MIL-STD-461 or MIL-STD-464, as applicable, should be performed before operational testing to provide a performance baseline and to identify any areas that may require special attention during the operational testing.
- All items should be placed in modes of operation and, where applicable, in platform unique azimuths and elevations, that will maximize potential indications of interference or susceptibility, consistent with overall operational performance requirements.
- Any external electrical power used to operate the item should conform to the power quality standards of the platform or system.
- Any anomalies found should be evaluated to determine whether they are truly an E3 issue or some other type of malfunction or response.
- Any modifications resulting from verification efforts should be validated for effectiveness after they have been engineered.
- Margins need to be demonstrated wherever they are applicable.

7.3.2 Intra-Platform/System EMI Testing

As noted earlier, developmental testing of EMI requirements is a risk reduction initiative. Adherence affords a higher degree of confidence that the platform or system and its associated subsystems and equipment will function compatibly in the operational EME. Subsystems and equipment should be designed and integrated to coexist and to provide the operational performance required by the user. However, varying degrees of functionality may be necessary depending upon the operational requirements of individual items during particular missions. Certain subsystems and equipment may not need to be exercised at the time of operation of other subsystems or equipment. The following issues should be addressed during operational intra-platform/system EMI testing:

- Potential EMI source vs. victim pairs should be identified and systematically evaluated by exercising the subsystem and equipment onboard the platform or system through the various modes and functions while monitoring the remaining items for degradation. Both one source vs. one victim and multiple sources vs. one victim conditions should be evaluated.

- A frequency selection plan should be developed for antenna-connected transmitters and receivers. This plan should include:

  - Predictable interactions between transmitters and receivers such as those at transmitter and receiver fundamental frequencies, harmonics, intermodulation products, other spurious responses, and cross modulation,
  - Evaluation of transmitters and receivers across their entire operating frequency ranges, including emergency frequencies, and
  - Evaluation of EMI issues with subsystems and equipment, including ordnance.

- Margins should be demonstrated for subsystems and equipment, including ordnance.

- Operational evaluations of undesirable responses found in the laboratory environment.

- Testing should be conducted in an area where the ambient, or background, EME does not affect the validity of the test results. A dense environment can hamper efforts to evaluate the performance of antenna-connected receivers with respect to emissions of other subsystems or equipment installed in the platform or system.

- Testing should include all relevant external hardware such as weapons, stores, provisioned items (that is, those installed in the platform/system by the user) and support equipment.

- Verify that any external electrical power conforms to applicable power quality standards.

- All subsystems and equipment should be capable of simultaneous operation using power supplied by the platform power. Power line distortion, harmonics, or transients should not degrade the operation of the subsystems and equipment using that power.

A common issue in intra-platform/system testing is the use of instrumentation during the test. The most common approach is to monitor subsystem and equipment performance through visual and aural displays and outputs. To do this, it may be necessary to modify cabling and electronics; however, these modifications may change subsystem and equipment responses and introduce unexpected problems. Care should be exercised when using such external instrumentation. The need to evaluate antenna-connected receivers across their operating frequency ranges is important for proper assessment. While it might be tempting to check a few channels of a receiver and conclude that there was no EMI, this practice should not be used. The use of modern circuitry with microprocessor clocks and power supply choppers necessitates that all antenna-connected outputs be monitored during intra-platform/system testing.

7.3.2.1 Additional Intra-Ship Concerns

7.3.2.1.1 Intermodulation Interference (IMI)

The large number of high frequency transmitters, their high output power, and the construction techniques and materials used on modern ships make the presence of intermodulation interference (IMI) a reality. On surface ships, the HF transmissions induce a current flow in the hull. The various currents from the different transmitters mix in non-linearities within the hull to produce signals at sums and differences of the fundamental and harmonic frequencies of the incident signals. MIL-STD-464 requires tests and analyses to control the 19th order and higher IMI to effectively manage the spectrum. Specific controls should be imposed to limit internal EM fields on ships to ensure that the variety of equipment used onboard, particularly CI/NDI, will be able to function with little, or no, performance degradation. Tests need to be performed with subsystems and equipment operating under normal conditions to detect the electric fields below deck and to verify compliance with the applicable internal EME requirements.

7.3.2.1.2 Shipboard HERO and EME Surveys

Procedures are implemented onboard Navy ships to protect ordnance from the effects of the EME generated by high-power shipboard transmitters. These procedures include creating a ship-specific HERO emission control instruction. A survey should be performed to identify transmitters, antennas, and ordnance handling and loading areas throughout the ship. After the susceptibility characteristics of the ordnance are ascertained, the ship's operational worst-case EME should be determined to ensure that potentially hazardous EME levels are not present in areas where ordnance may be stored, handled, or used. Emissions from transmitters capable of producing potentially hazardous EMEs should then be measured at all ordnance locations. Transmitters should be operated to simulate the worst-case operational EME to the maximum extent possible. Measured data is then analyzed and used to determine HERO emission control procedures. An assessment report should be prepared and a HERO emission control bill specific to the ship under test generated. NAVSEA OP 3565/ NAVAIR 16-1-529, Volume II, should be consulted for detailed rationale, guidance, and procedures to conduct HERO surveys.

New and higher-powered radars have been introduced into the fleet during recent years. As a result, reports of EMC problems with aircraft avionics and other electronic systems have increased. Accordingly, systematic EME surveys of helicopter landing zones and flight decks of air-capable ships (such as CG, CGN, FFG, DD, DDG), amphibious aviation (such as LHA, LHD, LPD, LPH, and LSD), and aviation (such as CV and CVN) ships should be performed. The purpose of these surveys is to record the EMEs for application in support of designing and testing avionic and support equipment and de-conflicting emitter and ordnance operations. Data gathered during these surveys are used to determine the EME on the flight deck and update JOERAD, MIL-STD-464 and 461, and MIL-HDBK-235. Shipboard EMEs must be continually evaluated as updates and changes are made to ships' EM transmission capabilities.

7.3.3 Inter-Platform/System E3 Evaluations

As noted earlier, platform and system DT&E requirements are based on MIL-STD-464. In addition, a thorough operational analysis, including M&S, may be required to verify performance in all EME levels that may be encountered. The following guidance on issues that should be addressed during operational inter-platform/system E3 evaluations, both testing and analyses:

– Potential EMI source vs. victim pairs from friendly, hostile (if known), Joint and Combined forces should be identified and systematically evaluated by exercising the subsystems and equipment on each platform and system through their various modes and functions while monitoring the remaining items for degradation. Both one source vs. one victim and multiple sources vs. one victim conditions should be evaluated.

– A frequency selection or emission control plan should be developed for antenna-connected transmitters and receivers on platforms and systems in the intended operational EME. This plan should include:

  - Predicable interactions between transmitters and receivers at fundamental frequencies and harmonics,
  - Evaluation of transmitters and receivers across their entire operating frequency range, including emergency frequencies, and
  - Evaluation of ordnance susceptibility and associated control measures (frequency and power management and spatial separation).

– MIL-STD-464 margins should be demonstrated for ordnance and other subsystems and equipment.

– Operational evaluation of responses identified by M&S should be performed.

– Testing should be conducted in an area and at a time when the ambient, or background, EME does not affect the validity of the test results. An environment with dense utilization of the frequency spectrum can hamper efforts to evaluate performance.

– Testing should include all relevant external hardware such as weapons, stores, provisioned equipment (that is, items installed in the platform or system by the user), and support items.

7.3.3.1 Additional Ordnance Concerns

Inter-platform/system E3 testing involving ordnance should include preflight, captive-carry, and free-flight configurations of the ordnance. Pre-flight testing should be conducted to ensure that the platform/system successfully performs those pre-flight operations required during service use.

Operations, such as mission or target data uploading and downloading, should be performed while exposing the ordnance to the test EME. Captive-carry testing determines survivability following exposure to the main beam, operational EME. Since this test simulates the ordnance passing through the radar's main beam during takeoff from and landing on the host platform/system, the ordnance should be operated as it normally would be for those flight conditions. The duration of exposure to the EME from the main beam should be based on normal operational considerations. Verification of ordnance survivability may, in many cases, be made utilizing the ordnance built-in test function. However, if this is not possible, verification utilizing an appropriate test set is suggested. Free-flight testing of ordnance may be simulated utilizing an inert, instrumented, ordnance device suspended in a quiet, EM-free environment, such as an anechoic chamber. Use of the anechoic chamber is recommended to determine the RF points and aspect angles associated with specific susceptibilities determined as described in 7.2.4.4.3 of this document. The free-flight test program consists of evaluating weapon performance during the launch, cruise, and terminal phases of flight, while exposed to friendly and hostile EME

7.3.3.2 Additional Aircraft Concerns

An aircraft often undergoes extensive development and integration tests prior to inter-platform/ system and formal acceptance testing. The EME that may be encountered must be reviewed and the status of the aircraft with regard to the environment must be evaluated prior to flight. EMI testing of the subsystems/equipment can be used as a baseline of hardness. However, limited, inter-platform/system testing involving specific emitters may be necessary. If such tests are not performed, operational restrictions on flight paths may need to be imposed.

7.4 E3/SS Analyses and Predictions

7.4.1 General

It is essential that E3/SS analyses and predictions be employed in the planning, design, development, installation, and operation of electronic platforms, systems, subsystems, and equipment. These techniques are necessary to:

- Demonstrate that the required level of performance has been, or will be, achieved, and,
- To show efficient use of the frequency spectrum.

Analyses and predictions are used to identify, localize, and define potential E3/SS problems and possible solutions. They should be employed as early in a program as possible, before there are significant expenditures of time, effort, and money. E3/SS analyses are critical in identifying and resolving potential problems during development and ensuring compatibility in the operational phase of the program. The analyses provide essential information to guide the selection of appropriate courses of action to correct problems. Finally, the need for performing these analyses is closely related to the ESC process as described herein.

7.4.2 E3/SS Analyses and Predictions Throughout the Acquisition Life Cycle

E3/SS analyses should be conducted and continually refined throughout the item's life cycle, as the operational EME is updated and as technical characteristics of the end-item become available.

These analyses are typically performed at an increasing level of detail during each stage of the development life cycle. For example, early in Concept and Technology Development of a spectrum-dependent subsystem/equipment, the technical feasibility of using one or more potential frequency bands and waveforms should be evaluated. The initial analysis should evaluate the suitability of alternative frequency bands and waveforms. This type of study will:

– Identify frequency bands already allocated for the type of service within the geographic areas of intended use,
– Determine the feasibility of using a proposed waveform in the allocated bands, and
– Identify issues that may enhance or preclude the ability to obtain a frequency allocation.

The E3/SS WIPT can provide advice on the EME to be considered in the analyses, scheduling concerns, organizations capable of performing the analyses, and required measurements. Analyses should be conducted to determine if any of the following E3 problems are likely to be encountered:

– Within or between subsystems and equipment on a platform or system, for example, intra-platform/system or inter-subsystem/equipment problems,
– Between elements of the platform or system and elements of others that are likely to be operating in the same general area, such as, inter-platform/system problems, or
– Between elements of a platform or system and the EME in which they are to be operated.

Analyses usually rely on assumed or typical characteristics for the subsystem or equipment on a platform or system. The results from these analyses should provide the information needed to:

– Determine the most suitable frequency band(s) and subsystem and equipment parameters such as transmitter power, antenna gains, receiver sensitivity, type of modulation, rise times, information bandwidth, and so forth,
– Define E3 performance requirements, and
– Identify potential E3 problem areas and the risk involved if corrective action is not taken.

The E3 control characteristics of the proposed item should be evaluated against other existing and planned items in the EME, including natural, friendly, and hostile sources, and Joint and Combined operating forces. This will identify the items operating in the EME that could cause EMI to, or be degraded by, the proposed item. Estimated parameters and analytical techniques can be used to determine the degradation criteria. Careful application of E3 analysis and prediction techniques at the appropriate phases of an item’s life cycle should ensure the required level of E3 control is defined without having either the wasteful expense of over-engineering or uncertainties of under-engineering. As the program progresses, more detailed characteristics of the item will be available. Early E3/SS analyses should be refined, based on these characteristics and the most recent EME definitions. As measured characteristics are determined, earlier analyses may be refined. Available test data for interference interactions should also be fed back into the E3 analysis. The main goal, at this time, is to resolve all potential EMI interactions. The results of this analysis will be critical for obtaining approval of the final DD Form 1494.

Additional E3/SS analyses should be performed, as required, during the Production and Deployment and Operations and Support Phases. These may be required because of:

- System modifications,
- Reported inadequate performance,
- Changing EME, or
- New mission requirements.

When a modification to an item is planned, an analysis should be performed to determine whether the modification affects the E3 characteristics of the item or others in the EME. A new EME may have to be considered; platform or system E3 requirements should be reviewed and updated, as required. If E3 is suspected as possibly causing performance degradation after an item has been fielded, then an E3 analysis may help identify the cause. Corrective action can be taken, then, to resolve the problem. If the mission requirements of the item are modified either by a new platform, additional geographic locations, and so forth, the data describing the EME must be updated. Then, an E3 analysis should be performed to determine the compatibility of the item in the new EME. Guidance throughout development is available from the E3/SS WIPT, the JSC, and the Service E3/SS points of contact noted in Appendix D.

When an item is deployed in its intended operational EME, E3 should be considered from various operational aspects such as siting effects, frequency assignment(s), effective radiated power limits, and antenna coverage. Operational inter-platform/system E3 control is generally achieved through frequency management, time-sharing, and distance separation. Usually, at this time, personnel responsible for compatible system operations should be mostly concerned with the interaction of system elements, both with each other and with elements from other systems, and less with the internal characteristics of the elements. E3 problems during operation generally involve signals that are coupled among elements of either the same or different systems.

7.4.3 E3/SS Analysis Process

There are a number of different applications for which E3/SS analyses are performed. The methods and procedures utilized are dependent upon the application and the results desired. In general, the analysis process to be used depends on the specific application, the accuracy and completeness of available data, and the costs to perform the analysis.

7.4.4 Cost of Analysis

Cost is an important factor that should be considered when selecting the specific techniques that will be used for E3/SS analyses. The costs for developing the approach, method, and procedures for E3/SS analyses, along with the manpower required to conduct the analyses, can vary considerably. The cost depends on a number of factors, including: the type of problem being addressed; the number of items involved; the accuracy and completeness of the data available; and, the need to evaluate the impact of E3 on operational performance of an item or its overall mission.

7.5 DOT&E Policy Memorandum of 25 Oct 1999

7.5.1 General

E3 has the potential to adversely impact performance and effectiveness of military operations. Today’s complex military operational environment is also characterized by an increasingly crowded EM spectrum, coupled with a reduction of the frequency spectrum reserved for exclusive military use. Additionally, the mix of DoD systems along with CI/NDI increases the importance of effectively managing E3 and spectrum usage in the battle space. It is the responsibility of Program Offices to assure, and of OTAs to validate the readiness of systems to be fielded into this environment. Acquisition programs have traditionally evaluated E3 in narrowly scoped operational scenarios. Moreover, operational evaluations have been limited to:

– Intra-platform/system environments rather than inter-platform/system environments,
– Single Service participation in testing rather than multi-Service, or
– Single mission areas rather than multiple mission areas.

The DOT&E policy memo was intended to more clearly define the role of OT&E in identifying potentially adverse E3 and spectrum availability situations. The policy was intended to make PMs and OTAs aware that the DOT&E plans to assess this area more systematically. This policy encompassed all aspects of E3, but emphasized EMC/EMI and HERO. The policy memo also focused on limitations to operational performance caused by restrictions on spectrum availability. The memo was effective immediately and applied to all DOT&E oversight programs. It was applicable to programs at the time of approval. Programs already underway were to incorporate this approach during their next TEMP approval cycle.

7.5.2 Responsibilities

The following are some of the responsibilities that were delineated in the DOT&E memorandum and will be included in a new DoDI 3222 in preparation at the time of the publication of this guide.

7.5.2.1 DOT&E Responsibilities

DOT&E will:

– Review Service TEMPs, operational test plans, early assessments, and test reports on Test and Evaluation Oversight programs to assess the adequacy of E3 testing.
– Monitor and cite E3 issues and resolutions during participation on Test and Evaluation Oversight programs acquisition IPTs.
– Review Services' evaluation approaches, including M&S, small-scale tests, and appropriate chamber, field, and laboratory tests.
– Review spectral characteristics data to ensure sufficient information is available for test scenarios and to support the resolution of E3 issues.
– Report the status of E3 issues for Test and Evaluation Oversight programs in the DOT&E Annual Report, and report specific program findings as part of Beyond Low-Rate Initial Production reports to the Secretary of Defense and the Congress.
– As E3 issues related to fielded systems arise during OT&E or during large-scale training exercises used to complement operational tests, report these issues to the appropriate agencies for resolution.

7.5.2.2 OTA Responsibilities

OTAs are to:

- Coordinate E3 assessments during OT&E with Services E3 points of contact and other DoD agencies.
- Conduct early assessments of DoD programs to identify and mitigate potential E3 problems, including HERO.
- Include E3 and spectrum availability assessment issues as a standard presentation at Operational Test Readiness Reviews.

7.5.2.3 PM Responsibilities

PMs are to:

- Ensure that E3 T&E efforts receive adequate funding, and
- Ensure that E3 is sufficiently addressed in TEMPs since it will receive scrutiny during the TEMP approval process.

7.5.3 Process

To accomplish the objectives of the policy memo, a process and a number of actions are required throughout the acquisition by DOT&E, the Program Offices, and OTAs. DOT&E, with the support of the JSC, has defined in the DOT&E "E3 and SM Assessment Guide" E3 evaluation criteria. Together, they evaluate testing and analyses results to define any limitations and vulnerabilities as a result of E3 and SS problems. The guide is available on the JSC web site www.jsc.mil. The information necessary to make these determinations is gathered throughout the procurement process and should all be available prior to Milestone C. The information required to perform the OT&E E3/SS assessments is shown on Table 4 of this handbook, which has been extracted from the guide. Items 1-8 on the table are to be provided by the Program Office, whereas items 9 and 10 are the responsibility of the OTAs. As hardware becomes available, test data can be used to validate and supplement the analyses and models. When hardware is actually produced, inspection, testing, and follow-on analysis of potential problems previously identified complete the process. Additional guidance may be obtained from the DISA/JSC.

7.6 Summary E3/SS T&E Checklist

As noted earlier, the items procured must be in compliance with established E3/SS policies and with the DT&E and OT&E requirements and KPPs discussed earlier in this handbook. The following checklist should be used when developing and evaluating the adequacy of a planned verification program. The list should be used with those provided earlier in the handbook.

- Have developmental tests been planned to demonstrate compliance with the applicable contractual requirements, based on tailored MIL-STD-461 or 464 requirements?
- Have OT&E efforts been planned to identify and verify performance in the operational EME, or identify limitations in performance due to E3? (Note that all items are to be operated as in normal operations and tested in all modes, both on the platform and against those same systems on other, or similar platforms.)
- Will sufficient data be taken to identify and resolve E3 risks?
- Have tests been planned to verify effectiveness of proposed spectrum control and usage?

- Have evaluations been planned to determine EMP hardness when required?
- Have tests of HERO characteristics in Joint EME been planned for ordnance?
- Is sufficient data available to assess intra-and inter-system/platform EMI?
- Will tests provide adequate data for EMV analyses? Are items being tested in an EME where susceptibility has been identified during a laboratory test?
- Are properly trained test personnel available to operate the test equipment?
- Will CI/NDI be tested or analyzed against the applicable requirements of MIL-STD-461?

8. NOTES

8.1 Intended Use

This handbook provides guidance for establishing an effective E3/SS program.

8.2 Supersession

This document supersedes all previous issues of MIL-HDBK-237.

8.3 Changes From Previous Issues

Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

8.4 Subject Term (Key Word) Listing

E3
E3/SS WIPT
EMC
EME
EMI
EMP
EMV
ESC
HERF
HERO
HERP
RADHAZ
Spectrum Management
Spectrum Supportability

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APPENDIX A

BIBLIOGRAPHY

CONTENTS

Paragraph **Page**

A.1 General

This Appendix supplements the documents listed in section 2 of this handbook. It identifies many pertinent DoD and U.S. commercial documents relative to E3/SS. Additional documents such as those issued by the International Electrotechnical Commission (IEC), International Special Committee on Radio Interference (CISPR), and Industry associations are discussed in EPS-0178 or are themselves listed in the documents included below.

A.2 Directives, Instructions, Regulations, and Manuals

DoD DIRECTIVES

DoDD 3222.3	DoD Electromagnetic Environmental Effects (E3) Program
DoDD 4630.5	Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)
DoDD 4650.1	Policy for the Management and Use of the Electromagnetic Spectrum
DoDD 5000.1	The Defense Acquisition System

DoD INSTRUCTIONS

DoDI 3222.3 (in preparation)	Operation of the DoD Electromagnetic Effects Program
DoDI 4630.8	Procedures for Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)
DoDI 5000.2	Operation of the Defense Acquisition System
DoDI 6055.11	Protection of DoD Personnel from Exposure to Radio Frequency Radiation and Military Exempt Lasers

CJCS INSTRUCTIONS AND MANUALS

CJCSI 3170.01	Joint Capabilities Integration and Development System
CJCSI 3220.01	EM Spectrum Use in Joint Military Operations
CJCSI 6212.01	Interoperability and Supportability of Information Technology and National Security Systems
CJCSM 3170.01	Operation of the Joint Capabilities Integration and Development System

OTHER DoD DOCUMENTS

DFAR Supplement 252.235-7003	DoD Federal Acquisition Regulations Clause, Frequency Authorization Act
DoDISS	Department of Defense Index of Specifications and Standards

DoD 5010.12-L	DoD Acquisition Management Systems and Data Requirements Control List
DOT&E Memo	Policy on Operational Test and Evaluation of Electromagnetic Environmental Effects and Spectrum Management, 25 Oct 1999
NACSEM 5112	NONSTOP Evaluation Techniques
NSTISSAM TEMPEST/1-92	Compromising Emanations Laboratory Test Requirements, Electromagnetics
NSTISSAM TEMPEST/1-93	Compromising Emanations Field Test Evaluations
NSTISSAM TEMPEST/2-95	Red/Black Installation Guidelines

DEPARTMENT OF COMMERCE

NTIA Manual	Manual of Regulations and Procedures for Federal Radio Frequency Management

FEDERAL AVIATION ADMINISTRATION (FAA)

DOT/FAA/CT-89-2	Aircraft Lightning Handbook
FAA Advisory Circular AC 20/136	Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning

FEDERAL COMMUNICATIONS COMMISSION (FCC)

Code of Federal Regulations (CFR) 47 Part 15	RF Devices
CFR 47 Part 18	Industrial, Scientific and Medical Equipment

OFFICE OF MANAGEMENT AND BUDGET (OMB)

OMB Circular A-11	Preparation and Submission of Budget Estimates

A.3 Standards

MILITARY STANDARDS

DoD-STD-1399/070	Interface Standard for Shipboard Systems, DC Magnetic Field Environment
MIL-STD-188-125	HEMP Protection for Ground Based C4I Facilities Performing Critical, Time Urgent Missions
MIL-STD-220	Method of Insertion Loss Measurement

MIL-STD-331	Fuze and Fuze Components, Environmental and Performance Tests for
MIL-STD-449	Test Method Standard, Radio Frequency Spectrum Characteristics, Measurement of
MIL-STD-461	Interface Standard, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-464	Interface Standard, Electromagnetic Environmental Effects Requirements for Systems
MIL-STD-469	Interface Standard: Radar Engineering Design Requirements, Electromagnetic Compatibility
MIL-STD-1310	Standard Practice Document: Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety
MIL-STD-1377	Effectiveness of Cable, Connector, and Weapon Enclosure Shielding and Filters in Precluding Hazards of Electromagnetic Radiation to Ordnance, Measurement of
MIL-STD-1541	Electromagnetic Compatibility Requirements for Space Systems
MIL-STD-1542	Electromagnetic Compatibility and Grounding Requirements for Space Systems
MIL-STD-1576	Electroexplosive Subsystem Safety Requirements and Test Methods for Space Systems
MIL-STD-1605	Procedures for Conducting a Shipboard Electromagnetic Interference (EMI) Survey (Surface Ships)
MIL-STD-1686	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
MIL-STD-2169	High Altitude Electromagnetic Pulse Environment

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/ESD-S20.20	ESD Association Standard for the Development of an Electrostatic Control Program for – Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
ANSI/IEEE C63.011-2000	Limits and Methods of Measurement of Radio Disturbance Characteristics of Industrial, Scientific, and Medical (ISM) Radio Frequency Equipment
ANSI/IEEE C63.022-1996	Standard for Limits and Methods of Measurement of Radio Disturbance Characteristics of IT Equipment
ANSI/IEEE C63.2-1996	Standard for Instrumentation - Electromagnetic Noise and Field Strength, 10 kHz to 40 GHz - Specifications

ANSI/IEEE C63.4-2000	Standard for Electromagnetic Compatibility – Radio - Noise Emissions from Low Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz - Methods of Measurement
ANSI/IEEE C63.5-1998	Standard for Calibration of Antennas Used for Radiated Emission Measurements in Electromagnetic Interference (EMI) Control Calibration of Antennas (9 kHz to 40 GHz)
ANSI/IEEE C63.6-1996	Standard Guide for the Computation of Errors in Open Area Test Site Measurements
ANSI/IEEE C63.7-1992	Standard Guide for Construction of Open-Area Test Sites for Performing Radiated Emission Measurements
ANSI/IEEE C63.12-1999	Standard for Electromagnetic Compatibility Limits - Recommended Practice
ANSI/IEEE C63.14-1995	Standard Dictionary for Technologies of Electromagnetic Compatibility (EMC), Electromagnetic Pulse (EMP), and Electrostatic Discharge (ESD)
ANSI/IEEE C63.16-1993	Standard Guide for Electrostatic Discharge Test Methodologies and Criteria for Electronic Equipment
ANSI/IEEE C95.1-1991	Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields (3 kHz - 300 GHz)
ANSI/IEEE C95.2/ ANS N2.1-1994	Warning Symbol-Radiation Symbol
ANSI/IEEE C95.3-1972	Radiation, Electromagnetic, Potentially Hazardous, at Microwave Frequencies, Techniques & Instrumentation for the Measurement of
ANSI/IEEE C95.4-2002	Recommended Practice for Determining Safe Distances from Radio Frequency Transmitting Antennas When Using Electric Blasting Caps During Explosive Operations
ANSI/IEEE C95.6-2002	Safety Levels With Respect to Human Exposure to Electromagnetic Fields, 0 to 3 kHz
ANSI/NCSL-Z540-1-2002	Calibration - Calibration Laboratories and Measuring and Test Equipment - General Requirements

ELECTROSTATIC DISCHARGE ASSOCIATION

ESD-TR-20.20	Handbook for the Development of an Electrostatic Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment

RADIO TECHNICAL COMMITTEE FOR AERONAUTICS (RTCA)

RTCA DO-160	Environmental Conditions and Test Procedures for Airborne Equipment

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE-J551	Performance Levels and Methods of Measurement of Electromagnetic Radiation from Vehicles and Devices
SAE-J1113	Electromagnetic Susceptibility Measurement Procedures for Vehicle Components (Except Aircraft)
SAE ARP 958D	Electromagnetic Interference Measurement Antennas; Standard Calibration Method
SAE ARP 1173	Test Procedures for Measuring the RF Shielding Characteristics of EMI Gaskets
SAE-ARP 1870	Aerospace Systems Electrical Bonding and Grounding for Electromagnetic Compatibility and Safety
SAE ARP 1972	Measurement Practices and Procedures Recommended for Electromagnetic Compatibility Testing
SAE ARP 4242	Electromagnetic Compatibility Control Requirements Systems
SAE ARP 5412	Aircraft Lightning Environment and Related Test Waveforms
SAE ARP 5413	Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning
SAE ARP 5414	Aircraft Lightning Zoning
SAE ARP 5415A	Users Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lighting
SAE ARP 5577	Aircraft Lightning Direct Effects Certification

NORTH ATLANTIC TREATY ORGANIZATION (NATO) STANDARD AGREEMENTS (STANAGS)

ADV-PUB-20/36	Hazards of Electrostatic Discharge to Aircraft Stores
AEP-18	NATO Users Guide to EMP Testing and Simulation
AEP-20	EMP Design and Test Guidelines for Systems in Mobile Shelters
ANEP-45	Electromagnetic Compatibility (EMC) in Composite Vessels
INFO-PUB-20/36A	Aircraft/Stores Electromagnetic Compatibility/ Electromagnetic Interference and Hazards of Electromagnetic Radiation to Ordnance
STANAG 1307	Maximum NATO Naval Operational EME Produced by Radar and Radio
STANAG 1308	RADHAZ to Ships Personnel During Helicopter (and VSTOL Aircraft) Operations on Ships Other Than Aircraft Carriers
STANAG 1380	NATO Naval Radio and Radar Radiation Hazards Manual (AECP-2)
STANAG 1397	RADHAZ Classification of Munitions and Weapons Systems Embodying Electro-Explosive Devices

STANAG 3516	EMC Test Methods for Aerospace Electrical and Electronic Equipment
STANAG 3614	EMC of Installed Equipment in Aircraft
STANAG 3659	Bonding and In-flight Lightning
STANAG 3682	Electrostatic Safety Connection Procedures for Aviation Fuel Handling and Liquid Fuel Loading/Unloading Operations During Ground Transfer and Aircraft Fuelling/Defuelling
STANAG 3731	Bibliography on EMC
STANAG 3856	Protection of Aircraft, Crew and Sub-Systems in Flight against Electrostatic Charges – (AEP-29)
STANAG 3968	NATO Glossary of EM Terminology
STANAG 4234	EM Radiation, 200 kHz – 40 GHz, Environment Affecting the Design of Material for Use By NATO Forces
STANAG 4235	Electrostatic Environmental Conditions Affecting the Design of Materiel for Use by NATO Forces
STANAG 4236	Lightning Environmental Conditions, Affecting the Design of Materiel, for Use by the NATO Forces
STANAG 4238	Munition Design Principles, Electrical/Electromagnetic Environments
STANAG 4239	Electrostatic Discharge, Munitions Test Procedures
STANAG 4327	Lightning, Munition Assessment and Test Procedures
STANAG 4370	Environmental Testing
STANAG 4416	Nuclear Electromagnetic Pulse Testing of Munitions Containing Electro-Explosive Devices
STANAG 4434	NATO Standard Packaging for Materiel Susceptible to Damage by Electrostatic Discharge (AEPP-2)
STANAG 4435	EMC Test Procedures and Requirements for Surface Ships (Metallic)
STANAG 4436	EMC Test Procedures and Requirements for Surface Ships (Non-metallic)
STANAG 4437	EMC Test Procedures and Requirements for Submarines
STANAG 4490	Explosives, Electrostatic Discharge Sensitivity Test(s)

A.4 Data Item Descriptions (DIDs)

DI-EMCS-80157	Suspected RF Radiation Overexposure Report
DI-EMCS-80199B	EMI Control Procedures (MIL-STD-461)
DI-EMCS-80200B	EMI Test Report (MIL-STD-461)
DI-EMCS-80201B	EMI Test Procedures (MIL-STD-461)
DI-EMCS-80217A	TEMPEST Assessment Report
DI-EMCS-80218	Request for TEMPEST Test
DI-EMCS-80219	Adverse TEMPEST Impact Statement
DI-EMCS-80220	TEMPEST Inspection Report
DI-EMCS-81295A	Electromagnetic Effects Verification Procedures (EMEVP)

DI-EMCS-81528	Electromagnetic Compatibility Program Procedures (EMCPP)
DI-EMCS-81540A	E3 Integration and Analysis Report (MIL-STD-464)
DI-EMCS-81541A	E3 Verification Procedures (MIL-STD-464)
DI-EMCS-81542A	E3 Verification Report (MIL-STD-464)
DI-NUOR-80156	Nuclear Survivability Program Plan
DI-NUOR-80926	Nuclear Survivability Assurance Plan
DI-NUOR-80928	Nuclear Survivability Test Plan
DI-NUOR-80929	Nuclear Survivability Test Report
DI-MISC-81113	Radar Spectrum Management Test Plan (MIL-STD-469)
DI-MISC-81114	Radar Spectrum Management Control Plan (MIL-STD-469)
DI-MISC-81174	Frequency Allocation Data

A.5 Guidance Documents, Handbooks, Specifications, and Studies

MIL-HDBK-235	Electromagnetic (Radiated) Environment Considerations for Design and Procurement of Electrical and Electronic Equipment, Subsystems and Systems
MIL-HDBK-240	Hazards of Electromagnetic Radiation to Ordnance (HERO) Test Guide
MIL-HDBK-263	Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)
MIL-HDBK-274	Electrical Grounding for Aircraft Safety
MIL-HDBK-293	ECCM Considerations in Radar Systems Acquisitions
MIL-HDBK-294	ECCM Considerations in Naval Communications Systems
MIL-HDBK-335	Management and Design Guidance for EM Radiation Hardness for Air Launched Ordnance Systems
MIL-HDBK-419	Grounding, Bonding, and Shielding for Electronic Equipment and Facilities
MIL-HDBK-423	HEMP Protection for Fixed and Transportable Ground Based Facilities
MIL-HDBK-454	Electronic Equipment, General Guidelines for
MIL-HDBK-1568	Materials and Procedures for Corrosion Prevention and Control in Aerospace Weapons Systems
MIL-HDBK-1857	Grounding, Bonding and Shielding Design Practices
MIL-HDBK-2036	Electronic Equipment Specifications, preparation of
MIL-I-17161	Absorber, Radio Frequency Radiation (Microwave Absorbing Material), General Specification for
EPS-0178	Results of Detailed Comparisons of Individual EMC Requirements and Test Procedures Delineated in Major National and International Commercial Standards with Military Standard MIL-STD-461E

A.6 Service Documents

DEPARTMENT OF THE ARMY

ADS-37A-PRF	Aeronautical Design Standard, E3 Performance and Verification Requirements (Aviation and Missile Command Report)
AR 5-12	Army Management of the Electromagnetic Spectrum
AR 11-9	The Army Radiation Safety Program
AR 40-6	Policy and Procedures for the Acquisition of Medical Materiel
AR-70-1	Systems Acquisition Policy and Procedures
AR-70-75	Survivability of Army Materiel and Equipment
AR-71-9	Material Objectives and Requirements
AR-73-1	Army Test and Evaluation Policy
DA PAM 70-3	Army Acquisition Procedures
DA PAM 73-2	T&E Master Plan, Procedures and Guidelines
DA PAM 73-3	Critical Operational Issues and Criteria (COIC) Procedures and Guidelines
FM-11-490-30	Electromagnetic Radiation Hazards
TB 43-0133	Hazard Controls for CECOM Radio Frequency and Optical Radiation Producing Equipment
TB 43-0129	Safety Requirements for Use of Antenna and Mast Equipment
TR-RD-TE-97-01	EM Effects Criteria and Guidelines for EMRH, EMRO, Lightning Effects, ESD, EMP and EMI Testing of US Army Missile Systems (Redstone Technical Test Center Report)

DEPARTMENT OF THE NAVY

SECNAVINST 2410.1	EMC Program Within the Department of the Navy
SECNAVINST 5000.2	Implementation and Mandatory Procedures for Major and Non-major Acquisition Programs
OPNAVINST 2400.20	Navy Management of the Radio Frequency Spectrum
OPNAVINST 2450.2	EMC Program within the Department of the Navy
OPNAVINST 3960.10	Test and Evaluation
OPNAVINST 5000.42	Research, Development, and Acquisition Procedures
OD 30393	Design Principles and Practices for Controlling Hazards of Electromagnetic Radiation to Ordnance

OP-3565/NAVAIR 16-1-529	Volume I - Technical Manual, Electromagnetic Radiation Hazards (Hazards to Personnel, Fuel, and other Flammable Material) Volume II - Technical Manual, Electromagnetic Radiation Hazards (Hazards to Ordnance)
NAVAIRINST 2450.2	Electromagnetic Environmental Effects (E3) Control Within The Naval Air Systems Command
NAVAIRWARCEN INST 2400.1A	Radio Frequency Management
NAVSEAINST 2450.1	Frequency Allocations and Frequency Assignments
NAVSEAINST 2450.2	Electromagnetic Compatibility (EMC)
NAVSEAINST 8020.7C	Hazards of Electromagnetic Radiation to Ordnance (HERO) Safety Program
NAVSEAINST 8020.17	Navy Explosives Hazard Classification Program
NAVSEAINST 8020.19	Electrostatic Discharge Safety Program for Ordnance
NAVSEAINST 9700.2	Integrated Topside Safety and Certification Program for Surface Ships
NAVSEA S9040-AA-GTP-010/SSCR	Shipboard Systems Certification Requirements for Surface Ship Industrial Periods (Non-Nuclear)
NAVSEA S9407-AB-HDBK-010	Handbook of Shipboard Electromagnetic Shielding Practices

DEPARTMENT OF THE AIR FORCE

AFOSH Standard 48-9	Exposure to Radio Frequency Radiation Safety Program
AFI 32-7061	The Environmental Impact Analysis Process
AFI 99-102	Operational Test & Evaluation
AFI 99-106	Joint test and Evaluation
AFMAN 33-140	Radio Frequency Spectrum Management
AFPD 63-1	Acquisition System
AFPD 99-1	Test and Evaluation Process
AFSC DH 1-4	Air Force Systems Command Design Handbook, EMC
TO 31Z-10-4	Electromagnetic Radiation Management

MARINE CORPS SYSTEMS COMMAND (MARCORSYSCOM)

MCO 2400.2	Marine Corps Management of the Radio Frequency Spectrum
MCO 2410.2	Electromagnetic Environmental Effects Control Program
MCO 5104.2	Marine Corps Radio Frequency Electromagnetic Field Personnel Protection Program

A.7 Specific Regulations, Directives and Instructions Affecting Policy

Federal and DoD regulations exist, as well as DoD directives and instructions, which set the E3/SS policies with regard to the acquisition and fielding of military C-E equipment. The following paragraphs summarize the policies established by these documents.

A.7.1 Federal

A.7.1.1 Code of Federal Regulations

- TITLE 47, CHAPTER I, PART 2, Subpart B, Section 2.103 provides regulations pertaining to Government use of non-Government frequencies.

- CHAPTER III, PART 300, indicates that Federal Agencies shall comply with the requirements set forth in the NTIA Manual, which is incorporated by reference with approval of the Director, Office of the Federal Register, in accordance with 5 U.S.C. 552(a) and 1 CFR part 51.

A.7.1.2 OMB Circular A-11

Part 2 states that the NTIA Department of Commerce must provide a certification by that the RF required is available before estimates are submitted for the development or procurement of major communications-electronics systems, including all systems employing space satellite techniques.

A.7.1.3 NTIA Manual of Regulations & Procedures for Federal Radio Frequency Management

The entire NTIA manual is devoted to minimum Federal standards, regulations, and procedures for RF management. It is available on: www.ntia.doc.gov/osmhome/redbook/redbook.html.

A.7.2 DoD

A.7.2.1 DFAR Supplement 252.235-7003

This document requires specific clauses in solicitations and contracts for developing, producing, constructing, testing, or operating a device requiring a frequency authorization. The clauses require contractors to obtain authorization for RF needed in support of the contract and associated procedures.

A.7.2.2 DoDD 5000.1

This directive provides management principles and mandatory policies and procedures for managing all acquisition programs. It requires acquisition managers to provide U.S. Forces with systems and families of systems that are interoperable and compatible with the EM spectrum environment.

A.7.2.3 DoDI 5000.2

This instruction establishes a simplified and flexible management framework for translating mission needs and technology opportunities, based on approved mission needs and requirements, into stable, affordable, and well-managed acquisition programs that include weapon systems and automated information systems. It notes that interoperability is a key attributes of systems. The instruction cites spectrum certification compliance as a statutory requirement that must be met at Milestone B or Milestone C (if no MS B).for systems/equipment that require utilization of the EM spectrum.

A.7.2.4 Defense Acquisition Guidebook (replaced DoDR 5000.2-R)

The guide notes the following, as related to E3 and SS:

- SS and E3 must be considered throughout the acquisition process to ensure the subsequent successful operation of spectrum-dependent systems in support of the warfighter.
- Actions must be taken by PMs in each acquisition phase to achieve and demonstrate effective and compatible operation.
- Guidance is provided to PMs to ensure that E3 requirements are addressed in program documentation that the applicable EME is defined and updated, and that E3 performance requirements are established and met.

A.7.2.5 DoDD 3222.3

This document establishes the DoD E3 Program. It provides policies and responsibilities to ensure mutual EMC and effective E3 control among ground, air, sea, and space-based systems, subsystems, and equipment, including ordnance. The directive requires E3 control requirements to be defined early during the concept and technology development process and included in the pertinent acquisition documentation (such as the CDD, CPD, ISP, TEMP, SOW, and contract specification) and verified throughout the acquisition process. A companion instruction is being prepared at the time of publication of this guide that will provide responsibilities and procedures for controlling E3.

A.7.2.6 DoDD 4630.5

This directive updates policy and responsibilities for interoperability and supportability of IT and NSS. It defines a capability-focused, effects-based approach to advance IT and NSS interoperability and supportability across the DoD. The directive establishes the NR-KPP to assess net-ready attributes required for both the technical exchange of information and the end-to-end operational effectiveness of that exchange. The NR-KPP replaces the Interoperability KPP and incorporates net-centric concepts for achieving IT and NSS interoperability and supportability. The directive requires that IT and NSS interoperability and supportability needs shall be managed, evaluated, and reported over the life of the system using an ISP.

A.7.2.7 DoDI 4630.8

This instruction implements policies and requirements for ensuring interoperability and supportability of IT and NSS. Requirements are to be documented, coordinated, verified, and approved to achieve interoperability and supportability, including ensuring SM, consideration of SS, and E3 control. NR-KPP assessments should include SS and E3 as part of the assessment.

A.7.2.8 DoDD 4650.1

This directive updates the policy and responsibilities for EM spectrum management and use by the DoD. The directive states that a DoD component developing or acquiring spectrum-dependent equipment or systems shall make a written determination, with the concurrence of the DoD or Component Chief Information Officer, that there is reasonable assurance of SS. Efforts to obtain SS for spectrum-dependent equipment or systems being developed shall be initiated as early as possible during the Technology Development Phase. In addition, no spectrum-dependent item being developed shall proceed into the SDD phase without such a SS determination unless specific authorization to proceed is granted by the Milestone Decision Authority. Furthermore, no spectrum-dependent equipment shall proceed into the Production and Deployment Phase without such a SS determination unless specific authorization to proceed is granted by the Under Secretary of Defense for Acquisition, Technology and Logistics or a waiver is granted by the ASD(NII). The directive goes on to say that no spectrum-dependent “off-the-shelf” or other NDI shall be purchased or procured without such a SS determination. This directive assigns responsibilities to the DoD Components for the use of the EM spectrum in DoD, including ESC, host nation coordination, and SS.

A.7.2.9 CJCSI 3170.01

This instruction establishes policies and procedures for the JCIDS process, and its relation to the acquisition decisions. It provides guidance for the preparation, review, and approval of JCIDS documents such as ICDs, including the Mission Area ICD, CDDs, and CPDs including interoperability and supportability certifications. It requires HERO, E3, and SS be addressed in all documents.

A.7.2.10 CJCSM 3170.01

This manual sets forth guidelines and procedures for operation of the JCIDS regarding the development and staffing of JCIDS documents. Guidance on the conduct of JCIDS analyses, the development of key performance parameters and the JCIDS staffing process are provided in this manual. This manual also contains procedures and instructions regarding the staffing and development of ICDs, including the Mission Area ICD, CDDs, and CPDs. HERO, E3, and SS are to be addressed in all documents.

A.7.2.11 CJCSI 6212.01

CJCSI 6212.01 establishes policies and procedures for the J-6 interoperability requirements and supportability certification and validation of JCIDS ACAT programs and for all non-ACAT and fielded systems. It provides guidance for the development and certification of ISPs as well as ICDs, CDDs, and CPDs. Furthermore, the instruction indicates that the J-6 Interoperability Certification includes conformance with Joint NSS and ITS policies, which includes the requirement to be mutually compatible with systems in the EME and not be degraded below operational performance requirements due to E3. It further requires all proposed NSS and ITS systems that include spectrum-dependent hardware document spectrum certification of the hardware. Commercial and non-developmental items must also comply with DoD policies on E3 and SS. The instruction also provides details for the development of NR-KPPs.

A.7.2.12 DOT&E E3 Policy Memo

This memo dated 25 October 1999 provided policy for DOT&E, OTAs, and PMs. The memo defined the role of OT&E in identifying potentially adverse E3 and spectrum availability situations.

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APPENDIX B

ACRONYMS AND ABBREVIATIONS

B.1 General

This appendix contains acronyms and abbreviations used throughout this handbook.

B.2 Acronyms and Abbreviations

AATF	Aircraft Anechoic Test Facility
ACAT	Acquisition Category
ACETEF	Air Combat Environment Test and Evaluation Facility
ACTD	Advanced Concept Technology Demonstration
AESOP	Afloat Electromagnetic Spectrum Operations Program
AFB	Air Force Base
AFC	Area Frequency Coordinator
AFFMA	Air Force Frequency Management Agency
AFFTC	Air Force Flight Test Center
AFRL	Air Force Research Laboratories
ANSI	American National Standards Institute
AoA	Analysis of Alternatives
APB	Acquisition Program Baseline
ARAPP	All Region All Platform Propagation
ARDEC	Armaments Research, Development, and Engineering Center
ARL	Army Research Laboratory
ASD(NII)	Assistant Secretary of Defense for Networks and Information Integration
ASIL	Advanced Systems Integration Laboratory
ASR	Alternative System Review
ATC	Aberdeen Test Center
ATD	Advanced Technology Demonstration
ATEC	Army Test and Evaluation Command
C4I	Command, Control, Communications, Computers, and Intelligence
C4ISR	C4I, Surveillance, and Reconnaissance
CAE	Component Acquisition Executive
CCEB	Combined Communications-Electronics Board
CDD	Capability Development Document
CDR	Critical Design Review
CDRL	Contract Data Requirements List
C-E	Communications-Electronics
CECOM	Communication and Electronics Command
CE Mark	Indication of Compliance With European Directives
CENELEC	European Committee for Electrotechnical Standardization
CFR	Code of Federal Regulations
CI	Commercial Item
CIO	Chief Information Officer
CISPR	International Special Committee on Radio Interference
CJCSI	Chairman of Joint Chiefs of Staff Instruction
CJCSM	Chairman of Joint Chiefs of Staff Manual
CNO	Chief of Naval Operations

COCOM	Combat Command
COSAM	Cosite Analysis Model
CPD	Capability Production Document
CPM	Communications Planning Module
CRD	Capstone Requirements Document
CW	Continuous Wave
DID	Data Item Description
DISA	Defense Information Systems Agency
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DoDISS	Department of Defense Index of Specifications and Standards
DOT&E	Director, Operational Test and Evaluation
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities
DSO	Defense Spectrum Office
DT&E	Developmental Test and Evaluation
E3	Electromagnetic Environmental Effects
EDM	Engineering Development Model
EED	Electro-Explosive Device
EID	Electrically Initiated Device
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EMCAP	Electromagnetic Compatibility Analysis Program
EME	Electromagnetic Environment
EMEGS	Electromagnetic Environment Generating System
EMENG	Electromagnetic Engineering System
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
EMR	Electromagnetic Radiation
EMV	Electromagnetic Vulnerability
EP	Electronic Protection
EPG	Electronic Proving Ground
EPS	Engineering Practice Study
ESC	Equipment Spectrum Certification
ESD	Electrostatic Discharge
ESGPWG	Equipment Spectrum Guidance Permanent Working Group`
EU	European Union
EW	Electronic Warfare
FAA	Federal Aviation Administration
FAAT	First Article Acceptance Test
FCC	Federal Communications Commission
FMO	Frequency Management Office
FOC	Final Operating Capability
FoS	Family of Systems
FRP	Full-Rate Production
GATE	Graphical Analysis Tool for EMEs
HEMP	High Altitude Electromagnetic Pulse

HERF	Hazards of Electromagnetic Radiation to Fuel
HERO	Hazards of Electromagnetic Radiation to Ordnance
HERP	Hazards of Electromagnetic Radiation to Personnel
HIRF	High Intensity Radio Frequency
HNA	Host Nation Approval
ICD	Initial Capabilities Document
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMI	Intermodulation Interference
IOC	Initial Operating Capability
IPT	Integrated Product Team
IRAC	Interdepartment Radio Advisory Committee
ISO	International Organization for Standardization
ISP	Information Support Plan
IT	Information Technology
ITR	Initial Technical Review
ITS	Information Technology System
ITU	International Telecommunications Union
JCIDS	Joint Capabilities Integration and Development System
JCS	Joint Chiefs of Staff
JEET	Joint E3 Evaluation Tool
JFP	Joint Frequency Panel
JOERAD	JSC Ordnance E3 Risk Assessment Database
JROC	Joint Requirements Oversight Council
JSC	Joint Spectrum Center
JTIDS	Joint Tactical Information Distribution System
KPP	Key Performance Parameter
LFT&E	Live-Fire Test and Evaluation
LRIP	Low-Rate Initial Production
M&S	Modeling and Simulation
MAE	Maximum Allowable Environment
MARCORSYSCOM	Marine Corps Systems Command
MCEB	Military Communications Electronic Board
MDA	Milestone Decision Authority
MIDLANT AFC	Mid-Atlantic Area Frequency Coordinator
MNS	Mission Need Statement
MOE	Measures of Effectiveness
MOP	Measures of Performance
MS	Milestone
NATO	North Atlantic Treaty Organization
NAVAIR	Naval Air Systems Command
NERF	Naval Electromagnetic Radiation Facility
NMCSC	Navy and Marine Corps Spectrum Center
NAVSEA	Naval Sea Systems Command
NAWCAD	Naval Air Warfare Center, Aircraft Division
NDI	Non Developmental Items
NR-KPP	Net-Ready Key Performance Parameter
NRL	Naval Research Laboratory

NSS	National Security Systems
NSWCDD	Naval Surface Warfare Center, Dahlgren Division
NTIA	National Telecommunications and Information Administration
NUWC NPT	Naval Undersea Warfare Center Newport
OATS	Open Area Test Site
OIPT	Overarching Integrated Product Team
OMB	Office of Management and Budget
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
OTA	Operational Test Agency
OTRR	Operational Test Readiness Review
PCR	Physical Configuration Review
PDR	Preliminary Design Review
PM	Program Manager
PRIMES	Preflight Integration of Munitions and Electronic Systems
P-Static	Precipitation Static
RADHAZ	Radiation Hazards
RCS	Radar Cross Section
RF	Radio Frequency
RR	Readiness Review
RTCA	Radio Technical Commission for Aeronautics
RTTC	Redstone Technical Test Center
SAE	Society of Automotive Engineers
SCS DMR	Spectrum Certification System Data Maintenance and Retrieval
SDD	System Development and Demonstration
SE	System Engineering
SFR	System Functional Review
SM	Spectrum Management
SoS	System of Systems
SOW	Statement of Work
SPAWAR	Space and Naval Warfare Systems Command
SPS	Spectrum Planning Subcommittee
SRR	System Requirements Review
SS	Spectrum Supportability
SSC	SPAWAR Systems Center
STANAG	NATO Standardization Agreement
SVAD	Survivability, Vulnerability, and Assessment Directorate
SVR/PRR	System Verification Review/Production Readiness Review
T&E	Test and Evaluation
TACOM	Tank Automotive Command
TC	Technical Committee
TDS	Technology Development Study
TEMP	Test and Evaluation Master Plan
TOA	Table of Allocations
TRR	Test Readiness Review
U.S.	United States
USD (AT&L)	Under Secretary of Defense for Acquisition, Technology, and Logistics

USMC	United States Marine Corps
V/m	Volts per meter
WIPT	Working Level Integrated Product Team
WRC	World Radio Conference
WSMR	White Sands Missile Range

APPENDIX C

OVERVIEW

OF THE

ACQUISITION SYSTEM

CONTENTS

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FIGURE

C.1 Introduction

This Appendix provides an overview of the DoD acquisition system. Information contained herein is based on the policies and procedures of DoDD 5000.1, DoDI 5000.2, CJCSI 3170.01, and 6212.01 and CJCSM 3170.01. It is designed to be an introduction to the world of defense systems acquisition management. It focuses on DoD-wide management policies and procedures, not on the details of any specific defense system. It is included in this handbook so that E3/SM engineers will have sufficient information on the acquisition process so that their requirements can be incorporated into the PM's tasks and associated documents at appropriate points during the acquisition life cycle. Information in this appendix is based on numerous source documents many of which are available on internet sites such as www.dau.mil.

C.1.1 Overview

The Defense Acquisition System exists to manage DoD's investments in technologies, programs, and product support necessary to achieve the National Security Strategy and support the U.S. Armed Forces. The investment strategy of the DoD supports not only today's force, but also future forces. The primary objective of defense acquisition is to acquire quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price.

C.1.2 Joint Vision 2020

Joint Vision is the Chairman of the Joint Chiefs of Staff's conceptual blueprint for future military operations. Joint Vision 2020, the latest version of the Joint Vision, provides a foundation for broad support of the "revolution in military affairs" through the creation and exploitation of information superiority. Central to the Chairman's vision, the concept of "full-spectrum dominance" is achieved through the interdependent application of four operational concepts - dominant maneuver, precision engagement, focused logistics, and full-dimensional protection. Together, these four concepts provide Joint warfighters the means to fulfill their primary purpose - victory in war - as well as the capability to dominate an opponent across the full range of military operations. Achieving full-spectrum dominance also means building an integrated, complex set of systems, especially a command, control, communications, computers, intelligence, surveillance, and reconnaissance architecture. To fulfill the Chairman's vision and the Military Service Chiefs' companion vision, the research, development, and acquisition of future systems will be a challenge for the defense acquisition system.

C.1.3 Transforming the DoD

The war on terrorism has shown that future threats to our national security may come from many diverse areas - domestic and international terrorists, computer hackers, state-sponsored sub-national groups, nation-states, and others. To help prepare for an uncertain and dangerous future, the Transformation Planning Guidance for DoD provides a strategy for transforming "how we fight, how we do business, and how we work with others." The guidance stated by the Secretary of Defense is that:

> Transformation is necessary to ensure U.S. forces continue to operate from a position of overwhelming military advantage in support of strategic objectives. We cannot afford to react to threats slowly or have large forces tied down for lengthy periods. Our strategy requires transformed forces that can take action from a forward position and, rapidly reinforced from other areas, defeat adversaries swiftly and decisively while conducting an active defense of U.S. territory.

A priority for the transformation of DoD is the streamlining of the acquisition process. The latest acquisition policies and procedures provide insight on the implementation of evolutionary acquisitions and spiral developments to reduce cycle time and field an initial increment of warfighting capability as fast as possible.

C.1.4 Acquisition Streamlining and Reforms

Given the changes in the threat and the fast pace of technological advances in the commercial market, DoD fundamentally has had to change the way it acquired systems. It has to be more efficient and effective in acquiring goods faster, better, and cheaper. The following initiatives, though not all-inclusive, capture the essence of the major thrusts of acquisition streamlining within the DoD:

C.1.4.1 Advanced Concept Technology Demonstrations (ACTDs)

To provide opportunities to try out mature technology directly with the warfighters, advanced concept technology demonstrations allow operational forces to experiment with new technology in the field to evaluate potential changes to doctrine, operational concepts, tactics, modernization plans, and training. Following a successful advanced concept technology demonstration, the system may enter the acquisition process at whatever point good judgment dictates.

C.1.4.2 Commercial Items and Practices

Maximizing the use of CI takes advantage of the innovation offered by the commercial marketplace and ensures access to the latest technology and a broader vendor base. DoD is also encouraging defense contractors to move to commercial practices that will enhance their global competitiveness. The goal is to establish partnerships with industry to create advanced products and systems with common technological bases and to allow production of low-volume defense-unique items on the same lines with high-volume commercial items.

C.1.4.3 Evolutionary Acquisitions

This is the preferred strategy for the rapid acquisition of mature technology for the user. An evolutionary approach delivers capability in militarily useful increments and recognizes, up front, the need for future capability improvements. The objective is to balance needs and available capability with resources and to put capability into the hands of the user quickly.

C.1.4.4 Performance-based Services Acquisition

As services become an increasingly significant element of what DoD buys, steps are being taken to ensure they are acquired effectively and efficiently. Service requirements must be stated using results required and not methods for performance of the work.

C.1.4.5 Specifications and Standards Reform

In mid-1994, Secretary of Defense Perry approved a new major policy for use of specifications and standards for defense systems acquisition contracts. In this policy, the first choice is the use of performance specifications. Design-specific specifications and standards were to be authorized only as a last resort, and their use requires a waiver.

C.2 Determining Joint Warfighter Needs

This section focuses on a capabilities-based approach to identifying current and future gaps in the ability to carry out Joint warfighting missions and functions. The current process is called the Joint Capabilities Integration and Development System (JCIDS). In 2003, JCIDS replaced the Requirements Generation System used for many decades. JCIDS involves an analysis of Doctrine, Organization, Training, Materiel, Leadership, Personnel and Facilities (DOTMLPF) in an integrated, collaborative process to define gaps in warfighting capabilities and propose solutions. CJCSI 3170.01 provides the policy and top-level description of JCIDS. The details for action officers who will be performing the day-to-day work of identifying, describing, and justifying warfighting capabilities are provided by CJCSM 3170.01.

JCIDS produces information for decision-makers on the projected needs of the warfighter. There are a number of key requirements documents used in the acquisition process. They promote a consistent approach to stating the requirements. Requirements are generated in many different ways: they are stated or derived; they are interrelated and interdependent; and, they must be traceable throughout. As stated in CJCSI 6212.01, requirements documents, such as the Initial Capabilities Document (ICD), Capstone Requirements Document (CRD), Capability Development Document (CDD), and Capability Production Document (CPD), must address National Security Systems (NSS) and Information Technology Systems (ITS) policies in DoDD 4630.5 and DoDI 4630.8, including those for E3 and SS. These documents are discussed later in this appendix. They are to be considered in the context of the overall Defense acquisition management framework, as defined in DoDI 5000.2 and depicted in Figure C-1.

PMs may tailor or streamline this model to the maximum extent possible, consistent with technical risk, to provide new systems to the warfighter as fast as possible. The process provides for multiple entry points consistent with a program's technical maturity, validated requirements, and funding. Entrance criteria for each phase of the life cycle guide the Milestone Decision Authority (MDA) in determining the appropriate point for a program to enter the acquisition process. The life cycle process consists of periods of time called phases separated by decision points called milestones. Some phases are divided into two efforts separated by program reviews. These milestones and other decision points provide the PM and MDA the framework with which to review acquisition programs, monitor and administer progress, identify problems, and make corrections. The MDA will approve entrance into the appropriate phase or effort of the acquisition process by signing an Acquisition Decision Memorandum upon completion of a successful decision review. The life cycle of a program begins with planning to satisfy a mission needs

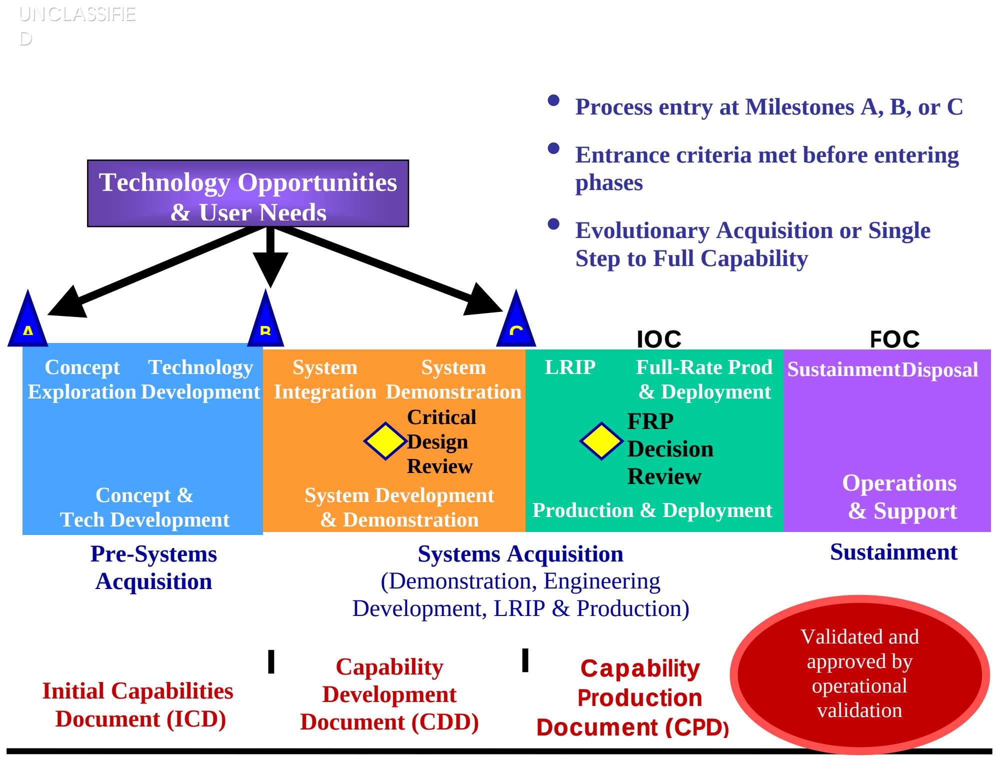

FIGURE C-1. The New 5000 Model.

before the program officially begins. Program initiation normally occurs at Milestone B. The life cycle process takes the program through research, development, production, deployment, support, upgrade, and finally, demilitarization and disposal. The Initial Operational Capability (IOC) is that point at which a selected number of operational forces have received the new system and are capable of conducting and supporting warfighting operations. This appendix provides a brief review of each of the phases, milestones, and other decision reviews. Each program structure must be based on that program's unique set of requirements and available technology. The process of adjusting the life cycle to fit a particular set of programmatic circumstances is often referred to as "tailoring." The number of phases, key activities, and decision points are tailored by the program manager based on an objective assessment of the program's technical maturity and risks and the urgency of the mission need.

C.2.1 Technological Opportunities and User Needs

The Defense Science and Technology Program identifies and explores technological opportunities within DoD. The aim is to provide the user with innovative war-winning capabilities and reduce the risk associated with promising technologies before they are introduced into the acquisition system. Several mechanisms are available to facilitate the transition of innovative concepts and superior technology to the acquisition process: (1) Advanced Technology Demonstrations (ATDs)/ Advanced Concept Technology Demonstrations (ACTDs), and (2) Joint Warfighting Experiments.

C.2.1.1 Advanced Technology Demonstrations (ATDs)/Advanced Concept Technology Demonstrations (ACTDs)

ATDs are used to demonstrate technical maturity and the potential for enhanced military capability or cost effectiveness. They are subject to oversight and review at the Service or Component level. An ATD can become the basis for a new acquisition program or for the insertion of new technology into an existing program. ACTDs are used to demonstrate the military utility of a proven technology and to develop the concept of operations for the system to be demonstrated. Consequently, these demonstrations are typically funded and engineered to endure up to two years of service in the field before entering the acquisition process. Oversight and review of ACTDs is performed at the Office of the Secretary of Defense and the Joint Staff levels.

C.2.1.2 Joint Warfighting Experiments

Joint Warfighting Experiments, such as the warfighting experiments conduced by the military services and the Joint Forces Command, are used to develop and assess concept-based hypotheses to identify and recommend the best value-added solutions for changes to doctrine, organizational structure, training and education, materiel, leadership, and people required to achieve significant advances in future Joint operational capabilities. They are also subject to oversight and review at the Military Department headquarters, and the Office of the Secretary of Defense and Joint Staff.

C.2.2 Defense Acquisition Framework

C.2.2.1 Pre-Systems Acquisition

Pre-systems acquisition is composed of activities in development of user needs, in science and technology, and in technology development work specific to the refinement of materiel solution(s) identified in the approved ICD. Two phases comprise pre-systems acquisition: Concept Refinement and Technology Development.

C.2.2.1.1 Concept Refinement

Concept refinement begins with a Concept Decision by the MDA. During this phase a Technology Development Strategy (TDS) is developed to help guide the efforts during the next phase, Technology Development. Also, a study called an Analysis of Alternatives (AoA) is conducted to refine the selected concept documented in the approved ICD. To achieve the best possible system solution, Concept Refinement places emphasis on innovation and competition and on existing commercial off-the-shelf and other solutions drawn from a diversified range of large and small businesses. Concept Refinement ends when the MDA approves the preferred solution supported by the AoA and approves the associated TDS.

C.2.2.1.2 Technology Development

Technology Development begins after a Milestone A decision by the MDA approving the TDS. The ICD and TDS guide the work during Technology Development. A favorable Milestone A decision normally does not mean that a new acquisition program has been initiated. For shipbuilding, however, programs may be initiated at the beginning of Technology Development.

The purpose of this phase is to reduce technology risk and to determine the appropriate set of technologies to be integrated into a full system. During Technology Development a series of technology demonstrations may be conducted to help the user and the developer agree on an affordable, militarily useful solution based on mature technology. The project is ready to leave this phase when the technology for an affordable increment of a militarily useful capability has been demonstrated in a relevant environment

C.2.2.2 Systems Acquisition

C.2.2.2.1 Milestone B

Milestone B will normally be program initiation for defense acquisition programs. For ship-building programs, the lead ship in a class of ships is also approved at Milestone B. Each increment of an evolutionary acquisition will have its own Milestone B. Before making a decision, the MDA will confirm that technology is mature enough for systems-level development to begin, the appropriate document from the JCIDS has been approved, and funds are in the budget and the out-year program for all current and future efforts necessary to carry out the acquisition strategy. At Milestone B, the MDA approves the acquisition strategy and the acquisition program baseline and authorizes entry into the System Development and Demonstration (SDD) Phase.

C.2.2.2.2 System Development and Demonstration Phase

Entrance criteria for this phase are technology (including software) maturity, funding, and an approved JCIDS document - the CDD. Programs that enter the acquisition process for the first time at Milestone B must have an ICD and a CDD. Unless there is some overriding factor, the maturity of the technology will determine the path to be followed by the program. A program entering at Milestone B must have a system architecture (defined set of subsystems making up the system) and an operational architecture (description of how this system interacts with other systems to include passing of data). The efforts of this phase are guided by the Key Performance Parameters (KPPs) found in the approved CDD and in the Acquisition Program Baseline (APB). The APB establishes program goals, called thresholds and objectives, for cost, schedule, and performance parameters that describe the program over its life cycle. This phase typically contains two efforts: Systems Integration and Systems Demonstration. A Design Readiness Review takes place at the end of Systems Integration.

– <u>Systems Integration.</u> A program enters System Integration when the program manager has a technical solution for the system, but the component subsystems have not yet been integrated into a complete system. This effort typically includes the demonstration of prototype articles or engineering development models, sometimes in a competitive "fly-off." A program leaves System Integration after prototypes have been demonstrated in a relevant environment (such as a first flight or interoperable data flow across system boundaries), the system configuration has been documented, and a successful Design Readiness Review has been completed. The Design Readiness Review provides an opportunity for a mid-phase assessment of design maturity as evidenced by measures such as the number of design reviews successfully completed; the percentage of drawings completed; planned corrective actions to hardware/software deficiencies; adequate developmental testing; and an assessment of environment, safety, and occupational health risks; and so forth. Successful completion of the Design Readiness Review ends System Integration and continues the SDD phase into the System Demonstration effort.

– Systems Demonstration. This effort is intended to demonstrate the ability of the system to operate in a useful way consistent with the approved KPPs. The program enters System Demonstration when the PM has demonstrated the system in prototypes. This effort ends when the system is demonstrated (using prototypes in its intended environment); measured satisfactorily against the KPPs; and determined to meet or exceed exit criteria and Milestone C entrance requirements. Industrial capabilities must also be reasonably available. Developmental test and evaluation is conducted to assess technical progress against critical technical parameters, and operational assessments are conducted to demonstrate readiness for production. The completion of this phase is dependent on a MDA decision to commit the program to production at Milestone C or to end the effort.

C.2.2.2.3 Milestone C

The MDA makes the decision to commit the DoD to production at Milestone C. Milestone C authorizes entry into Low Rate Initial Production (LRIP) or into production or procurement for systems that do not require LRIP. Milestone C authorizes limited deployment in support of operational testing for major automated information systems or software-intensive systems with no production components. If Milestone C is LRIP approval, a subsequent review and decision authorizes full rate production.

C.2.2.2.4 Production and Deployment Phase

The purpose of this phase is to achieve an operational capability that satisfies mission needs. OT&E determines the effectiveness and suitability of the system. Entrance into this phase depends on acceptable performance in DT&E, and operational assessment; mature software capability; no significant manufacturing risks; manufacturing processes under control (if Milestone C is full rate production); an approved ICD (if Milestone C is program initiation); an approved CPD; acceptable interoperability; acceptable operational supportability; and demonstration that the system is affordable throughout the life cycle, optimally funded, and properly phased for rapid acquisition. For most defense acquisition programs, Production and Deployment has two major efforts: LRIP and Full Rate Production and Deployment. It also includes a Full Rate Production Decision Review.

– LRIP. This effort is intended to result in completion of manufacturing development to ensure adequate and efficient manufacturing capability; produce the minimum quantity necessary to provide production or production-representative articles for Initial OT&E; establish an initial production base for the system; and permit an orderly increase in the production rate sufficient to lead to full rate production upon successful completion of operational and, where applicable, live-fire testing. The MDA determines the LRIP quantity at Milestone B. LRIP is not applicable to automated information systems or software-intensive systems with no developmental hardware; however, a limited deployment phase may be applicable. LRIP for ships and satellites is the production of items at the minimum quantity and rate that is feasible and that preserves the mobilization production base for that system. Before granting a favorable Full Rate Production Decision

Review, the MDA considers initial OT&E and live fire test and evaluation results (if applicable); demonstrated interoperability; supportability; cost and manpower estimates; and command, control, communications, computer, and intelligence supportability and certification (if applicable). A favorable Full Rate Production Decision authorizes the program to proceed into the Full Rate Production and Deployment portion of the Production and Deployment Phase.

– Full Rate Production and Deployment. The system is produced and delivered to the field for operational use. During this phase, the PM must ensure that systems are produced at an economical rate and deployed in accordance with the user's requirement to meet the initial operational capability requirement specified in the CPD. Follow-on OT&E may also be conducted, if appropriate, to confirm operational effectiveness and suitability or verify the correction of deficiencies. Operations and support begins as soon as the first systems are fielded or deployed; therefore, the Production and Deployment Phase overlaps the next phase - Operations and Support.

C.2.2.2.5 Operations and Support Phase

During this phase full operational capability is achieved, each element of logistics support (supply, maintenance, training, technical data, support equipment) is evaluated, and operational readiness is assessed. Logistics and readiness concerns dominate this phase. The supportability concept may rely on a Government activity, a commercial vendor, or a combination of both to provide support over the life of the system. System status is monitored to ensure the system continues to meet the user's needs. The operations and support phase includes sustainment and disposal.

– Sustainment. Sustainment includes supply, maintenance, transportation, sustaining engineering, configuration management, data management, manpower, personnel, training, habitability, survivability, environment, safety (including explosives safety), occupational health, protection of critical program information, anti-tamper provisions, and IT and NSS supportability and interoperability. The PM works with the users to document performance and support requirements in performance agreements specifying objective outcomes, measures, resource commitments, and stakeholder responsibilities. System modifications are made, as necessary, to improve performance and reduce ownership costs. Product improvement programs or service life extension programs may be initiated as a result of experience with the systems in the field. During deployment and throughout operational support, the potential for modifications to the fielded system continues.

– Disposal. Disposal of the system occurs at the end of its useful life. The program manager should have planned for disposal early in the system's life cycle and ensured that system disposal minimizes DoD's liability due to environmental safety, security, and health issues. Environmental considerations are particularly critical during disposal as there may be international treaty or other legal considerations requiring intensive management of the system's demilitarization and disposal.

C.3 Key Activities

All acquisition programs, regardless of Acquisition Category (ACAT), must accomplish certain key activities. These activities generate information that structures and defines the program and facilitates planning and control by the PM and oversight by a MDA. The information generated by key activities may be contained in stand-alone documents structured in accordance with the desires of the MDA. Most of this information/documentation is carefully constructed by the PM using IPTs. Key activities include, but are not limited to, development/update and approval of JCIDS documents, formulation of program structure, contract planning and management, formulation of an acquisition program baseline, test planning.

C.3.1 Pre-Acquisition Technology Projects

As noted above, ACTDs/ATDs, Joint Warfighting Experiments, Concept Refinements, and Technology Developments occur prior to acquisition program initiation. Generally, they demonstrate performance payoffs, increased logistics or interoperability capabilities, or cost reduction potential of militarily relevant technology. They are used to demonstrate the maturity and potential of advanced technologies for enhanced military operational capability or cost effectiveness, the military utility of proven technology, or a concept of operations that will optimize effectiveness. Their results are reviewed prior to making a Milestone A decision. Their roles in the acquisition process are described in DoDI 5000.2.

C.3.2 Initial Capabilities Document (ICD)

The ICD documents the need for a materiel approach to a specific capability gap derived from an initial analysis of materiel approaches executed by the operational user and, as required, an independent analysis of materiel alternatives. It defines the capability gap in terms of the functional area, the relevant range of military operations, desired effects, and time. The ICD summarizes the results of the DOTMLPF analysis and describes why non-materiel changes alone have been judged inadequate in fully providing the capability. It is to be prepared in accordance with CJCSI 3170.01, CJCSM 3170.01, and CJCSI 6212.01. It replaces the Mission Needs Statement (MNS) required by the older Requirements Generation System defined in CJCSI 3170.01B. No new MNS will be accepted for staffing. ICDs developed in accordance with CJCSI 3170.01D and later versions thereto will be used instead. Programs that have already completed acquisition Milestone A, or beyond, are not required to update the MNS with an ICD. No MNS greater than 2 years old will be used to support a Milestone A (or programs proceeding directly to Milestone B or C) acquisition decision. Effective with the issuance of CJCSI 3170.01E, the format of the ICD has been changed to allow for a Mission Area ICD to be written for capability definition.

C.3.3 Capstone Requirements Document (CRD)

The CRD contained capabilities-based requirements that facilitate the development of CDDs and CPDs by providing a common framework and operational concept to guide their development. The CRD captured the overarching requirements for a Joint mission area that forms a family-of-systems (FoS) (for example, space control and Theater Missile Defense) or system-of-systems (SoS) (for example, the National Missile Defense System). With the issuance of CJCSI 3170.01E the CRD has been eliminated as a JCIDS document and Mission Area ICDs has been created for capability definition.

C.3.4 Capability Development Document (CDD)

The CDD is the sponsor's primary means of defining authoritative, measurable, and testable capabilities needed by the warfighters to support the System Development and Demonstration (SDD) phase of an acquisition program. The CDD will be validated and approved before Milestone B. The CDD captures the information necessary to develop a proposed program, normally using an evolutionary acquisition strategy. In an evolutionary acquisition program, the capabilities delivered by a specific increment may provide only a part of the ultimate desired capability; therefore, the first increment's CDD must provide information regarding the strategy for achieving the full capability. The CDD provides the operational performance attributes necessary for the acquisition community to design a proposed system(s) and establish a program baseline. It states the performance attributes, including Key Performance Parameters (KPPs) that will guide the development and demonstration of the proposed increment. A Net-Ready KPP (NR-KPP) is required to assess information needs, timeliness, information assurance, Joint interoperability and supportability and other net-ready attributes. The CDD is to be updated or appended for each Milestone B decision. The CDD is to be prepared in accordance with the latest issues of CJCSI 3170.01 and 6212.01 and CJCSM 3170.01.

C.3.5 Capability Production Document (CPD)

The CPD is the sponsor's primary means of providing authoritative, testable capabilities for the Production and Deployment phase of an acquisition program. The CPD captures the information necessary to support production, testing, and deployment of an affordable and supportable increment within an acquisition strategy. The CPD provides the operational performance attributes necessary for the acquisition community to produce a single increment of a specific system. It presents performance attributes, including KPPs, to guide the Production and Deployment of the current increment. The CPD refines the threshold and objective values for performance attributes and KPPs that were validated in the CDD for the production increment. The refinement of performance attributes and KPPs is the most significant difference between the CDD and the CPD. As noted above, the NR-KPP is required to assess information needs, timeliness, information assurance, Joint interoperability and supportability and other net-ready attributes. The CPD is to be validated and approved before the Milestone C decision and prepared in accordance with the latest versions of CJCSI 3170.01 and 6212.01 and CJCSM 3170.01.

C.3.6 Information Support Plan (ISP)

The ISP is used by program authorities to document the program's interoperability, information, and support requirements, IT and NSS needs, objectives, interface requirements for all non-ACAT and fielded programs. ISPs should be kept current throughout the acquisition process and formally reviewed at each milestone, decision reviews and whenever the operational concepts, and IT and NSS support requirements change. The ISP addresses all ACAT, non-ACAT, and fielded systems. The ISP will contain sufficient detail, commensurate with the size of the program/effort, to permit an evaluation of the associated interoperability and supportability requirements. ISPs contain an Introduction (consisting of an overview and program data); an Analysis Chapter that consists of an incremental analysis process tailored to each program; and an Issues Chapter that details the information, interoperability and synchronization issues identified in the analysis section and the strategies to address or mitigate these issues. ISPs shall also include a number of mandatory appendices and other appendices, as necessary. The format within each chapter of an ISP may be tailored to include only those elements that apply to the subject program. DoDI 4630.8 provides additional information for completing each chapter and appendices in the ISP.

C.3.7 Integrated Product Teams (IPTs)

The Secretary of Defense has directed DoD to perform as many acquisition functions as possible, including oversight and review, using IPTs. IPTs promote teamwork by empowering their members, to the maximum extent possible, to make commitments on behalf of the organization or functional area they represent. There are two types of IPTs: Overarching IPTs (OIPTs) and Working Level IPTs (WIPTs).

C.3.7.1 Overarching IPTs (OIPTs)

OIPTs focus on strategic guidance, program assessments, and the resolution of issues. They provide assistance, oversight, and review as the program proceeds through the acquisition life cycle. The OIPT is composed of the PM, Component Staff, Joint Staff, and Office of the Secretary of Defense (OSD) staff principals involved in oversight and review of the program. The PM reports the status of the project to the OIPT. The OIPT shall then assess progress against stated goals. The PM's briefing to the OIPT shall specifically address interoperability and supportability (including spectrum supportability).

C.3.7.2 Working Level IPTs (WIPTs)

WIPTs focus on particular topics such as cost, performance, test, or specific technical issues such as E3/SS. WIPTs are advisory bodies to the PM and meet, as required, to help develop program objectives, review program documentation, and resolve program issues. WIPT responsibilities and activities can include:

- Assisting the PM in developing strategic and program planning,
- Assisting in the establishment of the IPT plan of action and milestones,
- Proposing tailored requirements and milestones,
- Reviewing and providing inputs to acquisition documents,
- Defining the approaches to verify requirements including analysis, modeling and
- simulation (M&S), and T&E,
- Establishing performance requirements,
- Defining budget requirements,
- Determining and assessing the feasibility of using CI/NDI, and
- Assuming responsibility for obtaining approval from principals on issues, as well as on
- applicable documents or portions of documents.

C.3.8 Test Planning

Test planning is central to the formulation of a coherent acquisition strategy. A variety of testing must be planned and accomplished either to confirm program progress or to conform to statutory dictate. It is by testing that the performance requirements identified by the user in the CPD and promised by the PM in the acquisition program baseline are validated. Testing includes DT&E,

OT&E, and live fire test and evaluation (LFT&E), as appropriate. The Test and Evaluation Master Plan (TEMP) documents the overall structure and objectives of the test and evaluation program. It provides a framework to generate detailed test and evaluation plans for a particular test, and it contains resource and schedule implications for the test and evaluation program.

C.3.8.1 Test and Evaluation Master Plan (TEMP)

The TEMP describes planned DT&E, OT&E, LFT&E, interoperability testing, information assurance testing, and M&S activities. It includes measures to evaluate the performance of the item during these test periods; an integrated test schedule; and the resource requirements to accomplish the planned testing. It is prepared by the PM, usually by a T&E WIPT, in concert with the user and T&E communities, and updated as the program progresses through its milestone decisions. It relates program schedule, test management strategy and structure, and required resources to critical operational issues, critical technical parameters, KPPs, operational performance parameters derived from the CDD or CPD, and major decision points. The TEMP translates the user's requirements and capabilities essential to mission accomplishment, as stated in the CDD or CPD, into testable critical operational issues, measures of effectiveness and performance (MOEs/MOPs), and measures of suitability. As noted earlier, a NR-KPP is required to assess information needs, timeliness, information assurance, Joint interoperability and supportability and other net-ready attributes. The procedures and format for the TEMP are provided in DoDI 5000.2 and the Acquisition Guidebook.

C.3.8.1.1 Key Performance Parameters (KPPs)

KPPs are those system capabilities or characteristics considered essential for a successful mission. Failure to meet a KPP threshold could cause the system selection to be re-evaluated or the program to be reassessed or terminated. KPPs are included in the acquisition program baseline. In accordance with the latest version of CJCSI 6212.01, the NR-KPP is to be used to assess information needs, information timeliness, information assurance, joint interoperability and supportability, and net-ready attributes required for both the technical exchange of information and the end-to-end operational effectiveness of that exchange. The NR-KPP consists of measurable, testable, or calculable characteristics and performance metrics required for the timely, accurate, and complete exchange and use of information. The NR-KPP assessment determines the impacts, risks, and vulnerabilities of fielding secure, interoperable, supportable, sustainable and usable systems. Parameters assessed include compatibility and SS, among others.

C.3.9 Procurement Activities

Identification or, when necessary, preparation of the applicable solicitation documents is a key part of the acquisition process. Without specific attention to clarity during the development of these documents, it becomes very difficult to evaluate proposals and to evaluate a contractor's performance after the contract has been awarded. The needs of the user should be clearly defined. The success of a procurement action relies on the contractual documents being a true and accurate statement of the user's requirements. Policies and guidelines emphasize that requirements in the solicitation for hardware are to be stated in terms of performance or "what the product must do" rather than "how-to" produce the product. Performance specifications SOW, and CDRLs, and DIDs are the documents used in solicitations that become part of a contract.

C.3.9.1 Performance Specifications

Preparing an end item specification is a key part of the acquisition process. DoD policies emphasize that requirements should be stated in terms of performance or "what-is-necessary" rather than telling a contractor "how-to" perform a task. The performance specification is created from the CDD and CPD and should contain only performance-based requirements. It is the functional and technical description for the item being procured. It addresses what the item should do, the accuracy with which it should be done, the environment that it should do it in, and the required interfaces. Contracting to a performance specification allows a contractor to become more efficient in his operations, to incorporate product enhancements, and to reduce both direct and indirect costs associated with his effort. A performance specification should state the requirements in terms of results along with criteria for verifying compliance, but without stating the methods for achieving the required results. Performance specifications give a contractor the flexibility and freedom in his design process to incorporate innovative approaches without being constrained by the specifications or contractual issues, Government oversight, and contract administration. (See Appendix A of this handbook for a list of applicable E3 and SS documents).

C.3.9.2 Statement of Work (SOW)

While specifications state the performance requirements for an item, the SOW establishes the work efforts that must be accomplished to successfully execute the contract, develop, and produce the desired product. This document is used as an input to detailed management tools used to establish program costs and schedules.

C.3.9.3 Contract Data Requirements List (CDRLs)

The CDRL is the proper vehicle for describing and ordering non-hardware deliverables that result from work tasked in the SOW. The SOW should direct the performance of any non-hardware-associated work necessary to create the data used in a deliverable item, if the information is not a by-product of tests and verifications from the requirements of the specification. CDRLs are displayed on a DD Form 1423. The DD Form 1423 provides a format that can be used to tailor the details of the data being ordered to the needs of the project. A DID utilizing DD Form 1664 is used to define each item on the CDRL. DIDs establish the content required for a data product. CDRL entries other than DIDs can be tailored on the DD Form 1423 as well as the DIDs themselves. When applicable, data items should be tailored to buy only what is actually needed for a project while at the same time requiring essential efforts be performed and critical data be delivered.

C.3.9.4 Commercial Items and Non-Developmental Items (CI/NDI)

Use of CI/NDI provides a cost-effective alternative to what can be a costly and time consuming design process and takes advantage of the latest technology. However, there needs to be an increased awareness of the limitations associated with the use of these items. A commercial item is any item customarily used for non-Government purposes and has:

- Been sold, leased, or licensed to the general public,

- Been offered for sale, lease, or license to the general public, or
- Evolved through advances in technology or performance and is not yet available in the commercial marketplace, but will be in time to satisfy the delivery requirements of a Government solicitation.

NDI is any item previously developed and being used exclusively for Governmental purposes by another DoD or Federal Agency, a State or local Government, or a foreign Government with which the U.S. has a mutual defense cooperation agreement.

Federal and DoD acquisition policies dictate that all material requirements should be satisfied to the maximum extent practicable through the use of CI/NDI when such products will meet the user's needs and are cost-effective over the entire life cycle. Acquisition procedures for CI/NDI are neither new nor significantly different from established acquisition procedures. The objective is to obtain best value in meeting an item's requirements. Market research and analysis should be con-ducted to determine the availability and suitability of existing CI/NDI prior to the commencement of a development effort, and prior to the preparation of any product description. The desired performance requirements should be defined in terms that enable and encourage offerors of CI/NDI an opportunity to compete in any procurement to fill such requirements. CI/NDI acquisitions require flexibility, innovation, and practical trade-offs between performance, supportability, cost, and schedule. The acquisition process should be tailored to the unique circumstances of an acquisition in order to provide the greatest benefit to the Government in terms of overall cost, product quality, timeliness of delivery, and supportability.

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APPENDIX D

E3/SS

TEST FACILITIES AND CAPABILITIES

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D.1 Army Facilities and Capabilities

D.1.1 Army Research Laboratory (ARL)

The following facility is used to test and evaluate a system's performance in an EME. It can also be used to support the system analysis and evaluation process.

D.1.1.1 Electromagnetic Coupling Facility

This EM coupling facility located at the Survivability/Lethality Analysis Directorate, Aberdeen Proving Ground, MD, supports the survivability analysis of developmental systems. System coupling characteristics can be determined which can then be used by design engineers in hardening systems against the effects of an EMP or other EME levels. The facility measures coupling levels when exposed to an externally radiated, low power EME. The low level coupling response is then scaled to determine the system response to the actual high level EME. The facility can also use current injection techniques to simulate the high level coupling to further analyze the system performance.

D.1.2 Army Test and Evaluation Command (ATEC)/Development Test Command Test Centers

D.1.2.1 Aberdeen Test Center (ATC)

The ATC Electromagnetic Test Facility, located at Aberdeen Proving Ground, MD, is a large, free standing shielded enclosure that will accommodate combat vehicles, artillery, tractor trailers, portable shelters, electric power generation equipment, and materials handling and construction equipment. The facility size and structural integrity allow testing of large heavy pieces of equipment and complete systems as well as bench testing of components and systems in a noise-free environment. The facility has a double-walled design that provides a high degree of attenuation to magnetic, electric, and plane wave fields to assure excellent isolation from the outside EME. It currently has the capability to conduct tests in accordance with the following E3 military and commercial standards and has been certified as an acceptable test facility that meets European Certification Laboratory approved standard requirements.

- MIL-STD-461 and 464,
- SAE-J551 and SAE-J1113,
- C.I.S.P.R. Publication 16, Specification for Radio Interference Measuring Apparatus and Measurement Methods, and
- C.I.S.P.R. Publication 22, Limits and Methods of Measurement of Radio Interference Characteristics of Information Technology Equipment.

D.1.2.2 Redstone Technical Test Center (RTTC)

RTTC, located at Redstone Arsenal AL, is a comprehensive test facility that can be utilized for E3 testing of tactical missiles and missile platform system. The E3 Test Branch provides a full spectrum of support to the Aviation and Missile Command Program Executive Officers and PMs, as well as other DoD Agencies and contractors. Among the comprehensive E3 test capabilities described below are the DoD unique capabilities to conduct lightning effects testing on live missiles and munitions.

D.1.2.2.1 Electromagnetic Interference Test Facility

The EMI test facility consists of a 13-feet by 30-feet double-shielded, copper screen room, divided into a test and a control room. The facility is capable of measuring emissions and susceptibilities during subsystem/equipment tests as required by MIL-STD-461. To ensure that there are no problems when assembled into a weapon system, items may be tested to determine the EM effects between subsystems, the effects of subsystems upon external systems, and the effects of external systems upon the subsystem.

D.1.2.2.2 Electromagnetic Radiation Test Facility

This facility provides continuous wave (CW), amplitude modulation, frequency modulation, and pulse modulation testing with several subsets of antennas covering 2 MHz to 40 GHz. Testing is conducted at outdoor ranges as well as in a 40-feet wide, 70-feet long and 22-feet high anechoic chamber which incorporates a below ground fume removal duct system to allow operational testing of ground vehicles. Test items up to 1,000 pounds, such as missiles in simulated free-flight environments, can be positioned in azimuth (full 360 degrees of rotation) and either pitch or roll ($\pm$ 90 degrees). The facility also contains a-360 degrees of rotation turntable capable of accommodating a vehicle the size of an M-270 Launcher. RTTC also has facilities and methods for the testing of classified hardware up to the SECRET- SPECIAL ACCESS REQUIRED level.

D.1.2.2.3 Lightning Test Facilities

Lightning testing at RTTC is divided into two categories, direct-strike and near-strike tests. Test criteria are contained in MIL-STD-464 and RTTC Technical Report TR-RD-TE-97-01. Lightning simulators capable of generating up to 3.6 million volts and 200,000 Amps are used for these tests. Direct-strike test criteria are required for weapon system safety and to prevent permanent damage to electronic components. Near-strike lightning tests are required primarily for protection of EIDs and electronic components from detonation, burnout, destruction, and so forth, particularly during a launch sequence or when the electronics are active. Testing is conducted on inert and live tactical missile systems. The RTTC lightning test capabilities consist of several test facilities.

- The Inert Lightning Test Facility is utilized for instrumented and go/no-go testing of systems limited to class 1.4 explosives.

- The Hazardous Lightning Test Facility is comprised of two facilities. A Small System Lightning Test Stand is used for testing live, tactical, man-portable, and other small missile items. A Large System Lightning Test Stand is utilized for testing large, live, tactical missile systems and is currently limited to 100 pounds of Class 1.1, 5,000 pounds of Class 1.2, 15,000 pounds of Class 1.3, and unlimited Class 1.4 explosives. The Hazardous Lightning Test Facility is capable of testing live, tactical missile systems and has a portable chamber capable of conditioning vehicles to both "hot" and "cold" temperature extremes.

D.1.2.2.4 Electromagnetic Pulse Facility

The EMP test facility provides a sub-threat, high altitude, EMP environment to determine weapon system safety and survivability and to analyze system EMP effects.

D.1.2.3 White Sands Missile Range

The Survivability, Vulnerability, and Assessment Directorate (SVAD) performs E3 testing at the Electromagnetic Radiation Effects Site and Pulse Power Site at WSMR and at their test site located on Kirtland Air Force Base (AFB) in Albuquerque, NM. The test facility provides outdoor testing for combat systems, helicopters, and various types of combat support and combat service support equipment. A lightning test facility and two EMP facilities and an Ultra-Wideband facility is located near the SVAD main complex..

D.1.2.3.1 Electromagnetic Interference Facilities

These facilities are capable of performing the entire battery of MIL-STD-461 tests. Testing is conducted in one of two special facilities designed to minimize the ambient background noise. The first is an 18-foot long by 11-feet wide by 5-feet high anechoic chamber used for testing small items. The second is a large, shielded test cell used to test large items and those items requiring high capability air intake and exhaust. Two large intake fans and two large exhaust fans allow such items as the M1 Abrams tank to be tested in a fully operational mode with engines running. The test cell is large enough to test the Patriot on its launcher or an Abrams Tank.

D.1.2.3.2 Electromagnetic Radiation Facilities

Using any or all of five separate transmitters, outdoor test facilities provide RADHAZ, radiated susceptibility-Operational, inter-system EMI/EMC, and ESD (personnel and helicopter) testing. The five available transmitters cover frequencies from 100 kHz to 40 GHz, at power levels to 50 kW, depending upon the specific transmitter and test environment. These transmitters have sufficient power to perform entire-system uniform full-threat illuminations of test systems as large as Blackhawk helicopter. All modulations and the two polarizations can be accomplished. Maximum field intensities are typically on the order of 200 V/m. Levels up to 700 V/m can be achieved depending on frequency, size of the item under test, and the relative position of the item. A new mobile facility is being completed that complements existing capabilities and will enable peak power testing to the levels of Table 1E of MIL-STD 464A and ADS-37A from 1 to 18 GHz. Depending on frequency, up to 30 kV/m will be available for testing. Lastly, an Ultra-Wideband facility provides the Army with its only entire-system uniform threat-level testing. The frequency range of this simulator is 690 to 3850 MHz.

D.1.2.3.3 Electromagnetic Pulse Facilities

SVAD has the only operational EMP facilities in the Army. EMP testing is performed at Kirtland AFB using one of several threat level EMP simulators, either the Horizontally Polarized Dipole Facility or the Vertically Polarized Dipole Facility. These facilities can produce both horizontally and vertically polarized electric field strengths from 0.1 to 100 kV/m. Other facilities include a lightning simulator, a vertically polarized bounded-wave EMP simulator, and a Direct Drive

Laboratory for the direct application of controlled electrical over-stress signals into electronic components. Two additional EMP facilities are operational at WSMR. These simulators allow full threat HEMP testing in accordance with MIL-STD-2169. Direct drive and pulse current injection is available for testing and EMP/Lightning diagnostics. Adjacent to the two HEMP facilities at WSMR, SVAD has a 200K-Amp direct strike lightning facility and a near strike lightning facility, both are capable of meeting the respective requirements of MIL-STD-464.

D.1.2.4 Ft. Huachuca - Electronic Proving Ground (EPG)

D.1.2.4.1 Blacktail Canyon Test Facility

EPG has a capability to perform EMI/EMC testing in accordance with MIL-STD-464 and 461 for DoD platforms, systems, subsystems, and equipment as well as various commercial EMI/EMC standards tests that may be required by the customer. The facility is located at the Blacktail Canyon area of Ft. Huachuca, AZ, a RF-isolated area with a relatively low ambient RF level, which is ideal for open-field EMC/EMI testing efforts. Test equipment and fixtures necessary to conduct testing include three automated receiver systems, 20 Hz to 40 GHz, which can be used to perform radiated and conducted emission measurements. The facility instrumentation suites provide three automated EMI data collection suites and two integrated EMI susceptibility test systems allowing RF illumination of items under test from 10 kHz to 40 GHz at field levels greater than 200 V/m, depending upon test frequency. In addition to the fixed facility, EPG has readily available portable systems, offering worldwide on-site support to the customer.

D.1.2.4.2 Electromagnetic Environmental Test Facility

Located in the main post area of Ft. Huachuca, this test facility is a complex of experimental and analytical capabilities that can be used to measure and analyze system performance in a broad spectrum of intended EME. The facility assesses the ability of C4I systems to operate in their intended EME and to assess the influence of the system on the EME. This function is accomplished by a combination of M&S, hardware-in-the-loop testing, and field testing. It is also responsible for developing and maintaining databases of equipment characteristics and simulated tactical deployments to support EMC and EMV analyses and Army management of the EM spectrum.

D.1.2.4.3 Virtual Battlefield Environment Facility

This is a closed-loop facility that generates actual RF and digital message signals to provide a realistic EME to an item under test. It emulates signals that the test item would expect to see in its intended operational EME. These signals are computer-controlled and can represent the EME in any part of the world. The facility can create an electronic battlefield capable of simulating up to 1024 non-communications emitters (radar and sensors) in the 0.5 - 18 GHz frequency range and 32 communications emitters in the 0.5 - 500 MHz frequency range. These can be either friendly or enemy emitters. An enhancement is the Joint Tactical Information Distribution System (JTIDS) network linker unit. The network linker consists of a matrix switch that receives input from up to ten JTIDS terminals. The test facility provides the simulated EME to the JTIDS network. This allows the JTIDS network to be tested in a virtual EME without going to the field.

D.1.2.4.4 Virtual Electromagnetic C4I Analysis Tool

EPG has developed a set of integrated computer programs called the Virtual Electromagnetic C4I Analysis Tool to perform analysis and evaluation of C4I systems in their intended operational environments. The principal thrust is to provide C-E system analysis capabilities embedded in a user-friendly graphical user interface. It can overlay results using Defense Mapping Agency digital terrain and digitized raster graphics maps, or commercial-off-the-shelf graphics visualization and statistical analysis tools. The tool gives engineers and communicators a geographic information system that supports creation of simulated tactical deployments, military symbols, map displays for magnetic media or compact discs, line-of-sight profiles, and terrain high points display. The measures that can be calculated include EM propagation path loss, radio horizon, received signal level, signal-to-noise, ration, bit error rate, electric field, percentage of time available, fade, and dilution of precision values for global positioning system predictions. A foliage propagation model is available for analyzing attenuation of link communications, as are a number of other propagation models.

D.1.2.4.5 Mutual Interference Environments

For technical and operational tests, EPG can provide realistic battlefield conditions simulating "dirty" EME caused by mutual EMI of electronic equipment. This environment provides a virtual "friendly jamming" environment for operational or technical testing of C-E within an approved operational scenario. The effects of several thousand emitters, all sharing a common hop-set, can be simulated with as little as 100-200 actual radios through the use of propagation path loss models, specially designed automatic keyers, and emitter placement algorithms.

D.1.3 U.S. Army Armaments Research, Development & Engineering Center (ARDEC) Tank Automotive Command (TACOM)

The E3 team at TACOM-ARDEC provides E3 technical support to local, DoD, and Foreign developers of systems and equipment. Guidance is provided to ensure that developmental systems will not be susceptible to EME levels encountered during the system life cycle. The E3 team has several research and engineering facilities to study and evaluate instrumented or live weapon systems against a wide range of severe man-made or natural EME. Additionally, the E3 team provides technical and acquisition support to the Army Fuse Safety, Type Classification, and Material Release Boards, and the Foreign Intelligence Office and Joint HERO Sub-Committee. A description of the facilities follows.

D.1.3.1 HERO Research and Engineering Facility

The HERO facility is designed to perform RF studies on Army-developed weapon systems in accordance with MIL-STD-464 and MIL-HDBK-240. All HERO studies are performed inside a heated and air-conditioned shielded anechoic chamber. High power transmitters and TEM cells cover frequencies from 100 kHz to 40 GHz at power levels to 30 kW, with maximum field intensities on the order of 200 V/m. The facility can be used for RF susceptibility investigations, RF shielding measurements, in-band and out-of-band RF threat simulations, as well as specialized projects involving millimeter weapon technology.

D.1.3.2 Electromagnetic Radiation, Operational Test Facility

Testing at this facility is performed inside an anechoic chamber using the same RF transmitters, antennas, and fiber optic instrumentation as in the HERO facility described above. Studies are performed in accordance with the criteria in MIL-STD-464 and guidance in MIL-HDBK-240.

D.1.3.3 EMI Test Facility

The E3 team maintains laboratory capabilities for EM emission studies to evaluate Army electronics and electrical systems and subsystems in accordance with MIL-STD-461. Testing is conducted inside an RF-shielded anechoic room designed to reduce the ambient background noise to a minimum. The room size and structural integrity allow studies from small to mid-size pieces of equipment in a noise-free environment.

D.1.3.4 Helicopter Electrostatic Discharge (ESD) Test Facility

Helicopter ESD studies are performed in accordance with the criteria in MIL-STD-464 and 331. Instrumented, as well as go/no-go studies are conducted on inert and live tactical ammo systems in their shipping/storage and tactical configurations. Studies are also conducted on live weapon systems and electronic subsystems to determine detonation, upset, burnout and destruction levels.

D.1.3.5 Personnel Electrostatic Discharge Test Facility

Personnel ESD studies are performed in accordance with the criteria in MIL-STD-464 and MIL-STD-331. Studies are conducted on live weapon systems and electronic subsystems to determine detonation, upset, burnout, and destruction levels. Instrumented and go/no-go studies are conducted on inert and live tactical ammo systems in their handling configuration.

D.1.3.6 EMP Test Facility

The EMP facility uses a vertically-polarized, parallel plate chamber to simulate a HEMP environment, which is used to determine weapon system safety and survivability and to perform hardening evaluations. The facility is capable of producing a peak electric field of 50 kV/m, which meets the unclassified EMP threats specified in MIL-STD-461 and MIL-STD-464.

D.1.3.7 Bruceton and Langley Test Facility

This facility performs No-Fire and All-Fire statistical values of EIDs such as detonators, primers, and actuators. Constant current and capacitor discharge characteristics are determined that can handle class 1.3 and 1.4 explosives. Test data is computer-generated using an approved MIL-STD-1576 computer program.

D.1.4 Communication and Electronics Command (CECOM)

CECOM Research and Development Engineering Center, Space and Terrestrial Communication Directorate provides E3 engineering expertise to implement Army E3 policy. Design and test guidance are provided to CECOM developers. A limited EMI/EMC test facility is available to evaluate fixes, as necessary, and to evaluate CI/NDI. SM and frequency allocation support is also provided for all CECOM developments and procurements.

D.1.5 U.S. Army Center for Health Promotion and Preventive Medicine

The Center provides HERP support and radiation protective studies in support of health hazard assessments, safety assessments, and safety releases. Teams are available to assess compliance with applicable DoD and Army regulations regarding human exposure to RF radiation and to perform ad hoc testing for susceptibility of medical devices to RF fields. The test facility can generate and measure CW and pulse RF fields in 3 anechoic chambers and a TEM cell. Fields from 0.5 to 100 GHz can be generated at varying power levels. Additionally, there are portable RF probes from 3 kHz to 40 GHz, portable meters for measuring induced and contact currents below 300 MHz and magnetic flux density meters for extremely low frequency fields (60 Hz).

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D.2 Navy Facilities and Capabilities

D.2.1 Naval Air Systems Command (NAVAIR)

The NAVAIR, E3 Engineering Division, is the single entry point for E3 work within NAVAIR. The division ensures cradle-to-grave system EMC in NAVAIR aircraft, weaponry, and ground support systems in support of fleet mission needs. The division provides the E3 engineering expertise directly to NAVAIR PMs and class desks to meet technical performance objectives, schedule, and program cost across the total life cycle of naval aviation systems. The division is multi-sited at Patuxent River, Lakehurst, China Lake, and Point Mugu. The combination of these sites provides specialized E3 engineering as well as unique EMI facilities throughout NAVAIR for aircraft, aircraft launch and recovery equipment, support equipment, weapon systems, as well as targets and decoys. The division conducts EMI and SS analyses from initial concept, design, throughout the acquisition process, and beyond deployment, which include engineering investigations and recommended solutions to suspected EMI problems affecting the fleet. Engineers tailor the E3 requirements to fulfill specific mission needs, and conduct functional and risk analyses. The division also provides requirements to major range test facility base activities and assists in updating E3 standards, both within the U.S. military and within NATO.

D.2.1.1 Naval Air Warfare Center Aircraft Division (NAWCAD) Patuxent River, Maryland

NAWCAD Code 5.1.7 supports E3 research, development, and T&E. This support encompasses supplying the E3 test facilities and capabilities to conduct T&E of aircraft with their weapons, subsystems, and ground support equipment.

The Mid-Atlantic Area Frequency Coordinator (MIDLANT AFC) is a component of the Chesapeake Test Range for EM spectrum coordination for U.S. Navy and U.S. Marine Corps Commands in the Middle Atlantic Area. It is the frequency manager for NAWCAD and reports operationally to Commander in Chief, Atlantic Fleet. The mission of the MIDLANT AFC is to ensure effective and compatible authorized use of the frequency spectrum by all of the NAWCAD activities, tenants, and their contractors. The MIDLANT AFC coordinates with Government and non-Government activities throughout and adjacent to the Middle Atlantic area. For interference detection and resolution, the MIDLANT AFC has facilities that provide spectrum coverage from 2 MHz to 18 GHz.

D.2.1.1.1 Air Combat Environment Test and Evaluation Facility (ACETEF)

The ACETEF is a fully integrated, ground test facility allowing full-spectrum T&E of aircraft and aircraft systems in a secure, controlled, EME. The state-of-the-art facility uses simulation and stimulation techniques to provide test scenarios that will reproduce actual combat conditions. Aircraft systems are deceived through a combination of simulation by digital computers and stimulation by computer-controlled environment generators that provide radio frequency, electro-optical, and laser stimuli that closely duplicate real signals. The ACETEF complex has a variety of individual labs that, when networked, can simulate virtually all aspects of aircraft operations, and include:

- Shielded Hangar and Anechoic Chamber,
- Simulated Warfare Environment Generator,
- Electronic Warfare Integrated Systems Test Laboratory,
- Threat Air Defense Laboratory,
- Communication, Navigation, Identification Laboratory,
- Offensive Sensors Laboratory,
- Manned Flight Simulator, and
- Aircrew Systems Evaluation Facility.

D.2.1.1.2 Aircraft Shielded Hangar

Located with access to three runways, the shielded hangar provides a specialized environment for testing that includes the Aircraft Anechoic Test Facility. Large enough to accommodate multiple large aircraft, the shielded hangar has interior walls and doors covered with wire mesh and one anechoic wall. These features allow E3 testing and EW suite integration. Inside the hangar, an anechoic chamber provides a secure and realistic test environment for system stimulation for tactical aircraft. The hangar also supports lightning and p-static testing on full-scale test articles.

D.2.1.1.3 Aircraft Anechoic Test Facility (Small Anechoic Chamber)

The Aircraft Anechoic Test Facility (AATF) anechoic chamber, located inside the shielded hangar, is used for T&E of full-scale aircraft. It provides a quiet and secure test environment that simulates free space flight and can accommodate tactical aircraft and helicopters. External signals are suppressed 100 dB from 140 kHz to 40 GHz. It provides a test area 96 feet long, 56 feet wide, and 30 feet high.

D.2.1.1.4 Advanced Systems Integration Laboratory (ASIL) (Large Anechoic Chamber)

The large anechoic chamber provides a secure test environment for system stimulation of multiple tactical-sized aircraft via two 40-ton hoists, or a large aircraft the size of an E-6 or B-2. The anechoic chamber can hold multiple tactical aircraft and helicopters as well as large aircraft in a secure test environment utilizing the full capability of ACETEF. The ASIL main building contains a 180 feet long x 180 feet wide x 60 feet high radar absorbing material tip-to-tip, shielded anechoic chamber, along with several internal and external support areas. ASIL provides a quiet temporary secure working area test environment for hoisting two 40-ton (Max.) aircraft (test objects) or centerline floor space for an E-6 sized aircraft. Test support provisions include a 34' x 74' operations control center , an inside trailer mezzanine area, two large basement test pits, an outside basement level trailer ramp parking area, and outside power distribution units for ground level trailer mounted equipment. A full complement of aircraft support utilities is provided. A high bay, 65'L x 188'W x 60'H, aircraft preparation area is directly in front of the 187'L x 65'H anechoic chamber RF main door. This area also acts as a weather buffer to the main facility and as an alternate test area for lightning testing. The ASIL is located adjacent to the north side of the shielded hangar, about 200 feet from the center of the AATF and within 200 feet of all ACETEF laboratories. ASIL is tied to the AATF and to all of ACETEF and other internal/external NAVAIR labs via fiber optic networks and other secure worldwide links.

D.2.1.1.5 Naval Electromagnetic Radiation Facility (NERF) and Electromagnetic Environment Generating System (EMEGS)

The Naval Electromagnetic Radiation Facility (NERF) uses the Electromagnetic Environmental Generating System (EMEGS) to provide worldwide operational EMEs. The environmental generating systems consist of several radar simulator sources capable of creating MIL-STD-464 peak levels from 150 MHz to 35 GHz at discrete frequencies within specific frequency ranges. Additionally, NERF can provide swept (stepped) frequencies from 10 kHz to 18 GHz, continuous coverage at up to 300 V/M depending on frequency. Testing is primarily performed on a 100' x 240' steel ground plane or the shielded hangar apron, with embedded ground plane. Selected testing may also be performed inside the shielded hangar or one of the two anechoic chambers (AATF or ASIL). The facility emulates the worldwide Fleet operational EME for evaluating the effects on aircraft critical functions, mission systems and vehicle systems. It can be used to support intersystem EMC, EMV, EMR, EMW, HERO or any type of susceptibility test. The facility supports military and commercial aircraft, unmanned air vehicles, amphibious and other military vehicles, ground support equipment, and air-launched ordnance system testing.

D.2.1.1.6 Electromagnetic Transients Test and Evaluation Facility

This facility provides threat-level EMP, lightning, and p-static testing capabilities to determine the survivability and vulnerability of vehicle systems to the EMP threat. A high performance, fiber optic data acquisition and processing system designed for single-shot, fast rise-time measurements is available to collect data during testing. The following simulators are used to conduct tests on avionics equipment and full scale weapons systems:

- P-Static Simulators. The P-Static simulators provide up to 400 kV, 1.5 mA charges to test items via high-voltage charging probes. The simulators are hand held and can "spray" the high voltage charges onto small sections of the test aircraft. A portable VHF receiver and instrumentation are used to investigate and record a baseline to use in correcting problem areas. The P-Static simulator is portable.

- ESD Simulators. The 5 kV/25 kV simulators mimic the full threat effects of the natural human body ESD environment. The simulator is used to inject MIL-STD-464/MIL-STD-331 voltage waveforms into aircraft or weapon systems air launched ordnance. A pulse can be produced every 3 minutes. A portable 300 kV ESD simulator is also available. This simulator produces the full threat effects of the natural helicopter vertical replenishment ESD environments. The simulator can produce up to 300 kV through a 1-ohm series resistance into loads of up to 20 microhenrys.

- Horizontal Polarized Dipole EMP Simulator. This simulator simulates a high-altitude nuclear EMP environment. It is a free-field simulator that uses a 5 MV pulser to generate a double exponential, horizontally polarized field in the test volume. The EMP environment described in MIL-STD-464 and MIL-STD-2169 can be achieved. The tow way and facility will support very large fixed wing aircraft.

- Vertical Polarized Dipole EMP Simulator. This simulator, which is collocated with the horizontal polarized dipole, simulates a high-altitude nuclear EMP environment. It provides a fast rise-time EMP with a shot per minute capability. The test facility offers high fidelity, threat level environments and has the capability of providing slower rise time waveforms.

D.2.1.1.7 EMI Laboratories

The E3 Division's EMI Laboratories provide MIL-STD-461 evaluation capabilities to NAVAIR as well as other DoD agencies and private industry (via a Commercial Service Agreement). The facility manages four EMI chambers and provides engineering analysis, avionic troubleshooting, fleet support, EMI consultation, document reviews, site surveys, and aircraft emission control assessments. The EMI Laboratory at Patuxent River provides the following capabilities that are not readily available commercially.

- Shielded enclosure with 600-horsepower drive stand penetration for full performance testing of aircraft electrical generators and other high RPM applications,
- MIL-STD-461E compliant reverberation chamber capable of 1,000 V/m,
- Large anechoic facility for large test items (i.e. large, heavy vehicles and satellites),
- Power factor correction coils for realistic aircraft impedance simulation,
- Outdoor radiated susceptibility test site with airfield access,
- Shielding effectiveness testing of aircraft, vehicles, cables, connectors, and enclosures,
- Platform stimulation for subsystems via ACETEF,
- Global Positioning System accessibility, and
- Fume exhaustion, hydraulic and coolant oil interfaces, and high capacity air conditioning.

D.2.1.2 Naval Air Warfare Center Aircraft Division, Lakehurst, New Jersey

The Lakehurst EMI Laboratory's function is to provide E3 guidance, and EMI, MIL-STD-461, and other test capabilities associated with the development and production of aircraft launch and recovery, and fleet support equipment/systems. The EMI facility manages three EMI chambers. The laboratory provides emission tests from 20 Hz to 10 GHz, susceptibility tests from 30 Hz to 18 GHz, and radiated susceptibility tests up to 200 V/m.

D.2.1.3 Naval Air Warfare Center Weapons Division, China Lake, California

The E3 facilities at China Lake provide secure operational E3 test sites for engineering and development tests in support of local customer requirements, particularly for weapons, targets, EW, decoys, and test instrumentation. The facilities also provide T&E support during failure investigations and perform radiated and conducted emissions tests in order to obtain data to approve aircraft modification/flight clearance request packages, prior to test on the ranges at China Lake, Pt. Mugu, and San Nicholas Island. The laboratories are used primarily to obtain data necessary to assist engineers during hardware development or to support a flight clearance decision for aircraft and targets flown from these airfields. China Lake operates a three-chamber lab located in the Michelson laboratory building and one chamber in the Integrated Battlespace Arena laboratory. The E3 Branch also provides engineering support to various weapons and targets IPTs during the acquisition cycle.

The ground plane facility is a 245-ft x 245-ft outdoor test site. The ground plane includes aircraft tie downs, ground rods and all necessary equipment and facilities to support operation and testing of weapon systems, targets, decoys, and aircraft. The facility is used to perform susceptibility testing on weapon systems to support EMV preflight and HERO testing, and is usually operated through a teaming arrangement with NSWC, Dahlgren, VA.

D.2.1.4 Naval Air Warfare Center Weapons Division, Point Mugu, California

The E3 facility at Point Mugu provides a secure operational E3 test site for engineering and development tests in support of local customer requirements, particularly for weapons, targets, EW, decoys and test instrumentation. The facility also provides T&E support during failure investigations and performs radiated and conducted emissions tests in order to obtain data to approve aircraft modification/flight clearance packages, prior to test on the ranges at China Lake, Pt. Mugu, and San Nicholas Island. The laboratories are used primarily to obtain data necessary to assist engineers during hardware development or to support a flight clearance decision for aircraft and targets flown from these airfields.

D.2.2 Naval Sea Systems Command (NAVSEA)

D.2.2.1 Naval Surface Warfare Center, Dahlgren Division (NSWCDD)

NSWCDD is the surface Navy's lead laboratory for E3 RDT&E. Code J50 provides expertise and leadership to ensure the safety, reliability, and operational effectiveness of Navy and Joint systems exposed to the operational EME. To accomplish this, NSWCDD conducts a multi-faceted program using a systems engineering approach to achieve strike group, platform/system, and subsystem/equipment EMC. NSWCDD participates in all aspects of E3, including the development of new technologies and analytical tools, requirements definition, platform and system acquisition support, performance verification T&E, SM, fleet guidance, EMI mitigation, and solving fleet EMI problems. NSWCDD conducts shipboard and shore HERO surveys, shipboard HERP and EME surveys, shipboard full-scale EMC surveys, as well as system and ship certification T&E. NSWCDD facilities available to perform E3 evaluations are discussed below.

D.2.2.1.1 Ground Planes

NSWCDD maintains various ground planes that provide a simulated ship deck environment for conducting high power EMV and HERO testing. Transmitters provide the full range of power and frequency to simulate the mission EME, which also can be generated at customer locations/ facilities. Supporting instrumentation provides state-of-the-art telemetry data collection and reduction capability. NSWCDD has two unique ground plane facilities that permit evaluation of the effects of Naval and Joint tactical EMEs on ordnance items’ EIDs and aircraft/subsystems/ equipment. Aircraft, missiles, gun mounts, and fire control systems can be tested to evaluate their performance in a friendly or hostile operational EME or they can be evaluated to determine their operability during in-service use. These ground plane facilities provide a simulated ship, weather and flight deck environments, for conducting high power EMV and HERO testing. Transmitters provide the full range of power and frequency to simulate the mission EME. If susceptibility occurs, points of entry, susceptibility thresholds, and solutions are identified. The facilities allow a wide range of service conditions in which electromagnetic evaluations can be accomplished. Mobile radar, radio transmitters, and special generators with appropriate antennas for simulating the ship EME are positioned around the edges of the ground planes. The transmitting equipment operates over a frequency range of 2 MHz to 35 GHz, at power levels ranging from 15 kW continuous wave to 3 MW pulse power. Testing can also be conducted at customer facilities using equipment in trailers with the full range of power and frequency to simulate a mission EME.

Also located at NSWCDD is the EMV laboratory, which provides telemetry collection, data reduction, and analysis for the ground planes, anechoic chamber, and reverberation chamber. The individual test sites are connected to the laboratory through state-of-the-art, fiber optic data links, which allow for EMI-free data collection.

D.2.2.1.2 Anechoic Chamber

This facility, which is 60 ft x 28 ft x 27 ft, provides a controlled, reflection-free environment for conducting high power EMV test and evaluation on a broad range of systems. The chamber is a shielded enclosure within which missiles and other test items are immersed in a simulated operational (hostile and friendly) EME. It provides a full-threat level test chamber capable of evaluating electronic and weapon systems in their intended operational EME from 150 MHz through 60 GHz.

D.2.2.1.3 Reverberation Chamber

The reverberation chamber provides specialized reverberation conditions for system susceptibility and shielding effectiveness testing. The reverberation chamber developed by NSWCDD provides a time-efficient, cost-effective way to evaluate the performance of large equipment using a shielded enclosure in which very high fields can be safely generated for performing E3 testing in a simulated "real world," near-field EME. The reverberation chamber is used to conduct shielding effectiveness measurements of enclosures, planar materials, gaskets, cable assemblies, including cables with associated connectors, and other shielding materials; coupling measurements; radiated emissions measurements; HERO testing; and EMV testing of systems, subsystems, and components. Amplifiers are available in the facility to transmit swept or discrete continuous wave signals from 100 MHz - 18 GHz into the chamber. High power cavities and magnetrons from the ground planes can be positioned adjacent to the building and the power routed into the chamber.

D.2.2.1.4 Naval Ordnance Transient Electromagnetic Simulator

This simulator creates an EMP environment similar to that produced on the earth's surface from a high-altitude nuclear burst. The facility provides a threat-level HEMP to evaluate the susceptibility of naval weapons and other systems having EMP survivability requirements, to verify EMC of systems, and to perform EMP hardening evaluations. The facility is capable of producing simulated HEMP and peak electric fields of 50 kV/m, which meet the unclassified EMP threat of MIL-STD-461 and 464, and can satisfy major elements of MIL-STD-2169. The facility can also be used to provide developmental or design support and design validation by testing peak field strengths of up to 200 kV/m.

D.2.2.1.5 Electromagnetic Coupling Analysis

NSWCDD maintains a Computational Electromagnetic section with the capability for conducting complex EM analyses of land and shipboard systems. EM toolsets are used for modeling land and shipboard-based antennas (whips, fans, horns, apertures, phased arrays, radars, parabolic reflector dishes, etc.) operating anywhere from 2 MHz to 300 GHz radio and optical frequency ranges. These toolsets are also used for predicting EM coupling, EMI, and compatibility between "source" and "victim" antenna systems and for predicting EM power density levels to support evaluation of radiation hazards to personnel, ordnance, and fuel. The numerous numerical models use techniques such as: Method-of-Moments; Finite Difference Time Domain, High Frequency, Frequency Selective Surface, and Empirical. NSWCDD develops the Afloat Electromagnetic Spectrum Operating Program (AESOP) for surface ship spectrum management. This toolset is used in developing operational frequency assignments in achieving EMC.

D.2.2.1.6 DC Magnetic Field Generation Facility

The DC Magnetic Field test facility is designed to evaluate the effect of a DC magnetic field as defined in MIL-STD-1399, 070 on the performance of missiles, systems and equipment. It simulates shipboard deperming/degaussing environments. A test environment of 20 Oersteds with a rate of change of 20 Oersteds/second can be generated.

D.2.2.2 Naval Undersea Warfare Center Newport (NUWC Newport)

NUWC Newport, RI provides E3 expertise that encompasses all phases of submarine system and submarine platform development including concept formulation, system acquisition, operational support, and training. The EMC Branch provides the following engineering services to the Navy, DoD, and other customers in both the Government and private sectors.

D.2.2.2.1. Electromagnetic Compatibility Laboratory

The EMC Branch, Code 3431, operates a full spectrum EMC Laboratory capable of performing all MIL-STD-461 testing except for RS105 and CS115. In addition to MIL-STD-461 testing, the laboratory can perform limited MIL-STD-1399 section 300 testing including spike, power factor, harmonic current distortion and MIL-STD-2036 leakage current testing.

D.2.2.2.2 DC Magnetic Field Susceptibility Test Facility

The Branch operates the DC Magnetic Field Susceptibility Test Facility, which is designed to evaluate the effect of a DC magnetic field on the performance of submarine systems and equipment. A test environment of 20 Oersteds with a rate of change of 20 Oersteds/second, as defined in MIL-STD-1399, 070, can be generated in any orientation with a maximum of 90 Oersteds along the vertical axis

D.2.2.2.3 Antenna Test Facilities

The EM Systems Department, Code 34, of NUWC NPT operates antenna test facilities consisting of following:

- Tapered Anechoic Chamber, which is used for design, development, and test & evaluation of communication, navigation, and EW/ESM antennas. It provides complete antenna and RCS measurement capabilities
- Compact Range , which is used primarily for RCS measurements, including the measuring antenna patterns
- Submarine Antenna Overwater Arch Test Facility, which is used primarily used to characterize the performance of antennas over a seawater ground plane. Antennas under test can be rotated and elevated relative to the seawater surface
- Mile Site, which is used to measure antenna performance over a seawater ground plane
- Submarine Sensor Test Platform, which is used primarily for measuring antenna performance and RCS characteristics of submarine sensors over open ocean and varying sea state conditions
- Mobil RCS Measurement Van

D.2.2.3 Naval Surface Warfare Center, Crane

The Naval Surface Warfare Center, at Crane, Indiana, maintains 2 anechoic chambers.

D.2.3 Space and Naval Warfare Systems Command (SPAWAR)

SPAWAR has developed the following capabilities:

- AESOP performs the frequency planning and interference resolution for afloat combat systems, radars, and communication systems. AESOP runs on Microsoft Windows based personal computers and is approved for installation on IT-21 networks. AESOP is an integration of the former EMCAP (a radar planning program) and the CPM (a communications planning program) software modules.

- SPAWAR maintains SPAWAR Instruction 3090.1, C4ISR System Criteria for Shipboard Topside Integration. This is a complete compilation of requirements for topside design of C4ISR systems, including, but not limited to, EM and structural. It is an invaluable reference for program managers and developers.

D.2.3.1 SPAWAR Systems Center Charleston (SSC Charleston)

The E3 Branch, Code 725, at SSC Charleston provides E3 services to Navy, DoD, and other customers. Specific functions include conducting EMI investigations, recommending preventive and corrective measures for EMI and RADHAZ, performing EMC and RADHAZ surveys and analyses, conducting EM susceptibility testing on electronic equipment, and providing E3 certification for facility planning documents. The branch maintains laboratory test capabilities for

MIL-STD-461 as well as commercial test procedures. A variety of tests can be performed, including radiated susceptibility testing, transient testing (conducted and radiated), and EMP.

D.2.3.2 SPAWAR Systems Center San Diego (SSC SD)

Code 285 at SSC SD provides products, services, and support in the following areas:

- Electromagnetic modeling, simulation, and interference mitigation, and
- Systems analysis.

This division maintains and manages the following capabilities:

- Antenna Characterization Range,
- Antenna Pattern Range,
- Composite Materials Test Facility,
- GHz Transverse Electromagnetic Mode Cell,
- Numerical Modeling Facility.

Project areas supported include the design, development, integration, evaluation, and modification of communications, surveillance, and other EM systems. The following are examples of tasks that are performed in those project areas:

- Antenna designs and placements,
- EMP and survivability testing,
- EMI and IMI testing,
- E3 and EME analyses, and
- Shipboard design, including topside arrangement studies, antenna radiation patterns, complex impedance/isolation measurements and predictions, and EMP protection.

D.2.4 Naval Research Laboratory (NRL)

D.2.4.1 Compact Range Facility and Anechoic Chamber

The Naval Research Laboratory, Radar Division, operates and maintains a Compact Range Facility and a smaller anechoic chamber. The Compact Range, which produces far field conditions in a limited space, enables users to characterize antennas that would normally need a space thousands of feet long to properly measure. These facilities are used to measure antenna characteristics, such as beam width, gain, side lobe levels and polarization over a frequency range from 2 to 100 GHz. This range can also be configured to measure the RCS of antennas or other targets from 2 to 18 GHz. The largest object that can be measured in the Compact Range Facility must fit into a cylinder that is 8 feet in diameter and 8 feet in length. Below 6 GHz, the diameter drops to 6 feet. The Compact Range Facility is also configured to perform near field measurements. The Near Field test facility is capable of scanning a 12-foot by 20-foot region and can be configured for Planar, Cylindrical or Spherical Near Field Testing.

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D.3 U.S. Marine Corps (USMC) Facilities and Capabilities

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D.4 Air Force Facilities and Capabilities

D.4.1 Air Armament Center

D.4.1.1 Preflight Integration of Munitions and Electronic Systems (PRIMES)

The PRIMES Test Facility performs installed systems testing of air-to-air and air-to-surface munitions and electronics systems on full-scale aircraft and land vehicles. The tests include system level integration performance, weapon system effectiveness via the Guided Weapons Evaluation Facility/PRIMES Link, and electromagnetic compatibility and vulnerability measurements.

The PRIMES facility has the following capabilities:

- 100-dB, RF-isolated, anechoic chamber with a hoist lift capacity of 40 tons and capable of testing all current U.S. Air Force and Navy fighter aircraft and helicopters,
- Hanger - a sheltered, non-anechoic testing environment with access to all facility simulation and instrumentation capabilities,
- Outdoor Ramp – an open-air flight line area for testing of large aircraft, with access to all facility simulation and instrumentation capabilities,
- Test Stations **-** shielded laboratories for subsystem level testing of fighter and bomber electronics and weapon systems,
- EMI/EMC Chamber - semi-anechoic shielded enclosure for testing to MIL-STD-461 and commercial EMI standards.

The major PRIMES modeling and simulation systems include:

- Real-time six-degrees-of-freedom flight motion simulator for shooter and target motion,
- Four target, closed loop radar target simulator with dynamic radar cross section, jet engine modulation, electronic countermeasures, and clutter signatures,
- 6174 open loop, multiplexed threat radar emitters,
- MIL-STD-1760 weapons and aircraft simulators,
- Two, 10-channel, differential Global Positioning System constellations and jammers, and
- Test instrumentation systems, include MIL-STD-1760, MIL-STD-1553, H009, AIM-7/9/120 umbilical and telemetry analyses.

D.4.2 Air Force Research Laboratories (AFRL)

D.4.2.1 Information Directorate

The Newport Research Facility is used to evaluate antennas and antenna systems in a far-field "free space" environment, to determine radiation pattern changes due to airframe effects, for the measurement of antenna-to-antenna isolation, and to support advanced antenna measurement technology development. This facility provides the capability to conduct accurate measurements of antennas installed on airframes (such as F-4, F-111, A-10, F-15, F-16, F-22, F-14, C-12, RAH-66, B-1 sections), complex multi-beam and phased arrays, advanced ultra low side lobe arrays and multiple antenna systems.

The Stockbridge Research Facility is located atop a 2300-foot hill. Real property consists of a 5800-square foot laboratory and 4000-square foot storage area on 300 acres of land. The facility uses a modified AN/FPS-35 pedestal to mount and rotate large airframes such as the B-52, KC-135, AH-1, C-130, and B-1B. An antenna pattern measurement system is used to evaluate the performance of large platforms. The system provides the capability for measuring antenna patterns and antenna isolation (coupling) on large airframes mounted in an upright or upside down configuration. Airframe modifications can be performed on-site to simulate numerous aircraft types and configurations.

The Anechoic Research Facility provides the capability to simulate, measure, and improve the EM performance of weapon, communication, command, control, computer, and intelligence systems in the EME in which they operate. It also performs EM effects research investigations of antenna/aircraft EM interactions and EM characterizations of advanced technologies. Intra-system coupling and isolation can be measured. The measurement area consists of two EM anechoic chambers, two reverberation chambers, RF sources, and instrumentation. The two anechoic chambers (40ft x 32ft x 48ft and 12ft x12ft x36ft) provide a “free space” EME for detailed evaluation. A reverberation chamber (32ft x17ft x12ft) provides a "quick look," evaluation capability for assessments of RF coupling and shielding effectiveness.

D.4.2.2 Sensors Directorate

The EMI Test Laboratory is capable of performing all of the standard test methods of MIL-STD-461, including 200 V/m evaluations up to 18 GHz. The primary test chamber is 18 ft x 20 ft and is semi-anechoic in accordance with MIL-STD-461. The adjacent control room is shielded and is 12 ft x 16 ft. Available power is 115 Volt, three-phase, 400 Hz; 28 Volt DC; and 115 Volt, single phase 60 Hz.

D.4.3 Air Force Flight Test Center (AFFTC)

D.4.3.1 Benefield Anechoic Facility

This facility supports installed systems testing for aircraft and avionics test programs requiring a large, shielded anechoic chamber with RF absorption capability that simulates free space. The chamber is 264 ft x 250 ft x 70 ft. The facility is used to investigate and evaluate anomalies associated with EW systems, avionics, tactical missiles and their host platforms and is suitable for EMC evaluations where isolation from the external EME is required. Tactical-sized, single or multiple, or large vehicles can be operated in a controlled EME with emitters on and sensors stimulated while RF signals are recorded and analyzed. The largest platforms tested at this facility have been the B-52 and C-17 aircraft. It also supports testing of other types of systems such as spacecraft, tanks, satellites, air defense systems, drones, and armored vehicles.

Test equipment generates signals with a wide variety of characteristics, simulating unfriendly, friendly, and unknown surface-based, sea-based, and airborne systems. With the combination of signals and control functions available, a wide variety of test conditions can be emulated. Many conditions that are not available on outdoor ranges can be easily generated from the aspect of signal density, pulse density and number of simultaneous types.

D.4.4 738 Engineering Installation Squadron

The squadron provides measurement and specialized engineering services to include communications circuit analysis, EMC, RADHAZ measurements, interference resolution and direction finding, shielding effectiveness measurements, and EMP hardness verification testing. The squadron has several mobile vans with telescoping antenna masts and spectrum analysis suites equipped to make sophisticated measurements on site. Examples of past projects are evaluating the EME in the vicinity of large ground radar systems and ensuring that protective systems for ground communications shelters provide the required levels of performance against the EMP threat.

D.4.5 Air Force Points of Contact

Air Force Frequency Management Agency (AFFMA)
2461 Eisenhower Ave, Hoffman I, Suite 1203
Alexandria, VA 22331-1500
ATTN: E3 Issues (703) 428-1512
ESC issues (703) 428-1509

738 Engineering Installation Squadron (EIS)
ATTN: 738 EIS/EEE
670 Maltby Hall Dr. Suite 234
Keesler AFB, MS 39534-2633
(228) 377-1037
DSN: 597-1037

Aeronautical Systems Center (ASC)
ASC/ENAD
2530 Loop Road West
Wright-Patterson AFB, OH 45433-7101
(937) 255-8928

Air Armament Center (AAC)
PRIMES Facility
46 TW/TSP
401 Choctawhatchee Ave
Eglin AFB, FL 32542
(850) 882-9354

Air Armament Center (AAC)
46 SK/SKI
205 West D Ave, Suite 348
Eglin AFB, FL 32542-6865
(850) 882-0970

Air Force Research Laboratory (AFRL)
Human Effectiveness Division
2504 Gillingham Drive, Suite 25
Brooks AFB, TX 78235-5104
(210) 536-2937
DSN: 240-4837

Air Force Research Laboratory (AFRL)
Information Directorate
ATTN: AFRL/IFSE
525 Brooks Rd
Rome, NY, 13440-4505
(315) 330-4826
afrl.ifse@afrl.af.mil

Air Force Research Laboratory (AFRL)
Sensors Directorate
ATTN: AFRL/SNZW
2241 Avionics Circle
Wright-Patterson AFB, OH, 45433-7318
(937) 255-2811 x3695

Electronics Systems Center (ESC)
ESC/EN
5 Eglin St.
Hanscom AFB, MA 01731-2116
(781) 377-9573

Space and Missile Systems Center (SMC)
P.O. Box 92960
Worldway Postal Center
Los Angeles, CA 90009
(213) 363-1880

Air Force Flight Test Center (AFFTC)
Benefield Anechoic Facility (BAF)
412 TW/EWWA
30 Hoglan Ave
Edwards AFB, CA 93524
(661)-277-0840

Air Force Operational Test and Evaluation Center (AFOTEC)
ATTN: AFOTEC/AS
Kirtland AFB
Albuquerque, NM 87117
(505) 853-1988

D.5 Joint Spectrum Center (JSC)

The JSC mission is to ensure the effective use of the EM spectrum in support of National security and military objectives. The JSC makes its primary contribution to the warfighter in five areas:

- Spectrum planning support the warfighter's spectrum requirements by assisting in spectrum policy planning, ESC, and frequency assignment planning,
- Acquisition support to optimize the performance of systems in their intended operational EMEs while minimizing system acquisition cost and schedule,
- Direct operational support to the warfighter provides SM and interference resolution support to the warfighting COCOMs and Military Departments,
- Modeling and simulation by incorporating E3 into DoD models and simulations used for tests, training, and acquisition, and
- Information systems by supplying the databases, E3 tools, and battlefield SM systems for the warfighter.

Analyses in support of these objectives have as their goal an evaluation of the impact of E3 on systems, personnel, ordnance, or fuel. The application of E3 analyses may be to identify optimum spectrum use, operational constraints, or system design alternatives for systems. For personnel, ordnance, and fuel, predictions of RADHAZ distances are often required. E3 analyses must identify not only impacts to system performance alone, but also the impact of system performance degradation in military missions, or, mission effectiveness. These analysis requirements define the M&S tools of the JSC. A number of these tools are described below.

D.5.1 Joint E3 Evaluation Tool (JEET)

JEET examines potential E3 interactions between equipment scheduled for developmental or operational testing and its EME. It identifies environmental equipment capable of an EMI interaction with the system of interest and the conditions under which EMI is likely to occur. JEET computes frequency and distance separation criteria required to preclude EMI. It utilizes electronic and design parameters for the system under test, coupled with an operationally-based or generic lay down to mirror the intended or any imaginable operational deployment of the system. JEET identifies emitters capable of producing power density/field strength levels in support of E3 susceptibility testing and vulnerability analyses. The EME is culled from a database containing the electronic and operational characteristics of nearly 40,000 systems. DoD, Government, civilian, and foreign equipment are reflected in the database.

D.5.2 JSC Ordnance E3 Risk Assessment Database (JOERAD)

The primary purpose of JOERAD is to collect, develop, and provide the data needed by the operational commanders and planners to safely and effectively manage any conflict between ordnance and EM emitters employed in an integrated Joint operation or exercise. JOERAD contains the ability to view, query, and maintain stored HERO susceptibility data. With this information, the warfighter can make informed decisions regarding the risks associated with the use (or non-use) of certain emitters or ordnance items. JOERAD is a tool that the warfighter can use to make these critical decisions. With JOERAD, the warfighter has the ability to compare the maximum allowable environment that an ordnance item can be exposed without creating a safety or operational (reliability) problem with the EM emitters found on various platforms.

D.5.3 All Region All Platform Propagation (ARAPP) System

ARAPP computes the coupling between antennas on an aircraft or any 3-D platform, based on the Uniform Theory of Diffraction. ARAPP computes coupling of aircraft employing low observable coated surfaces. Although ARAPP was developed for airframe analysis, it can in principle be applied to ships and land-mobile platforms. Computer-aided design files have been created for many aircraft and helicopters, as well as a few ship classes.

D.5.4 Cosite Analysis Model (COSAM)

COSAM analyzes the effects of EMI on a system due to relatively high-power undesired signals from other systems in close proximity. It analyzes the performance of communications and radar receivers operating in a cosite environment of conventional, frequency-hopping, direct-sequence, and radar transmitters. The interference mechanisms considered by the model include spurious responses, desensitization, cross modulation, intermodulation, broadband transmitter noise, spurious emissions, and noise. COSAM provides the following types of outputs:

- Probability of satisfactory receiver performance,
- Achieved performance measure,
- Probability density function and cumulative density function of the performance measure,
- Excess interference levels,
- Required desired power level to achieve satisfactory receiver performance,
- Bit error rate,
- Articulation score,
- Mean equivalent input on-tune undesired power level for one-signal interactions, such as receiver adjacent signal and transmitter adjacent signal, and
- Communications range.

COSAM can be used for the following applications:

- Determining optimal antenna placement on an antenna tower, topside of a ship, or within an antenna farm,
- Determining the effects of adding new equipment to an existing site, and
- Selecting optimum frequencies for assignment in a cosite environment.

D.5.5 Graphical Analysis Tool for EMEs (GATE)

GATE is a cull model that provides inter-site EMC analyses. GATE analyzes the effects of introducing new transmitters or receivers into an existing environment. It calculates interference-to-noise power ratios, desired signal-to-interference ratios, power densities, and line-of-sight contours. GATE generates frequency-distance curves based on DoD, government, civilian, and foreign equipment technical parameters as defined by the JSC's Frequency Environmental database. GATE considers the effects of terrain-dependent propagation for fixed equipment and spherical-earth propagation for mobile equipment, combined with off-axis coupling and frequency-dependent rejection, cross polarization, and harmonic effects. GATE also analyzes EM interactions between equipment mounted on a platform moving along a specified track (i.e., airborne, shipboard, or land-mobile systems) and an EME of fixed ground equipment. The data required by GATE is a subset of the JSC frequency environmental database containing frequency assignment data. It also uses a subset of the Equipment Characteristics/ Space data taken from the JEET database

D.5.6 SPECTRUM XXI

SPECTRUM XXI is an automated SM tool that supports operational planning as well as near real time management of the EM spectrum with emphasis on assigning compatible frequencies and performing spectrum engineering tasks.

D.5.7 JSC Points of Contact

Joint Spectrum Center
2004 Turbot Landing
Annapolis, MD 21402-5064
- E3 Engineering Division (J5) (410) 293-4958
  (Chief: Mr. M. Williams)
  (JOERAD: Mr. M. Grenis)
- SM IT Division (J6) (410) 293-4956
  (Mr. T. Diep)
- Acquisition Support Division (J8) (410) 293-2609

web site: www.jsc.mil

APPENDIX E

GUIDE FOR THE USE OF

COMMERCIAL STANDARDS

CONTENTS

Paragraph **Page**

FIGURE

E.1 General

On June 29, 1994, the Secretary of Defense issued a Directive requiring the military to use performance-based requirements in procurements and to apply commercial specifications and standards whenever possible. This Appendix is intended to aid acquisition personnel to assess the suitability of using equipment qualified to commercial EMI/EMC standards in specific military applications.

This Appendix should be used in conjunction with the EPS-0178 study. The EPS study provides the results of detailed comparisons between major National and International commercial EMI/EMC standards and MIL-STD-461E. Differences in limits, frequency ranges, and test procedures were identified, and their potential significance was discussed in the study. In addition, guidance was provided in the study on judging the acceptability of a particular commercial standard for a specific military application.

E.2 Applicability Considerations

In general, the factors that need to be considered in evaluating the applicability of commercial equipment for military applications include the following:

- System performance requirements,
- Impact on mission and safety,
- Operational EME,
- Platform installation characteristics, and
- Equipment EMI characteristics.

Given the complexity and number of factors that must be considered in the overall evaluation process, the process may require the assistance of E3 personnel.

E.3 Detailed Requirements

E.3.1 Rationale for Requirements

The motivation behind the development of military and commercial EMC requirements is similar. Both are concerned with controlling emissions from equipment that may couple to other equipment with very sensitive interfaces, particularly antenna ports. Also, both are concerned with providing adequate immunity against EM disturbances that may be present in the environment, such as EM emissions, both intended and unintended, electrical transients, and power line voltage distortions. The reason for the distinctions between the military and commercial requirements occurs because of the military platform types, particularly ships, aircraft, ground vehicles, space vehicles, and ordnance. Typically, these platforms have a heavy concentration of equipment including high-power transmitters and very sensitive receivers. Submarines and certain aircraft may also have special requirements because of the frequency ranges of many of their subsystems/equipment.

E.3.2 Evolution of Requirements

E.3.2.1 Military

The military first established EMI emission requirements for equipment in 1945 with the issuance of JAN-I-225. Conducted and radiated measurements were imposed over the frequency range of 0.15 to 20 MHz. The first susceptibility requirement (expressed in terms of “immunity” in most commercial standards) was introduced in 1950 with the publication of MIL-I-6181. As electronics became more sophisticated and applications more widespread, the requirements evolved and expanded significantly over time. A variety of documents were issued with broader frequency ranges for emission requirements and an increased emphasis on various types of susceptibility requirements. In 1967, many of these documents were canceled or consolidated with the issuance of MIL-STD-461/462. MIL-STD-461E merges these two documents into one.

E.3.2.2 Commercial

The FCC has imposed requirements in the U.S. for many years on radiated characteristics from equipment antennas. The FCC first introduced requirements on more general types of electronics in 1979 for “computing devices” in the CFR 47, Docket 20780. The requirements used today are essentially the same and are limited to conducted emissions on power interfaces and radiated emissions. The FCC does not yet mandate immunity requirements for general electronics. Significant changes are occurring in the commercial world because of the EMC Directive 89/336/ EEC, which was issued by the European Union (EU) and became effective as of January 1, 1996. This directive requires equipment sold in Europe to meet both emission and immunity requirements. U.S. manufacturers who wish to sell their products in Europe must meet these requirements. This situation has prompted greater interest in the U.S. in establishing voluntary immunity requirements on equipment.

E.3.3 Summary of Relevant EMC/EMI Standards

Significant differences exist between military and commercial standards, not only in the ways that requirements are specified, but also in the test methodologies that are implemented. These differences present major challenges in making comparisons and are treated in detail in the EPS. A summary of the major aspects of various standards is presented below.

E.3.3.1 Military

MIL-STD-461E specifies requirements and limits based on platform types (that is, surface ships, aircraft, and so forth), equipment location in the platform (for example internal or external to the structure), and unique platform features, such as anti-submarine warfare capability. Although tailoring of the requirements is encouraged for individual procurements, MIL-STD-461E is structured to provide a reasonable set of default requirements if tailoring is not specified. It also provides a standardized test methodology, which is consistent among the various requirements. There are setup conditions that are common to all the tests, such as ground plane usage, electrical cable construction and routing, and power line treatment.

E.3.3.2 Commercial

A variety of commercial standards are discussed in the EPS study. The most predominant are those established by the European Community. Other standards are FCC regulations, RTCA DO-160D, and those issued by ANSI.

E.3.3.2.1 International Standards

IEC, CISPR, and the International Organization for Standardization (ISO) have published the most significant standards. CISPR standards primarily limit emissions, both conducted and radiated that are capable of causing interference to radio, television, and other radio services. The devices creating the emissions are categorized in various ways. The IEC Technical Committee (TC) 77 is concerned with emissions below 9 kHz and has established basic immunity measurement techniques over the entire frequency range. In addition, various IEC technical committees concerned with specific products prepare EMC standards for these products. Similarly, ISO technical committees prepare EMC standards. Examples are TC 20 for aircraft and TC 22 for motor vehicles.

– European Union (EU). The EU EMC efforts are extensive and complicated. The EU EMC Directive specifies general requirements that equipment be designed and built to achieve the following:

  - The EM disturbance that the equipment generates should not prevent radio and telecommunications equipment and other apparatus from operating as intended.
  - The equipment has an adequate level of intrinsic immunity from EM disturbances to enable it to operate as intended.

  The European Committee for Electrotechnical Standardization (CENELEC) is largely responsible for approving detailed standards that are acceptable for demonstrating compliance with the EMC Directive. Most, but not all, CENELEC standards are identical to, or contain only minor deviations from, those developed by the IEC and CISPR. All of the European documents discussed in the EPS report are either IEC or CISPR standards. All are not yet adopted by CENELEC. Immunity test procedures covered in the basic IEC standards tend to be written so that there is flexibility in applying them, depending on the particular application. Also, a range of suggested limits is generally given. The manufacturer or some other authority must specify a particular level for certification. Another characteristic of these documents is that each tends to stand alone regarding test methodology. They do not have the same consistency among test setups as those specified in the MIL-STD-461E.

– CE Mark. Products sold in Europe must comply with a number of EU directives and contain the "CE" mark as an indication of compliance. For electronic products, this mark indicates compliance with both Low Voltage Directives, 73/23/EEC and 93/68/EEC, which address electrical safety, and the EMC Directive. The following discussion concentrates on aspects of the EMC Directive. Several paths can be followed for compliance. One approach is a self-declaration where the manufacturer issues a "Declaration of Conformity" that the product complies without third party participation. This declaration should be available upon request and must list the specifications used to demonstrate compliance. When complications exist, a technical construction file is produced containing the details of the methods for complying with the EMC Directive. It is submitted it to a "Competent Body" for approval. The self-declaration is apparently the most common path for items that clearly fall under a particular generic or product standard (see below). The self-declaration is more risky for the manufacturer in the event that compliance is challenged. The CE mark indicates that a decision has been made by someone that the equipment meets the broad intent of the wording in the EMC Directive. It does not necessarily indicate what specific tests have been performed or what specific limits have been met.

– Generic Standards. The IEC has issued a number of generic standards, IEC 61000-6-1, 2, 3, and 4, which specify emission and immunity requirements for two classes of equipment: "residential," which includes commercial and light industrial, and "industrial." The generic standards may be used when a "product" standard that addresses the particular item does not exist. The generic standards list the individual test standards, generally IEC and CISPR documents that are applicable, and the limits that apply.

– Product Standards. These standards are prepared by product committees who determine what requirements must be applied for a particular product or product family to meet the intent of the EMC Directive. To determine the appropriate requirements, these committees review the application of the product and its intended EME. The selected requirements generally will be derived from the IEC and CISPR standards.

E.3.3.2.2 United States National Standards

In the U.S., the FCC controls non-Government use of the frequency spectrum. Emissions below 9 kHz and immunity of equipment are controlled by a variety of commercial "voluntary" standards.

– FCC. For certain types of non-transmitting electronics, most notably computers, the FCC has issued requirements presently contained in CFR 47, Part 15, which are similar to CISPR 22. The requirements are limited to conducted emissions on commercial AC power lines and radiated emissions. There are two sets of limits, one for residential areas and a second for industrial areas. Separate FCC requirements in CFR 47, Part 18 are applicable to industrial, scientific, and medical equipment that intentionally uses RF energy in its basic operation. These are similar to CISPR 11. Requirements for Part 18 are limited to radiated emission controls that are dependent on the characteristics of the RF source.

– ANSI. Test methodology for certifying equipment as meeting requirements in CFR 47, Part 15, is provided in ANSI/IEEE C63.4, prepared by the American National Standards Committee C63. In addition, ANSI/ IEEE C63.12 contains guidance in selecting immunity for three classes of equipment: residential, industrial, and those in severe environments. Other C63 standards cover instrumentation, site and antenna calibration, and other related topics.

– RTCA DO-160D. DO-160D is used by the commercial airline industry to qualify equipment as part of FAA certification of aircraft. Among commercial standards, DO-160D is the commercial standard most similar to MIL-STD-461E. The test methodology addresses many issues that are also important in MIL-STD-461E, including ground planes, electrical cabling, and consistency among setups. DO-160D provides a number of different categories that equipment can be certified to, depending on the type of equipment, its installation location, and the desires of the equipment and aircraft manufacturers.

– Other Commercial Standards. Many standards covering specialized topics are produced under the auspices of various professional and trade organizations. Because of their specialized nature, they are not specifically compared in the EPS study with MIL-STD-461E. The EPS study, in some cases, provides a broad evaluation of the standards. As an example, the EPS study notes that fourteen SAE J1113 series standards covering motor vehicles were screened for homogeneity to requirements and test methods specified in MIL-STD-461E. The result was that none of these standards could be accepted as replacements for MIL-STD-461E requirements without modification of some performance parameter, but the test methodology for each of the fourteen is identical to the corresponding MIL-STD-461E test method.

E.3.3.3 Differences Between Commercial and Military Standards

Major reasons for the most significant differences between commercial and military EMC standards are as follows:

– Requirements for submarines are unique because of critical dependence on the reception of lower frequencies of EM signals.

– There is a large concentration of electronic equipment, including high-power emitters and very sensitive receivers, aboard military platforms. For this reason, military radiated emission limits are more severe than corresponding civilian limits. The military also places high immunity requirements on devices exposed to nearby intentional emitters.

– Military platforms have the general availability of grounded conducting surfaces such as ground planes for mounting equipment, whereas most civilian equipment is mounted on an ungrounded tabletop. However, this difference is not pervasive; for example, floor-mounted civilian equipment is frequently bonded to a ground plane.

– Some frequency ranges are more extensive in military requirements than they are in commercial requirements; hence, if equipment is tested to meet civilian requirements, additional testing may be needed for military use.

These significant differences make it impossible to find commercial qualified equipment that is completely equivalent to equipment meeting military requirements. This means that a detailed analysis is required to determine the adequacy of equipment tested to civilian requirements versus the requirements of a particular military environment.

E.3.4 Selection of Commercial Items for Military Use

In selecting CI for military purposes, the Program Office must relate the characteristics of the anticipated EME to the characteristics of the equipment under consideration. In order to determine if a CI is adequate for a particular military application, it is necessary to accomplish the following:

- Determine which commercial standards are applicable to the equipment,
- Evaluate whether the commercial standards are adequate for the intended use, and
- Determine, if necessary, which additional requirements should be imposed.

E.3.4.1 Decision Process

Ideally, the overall decision process that should be used to evaluate the adequacy of any item for an intended military application is illustrated in Figure E-1. The process is similar for both military and commercial equipment. The performance requirements should take into account whether the performance of the equipment is safety or mission critical. The process must consider both the potential impact of externally imposed EMI on equipment and the impact of emissions from the equipment to other equipment.

E.3.4.2 Anticipation of the Environment

In order to evaluate the applicability of commercial standards for military purposes, it is necessary to define, as indicated in Figure E-1, the EME in which the equipment will operate. Examples of areas that may be considered to have particular environmental characteristics include ship topside, ship below deck, submarines, aircraft carriers, aircraft external, aircraft internal, ground combat, and so forth. In a traditional military procurement, the acquisition personnel would assess the anticipated use of the equipment and levy appropriate requirements from MIL-STD-461E, tailored as necessary to match the anticipated EME. The equipment would then be designed to meet these requirements and would be tested accordingly. However, if existing CI is to be utilized, the availability of test data must be determined, whether the data describes the EM characteristics of that equipment, and how well those characteristics meet anticipated needs. Thus, it is most expedient to use MIL-STD-461E as the basic reference for establishing EMI requirements as shown in Figure E-1. The procedure then deviates, depending on whether the equipment is a military type or CI. If the latter, a complex evaluation process should be initiated. Guidance for such an evaluation is the subject of the EPS report.

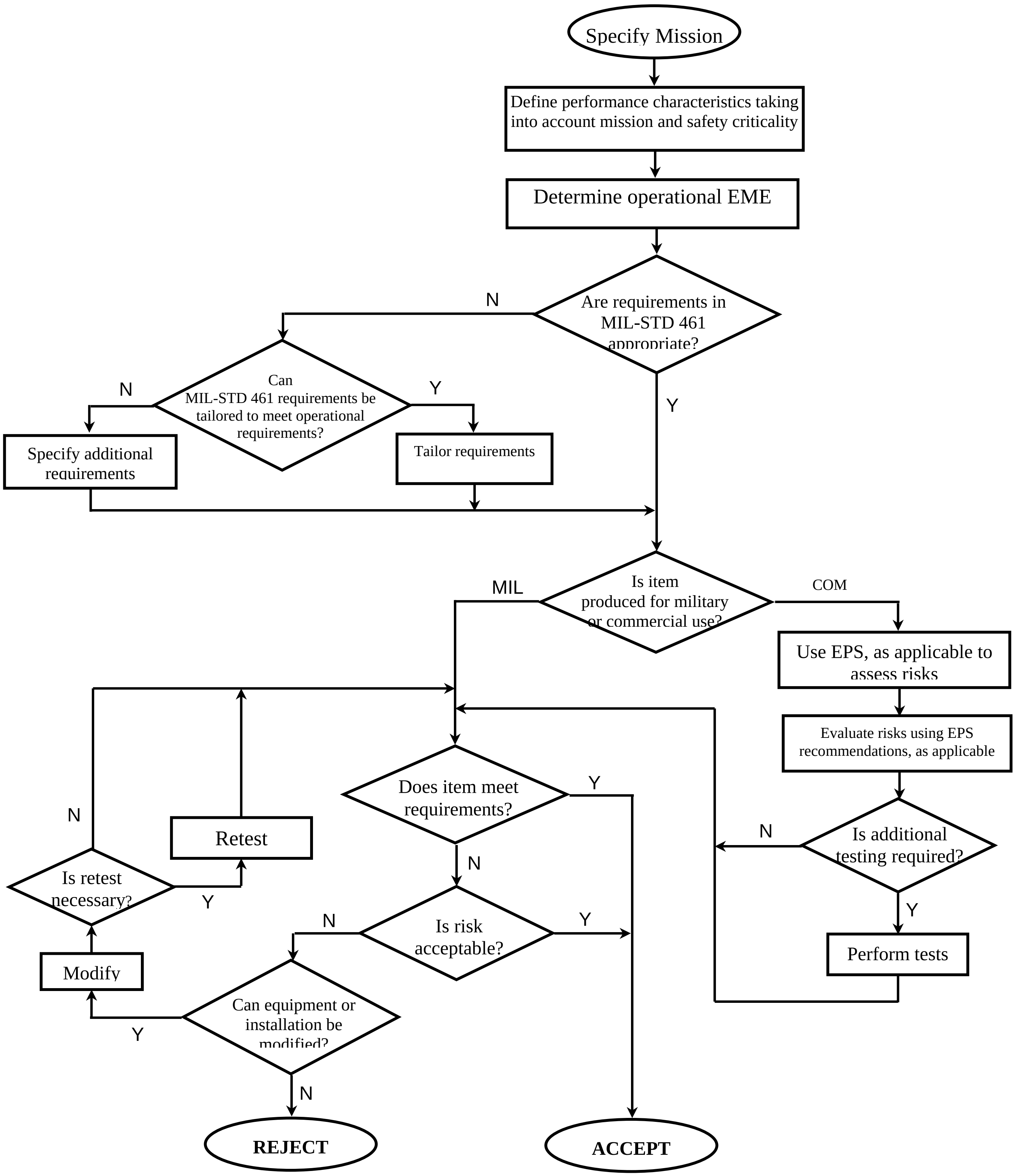

FIGURE E-1. Defining Applicable EMI Requirements.

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CONCLUDING MATERIAL

Custodians:

Army - CR
Navy - EC
Air Force - 11

Review Activities:
DTRA

Preparing Activity:

DISA (DC5)
Project No. EMCS-2005-002

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 http://assist.daps.dla.mil.
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