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MIL-HDBK-237B
O1 OCTOBER 1997

SUPERSEDING
02 FEBRUARY 1981

DEPARTMENT OF DEFENSE HANDBOOK

GUIDANCE FOR CONTROLLING ELECTROMAGNETIC ENVIRONMENTAL EFFECTS ON PLATFORMS, SYSTEMS, AND EQUIPMENT

This handbook is for guidance only.
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AMSC: N/A

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FOREWORD

1. This Handbook is approved for use by all Departments and Agencies of the Department of Defense (DoD).

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 an effective electromagnetic compatibility (EMC) Program throughout the life cycle of platforms, systems, subsystems and equipment.

4. This handbook was prepared in accordance with the guidelines of the Standardization Reform Policy established by the Secretary of Defense.

5. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Joint Spectrum Center, Attn: JSC/J52, 120 Worthington Basin, Annapolis, MD 21402-5604, by using the self-addressed standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

APPENDIXES

APPENDIXES

APPENDIXES

PARAGRAPH PAGE

APPENDIXES

PARAGRAPH PAGE

APPENDIXES

APPENDIXES

PARAGRAPH PAGE

FIGURES

TABLES

1. SCOPE

1.1 Purpose. This handbook is intended to provide personnel responsible for the design, development, and acquisition of DoD platforms, systems, subsystems, equipment, and devices with the guidance necessary for achieving the desired level of electromagnetic compatibility (EMC). This handbook describes the tasks that should be accomplished to ensure electromagnetic environmental effects (E^3) control/EMC measures are incorporated into the development and operational procedures of an item to achieve the desired level of EMC during its life cycle. This handbook may also be used by program managers (PMs) to identify the critical E^3 issues that need to be addressed when preparing their required Program Status Reports.

1.2 Applicability. This handbook is consistent with the policies and procedures of DoD Directives 5000.1, 3222.3 and 4650.1 and DoD Regulation 5000.2-R. Provisions of this handbook should be used by research, development and acquisition (RD&A) activities, at appropriate times during the life cycle of any platform, system, equipment or device which emits or which can be susceptible to electromagnetic energy. For example, the handbook is applicable:

a. During acquisition to assure visibility, accountability, and controllability of the EMC effort, as well as its integration into the overall program.

b. During the design process to assure management awareness and cost effective tailoring of applicable EMC performance requirements and interface standards.

This handbook may also be used by contractors as a guide for establishing and implementing an effective EMC program.

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

1.3 Contents. This handbook describes the steps that should be taken during the life cycle to ensure an equipment, subsystem, system, or platform is not only compatible within itself (that is, self-compatible) but also has a high probability of continued operation, within acceptable tolerances, with other equipment, systems, and platforms in its intended Electromagnetic Environments (EMEs).

1.3.1 Organization. Section 2 provides a list of applicable documents and Section 3 defines the terms that are used in this handbook. Section 4 describes, in general terms, the tasks that should be accomplished to ensure the desired level of EMC performance is achieved. The remaining Sections and Appendices describe in greater detail aspects of the various tasks and include:

a. Spectrum Management.

b. Establishing an E^3 Working-Level Integrated Product Team (WIPT).

c. Specifying EMC Performance Requirements.

d. Tailoring.

e. Use of Commercial and Non-Developmental Items (NDIs).

f. Implementation of the Joint E^3 Control Strategy (JECS).

g. EMC Verification.

h. E^3 Analysis and predictions.

i. EMC Training.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed below are only a portion of those referenced herein. These documents are the most relevant to fully understand the information provided by this handbook.

2.2 Government documents

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the latest issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto.

STANDARDS

MILITARY

MIL-STD-449	-	Test Method Standard: Radio Frequency Spectrum Characteristics, Measurement of.
MIL-STD-461	-	Interface Standard: Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility.
MIL-STD-462	-	Test Method Standard: Measurement of Electromagnetic Interference Characteristics.
MIL-STD-464	-	Interface Standard for Systems Electromagnetic Environmental Effects.
MIL-STD-469	-	Interface Standard: Radar Engineering Design Requirements, Electromagnetic Compatibility.
MIL-STD-961	-	Defense Specifications.

HANDBOOK

MILITARY

SD-2 - Buying NDI - Nondevelopmental Item Program.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available 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.

PUBLICATIONS

DEPARTMENT OF DEFENSE (DoD)

DoD Directive 3222.3	-	Department of Defense Electromagnetic Compatibility Program (EMCP).
DoD Directive 4650.1	-	Management and Use of the Radio Frequency Spectrum.
DoD Directive 5000.1	-	Defense Acquisition.
DoD Regulation 5000.2-R	-	Mandatory Procedures for Major Defense Acquisition Programs and Major Automated Information Systems.
DoD Manual 5000.37-M	-	DoD Non-developmental Items Acquisition Manual.
JCS Pub. No. 1-02	-	Department of Defense Dictionary of Military and Associated Terms.
USD(A&T) Memorandum	-	Requirements for Compliance with Reform Legislation for information Technology (IT) Acquisitions (Including National Security Systems), May 1, 1997.

Navy

NAVSEA OP-3565/NAVAIR 16-1-529/SPAWAR 0967 LP-624-6010	-	Technical Manual,Electro-magnetic Radiation Hazards (Volumes I & II).

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

(Copies of DoD Directives, Instructions and Manuals are available from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094. Copy of NTIA Manual is available from the US Government Printing Office, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954).

2.3 Non-government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the latest issue of the DODISS, supplement thereto.

AMERICAN NATIONAL STANDARDS (ANS) INSTITUTE

ANS C63.14	-	Standard Dictionary for Technologies of Electromagnetic Compatibility (EMC), Electromagnetic Pulse (EMP), and Electrostatic Discharge (ESD).
ANS/IEEE C95.1-1991	-	IEEE Standard Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields (3 KHz - 300 GHz).

(Non-Government standards are generally available for reference from libraries. They are also distributed among non-government standards bodies and using Federal agencies. Application for copies should be addressed to the IEEE Service Center, 445 Hoes Lane, P. O. Box 1331, Piscataway, NJ 08855-1311).

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

2.5 EMC bibliography. Lists of additional EMC/E^3 documents are presented in Appendix A.

3. DEFINITIONS

3.1 General. The terms used in this handbook are defined in ANS C63.14 and JCS Pub. No. 1-02. In addition, the following definitions are applicable for the purpose of this handbook.

3.1.1 Acquisition category I (ACAT I) programs. ACAT I programs are Major Defense Acquisition Programs (MDAP) that will require an eventual expenditure of more than $355 Million (fiscal year (FY) 1996 constant dollars) for research, development, test, and evaluation or more than $2.135 Billion (FY 1996 constant dollars) for procurement, or those designated by the Under Secretary of Defense (Acquisition and Technology (USD(A&T)) to be ACAT I.

3.1.2 Acquisition category II (ACAT II) programs. ACAT II programs are acquisition programs that do not meet the criteria for an ACAT I program, but do meet the criteria for a major system. A major system is defined as a program estimated by the DoD Component Head to require an eventual expenditure of more than $75 Million in FY 1980 constant dollars (approximately $140 Million in FY 1996 constant dollars) for research, development, test, and evaluation or for procurement of more than $300 Million in FY 1980 constant dollars (approximately $645 Million in FY 1996 constant dollars), or those designated by the DoD Component Head to be ACAT II.

3.1.3 Acquisition category III (ACAT III) programs. ACAT III programs are those acquisition programs that do not meet the criteria for an ACAT I or an ACAT II.

3.1.4 Acquisition program. A directed, funded effort that is designed to provide a new or improved material capability in response to a validated need.

3.1.5 Intra-system vs. inter-system EMI problems. EM interactions between elements of a system are termed intra-system whereas EM interactions between systems are termed inter-system. This concept may be extended to platforms by considering EM interactions between equipment and systems on a platform as intra-platform whereas interactions between the platform and its EME or other platforms are considered inter-platform.

3.1.6 Joint E^3 control strategy (JECS). JECS is a problem avoidance measure that supplements the policies of DoD Directive 3222.3. JECS is based on the recognition that electromagnetically interfering and susceptible equipment designs should be eliminated or avoided during development and in acquisition.

JECS method uses a positive control methodology called gating in conjunction with established "exit criteria" to monitor the planning and application of E^3 control measures.

3.1.7 Milestones. They are major decision points that separate the phases of an acquisition program.

3.1.8 Milestone decision authority (MDA). The individual designated in accordance with established criteria to approve entry of an acquisition program into the next phase.

3.1.9 Performance. Those operational and support characteristics of the system that allow it to effectively and efficiently perform its assigned mission over time. The support characteristics of the system include both supportability aspects of the design and the support elements necessary for system operation.

3.1.10 System operational performance. A set of minimal acceptable parameters tailored to the platform and reflecting top level capabilities such as range, probability of kill (P_k), platform survivability, operational availability, etc.

3.1.11 Spectrum management. The process of maximizing the efficient use of the electromagnetic spectrum through operational, engineering, and administrative procedures to allow electronic systems to perform their functions in their intended environment without causing or receiving unacceptable levels of interference.

3.2 Acronyms and abbreviations. A Glossary of acronyms and abbreviations used in this handbook is presented in Appendix B.

4. PROGRAM TASKS

4.1 General. Program managers (PMs) are expected to manage assigned programs in a manner consistent with the policies and principles articulated in DoD Directive 5000.1. PMs should ensure, to the maximum extent possible, that their programs are in compliance with the EMC and spectrum management policies and procedures addressed in Paragraph 4.4.7 of DoD Regulation 5000.2-R, DoD Directives 3222.3 and 4650.1, and Office of Management and Budget (OMB) Circular A-11.

4.1.1 Program status. PMs should provide assessments of program status and risk to higher authorities including the designated Milestone Decision Authority (MDA) in accordance with the policies and procedures issued by the Office of the Secretary of Defense (OSD). MDAs address program requirements that are derived from both statutory and regulatory sources. Requirements addressed at each major Milestone include:

a. Pre-Milestone 0. Responsibility for ensuring compliance with requirements prior to MDA Milestone 0 approval belongs to the appropriate user or functional proponent in coordination with the Joint Requirements Oversight Council (JROC) process, the component, or the Principal Staff Assistant (PSA).

b. Milestones 0 through III. The EMC and Spectrum management requirements derived from Paragraph 4.4.7 of DoD Regulation 5000.2-R, DoD Directives 3222.3 and 4650.1, and OMB circular A-11 are appropriate for MDA review at each major milestone. The PM should provide the MDA an assessment of compliance with these requirements through the Defense Acquisition Board (DAB) process.

c. Post-Milestone III. Milestone III Acquisition Decision Memoranda (ADM) should include post-deployment performance evaluation and other performance measures guidance, as appropriate. The ADM should be clear as to who will perform this post-deployment evaluation, the user or functional proponent.

4.1.2 Guidance. This Section provides general guidance for establishing a workable and effective EMC program to ensure an end-item will operate in its intended EMEs without causing or suffering unacceptable mission performance degradation due to E^3. This Section can also be used as a guide by PMs to identify the critical E^3 issues that should be addressed when preparing

Program Status Reports. More detailed information and guidance are provided in the remaining Sections and Appendices of this handbook.

4.2 Tasks. Tasks that should be accomplished, if E^3 problems are to be avoided, include:

a. Budgeting for E^3 control.

b. Spectrum management.

c. Development of EMC Program Procedures.

d. Establishing a E^3 WIPT/EMC Advisory Board.

e. Development of applicable EMC performance requirements.

f. Using commercial items or NDIs.

g. Implementing the Joint E^3 control strategy.

h. Preparing EMI control procedures.

i. EMC verification.

j. Conducting E^3 analysis and predictions.

k. Determining safe-distances for HERP and HERF.

l. Certification of ordnance.

m. EMC Training.

The extent to which these tasks are applied to a program depends on the costs, schedules, goals, and risks associated with not addressing a particular aspect of E^3 control. The proper application of management controls, EMC performance requirements, and E^3 control features should contribute to the accomplishment of a successful program.

4.3 Budgeting for E^3 control. Adequate resources should be allocated early in an EMC program. Without adequate resources EM incompatibilities or vulnerabilities may not be discovered until the later stages of testing or during operational deployment which may result in potentially severe program cost and schedule impacts. Sufficient resources should be requested and allocated to support all of the applicable tasks listed in 4.2.

4.3.1 Cost as an independent variable (CAIV). Fiscal constraints is a reality in DoD procurements and should be addressed during the acquisition process. Cost should be viewed as an independent variable. Program managers should establish aggressive but realistic objectives for their programs. Trade-off studies should be conducted early in a program, when the majority of costs are determined, to achieve a balanced set of goals, based on guidance from the MDA. Cost objectives should be established that balances mission requirements with projected resources.

4.4 Spectrum management.

4.4.1 General. Spectrum management is the process of maximizing the efficient use of the electromagnetic spectrum through operational, engineering, and administrative procedures to allow electronic systems to perform their functions in their intended EMEs without causing, nor suffering from, unacceptable levels of EMI. Section 5 discusses spectrum management in more detail and Appendix C presents a discussion on EMEs.

4.4.2 DoD spectrum policy. An approved frequency allocation must be obtained prior to the expenditure of funds for the development or procurement of an electronic equipment or system.

4.4.3 Frequency allocations. The program manager should initiate a request for a frequency allocation on DD Form 1494 as early as possible in Phase 0. All electronic equipment, subsystems, and systems designed to either emit or respond to EM energy require a frequency allocation. The data provided on DD Form 1494 is reviewed for conformance to international, national and DoD criteria. As the item progresses through development and eventually into procurement, requests for frequency allocations need to be updated. An approved frequency allocation, however, does not provide authorization to operate an item on specific frequencies within the tuning range of the item. A frequency assignment needs to be obtained prior to operating the item. The program manager should be responsible for submitting all requests for frequency allocations in accordance with the procedures delineated in the various service regulations. Failure to comply with the international, national and DoD EMC criteria will, in all likelihood, result in denial of the frequency allocation request.

4.4.4 Frequency assignments. An approved frequency assignment is a discrete frequency or set of frequencies on which an electronic device, equipment or system is authorized to operate within its allocated frequency band for a particular application at the location(s) designated and within the constraints of the authorizing assignment. Following the approval of a frequency allocation, military departments may assign approved frequencies to contractors with valid contracts for contractor test and evaluation operations at either a military installation or a contractor's facility under control of the installation Commander or a military department representative, respectively. Requests for military department frequency support should be through appropriate channels. If neither situation applies, the contractor should request frequency support from the Federal Communications Commission (FCC) by filing an FCC Form to obtain a station license. Coordination between contractors and cognizant procuring activities is recommended before action is taken.

4.5 EMC program procedures (EMCPP).

4.5.1 General. The EMCPP should establish the sum total of direction and efforts required to achieve EMC in an end-item. The EMCPP should be prepared for each program that is either designated as, or meets the criteria for, ACATs I or II when the end-item may affect, or be affected by, its operational EMEs. The EMCPP may also be established for ACAT III equipment, subsystems, and systems when specified by the individual Services and are so designated on a case-by-case basis.

4.5.2 Purpose of EMCPP. Management and engineering personnel should establish an EMC program as early as possible in the acquisition process to achieve the greatest EMC engineering benefits. The EMCPP should accurately define the tasks and milestones that should be accomplished to achieve the desired level of EMC performance. The EMC effort should be tailored to the specific acquisition of an end-item based on its performance requirements, EMEs within which it is intended to operate, quantity of the end-item to be procured, and the budget available to meet the E^3 control/EMC performance goals of the program. The EMCPP is intended to ensure there is:

a. Efficient integration of engineering, testing, management, and quality assurance tasks to achieve the required level of EMC.

b. Continuous traceability of E^3 control/EMC performance requirements and design alternatives throughout the program. This should permit the sources and impact of design changes along with any EMC deficiencies, and the impact of any contractual requirements, to be promptly determined, accurately identified, and properly communicated.

4.5.3 Preparation of EMCPP. The EMCPP should be prepared in accordance with the requirements of Data Item Description (DID) DI-EMCS-81528. The EMCPP should be prepared and implemented at the earliest possible time so the greatest benefit can be derived from the effort. The EMCPP should be presented in

an interactive document and should be updated periodically in order to remain applicable with an item's E^3 control/EMC performance requirements as the program progresses from concept to production and, eventually, to operational support. The EMCPP should emphasize the policy, philosophy, and management of the EMC program that is to be implemented and the analysis techniques and general design guidance that is to be employed.

4.5.4 EMCPP evaluation guide. An EMCPP Evaluation Guide is presented in Appendix G, Paragraph G.3.7.

4.6 Working-level IPT/EMC advisory board (E^3 WIPT/EMCAB).

4.6.1 General. A E^3 WIPT/EMCAB is established by the program manager to monitor the EMC program associated with his project, to provide assistance in expediting solutions for E^3 problems, and to establish high-level channels of coordination. A E^3 WIPT/EMCAB Charter is usually included as part of the EMCPP document. The E^3 WIPT/EMCAB functions as a major resource for reviews, advice and technical consultations on all aspects of the program involving E^3 considerations. Section 6 discusses the membership, responsibilities and Charter of a E^3 WIPT/EMCAB.

4.7 Applicable E^3 control/EMC performance requirements.

4.7.1 General. The complexity of E^3 problems requires the EMC performance requirements in procurement specifications of an item to be tailored specifically to the mission needs, including the end-item's intended operational EMEs. This is normally accomplished through the application and tailoring of general E^3 specifications and performance standards. Compliance with untailored general E^3 specifications and standards can result, in some cases, in unnecessarily costly design-to requirements, and in other cases, requirements that are inadequate for a particular operational EME.

4.7.2 Application and tailoring. E^3 control/EMC performance 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. The application and tailoring of general E^3 specifications and standards should be based on adequate analysis and test data, and should be initiated in Phase 0 or Phase I and updated, as required, during the acquisition process. Tailoring of E^3 control/EMC performance requirements should be reflected in the preparation of solicitation documents. Tailoring may take the form of deleting, adding, or modifying general requirements from E^3 specifications and standards. The depth of detail, level of effort required, and the data expected should be defined when tailoring the requirements. Subsequent tailoring of E^3 control/EMC performance requirements may be requested or recommended by a contractor but should be subject to Government approval during contract negotiations. The agreement reached on the engineering effort, including the E^3 control/EMC performance requirements that should be achieved with the end-item, is reflected in the resultant contract. Section 8 provides more details on tailoring.

4.7.3 Solicitations. Identification or, when necessary, preparation of the applicable specification(s) is a key part of the acquisition process. DoD policies and guidelines emphasize that requirements in the solicitation for both commodity (equipment/system/platform) and data (test plans/findings) products are to be stated in terms of performance or "what the product must do" rather than "how-to" produce the product.

4.7.3.1 Request for proposal (RFP). The program manager should define the baseline of an end-item. The baseline should include the E^3 control/EMC performance requirements that must be met to achieve the desired level of performance. The baseline with these requirements should then be included in an RFP or invitation for bid (IFB). This baseline should include all anticipated uses and installations of the end-item. The RFP or IFB should specify the tailored E^3 control/EMC performance requirements which the end-item will be required to meet. Subsequent to the publishing of an RFP or IFB, the bidder should determine the adequacy of the baseline requirements. If the baseline is not considered feasible, the bidder may propose alternate requirements. The mission objectives, operational EMEs, minimum acceptable functional requirements, and desired operational performance as stipulated in the RFP or IFB should be examined for consistency and attainability.

4.7.3.2 Solicitation documents. Specifications, statements of work (SOW) and contract data requirements lists (CDRLs) are requirements documents used in solicitations. A contractor can not unilaterally change any of the requirements identified in these documents after a contract is awarded to him since these requirements form the basis for the award. Section 7, Specifying EMC Performance Requirements, provides details concerning the preparation and use of specifications, SOWs and CDRLs.

4.8 Commercial items and non-developmental items (NDIs).

4.8.1 General. For some acquisition programs, the procurement of commercial items and NDIs is a cost-effective approach to meeting the mission needs established in the Mission Need Statement (MNS). Commercial items and NDIs should meet the basic operational requirements specified in the Operational Requirements Document (ORD) and be capable of functioning compatibly in their intended operational EMEs. When applicable, commercial items and NDIs are an attractive alternative to expensive and time-consuming development programs.

4.8.2 Compliance. A commercial item's or NDI's degree of compliance with E^3 specifications and standards should be ascertained to ensure it will operate in the intended EMEs without causing nor suffering unacceptable mission performance degradation due to E^3. The fact that a commercial item or NDI may already be accepted in the commercial marketplace does not ensure that the E^3 control/EMC performance requirements are sufficiently met. The level of risk associated with employing a commercial item or NDI in the intended operational EMEs should be determined. Verification of a commercial item's or NDI's performance capability should be accomplished through both technical and operational evaluations. A commercial item or NDI usually requires some operational testing. Additional information is provided in Section 9, Commercial and NDIs.

4.9 Joint E^3 control strategy (JECS).

4.9.1 General. JECS is a problem-avoidance measure that provides, for the disciplines of E^3, a mechanism for monitoring an acquisition program to ensure appropriate E^3 control considerations are addressed. By the use of JECS, joint forces should be able to attain maximum effective performance from warfare systems that depend upon or which are susceptible to EM energy. JECS is adaptable to all acquisition programs.

4.9.2 Beneficiaries of JECS. Beneficiaries of the JECS extend beyond the operating environments of the evaluator and program manager. The JECS engineering process can serve as a reference on the E^3 information that should be available for each acquisition. The program manager may also use the JECS engineering process as a guide and it should be of significant value when:

a. Preparing EMC Program Procedures.

b. Approving vendor deliverables involving pertinent E^3 considerations and/or issues.

c. Refining and assessing program E^3 control efforts.

4.9.3 Engineering process (EP). Basic aspects of the JECS operation are covered in Section 10. Appendix G contains details on the JECS EP that may be used by evaluators to facilitate their work in applying the JECS on a day-to-day basis.

4.10 EMI control procedures (EMICP)/E^3 integration and analysis report (E3IAR).

4.10.1 General. The EMICP/E3IAR should be prepared by a contractor, submitted for review, and approved by the program manager and E^3 WIPT/EMCAB. The EMICP should be prepared for equipment and subsystem acquisitions in accordance with the requirements of DID DI-EMCS-80199. The E3IAR should be prepared for system acquisitions in accordance with the requirements of DID DI-EMCS-81540. The EMICP/E3IAR should become the technical policy document of engineering projects and should provide much more detailed information than the EMCPP. The EMICP/E3IAR should identify how all E^3 control/EMC performance requirements will be implemented, providing a detailed comprehensive account of all the E^3 control measures and design techniques that will be employed during the acquisition program to ensure the end-item meets all contractual E^3 control/ EMC performance requirements. The EMICP/E3IAR should describe in detail what the contractor's effort will be for controlling E^3, beginning with program initiation, through final design and production, and throughout the operational life of the end-item being procured. The EMICP/E3IAR should reveal the extent of a contractor's E^3 awareness and his understanding of E^3 control measures.

4.10.2 EMICP/E3IAR evaluation guide. An EMICP/E3IAR Evaluation Guide is presented in Appendix G, Paragraph G.3.12.

4.11 EMC verification.

4.11.1 General. The objective of EMC verification is to obtain a reasonable degree of confidence that an end-item and its integral components will function in a specified manner when in their intended operational EMEs. A measurement program along with E^3 analyses provides the data needed to determine an item's compliance with the contractual E^3 control/EMC performance requirements. Critical test points should be specified for circuits suspected of having low susceptibility margins and these circuits should be categorized by degree of mission criticality. Measurements should be made in accordance with applicable standards and approved E^3 test procedures. Test data obtained from various measurements should form the basis for acceptance or rejection of an item, and any actions required to correct operational deficiencies or malfunctions. Unless otherwise specified by the procuring activity, the contractor should be responsible for conducting all of the tests needed to demonstrate an end-item's compliance with the contractual E^3 control/EMC performance requirements. The Government has the right to witness these tests. Additional information on EMC verification is presented in Section 11 and an Evaluation Guide for test and evaluation (T&E) reports is presented in Appendix G, Paragraph G.3.11.

4.11.2 Test and evaluation master plan (TEMP). The TEMP defines the T&E that should be required for an acquisition program and is the most fundamental of the program documents. Information on TEMPs is presented in Appendix H, T&E Considerations for EMC.

4.11.3 E^3 test/verification procedures. E^3 test/verification procedures should describe the measurement procedures that will be employed to demonstrate an item's compliance with its contractual E^3 control/EMC requirements. Testing should be mandatory if an item is to be qualified to a specification or standard. Until the item is actually tested, whether of developmental, commercial or NDI origin, there is no assurance that an item possesses the desired EMC qualities. Testing should not be started until after the test procedures have been approved by the procuring activity.

4.11.3.1 Content. Military standards such as 449, 461, 462, 464 and 469, and the DIDs associated with them, delineate content requirements for E^3 test/verification procedures. Specific details regarding inter-system and intra-system testing, including emission and susceptibility testing of items provided by a subcontractor, should be considered and addressed by the prime contractor in his test procedures. In general, E^3 test/verification procedures should provide:

a. Measurement objectives.

b. Test configurations.

c. Test points.

d. Detailed measurement procedures.

e. Formats for recording test data.

4.11.3.2 Test procedures. Specific test techniques should be based on the procedures presented in the E^3 standards and specifications that are referenced in the contract. The test procedures should be described in sufficient detail to enable the procuring activity to duplicate the proposed testing at a later date.

4.11.3.3 Evaluation guide. A E^3 test/verification procedures Evaluation Guide is presented in Appendix G, Paragraph G.3.13.

4.11.4 E^3 test/verification reports. E^3 test/verification reports are the most important source of E^3 control information that is readily available. An E^3 test/verification report should provide the data and information needed to evaluate an item's compliance with its contractual EMC performance requirements. When test results are properly documented and clearly explained, the information provided should form conclusive evidence of the project's success or failure. The test results of a package of properly selected tests, performed in accordance with MIL-STD-462 and MIL-STD-464 (when applicable), should provide an EM baseline profile of the end-item.

4.11.4.1 Content. E^3 standards and DIDs DI-EMCS-80200 and DI-EMCS-81542 specifies the content requirements for E^3 test/verification reports. Omissions of apparently minor facts can nullify the usefulness of the entire report.

4.11.4.2 Evaluation guide. An E^3 test/verification report Evaluation Guide is presented in Appendix G, Paragraph G.3.14.

4.11.5 Retrofit and new design. Program managers should be provided proof through analysis and testing that changes, as the result of retrofit procedures or a new design, have no adverse impact on the electromagnetic characteristics (performance) of the item being retrofitted or redesigned. Depending on the applicable E^3 standards and the significance of the change(s), the item may have to repeat qualification testing.

4.12 E^3 analyses and predictions.

4.12.1 General. E^3 analyses and predictions is one of the most vital elements of an EMC program. E^3 analyses should be conducted to predict potential E^3 problems and to evaluate the effectiveness of different techniques, procedures, and design changes that can be implemented to prevent or minimize E^3 problems. It is far less costly to analyze, predict, and control potential E^3 problems at the outset of a program rather than be overtaken by them late in the acquisition process. Solutions are usually extensive, time-consuming, and costly for E^3 problems that are discovered late in the acquisition process.

4.12.2 E^3 analysis. An effective E^3 analysis should consider the following:

a. The end-item's intended operational EMEs.

b. Design concepts.

c. Mission requirements.

d. Electromagnetic characteristics of interfacing and co-located equipment, subsystems and systems.

e. Signal flow, power distribution, and installation procedures associated with the end-item.

f. Electromagnetic characteristics of the end-item.

g. Desired level(s) of EMC to be achieved.

Following a contract award, the contractor may be required to perform other analyses, such as predicting the performance of an end-item in its intended operational EMEs, by utilizing modeling techniques or simulations. Some of the testing that is usually required in EMC programs may be precluded when sufficient data is derived from E^3 analyses, modeling, and simulation efforts. However, in order to have a contractor perform E^3 analyses, modeling or simulation tasks, the requirement(s) should be established in the SOW. If documentation of the results is desired, the requirement for a report should be included on the CDRL. Additional information is presented in Section 12, E^3 Analyses and Predictions, and in Appendix I, E^3 Models and Simulations.

4.13 Hazards of electromagnetic radiation to personnel (HERP).

4.13.1 General. HERP is concerned with the danger of producing harmful biological effects in humans from exposure to radio frequency electromagnetic fields. The effect is caused by the human body becoming an unintentional receive antenna and absorbing electromagnetic energy. The primary concern is that absorption of the energy causes warming of body tissue and internal organs. Heat from RF field interactions 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. If significant RF power is absorbed an increase in body temperature can be expected and this could have a competing effect on the metabolic process with potentially deleterious effects.

4.13.2 Safety precautions. Personnel should not be exposed to electromagnetic levels higher than the maximum permissible exposure (MPE) levels specified in Tables 3 and 4 of MIL-STD-464. MIL-STD-464 also provides additional requirements for pulsed fields 0.1 to 300,000 MHZ. ANSI/IEEE C95.1-1991 defines personnel hazards criteria and provides guidance on interpreting and applying the criteria. DoDI 6055.11 implements the criteria for military operations. Radar and electronic countermeasures (ECM) systems usually present the greatest potential for personnel hazards due to high transmitter output powers and antenna characteristics and possible exposure of servicing personnel. Personnel assigned to repair, maintenance, and test facilities have a higher potential for being overexposed because of the variety of tasks, the proximity to radiating elements, and the pressures for rapid maintenance response.

4.13.2.1 Safe distances. An RF hazard evaluation is performed by determining safe distances for personnel from RF emitters. Safe distances can be determined from calculations based on RF emitter characteristics or through measurements. 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 placing warning signs and documenting the hazards/restrictions in service publications, guidance manuals, operating manuals, etc.

4.14 Hazards of electromagnetic radiation to fuel (HERF).

4.14.1 General. HERF deals with the possibility of accidentally igniting fuel vapors by RF induced arcs during fuel handling operations in proximity to high-powered radio and radar transmitting antennas. RF energy can induce currents into any metal object. The hazard arises from the fueling device or other metal objects becoming unintentional receive antennas in the proximity of fueling vapors. This causes a current and charge to be produced on the fueling device or metal object. The amount of current, and thus the strength of a spark across a gap between two conductors, depends on both the field intensity of the RF energy and how well the conductors can act as receiving antennas.

4.14.2 Safety precautions. The existence and extent of a fuel hazard are determined by comparing the actual RF power density to established safety criteria. TO 31Z-10-4 (Army FM-11-490-30) and OP 3565 provide procedures for establishing safe operating distances from RF emitters. The induced current depends mainly on the conductor length in relation to the wavelength of the RF energy and the orientation in the radiated field. Since its not feasible to predict nor control these factors the hazard criteria should be based on the assumption that an ideal antenna could be inadvertently created with the required spark gap. Any area in the system where fuel vapors may be present needs to be evaluated. The volatility and flash point of particular fuels influence whether there is a hazard under varying environmental conditions. Restrictions on the use of some RF emitters may be necessary to ensure safety under certain operations such as refueling. Any required safety procedures should be carefully documented in technical orders or other appropriate publications.

4.14.2.1 Low-power transceivers. There is a special case when a fuel or weapon RF hazard can exist even though the RF levels may be within the safe limits. This special case is for both hand-held (1-5 watts) and mobile (5-50 watts) transceivers. The antennas on these equipment can generate hazardous situations when they are allowed to accidentally touch the system, ordnance, or support equipment. To avoid this hazard, transceivers should not be operated any closer than 10 feet from ordnance, fuel vents, etc.

4.15 Hazards of electromagnetic radiation to ordnance (HERO).

4.15.1 General. Acquisitions involving ordnance are of particular concern due to the potential safety hazard. HERO arises from the functional characteristics of electrically initiated ordnance. Ordnance electrically initiated devices (EIDs) can be unintentionally initiated due to exposure to electromagnetic energy. In general, ordnance is more susceptible to electromagnetic environments during assembly, disassembly, handling, loading and unloading.

4.15.2 Safety precautions. HERO can be controlled by either limiting the field intensity that the ordnance and its EIDs will be exposed to or by hardening the ordnance and its EIDs to the electromagnetic radiations they will encounter. The primary means of controlling HERO include:

a. Maintaining adequate separation distances between the radiating sources and the ordnance and its EID.

b. Grounding, bonding and shielding of the ordnance and its EID.

c. Implementing operational restrictions.

4.15.3 Certification. HERO certification establishes (documents) the maximum levels of electromagnetic radiation that the ordnance and its EIDs can be exposed to without risking a potential safety hazard. HERO certification is extremely important, especially for ordnance intended for use during Joint Operations. Using ordnance not certified for use during Joint Operations creates potential safety hazards for personnel and equipment. Oftentimes, operational restrictions that lessen the effectiveness of other military systems need to be imposed because of the presence of HERO uncertified ordnance during military operations.

4.15.4 HERO considerations. Appendix D, HERO Considerations, presents information on the HERO certification process and the precaution(s) that can be implemented to reduce the risk of a potential safety hazard.

4.16 EMC training.

4.16.1 General. All personnel involved in the acquisition process should have an awareness of E^3 and the adverse effects that may result from EMC deficiencies. A well-implemented EMC training program can be beneficial in preventing potential E^3 problems from occurring during the design, development, production, procurement, test, operational use, and maintenance of military electrical and electronic equipment, subsystems, and systems. Section 13 provides more details on EMC training.

4.16.2 Requirements. EMI identification techniques and the adverse effects of EMI should be known, understood, and accurately communicated in order to avoid operational performance degradation from E^3. All personnel, especially operational and maintenance personnel, should be required to have some knowledge of the emission characteristics and susceptibility mechanisms for different types of equipment and systems. Technical publications should address the actions that are required by operational and maintenance personnel to ensure E^3 control/EMC design features are not compromised. Training publications should describe how E^3 problems can manifest themselves in an item and the potential adverse impact this can have on an item's performance. These publications can be used for training personnel involved with the operation or maintenance of the equipment. Planned maintenance procedures should be revised and modified, as needed, to include guidelines for identifying and preventing E^3 problems.

5. SPECTRUM MANAGEMENT

5.1 General. As more and more systems use the available spectrum, the operational performance of equipment and systems that were once only limited by background environmental noises have become increasingly affected by interference from other equipment and system signals. Several recent real-world contingency operations involving the deployment of Joint Service Task Forces have served to highlight the spectrum management problems and the difficulties experienced among the Services in achieving interference-free communications. The availability of adequate spectrum support is a firm prerequisite to the successful operation of an item in its intended EMEs. Spectrum-related aspects should be given appropriate and timely consideration, in conjunction with other major influences, in the planning, development, procurement and operational phases of electronic equipment and systems, if they are to effectively perform their intended functions without causing disruption to, or being disrupted by, other electronic equipment and systems.

5.2 Spectrum policy. Electromagnetic spectrum management policy and decisions precipitate from the International Telecommunications Union (ITU), through the National Telecommunications and Information Administration (NTIA) of the Department of Commerce and the DoD, to Service departments and subordinate commands. The organization that serves the Administrator of NTIA in the area of frequency management is the Interdepartment Radio Advisory Committee (IRAC). Program managers must accept the constraints imposed by these organizations since they are unalterable. Spectrum management and EMC policies within DoD are the responsibility of the Assistant Secretary of Defense (ASD) for Communications, Command, Control and Intelligence. The ASD (C^3I) coordinates the DoD interface with the IRAC and is responsible for monitoring and reviewing policies, plans, programs, and budgets for telecommunications within the DoD. The predominant requirement imposed by DoD spectrum management policies is that prior to the expenditure of funds for the development or procurement of any electronic equipment or system, an approved frequency allocation must be obtained.

5.2.1 National policy. The requirement for a frequency allocation is derived from the Office of Management and Budget (OMB) circular No A-11 which states: "Estimates for the development or procurement of major communications-electronics systems (including all systems employing space satellite techniques) will be submitted only after certification by the National Telecommunications and Information Administration, Department of Commerce, that the radio frequency required for such systems is available".

5.2.2 DoD policy. DoD Directive 4650.1 establishes DoD policy for management and use of the radio frequency spectrum. Under "Procedures" it states: "All DoD components shall: Obtain radio frequency spectrum guidance for communications-electronics systems from the Military Communications Electronic Board (MCEB) as early as possible during the concept, exploration and demonstration, and validation stages of system acquisition. MCEB guidance must be obtained before assuming contractual obligations for the full-scale development, production, or procurement of those systems. Radio frequency spectrum support requirements shall be sent through the MCEB, for coordination with host nations where this equipment is intended to be deployed, as early in the acquisition as practical. Host-nation coordination must be initiated before contracting for a system's full-scale development".

5.3 Spectral characteristics. Spectral characteristic data, or spectrum signatures, are quite often needed both for existing items and for developmental and planned items that are designed to either emit or respond to EM energy. The transmitter emission spectra should be known as well as the immunity (susceptibility) of receivers to the various frequencies, powers, and modulations that may occur in their intended operational environments. This type of data is required when conducting in-depth E^3 analyses to:

a. Predict the performance of an item in its intended operational EME.

b. Predict the effect of a particular item on the EME of other equipment or systems.

c. Establish the characteristics required of new items for compatible operation in present and future EMEs.

d. Confirm the objectives of the DoD EMC program are achieved.

5.3.1 Measurements. Spectral characteristic measurements are usually performed when the item is in:

a. Its final configuration or at a time as agreed upon between the contractor and procuring activity.

b. The configuration it will have in production, even though it may not have been officially accepted.

It is essential the spectral characteristic data be representative of the electromagnetic emission and immunity (susceptibility) characteristics that will occur in production equipment, subsystems, and systems. In some cases it may be desirable to perform partial spectral characteristic measurements on an item before it reaches production status to support the frequency allocation process or the determination of other EM characteristics of an item. MIL-STD-449, Measurement of Radio Frequency Spectrum Characteristics, provides the measurement techniques that should be used when making spectral characteristics measurements. In order to have a contractor perform spectral characteristic measurements the requirement should be established in the SOW. If documentation of the results is desired, the requirements for a report and/or the data should be included on the CDRL. When available, equipment spectral characteristic data should be provided to the Joint Spectrum Center (JSC) for storage and use by all DoD agencies. This data can assist personnel in the areas of:

a. Spectrum planning.

b. Emission and susceptibility characteristics evaluation.

c. Deployment and site analysis.

d. Consultation services.

5.4 Frequency management considerations. Electronic equipment, systems and platforms should be capable of operating in the vicinity of other equipment, systems and platforms without causing or responding to undesirable electromagnetic energy while at the same time achieving their specified performance requirements. Equipment electromagnetic emissions and immunity (susceptibilities) to EM energy are two (2) primary factors that should be addressed to achieve the required system EMC. When equipment emissions and immunities are within the limits established by applicable E^3 standards, the composite system and its associated subsystems and equipment should not only be compatible with themselves but they should also have a high probability of continuing to operate within acceptable tolerances among other systems, subsystems and equipment. The procurement contract should explicitly delineate the applicable EMC performance requirements. Frequency management considerations should be applied early in the conceptual phase of an item's development, and periodically reviewed throughout the design. Compatibility is achieved, in part, through the application of frequency management procedures. Frequency management involves a number of actions including the efforts required to obtain approved frequency allocations and frequency assignments. Unless there are frequencies available within the appropriate frequency band (available spectrum) in which an item can operate, there is no point in developing the item.

5.5 Spectrum certification. Spectrum certification denotes the supportability of an electronic system or equipment for operation in a designated frequency band of the EM spectrum. The DoD spectrum certification process involves the submittal and approval of an application for a frequency allocation.

5.5.1 Frequency allocation. An approved frequency allocation provides the authorization to utilize a defined frequency band(s) or frequencies for the accommodation of a specific electronic function. Without an approved frequency allocation the program manager does not have the authority to obtain electronic equipment, either through development or the purchase of off-the-shelf equipment. Frequency allocations, however, do not provide the authorization to operate electronic equipment on specific frequencies within the tuning range of the equipment. A frequency assignment must be obtained prior to operating the equipment. The procedures to be used for obtaining frequency allocations are delineated in the various service regulations.

5.5.1.1 DD form 1494. An application for a frequency allocation is prepared on DD Form 1494. An item should have four (4) frequency allocation stages during its life time, as it transitions from one acquisition phase to another. Each frequency allocation has a distinct J/F-12 number. The J/F-12 number is assigned when a frequency allocation application is initially approved. The purpose of a frequency allocation application in general is to:

a. Ensure there is compliance with the frequency allocation policies and tables which provides order in the use of the spectrum.

b. Ensure there is spectrum available to support the item in its intended operational environments.

c. Elicit guidance from the MCEB pertaining to the development of an item so as to achieve acceptable EMC in the item's intended operational EMEs.

5.5.1.2 Processing time. The time required to process a DD Form 1494 is dependent upon the quality of the data in the submission and the possible environmental impact of the item. All too often frequency allocation requests are delayed due to incomplete or erroneous information. Incomplete and inaccurate applications results in increase manpower demands and increases the processing time. The nominal processing time required for a frequency allocation application is from 3 to 9 months. The program manager is responsible for the accuracy of the applications and submitting them as early as practical.

5.5.1.3 Responsibility. The program manager should understand that the responsibility to obtain an approved frequency allocation for his system resides with him. No contractor or testing agency can take this responsibility. They may support the program manager in acquiring measured data for describing the item, but the program manager has the responsibility for submitting the frequency allocation application. It should be noted that local frequency coordinators have denied frequency assignments because a frequency allocation was never obtained for a particular item.

5.5.2 Frequency allocation data. For each item requiring a frequency allocation, appropriate data should be provided by the procuring activity through their frequency management offices. When specific contracts exist, contractors should be requested to provide the appropriate data to the procuring activity. The submission of a DD Form 1494, Application for Frequency Allocation, is normally required when any of the following conditions exist:

a. Sufficient information becomes available on the intended use and feasible frequency limits of a proposed system or equipment to warrant consideration of a specific allocation.

b. A system or equipment is being considered for development.

c. Procurement of a commercial item or NDI for military use is being considered.

5.5.2.1 Amended DD Form 1494. An amended DD Form 1494 should be submitted to correct or update a previous application when:

a. Experimental leads to development, or development leads to production for operational use.

b. A new military scenario is planned for a previously approved system or equipment.

c. The needs exist to alter any of the conditions of an existing frequency allocation regarding equipment characteristics, nomenclature or operational environmental conditions.

5.5.3 J-12 process. DoD has incorporated into the acquisition process a system of reviews called the frequency allocation or J-12 process. The MCEB, through the Joint Frequency Panel (FP), reviews the characteristics of electronic equipment, subsystems, and systems being purchased or developed by the DoD when they are designed to either emit or respond to EM energy. The purpose of the J-12 process is to ensure that DoD equipment, subsystems, and systems are designed to conform to applicable E^3 standards, international and national tables of frequency allocations and other frequency guidance. Characteristics of an item are reviewed at each stage of procurement to determine compliance and to provide guidance to the developer. The J-12 review process consists of four (4) stages which corresponds to the phases of an item's life cycle. A frequency allocation is required for each phase of an item's development and is requested by submitting DD Form 1494. It is expected that each application for a frequency allocation will build upon its predecessor(s), containing more complete and more accurate technical characteristics with the final stage (operational phase) being based entirely on measured data. A by-product of the J-12 process is to provide JSC's equipment characteristics file (ECF) with the technical characteristics from each reviewed item.

5.5.3.1 J-12 working group. Within the MCEB, the J-12 Working Group (WG) of the Joint FP is responsible for the review of all DoD frequency allocation applications. The J-12 WG is composed of a representative from each service. The JSC provides technical support to the J-12 process in accordance with DoD Directive 3222.3.

5.5.4 Requirements for a frequency allocation. The requirements that should be satisfied before receiving an approved frequency allocation for each stage of development are:

a. Stage 1 (Conceptual) correlates with acquisition Phase O: Concept Exploration. A frequency allocation for Stage 1 should be requested (DD Form 1494) and approved prior to the releasing of funds for studies or assembling "proof-of-concept" test beds. The system purpose, the planned frequency range, and planned power should be provided along with any other planned or estimated details concerning the item that are available.

b. Stage 2 (Experimental) correlates with acquisition Phase I: Program Definition and Risk Reduction. An approved frequency allocation for Stage 2 is required prior to the releasing of funds for building a radiating test model or obtaining an approved frequency assignment for experimental usage. Estimated and calculated data can be used for nearly all of the blocks on DD Form 1494 when requesting a frequency allocation for Stage 2.

c. Stage 3 (Development) correlates with acquisition Phase II: Engineering and Manufacturing Development. A Stage 3 frequency allocation should be approved prior to contracting for engineering development models. Most of the blocks on DD Form 1494 should be completed with measured data when requesting a frequency allocation for Stage 3. Calculated data should be used for the blocks where measured data is not available.

d. Stage 4 (Operational) correlates with acquisition Phase III: Production, Fielding/Deployment, and Operational Support. Prior to contracting for production units an approved frequency allocation for Stage 4 is mandatory. All of the blocks on DD Form 1494 requiring technical characteristics should be completed with measured data. Calculated data is generally unacceptable when requesting a frequency allocation for Stage 4.

5.5.5 Note-to-holder. A Note-To-Holder is a provision provided for within the "J-12 Procedures" that permits some changes to be made to existing frequency allocations. The types of modifications for which a Note-To-Holder may be used include:

a. Adding nomenclature(s) of equipment which has essentially the same technical and operating characteristics to those equipment with a frequency allocation that has been previously approved by the MCEB.

b. The cancellation or reinstatement of a frequency allocation.

c. Adding comments that have been provided by the NTIA or Host Nation.

d. Making minor changes to an approved frequency allocation.

5.5.6 Frequency assignment. An approved frequency assignment is a discrete frequency or set of frequencies on which an electronic device, equipment or system is authorized to operate within its allocated frequency band for a particular application at the location(s) designated and within the constraints of the authorizing assignment. The frequency assignment subcommittee (FAS) of the IRAC is responsible for approving routine frequency assignments and handling related problems referred to it by the IRAC. Since the usable frequency spectrum is limited, competition for frequency assignments necessitates coordination of requirements with users both in the United States and all other applicable countries. The earlier the submission of a request, the sooner the coordination can be completed and a frequency assignment can be made available for use. The procedures to be used for obtaining frequency assignments are delineated in the various service regulations. An approved frequency assignment should be obtained before a contractor operates an electronic device, equipment or system in his plant. A contractor should be made responsible for providing the information needed for requesting a frequency assignment.

5.6 Frequency plans. A frequency plan lists all of the frequencies that are assigned to an operational force to satisfy its frequency requirements for communication circuits, radars, weapon systems, and Electronic Warfare/Signal Intelligence (EW/SIGINT) systems. A frequency plan is essential if the effects of mutual EMI between electronic equipment, subsystems, and systems in an operational environment is to be minimized. Basic factors that should be considered, and the minimum information needed, during the process of developing a frequency plan includes:

a. Siting and path engineering.

(1) Force laydown, geometry, and locations.
(2) Physical characteristics of the area such as terrain and climate.
(3) Frequency/distance trade-offs.
(4) Channel spacings.

b. Equipment characteristics.

(1) Power.
(2) Tuning range.
(3) Type of modulation.
(4) Antenna patterns and take off angles.

c. Mission requirements.

(1) Communications.
(2) Radars.
(3) Weapons.
(4) EW/SIGINT.

d. Electromagnetic wave propagation.

(1) Skywave.
(2) Groundwave.
(3) Line of Sight (LOS).

e. Rules and Regulations.

(1) DoD.
(2) International and national allocation tables.
(3) Frequency channeling plans.
(4) Government and non-government frequency assignments.

f. Area wide emitters and receivers.

(1) All electronic equipment, subsystems, and systems required for normal platform (ships, aircraft, or shore sites) operations, plus those directly supporting the mission.
(2) In-band and out of band emissions from all sources, including those not participating in the operations.

6. E^3 WORKING-LEVEL INTEGRATED PRODUCT TEAM

6.1 General. The Secretary of Defense has directed DoD to perform as many acquisition functions as possible, including oversight and review, using Integrated Product Teams (IPTs). IPTs are intended to promote teamwork by empowering its members, to the maximum extent possible, to make commitments for the organization or functional area they represent. There are three (3) types of IPTs: Program IPTs, Overarching IPTs (OIPTs) and Working-Level IPTs (WIPTs).

6.1.1 Program IPTs. Program IPTs focus on program execution and may include representatives from both the Government, and after contract award, industry.

6.1.2 OIPTs. OIPTs focus on strategic guidance, program assessments, and the resolution of issues.

6.1.3 WIPTs. WIPTs focus on particular topics such as cost/performance, test, or E^3 issues. WIPTs are established by the PM and meet, as required to help the PM develop program objectives, review program documentation, and resolve program issues. WIPTs responsibilities and activities should include:

a. Assisting the PM in developing strategic and program planning, as requested by the PM.

b. Assisting in the establishment of the IPT plan of action and milestones.

c. Proposing tailored document and milestone requirements.

d. Reviewing and providing inputs to documents.

e. Coordinating WIPT activities with the OIPT members.

f. Assuming responsibility for obtaining concurrences from principles on issues as well as with applicable documents or portions of documents.

6.1.3.1 E^3 issues. E^3 issues is one of the areas that should be addressed by a WIPT. Due to the complex nature of E^3, the program manager may choose to establish a WIPT dedicated solely to E^3 issues. Such an E^3 WIPT functions much like an EMC Advisory Board (EMCAB) and hence supersedes an EMCAB.

6.1.4 <u>E^3 WIPT/EMCAB</u>. A E^3 WIPT/EMCAB is an advisory body established by the Program Manager to assist him in assuring that the platform, system, or equipment under development will be electromagnetically compatible with its intended operational EMEs. A E^3 WIPT/EMCAB monitors the EMC program associated with a project, provides assistance with formulating and implementing solutions for E^3 problems, and establishes high-level channels of coordination. The E^3 WIPT/EMCAB functions as a major resource for reviews, advice and technical consultations on all aspects of the program involving E^3/EMC considerations.

6.2 <u>Applicability</u>. A E^3 WIPT/EMCAB should be established to ensure that the resulting platform, system, or equipment will operate compatibly in its intended operational EMEs. A E^3 WIPT/EMCAB should be established for each program that is either designated as, or meets the criteria for, ACATs I or II when the end-item may affect, or be affected by its intended operational EMEs. E^3 WIPTs/EMCABs may also be established for ACAT III equipment, subsystems, and systems when specified by the individual Services and are so designated on a case-by-case basis. A E^3 WIPT/EMCAB 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 E^3 considerations.

6.3 <u>E^3 WIPT/EMCAB members</u>. The E^3 WIPT/EMCAB should be administered by a chairman operating under the authority of the Program Manager. Members of a E^3 WIPT/EMCAB should include the prime contractor, invited subcontractors, and Government Project Offices and their contractors that are involved in the program. Membership should be composed of representatives from the various E^3 related disciplines as deemed appropriate for a particular acquisition. The number of E^3 WIPT/EMCAB members should be dependent upon the complexity of the program. Prime contractors and major subcontractors should be required, by their contracts, to be members of the E^3 WIPT/EMCAB, to participate in E^3 WIPT/EMCAB activities, and to respond to E^3 WIPT/EMCAB requests for information on E^3 issues.

6.4 <u>Responsibilities</u>. Responsibilities of a E^3 WIPT/EMCAB should be defined in a Charter. The E^3 WIPT/EMCAB Charter is usually included as part of the EMCPP document, but can exist as a separate document depending on the program manager's preference. The responsibilities of a E^3 WIPT/EMCAB should include:

a. Assisting with the preparation of EMCPP.

b. Reviewing all aspects of the EMC program documentation including:

(1) E^3 control procedures.
(2) E^3 integration and analysis reports.
(3) E^3 test/verification procedures.
(4) E^3 test/verification reports.
(5) E^3 prediction and analysis methods and the results.
(6) Proposed resolutions of E^3 problems.
(7) Tailoring of E^3 specification and standard requirements.
(8) Design documents with E^3 control/EMC performance criteria.

c. Assisting in the identification and resolution of potential operational E^3 problems during the acquisition process.

d. Reviewing predicted and reported E^3 problems to determine their applicability as potential problems for the program's specific end-item.

6.5 Charter.

6.5.1 Purpose. The charter should delineate the responsibilities, objectives, membership, and operations of the E^3 WIPT/EMCAB. The charter should provide guidance for the E^3 WIPT/EMCAB to ensure that all pertinent E^3 control considerations are being implemented during a program and to establish confidence that the platform, system, or equipment being developed can be expected to operate in its intended EMEs without degradation due to effects from electromagnetic energy and without causing degradation to other platforms, systems, or equipment in the same environment.

6.5.2 Scope. The charter should present its purpose and scope, including the general requirements applicable to the formation and operation of the E^3 WIPT/EMCAB. The equipment, system, or platform to be coordinated by the E^3 WIPT/EMCAB should be briefly described, including its subunits and functions, intended uses, installations, and operations. The charter should also identify the E^3 disciplines that should be addressed during the program.

6.5.3 Responsibilities. The charter should describe the responsibilities and role of the E^3 WIPT/EMCAB and its members. Relationship of the E^3 WIPT/EMCAB, and how the E^3 WIPT/EMCAB recommendations should be handled, with regards to the overall program and its related contractual obligations should be clearly delineated.

6.5.4 Objectives. The charter should define the objectives of the E^3 WIPT/EMCAB. All of the individual types of activities to be performed by the E^3 WIPT/EMCAB should also be listed. When there is more than one (1) E^3 WIPT/EMCAB involved in an overall program, such as E^3 WIPTs/EMCABs for individual subsystems and one (1) for the platform, the relationship between the E^3 WIPTs/ EMCABs should be clearly delineated.

6.5.5 Organization. The charter should identify which organizations, activities, and contractors need to be represented on the E^3 WIPT/EMCAB. Specific categories of representatives, such as Chairman, Vice-Chairman, Secretary/Manager, and Members, should be defined and each of their individual responsibilities and functions should be delineated.

6.5.5.1 Membership categories. The charter should identify the types of members on the E^3 WIPT/EMCAB. Typical categories of membership are Permanent Members, including administrative, technical specialists, and first level contractor members, and consulting members who are technical support individuals that attend only when requested. The charter should specifically identify the E^3 WIPT/EMCAB members by title or by organization if it's appropriate and not confusing.

6.5.6 Activities. The charter should describe in detail the E^3 WIPT/EMCAB activities and required schedules and milestones that should be formulated for these activities once the E^3 WIPT/EMCAB is established. As a minimum the following should be addressed under activities:

a. E^3 WIPT/EMCAB meetings and their schedules.

b. EMC program procedures.

c. Spectrum certification.

d. EME assessments.

e. Specification reviews.

f. Reviews of E^3 control measures and verification procedures.

g. Reviews of technical reports such as E^3 control procedures, E^3 test/verification procedures and E^3 test/verification reports.

h. Reviews of all contractor and subcontractor efforts and products with regards to E^3 considerations.

i. Reviews of precautions being taken to preclude safety hazards due to E^3.

6.5.7 Documentation. The charter should delineate all of the documentation requirements to be provided by the E^3 WIPT/EMCAB. A description of the contents expected for each type of documentation should also be provided. Typical E^3 WIPT/EMCAB documentation includes:

a. Agendas, both permanent and specialized agenda items.

b. Minutes of all meetings.

c. Action items, including their assignments, status, related decisions, and actions necessary to close.

6.5.7.1 E^3 WIPT/EMCAB activities. A E^3 WIPT/EMCAB should document all decisions concerning E^3 which may later have an impact; identify essential EMC features or qualities such as special components and required specialized installation techniques; and identify as appropriate, any E^3 deficiencies and the risks associated with them. The E^3 WIPT/EMCAB documentation should address, as a minimum, each of the following:

a An integrated operational profile of the intended EMEs.

b. EMC Program tasks accomplished and the milestones that have been achieved.

c. Identification of documents used such as handbooks, standards, specifications, etc.

d. Design methodology, requirements, and techniques used to achieve and maintain EMC.

e. Analysis and measurement techniques used to define and verify EMC.

f. Documents provided to confirm/verify EMC.

6.5.7.2 Final report. The final report should be compiled progressively during a E^3 WIPT/EMCAB's existence, with interim reports issued annually. The final report should include summaries of all E^3 test results, deviation and waiver recommendations, and any exceptions taken to achieve EMC. The final report should also include an overall index, technical and executive summaries, and a list of documents which addresses the maintenance of an item's EMC.

7. SPECIFYING EMC PERFORMANCE REQUIREMENTS

7.1 General. E^3 control/EMC performance requirements are intended to promote EMC and thus minimize EMI. EMI has been known to disable entire platforms (i.e., combat ships, helicopters, etc.), adversely affect communications and weapon systems, and has been responsible for failed missions and loss of life. With emphasis being placed on joint/combined operations in which the EMEs are virtually unknown, E^3 control/EMC performance requirements should be specified and tailored to accommodate all of the possible EMEs that an item may encounter during its life-cycle. Appendix E, EMC Performance Considerations, addresses some of the techniques that may be used for achieving the desired level of EMC.

7.2 Contractual documents. Specifications, statements of work (SOW) and contract data requirements lists (CDRLs) are requirements documents used in solicitations which then become part of the contract that is awarded. It is essential that the requirements are clearly articulated during the preparation of these documents. Without specific attention to clarity during the development of these documents, it becomes very difficult to evaluate proposals against a common standard, and to enforce a contractor's performance after the contract has been awarded. Needs of the user should be clearly defined as part of the requirements definition. The success of a procurement action relies on the contractual documents (especially the specification) being a true and accurate statement of the user's requirements.

7.3 Specifications. Preparing an equipment specification is a key part of the acquisition process. DoD policies and guidelines for the preparation of specifications emphasize that requirements should be stated in terms of performance or "what-is-necessary" rather than telling a contractor "how-to" perform a task. 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 define the functional requirements of the item, the environment(s) in which it must operate, and its interface and interchange characteristics. A performance specification should state the requirements in terms of required 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. A properly constructed performance specification should assure the Government of a quality product at reduced cost, and greatly reduce Government oversight and contract administration.

7.3.1 Applicable EMC documents. MIL-STDs such as 461 and 462 and MIL-HDBK 237, as a minimum, should be referenced in an equipment specification. These standards and handbook along with MIL-STD-464, as a minimum, should be referenced in a system specification. Appendix A "EMC Bibliography", should be reviewed for other possible documents that would be appropriate to reference in a specific acquisition.

7.3.2 Specification E^3/EMC paragraphs. E^3 control/EMC requirements should be identified in the specification. The following two (2) paragraphs are examples of how to address E^3 control/EMC performance requirements in a specification:

a. EMI Control - The equipment shall be self-compatible and operate compatibly in its intended operational electromagnetic environment. As a minimum the equipment shall conform to the performance requirements of MIL-STD-461 when tested in accordance with the test methodology of MIL-STD-462.

b. EMI Tests - The equipment shall be tested in accordance with the applicable test procedures of MIL-STD-462.

7.3.3 Specification evaluation guide. An Evaluation Guide for specifications is presented in Appendix G, Paragraph G.3.8. Paragraph G.3.8.3 lists a number of E^3 control considerations that should be addressed, when applicable, in an equipment specification.

7.4 SOW. Specifications are the only documents permitted to state the qualitative and quantitative design and performance requirements for an item. A SOW establishes all the other work that is to be accomplished on the contract and describes this work in tasks that should be accomplished if the necessary deliverable documents and data are to become available. The contractor should be tasked in the SOW to perform the non-specification work that leads to the creation of data itself and other types of required deliverables. These deliverables will only be available if the work to prepare or obtain them is specified (tasked) in the SOW.

7.4.1 Applicable EMC documents. MIL-STDs 461, 462 and 464 (when applicable) and MIL-HDBK 237, as a minimum, should be designated as "Applicable Documents" in the SOW. Appendix A, "EMC Bibliography", should be reviewed for other possible applicable documents.

7.4.2 SOW E^3/EMC paragraphs. E^3 tasks that should be identified in the SOW include the establishment of contractor control procedures, test procedures and test reports. The following three (3) paragraphs are examples of how to address E^3 efforts in a SOW:

a. If a E^3 WIPT/EMCAB is an appropriate measure for the project, is the role of the contractor defined?

b. Does the E^3 program provide for an EMICP in accordance with MIL-STD-461? A E3IAR in accordance with MIL-STD-464?

c. For radar development projects, does the E^3 program provide for an EMCCP in accordance with MIL-STD-469?

d. For aircraft systems projects, does the E^3 program provide for an EMCCP/E3IAR in accordance with MIL-STD-461/MIL-STD-464?

e. If any standard tests are to be performed with commercial or NDI components of partially developed subsystems, does the E^3 program provide for:

(1) An EMITP/E3VP and EMITR/E3VR in accordance with MIL-STD-462/MIL-STD-464?
(2) An EMCTP and EMCTR for radar projects in accordance with MIL-STD-469?
(3) An EMCTP/E3VP and EMCTR/E3VR for a aircraft system in accordance with MIL-STD-461 and MIL-STD-464?

f. If specific types of analyses or predictions need to be performed, does the E^3 program identify them?

g. Does parametric measurements provide the data needed for the preparation of a frequency allocation application?

7.4.3 SOW evaluation guide. An Evaluation Guide for SOWs is presented in Appendix G, Paragraph G.3.9. Paragraph G.3.9.3 lists a number of E^3 control considerations that should be addressed, when applicable, in a SOW.

7.5 CDRL. The CDRL is the only 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 DD Form 1423 or an automated version of this Form. 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 Data Item Description (DID) utilizing DD Form 1664 is used to define each item on the CDRL. Each DID establishes a standard requirement for a data product. CDRL entries other than DIDs can be tailored on 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.

7.5.1 Applicable DIDs. DIDs are used for ordering various data products associated with hardware development. The most frequently ordered EMC documents are associated with MIL-STD-461, Interface Standard: Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility. These DIDs are:

a. EMI Control Procedures
DID No. DI-EMCS-80199

b. EMI Test Procedures
DID No. DI-EMCS-80201

c. EMI Test Report
DID No. DI-EMCS-80200

7.5.1.1 System DIDs. Three (3) DIDs associated with the recently approved Interface Standard for Systems E^3 Requirements (MIL-STD-464) should be ordered when applicable. These DIDs are:

a. E^3 Integration and Analysis Report (E3IAR)
DID No. DI-EMCS-81540

b. E^3 Verification Procedures (E3VP)
DID No. DI-EMCS-81541

c. E^3 Verification Report (E3VR)
DID No. DI-EMCS-81542

7.5.1.2 Additional DIDs. Part III of Appendix A, EMC Bibliography, should also be reviewed for other possible applicable EMC documents that may be ordered.

7.5.2 CDRL evaluation guide. An Evaluation Guide for CDRLs is presented in Appendix G, Paragraph G.3.10. Paragraph G.3.10.3 lists some of the E^3 control considerations that should be addressed, when applicable, on a CDRL. EMC Program Procedures, EMI Control Procedures, EMI Test Procedures and EMI Test Reports are discussed in Section 4 and in Appendix G.

8. TAILORING

8.1 General. An item should be designed to be compatible with itself, other systems, and the external EME to ensure the required performance is achieved and to prevent costly redesigns after the fact for the resolution of E^3 problems. A basic step, in every engineering effort, is to define the end product that will satisfy the operational requirement(s). The design requirements for an item become more precise as more detailed data becomes available. Sufficient data on the EM characteristics of the EME as well as the proposed item are needed in order to develop specifications which are tailored to the operational requirements that provide cost-effective EMC performance. This data can provide invaluable guidance to a program manager, especially early in the conceptual phase of an item's development, for determining the feasibility of meeting various EMC performance requirements and for presenting alternative means with which to achieve the desired results. Conducting feasibility and trade-off studies early in an item's development will save a considerable amount of effort and costs from being expended later.

8.2 Tailoring. Tailoring is the process by which the requirements of a document are adapted to the characteristics or operational requirements of an item under development. Since each system, subsystem and equipment has its own requirements and characteristics, general EMC performance requirements may not be adequate. Quite often the design requirements for items that operate in critical EMEs need to be made more stringent. Tailoring involves making modifications, deletions, and/or additions to a basic document. Tailoring the requirements of a document should either improve the performance of the item under development or reduce the item's development or life-cycle costs without compromising the item's operational capabilities. Tailoring the requirements of a document does not constitute a waiver or deviation from the requirements of the document. DoD-HDBK-248, Guide for Application and Tailoring of Requirements for Defense Material Acquisitions, and DoD-HDBK SD-2, Buying NDI - Nondevelopmental Item Program, should be referred to for guidance on tailoring.

8.3 Tailoring process. Tailoring is an important step in the preparation of statements of work, data requirements, and the requirements document. 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, paragraphs and sentences of the selected standards, specifications, or related documents are evaluated to determine the extent to which they are suitable for an item's acquisition. As required, individual requirements should be tailored to ensure that each achieves an optimal balance between the items's operational needs and acquisition costs. After tailoring the specifications, standards and related documents they should be contractually invoked either wholly, or in part, at the appropriate point in the item's acquisition cycle.

a. Statements of work typically contain references to standards which describe requirements for processes, procedures, practices and methods. Contract Data Requirements are established through referenced data item descriptions. The requirements document may contain references to other specifications which establish additional requirements for the item. It is these referenced documents that should be tailored to the circumstances of each item being acquired.

b. The specific requirements for an item's acquisition is the responsibility of the program manager. He should tailor the performance and design criteria to meet the applications and operating conditions for which the item is intended to be used. When tailoring specific requirements they should always be kept within the range of acceptable limits for the item's intended use.

c. Unique requirements should be carefully addressed so that tailoring does not drive up the performance criteria and costs unnecessarily for all of the units of an item when the unique requirements apply to only a very small fraction of the total number of units being acquired. Separate and less expensive solutions such as the modification of individual units or the development of field kits/add-ons should be considered to satisfy a unique application involving only a few units.

d. Certain items may be operated only during particular phases of a mission. If it can be demonstrated that a group of equipment or subsystems will never be operated concurrently with the item, the requirement for intra-system compatibility can be tailored for that condition.

e. EME conditions under which an item is to be fully operational should be tailored to the specific application and use of the item should be based on the specified EME conditions. MIL-STD-461,462 and 464 are tri-serviced coordinated documents which standardize the EMC performance and test requirements. These requirements should be used as a baseline.

8.3.1 Operational EME. The operational environment includes the entire EME in which an item is to be placed. To acquire the EM characteristics for each system, subsystem, and equipment that the EME is comprised of is often prohibitively expensive and the quantity of data in many cases would also be too comprehensive for routine processing. A more practical method is to acquire the EM characteristics of only those systems, subsystems, and equipment that may either interfere with an item's performance or conversely be interfered with from the item, and thus potentially effect the intended operations.

8.3.2 Platform EME. The platform EME is comprised of all the EM characteristics from the components of all the systems, subsystems and equipment within the platform. Defining the platform EME accurately is dependent upon obtaining detailed data on the EM characteristics of each component. An initial gross analysis of the EM characteristics should indicate whether a more detailed analysis is required. MIL-HDBK-235, Electromagnetic (Radiated) Environment Considerations for Design and Procurement of Electrical and Electronic Equipment, Subsystems and Systems, may be used to obtain general information on the EM characteristics for some of the EMEs.

8.3.3 Defining EMC operational performance requirements. The EMC operational performance requirements should be defined as early as possible in the conceptual phase of an item's development. The Program Manager should gather as much information as possible on the EM characteristics of the item and the EMEs that the item is intended to operate in. Based on this information the specific requirements of an item can be defined. As more precise data becomes available the specific requirements should be updated. This information can normally be obtained from the users, engineers and systems developers. The following is a checklist of questions which may be used, with modifications as necessary, to compile the kinds of information needed for defining the EMC operational performance requirements and EMEs:

(1) What is the item intended to do?
(2) Is the item tactical? mobile? transportable? fixed plant? strategic? target-dependent?
(3) Does the item stand alone, or is it part of a larger system?
(4) What are the signal inputs and outputs, and their range of frequency and power?
(5) What are the frequency constraints and requirements?
(6) What are the basic power requirements?
(7) What are the frequency range requirements?
(8) What is the sensitivity requirement for receiving equipment?

(9) Where will the item be used?
(10) What will the platform EME be?
(11) Is the item required to operate continuously or intermittently?
(12) Are there any location, size, or weight restrictions?
(13) When is the item to be operative?
(14) How will the item be maintained, operated, and supported?
(15) To what extent is the item manned during operation?
(16) What are the classification aspects of the item and its application?
(17) Will classified information be accessible in a clear-text form at any point?
(18) Is the item critical to some military operation; and if so; what?
(19) Are there critical sequences of operations involving this item?
(20) To what extent will malfunctions affect mission success or personnel safety?
(21) What is the transmission medium?
(22) How is the item matched and coupled to the medium?
(23) If antennas are involved, what special characteristics should be considered?
(24) Is the item active or passive (that is, does it transmit, receive, or both)?
(25) Is signal processing equipment required?
(26) With what equipment does the item interface directly or indirectly?
(27) What type of modulation will be used?
(28) What waveforms are involved?
(29) What are the frequency and spectrum requirements?
(30) What are the required sensitivity and resolution.
(31) What are the minimum threshold responses for both amplitude and duration?
(32) What are the accuracy requirements?
(33) Is this an analog or digital operation?
(34) Are there any special remote control requirements?
(35) In what type of facility is the item to be installed?
(36) What other equipment will be in the same installation?
(37) Are there any inherent, definable problems expected as a result of grounding systems being used?
(38) Are there space-available problems to be anticipated?
(39) Are there any special co-site problems anticipated?
(40) What are the inherent shielding characteristics of the installation?
(41) Will the item be exposed to enemy electronic countermeasures (ECM)?

9. COMMERCIAL AND NDIs

9.1 General. Commercial and non-developmental items (NDIs) are items already developed that may be capable of fulfilling operational requirements either "as is" or with some modification(s).

9.1.1 Commercial item. A commercial item is any item customarily used for nongovernment purposes and has:

a. Been sold, leased, or licensed to the general public.

b. Been offered for sale, lease, or license to the general public.

c. 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.

9.1.2 NDI. A NDI is any item:

a. Previously developed and being used exclusively for governmental purposes by a Federal Agency, a State or local government, or a foreign government with which the United States has a mutual defense cooperation agreement.

b. Described in a., above, which requires only minor modification(s) to meet the requirements of the procuring agency.

c. Currently being produced but does not meet the requirements of a. or b., above, solely because the item is not yet in use.

9.2 Policy. DoD policy is that all material requirements should be satisfied to the maximum extent practicable through the use of commercial items and NDIs when such products will meet the user's needs and are cost-effective over the entire life cycle.

9.2.1 Procedures. Acquisition procedures for commercial items and NDIs are neither new nor significantly different from established acquisition procedures. The objective of the acquisition process, obtaining best value in meeting an item's requirements, should still be achieved with commercial items and NDIs. The acquisition process should ensure that operational and logistical requirements are met before systems and equipment are selected, acquired, and deployed.

9.2.2 Acquisition process. Market research and analysis should be conducted to determine the availability and suitability of existing commercial items and NDIs prior to the commencement of a development effort, during the development effort, and prior to the preparation of any product description. The PM should define the requirements in terms that enable and encourage offerors to supply commercial and non-developmental items and provide offerors of commercial items and NDIs an opportunity to compete in any procurement to fill such requirements. Commercial and 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. Simplifying the contracting process and eliminating practices which inhibit the acquisition of commercial and non-developmental items should be implemented to encourage greater use of these items.

9.2.3 Operational requirements. Commercial items and NDIs should meet the basic operational requirements and function in their intended operational EMEs. Commercial items, NDIs and developmental acquisition programs all should address logistics support, test and evaluation, reliability and maintainability, electromagnetic compatibility, and safety issues.

9.3 Electromagnetic compatibility (EMC). The degree of compliance with EMC performance specifications and interface standards should be ascertained to ensure a commercial or non-developmental item's performance is not degraded in its intended mission EMEs. Commercial items and NDIs should also be electromagnetically compatible with existing operational equipment and systems. The fact that a commercial item or NDI is already accepted in the commercial marketplace or another Service operational EME does not ensure the EMC performance requirements will be achieved in a new operational EME.

9.3.1 EMC in design. EMC is an important design consideration during a development program. Since the basic product of a commercial item or NDI is already designed it is essential that the intended EME(s) and required EMC performance characteristics of each candidate item be assessed. Modifications required to correct E^3 problems in an operational commercial item or NDI can be time consuming and very costly. E^3 problems can present a potentially hazardous situation resulting in loss of life, damage to hardware, or degradation of mission performance capability.

9.3.2 EMC performance requirements. Quantitative EMC performance requirements should be established for electrical and electronic commercial items and NDIs. Prior to Milestone I, a through analysis should be accomplished and EMC performance parameters identified for comparison with what is available in the marketplace. Criteria for evaluating the EMC performance of commercial items and NDIs should be the same as in development programs.

9.3.3 Commercial specifications/standards. One of DoD's goals, with respect to equipment acquisitions, is to have greater reliance on commercial products/processes. To achieve this goal DoD is emphasizing the use of commercial specifications/standards in lieu of military ones. However, not all commercial and NDI equipment will function properly in military EMEs. Some commercial E^3 specifications/standards are inadequate for military platforms (i.e. do not stipulate susceptibility/immunity performance requirements, do not address the concern of common-mode EMI, etc.). A comparison between military and commercial EMC performance requirements is a first step in determining if:

a. Use of commercial or NDI equipment is practical.

b. More testing is required.

c. Equipment must be hardened.

9.3.3.1 Comparisons. Items successfully tested to commercial EMC requirements may meet a portion of the military EMC performance requirements. Being able to make comparisons between military and commercial specifications/standards can save an appreciable amount of effort and money when qualifying commercial items and NDIs for military applications. In order to make useful comparisons the minimal EMC performance requirements essential for mission effectiveness should first be established by tailoring MIL-STD-461 and MIL-STD-464 (when applicable) to the specific application. These EMC performance requirements should then be compared to the EMC requirements of the specifications/standards that were used to develop the commercial item or NDI that is being considered for procurement. When a commercial EMC requirement is equivalent to or more stringent than a MIL-STD-461/464 tailored requirement it can be assumed the commercial item or NDI satisfies the military EMC performance requirement. If there is no equivalent commercial EMC requirement, testing in accordance with MIL-STD-462 can be conducted to demonstrate whether the commercial or NDI's EMC performance is in compliance with the established performance requirement(s) of MIL-STD-461/464.

9.3.3.2 Civilian standards. DoD Regulation 5000.2-R states commercial items being procured will be based on nongovernment standards and commercial item descriptions to the maximum extent practicable. Thus the application of civilian EMC performance requirements in military procurements has become part of the acquisition process. A guide on the Use of Civilian EMC Standards by Military Agencies is provided in Appendix F of this handbook. Comparison charts are included in Appendix F which delineates whether it is possible to compare MIL-STDs-461/462 with the FCC requirements for digital devices, European Union (EU) requirements for information technology equipment, and the Radio Technical Commission for Aeronautics (RTCA) environmental conditions and test procedures for airborne equipment. Comparisons were made on the basis of (1) performance requirements (limits), (2) test method(s) to be used for verifying compliance with the requirements(s) and (3) the applicable frequency ranges. Depending on the tailoring of MIL-STDs-461/462 for the specific application being considered, it might be necessary to perform an EMC assessment and/or conduct testing to demonstrate a commercial or NDI's level of EMC while operating in its intended operational EMEs.

9.3.4 EMC data. Various approaches can be taken to gather valid data for an EMC assessment of a commercial item or NDI. One approach is to request and review any EMC analyses or measurements that the manufacturer has performed during the design and development of an item. The EMC performance requirements stated in the Operational Requirement document should be used as a baseline for the EMC assessments. When quantitative data is not available, it may be possible to assess relative EMC values. This approach as well as others should be used to obtain enough EMC data upon which to support a commercial or NDI decision. Testing should be required when there is insufficient data available to resolve the EMC issues associated with a commercial or NDI acquisition.

9.3.5 Alternatives. Several alternatives exist when EMC assessments or the testing of commercial items or NDIs demonstrates that available equipment or systems cannot meet the EMC performance requirements. These alternatives include:

a. Shielding or isolation of the item.

b. Frequency management.

c. Filtering.

d. Blanking.

e. Modifying a commercial item or NDI to meet the EMC performance requirements.

f. Reassessing the existing mission profiles to determine if the commercial or NDI's demonstrated EMC performance is acceptable.

g. Abandoning the commercial and NDI acquisition strategy when EMC is an extremely critical design characteristic, or when the EMC parameters of available commercial items and NDIs are far inferior to the requirements

9.4 Test and evaluation. T&E is a major control mechanism of the acquisition process. Programs typically move from one acquisition phase to the next or are funded incrementally based on the resolution of critical operational issues and the achievement of established thresholds which are verified through T&E. General guidance for commercial and NDI acquisitions is that testing should be limited when existing data from the contractor or other sources is sufficient. The goal is to minimize testing requirements for commercial items and NDIs, when ever possible, by using existing historical data and marketplace acceptance of the item. It is important that development and operational test proponents become involved early in a commercial or NDI acquisition in order to actively participate in the verification of existing test data and the planning for any additional tests that may be required. Testing should focus on those areas where data is inconclusive or where performance assessments against unique operational requirements should be conducted.

9.4.1 Verification. Verification of a COTS or NDI's performance in its intended EMEs should be required through both technical and operational evaluations, as appropriate. The circumstances unique to a commercial or NDI acquisition dictates the level of testing required, if any, and should be delineated in the TEMP. Commercial and NDI acquisitions involving minor or no modifications, that will operate in the same EMEs for which they were designed, should result in having more reliance placed on the existing test data and the past history of the item. Conversely, commercial items and NDIs requiring some modification, or those that will be operated in EMEs for which they were not originally designed, should require additional testing in order to verify the performance, operational effectiveness, safety and suitability of the item.

9.4.1.1 T&E strategy. Per DoD Regulation 5000.2-R, Part 3, Paragraph 3.4.1, sufficient testing must be conducted on commercial and non-developmental items to ensure performance, operational effectiveness, and operational suitability for the military application. The test program should be tailored to recognize commercial testing and experience.

9.4.1.2 Development test and evaluation. This testing is conducted on a modified commercial item or NDI to verify the attainment of technical performance objectives and should be planned and reported by the developing agency acquisition manager. Development testing should not be reduced unless the acquisition manager or the test proponents identify specific existing commercial or other test data that meets the needs of the development program. Risks associated with hardware/software modifications and integration of components should be carefully considered when determining development testing.

9.4.1.3 Qualification testing. Qualification testing is used to verify the design and the manufacturing process and provides a baseline for subsequent acceptance tests. Follow-on evaluations may need to be performed on those items that demonstrated marginal EMC performance characteristics during qualification tests.

9.4.1.4 Operational test and evaluation. This testing is used to assess a systems operational effectiveness and operational suitability, identify the need (if any) for modifications and provides information on the tactics. Commercial items and NDIs usually require operational testing. However, if the cognizant developing agency can demonstrate that existing data indicates the commercial item or NDI meets both operational and suitability requirements, operational testing may be waived. This determination should be included in the decision milestone review documentation and should be approved by the MDA.

10. JOINT E^3 CONTROL STRATEGY

10.1 General. The Joint E^3 Control Strategy (JECS) is a problem-avoidance measure in direct support of the Electromagnetic Compatibility Program (EMCP) requirement and Policy of DoDD 3222.3. JECS implements direction that systems and equipment should be developed to be electromagnetically compatible with the electromagnetic environment (EME).

10.1.1 JECS formulation. In recognition that a majority of E^3 problems arising in the field can be shown to have been avoidable during development or in acquisition, JECS has been formulated for implementation at the Military Department (MILDEP) level. JECS was formulated in such a way as to:

a. Ensure that no additional work load was placed upon Program Managers (PMs).

b. Use only existing resources.

c. Be adaptable to new organizations or changes in policy and procedures.

10.1.2 Other uses. Although developed for engineering offices (ENO), PMs and E^3 WIPTs may also use the JECS process as a guide. The PM should find the JECS process of value when preparing his EMC Program Procedures, approving contract E^3 deliverables, documenting E^3 control/design issues, and in refining and assessing his program's E^3 control efforts.

10.2 JECS goal. The JECS goal is to eliminate the degradation of joint operational capabilities due to EMI and other electromagnetic effects, hazardous or destructive, that are present or latent in acquired equipment and systems. By the use of JECS, joint forces should be able to attain maximum effective performance from warfare systems that depend upon or which are susceptible to EM energy.

10.3 JECS purpose. JECS was created to be implemented within and by a MILDEP. The purpose of JECS is to establish, for the disciplines of E^3, a mechanism to monitor acquisition programs in order to ensure appropriate E^3 control considerations are addressed. E^3 status information is a by-product available to Acquisition Executives (AE) and designated subordinate officials, as is technical expertise to the program offices.

10.4 JECS scope. The scope of JECS is broad. JECS covers the acquisition of electromagnetically compatible platforms, systems, subsystems and equipment whether intended for employment on land, on or under the sea, in the air, or in space. JECS is adaptable to all acquisition programs.

10.5 JECS concept. JECS is based on the recognition that electromagnetically interfering and susceptible equipment designs should be eliminated or avoided during development and in acquisition. A majority of E^3 problems, including degradation by EMI, radiation hazards to personnel, ordnance, and volatile liquids, EM pulse effects, and other E^3 manifestations in joint force operations, will not mature to impact operating force systems performance if E^3 control deficiencies are eliminated at the onset. The JECS effort should be initiated at the earliest recognition of a requirement for an item and broadened during the DoD Research, Development and Acquisition (RD&A) process. When the item is deployed, the JECS effort should be reduced to a low monitoring level. The item should remain as a continuing E^3 concern, however, throughout its life cycle in all supporting platforms. Extended interest in E^3 concerns is necessary to ensure preservation of the features providing EMC.

10.5.1 JECS method. The JECS method was formulated with the intent to accommodate and to adapt to the needs of the MILDEPs and other DoD Components and their program offices. JECS functions within the acquisition process, supporting and in consonance with policies and procedures of DoDD 5000.1, and DoD Regulation 5000.2-R. Spectrum management policies of DoDD 4650.1 are also supported.

a. The JECS method uses exit criteria in conjunction with a positive control methodology called gating in its own internal operation to monitor the planning and application of E^3 control measures. Exit criteria serve as gates that, when successfully passed or exited, demonstrates that the program is on track to achieve the required level of EMC performance and should be considered for continuation into the next acquisition phase. Exit criteria follows the principle explained in Part 3 of DoD Regulation 5000.2-R. JECS is intended to be a parallel activity to the Milestone-Phase cycle of Defense acquisitions.

b. The JECS concept is implemented by monitoring the acquisition process. Within a command or activity performing acquisition functions for a MILDEP, a designated ENO selects a small group of engineers as JECS evaluators. These evaluators can use the JECS process to perform an oversight role for EMC and other E^3 concerns, and to offer supporting technical expertise. Each emerging requirement and subsequent program should become the object of a quasi-continuous evaluation by the ENO. The ENO should monitor the extent, along with evaluating the suitability and adequacy, of the E^3 control effort that has been incorporated. The gating process is carried on internally within the ENO only.

c. The ENO should monitor programs and advise PMs directly on the results of program E^3 control evaluations. Preferred E^3 control measures should be recommended when the efforts of a project appear inadequate. The ENO has no authority over any PM, but should have the right to liaison with each PM and program office directly on their level, and the right to have access to and to obtain copies of any program/project documents. The desired relationship between the ENO and a program office should be one of mutual support, rather than adversarial. Based on an evaluation of project documents and their timeliness, the ENO should provide the PM its reviews citing recommendations for additions and changes preferred in current and planned project E^3 control measures. These reviews and recommendations should not be binding upon the PM; they reflect an opinion on a technical area or on engineering management decisions affecting the area. The only obligation on the PM should be that he gives the recommendations due consideration. In this manner JECS adheres to the direction of DoDD 5000.1 and DoD Regulation 5000.2-R.

d. To facilitate evaluations, JECS establishes one or more objectives for accomplishment not later than the terminating milestone for each specific phase of development. In addition to their routine use as standards for evaluations performed by the ENO, the creation of these objectives responds to the direction in Part 3 of DoD Regulation 5000.2-R to prepare exit criteria for each milestone review. Since the exit criteria required are candidate materials for phase objectives during the next phase, the appropriate JECS objectives are those for the forthcoming acquisition phase following the current milestone. Used for exit criteria, an objective may be tailored and refined as appropriate to the circumstances of the program. Internally, the next milestone is referred to as the gate. When there are multiple JECS objectives for a particular milestone, each separate objective is said to have its own subgate. The satisfaction of all subgates is necessary to open the gate. Ten (10) objectives have been established to facilitate JECS evaluations. These objectives are broad and relate to the principle concerns of E^3 control for the phases in which they are presented. The objectives for the period prior to Milestone 0 and each of the four (4) RD&A phases are:

(1) PRE-CYCLE PERIOD - Determination of Mission Need(DMN) Objective:

Established fundamental guidance for bilateral EMC between the desired platform, system, or equipment item and the intended EME.

(2) PHASE 0 - Concept Exploration (CE) Objectives:

(a) Subgate CE-1 Objective. Establish, in the approved requirement, that the specified operational performance level of the item will be fully achieved in its intended EME.

(b) Subgate CE-2 Objective. Ensure that program and preproject planning addresses the E^3 control organization and provides arrangements for early EME assessment, analyses, and testing during development or acquisition.

(c) Subgate CE-3 Objective. Ensure that significant risks of EMI or EM radiation hazards characteristic of or inherent in each solution presented were adequately addressed during the decision process.

(3) PHASE I - Program Definition and Risk Reduction (PD&RR) Objectives:

(a) Subgate PD&RR-1 Objective. Establish E^3 control and testing requirements for engineering development.

(b) Subgate PD&RR-2 Objective. Determine that known or projected EMI or EM radiation problems of the project item are judged resolvable in engineering development.

(4) PHASE II - Engineering and Manufacturing Development (EMD) Objectives:

(a) Subgate EMD-1 Objective. Ensure that the developmental model achieves full operational performance levels in the intended EME without generating EMI problems or unresolvable EM Hazards.

(b) Subgate EMD-2 Objective. Ensure that the E^3 control requirements established for the production model will preserve the EM performance demonstrated by the approved development model.

(5) PHASE III - Production Fielding/Deployment, and Operational Support (PF&OPS) Objectives:

Subgate PF&OPS-1 Objective. Ensure through testing that the production model meets all E^3 control requirements established for it.

Subgate PF&OPS-2 Objective. Ensure that documentation supporting redevelopment or upgrading of an item incorporates the E^3 control requirements needed to correct any existing E^3 problems of the current item.

e. The phases of the JECS process and the DoD RD&A process as set forth in DoD Regulation 5000.2-R are concurrent and bear the same names. Also, the same milestones used in the Defense Acquisition process are used by the JECS. One additional JECS milestone, Production Acceptance Tests and Evaluation (PAT&E), is added to recognize when the last stage of Phase III, Operational Support (OPS), starts. The distinction of a JECS milestone is only necessary where the RD&A cycle has none, and for a JECS DMN period before Milestone 0. During an evaluation and each subsequent revaluation after receipt of new information, the adequacy of E^3 control measures and the status of the project for the next anticipated gate should be reexamined. The degree to which gate objective(s) (exit criteria) have been achieved should again be assessed. Consequently, as each major decision point is approached, the interactive nature of the JECS process affords an evaluator a current and on-going appreciation of the project E^3 control efforts. So informed, the ENO evaluator can effectively present the merits of permitting the project to proceed from the standpoint of E^3 control considerations.

f. Appendix G addresses the Defense Acquisition life cycle in greater depth. The major project concerns occurring in each of the five (5) phases are described as background for the JECS process. The JECS goal and the milestones/gates and objectives for each phase are displayed in FIGURE G-1. FIGURE G-1 is presented on a fold-out page at the end of Appendix G so it may be folded out for reference.

10.5.2 Issues for decision. The structure of the JECS, in particular the choice of gate points, is formulated so that the JECS process complements the decision-making process for the review and approval of military system requirements, the RD&A process that may follow, and the acquisition regardless of source. A characteristic mechanism of decision forums is their use of prepared issues to state fundamental problems and to focus the discussion when assessing items on an agenda. As a proposed requirement or an on-going project nears the time for its milestone review, it is placed on an agenda, and a call for issues relating to it is made by the secretariat of the decision forum. Generally, these forums work to a decision by weighing and balancing the considerations for a requirement or project as stated in the issues. Because schedules are tight, issues reaching the agenda are those of significance and which are truly critical. Presentations should be carefully scaled to essentials. Consequently, it is important that the E^3 issues be well considered, fully supportable, and clearly expressed. The issue(s) should establish in concise statements that there are critical and unacceptable threats of E^3 degradation to an items performance if the requirement or project proceeds without redirection of its current path.

10.5.2.1 Formulation of issues. The ten (10) objectives are established prior to the Milestones and the four (4) RD&A phases. The objectives are broad and relate to the principle concerns of E^3 control for the phases in which they are presented. In addition, a correspondingly broad primary issue statement is provided for each objective. The primary issues are presented in Appendix G, together with one or more corollary issues. Corollary issues are issues derived from the primary issues in terms more specific to the program situation being addressed. They are issues intended to be suitable for addressing serious E^3 control deficiencies at a program review level. Corollary issues presented in Appendix G are for some of the more important variations and aspects of the primary level issues. Corollary issues should be written to narrow the focus of E^3 control scrutiny to actual, more detailed considerations. The corollary issues presented are not expected to be directly applicable to any actual situations, except by coincidence. They serve to illustrate the tailoring of primary issues to more specific levels of concern for a number of common problems. It is unlikely that these corollary issues will directly cover the specifics of a real problem without some tailoring for the actual facts. On the other hand, a program well founded, with no evidence of E^3 problems or deficiencies may be reasonably characterized by affirmation of one of the broad primary issues.

a. An ENO evaluator, while employing the JECS process, should build and refine the evaluation of a project over a period of time. He should receive information concerning the project from relevant project documentation. The information from each document should be assessed to determine how well it supports the achievement of the JECS objective(s) for the current acquisition phase. An initial evaluation should be of limited scope because of the limited base of information. The JECS method requires a project be reevaluated each time new information becomes available. The evaluator, while evaluating a new or revised document, should assess the relevance of new or changed data to previous information. He can then modify the appropriate general gate issue set forth by JECS into more detailed issue statements which characterize the specific problem at hand. An issue should be written to afford an effective balance between generality and detail. More importantly, an issue should always illuminate the contribution that resolving a problem makes to the satisfaction of the program requirements.

b. As a project nears the milestone ahead and the end of a phase, the information expected from all sources should have been accumulated and integrated. In a properly planned and supported project, the residual E^3 concerns should have dissipated through a number of resolutions so that the general gate issues (exit criteria) will gradually suffice with little refinement. Ideally, at the milestone all basic issues should be fully resolved; all objectives should be completely achieved.

10.5.2.2 Raising an issue. Program impacts of significant E^3 control deficiencies not resolved through direct liaison should be raised as issues accompanied by risk assessments to program or milestone reviews. This places an E^3 issue for consideration and decision at a level of authority commensurate with the risk. Issue preparation should be an iterative task. An on-going JECS process should readily provide a current status on items being covered. Consequently, when issues are required for an approaching program review, or if an inquiry for program status in the area of E^3 is to be answered, the ENO can select from the previously developed issues and the anticipated E^3 control program status. Because existing issues on an item may vary widely in their substance and importance, the ENO should select the issues of greater significance and merit, refining and often consolidating as appropriate.

10.5.3 Key documents. For the purposes of JECS, it is not important that information is supplied by any particular document, only that it becomes available on a timely basis in a suitable form. During JECS formulation, however, a survey of available documents and information requirements identified a minimum set of document types applicable to and available for most programs. This set is listed in the first column of TABLE 1, the Key Documents List. These documents are responsive in time and scope to JECS needs, are normally available, and consequently are designated as Key Documents (KDs). The Key Documents list should be considered a floor, representing the minimum practical group of documents which can supply the information needed to effectively monitor the E^3 control considerations of a program. Ordinarily, the availability of these KDs should adequately support JECS evaluation needs. The use of other available documents is encouraged, to augment the range and depth of information available on a particular program. The term Additional Document (ADDOC), checked at the bottom of each phase column, is a reminder of this. The list is intentionally limited for a number of reasons, including redundancy of information, limited availability of documents, and dilution of a finite capability resident in an ENO to monitor a program.

10.5.3.1 Key documents list. The first column of TABLE 1 lists the names of Key Documents. The second through the sixth column are phase columns. These columns identify the RD&A phase to which a particular KD type applies. Those key documents listed in column 1 which show a check in more than one phase are considered as a family of distinct documents, a similar type of iterative document, of differing versions. At the top of TABLE 1 the names of the DoD acquisition phases are abbreviated (on the fold-out, FIGURE G-1, the full name for each of these phrases are shown). The DoD Milestones are shown by Roman Numeral on the phase boundaries below the phase abbreviations. The "P" after Milestone III represents the JECS Gate at the Production Acceptance Tests and Evaluation (PAT&E) milestone. All of the other JECS gates occur with corresponding DoD milestone. There are 45 KDs in TABLE 1 consisting of 15 types of documents.

TABLE 1. Key Documents List .

Key Document (KD)	Acquisition Phases					
	DMN	CE	PD& RR	EMD	PF&OPS	
	JECS Milestones					
	0	I	II	III	P@	
Mission Need Statement (MNS)*	x					
System Threat Assessment Report (STAR)*		x	x	x		x
Operational Requirements Document (ORD)*		x	x	x		x
EMC/EME/EMI Control Procedures/E3 Integrated and Analysis Report (E3IAR)			x	x	x	
EMC/EME/EMI Test Procedures (TP)/E3 Verifiction Procedures (E3VP)				x	x	
EMC/EME/EMI Test Report (TR)/E3 Verifiction Report (E3VR)				x	x	
Test & Evaluation (T&E) Report			x	x	x	
Eng. Ch. Proposal, Deviations & Waiver				x	x	
EMC Program Procedures (EMCPP)*		x	x	x		
Integrated Program Summary (IPS)*		x	x	x		x
Test & Evaluation Master Plan (TEMP)*		x	x	x		x
Application for Equip. Freq. Allocation (DD Form 1494)	x	x	x	x		
Specification (SPEC.)#		x	x	x		
Statement of Work (SOW)#		x	x	x		
Contract Data Rqmts. List (CRDL)#		x	x	x		
Additional Documents (ADDOCS)	x	x	x	x	x	x

@ - Project milestone for Production Acceptance Test & Evaluation
* - For next milestone # - For use in next phase

10.5.3.2 Document evaluation. The JECS evaluation of a document is performed to obtain information on the progress of a project and to evaluate, from an E^3 standpoint, the chances for project success in attaining the degree of E^3 control needed. The ENO evaluator should be interested in the amount and accuracy of the information present in a document bearing on E^3 control issues rather than the editorial form and quality. In the latter part of Appendix G there are 15 evaluation guides for the 15 types of Kds.

10.5.4 Gate closure and issue resolution. The JECS gate should remain closed for the forthcoming milestone when it becomes apparent from the information available that the program's direction ignores the JECS recommendations (objectives) and does not support the favorable resolution of E^3 issues deemed critical to the item. Moreover, a closed gate alerts the ENO that resolution of the issue(s) may be necessary at a higher level commensurate with the degree of risk to be accepted in failing to correct the perceived E^3 control deficiencies. The ENO evaluator assigned to the problem should refine the current (corollary) issue statement for use at the next program review. He should prepare a supporting risk assessment and should assemble documentation verifying the contentions of the ENO with respect to the E^3 status of the item. The ENO should then proceed to provide support as required for the milestone at hand. For programs other than Acquisition Category (ACAT) I, the individual MILDEPs implementing JECS should issue supporting instructions in accordance with DoD Regulation 5000.2-R.

10.5.5 The JECS concept summarized. The overall structure of the JECS, with its goal and objectives, is summarized in FIGURE G-1. The JECS process requires the ENO maintain an open-ended assessment of each project. An assessment should be based on the information in aggregate derived from the JECS evaluation of KD sources. So informed, an ENO evaluator can maintain a current appreciation of a program's status in fulfilling the JECS primary issue(s) and attaining the corresponding JECS objective(s) for the current ending phase. When E^3 problems do surface, more specific issues should be derived as central corollaries to the primary issue(s), and should be refined to highlight pertinent details. The ultimate measure to resolve unfulfilled issues is taken when these issues are raised to a program review forum.

10.6 JECS technical application. In a manner similar to that used by Defense Acquisition in tailoring acquisition strategies to meet the realities of development, the parallel tailoring of JECS is often appropriate. Tailoring is easily accomplished, and is addressed in the following paragraphs.

10.6.1 JECS and the acquisition process. The RD&A cycle is comprised of three separate and distinct activities: Research into new technologies; development of new hardware; and the acquisition of hardware items regardless of source (developmental, commercial or NDIs). This is more than a simple three-fold distinction, however, as sources include: Service-developed hardware; military items of other U. S. Services; foreign military items; ruggedized and special application hardware for space, civil aviation, or other high-stress fields; off-the-shelf commercial items; and the combination of items involving minor modifications, the integration of developed and non-developed units or higher level items, or the assembly of lower level combinations. It should be recognized that:

a. In the long view, the JECS process is applied on three levels: to requirements, to the degree of development effort that occurs, and to the acquisitions if they are pursued.

b. The JECS process should be applied to all sources of military material for which there are E^3 considerations, whether for developed items, commercial items or NDIs. Non-development is neither an issue nor is it an exemption.

c. The RD&A review framework and milestones provide the time-ordered structure to which JECS gates and objectives are matched. The structure of JECS also supports the search, analysis, evaluation, and selection process for commercial and NDI sources.

10.6.2 Development in the full RD&A cycle. FIGURE G-1, the JECS chart, presents the RD&A phases and Defense Acquisition milestones, as well as depicting JECS gates and objectives. Various changes have been made from time to time in the RD&A cycle over several decades of use. A process of the JECS type, providing oversight and monitoring capability, can be easily adapted or readapted to work under a larger system of similar functional methodology. Major system and subsystem projects for platforms and the more important non-platform military subsystems are of such complexity and magnitude that a full and unabridged development is usually essential. Maintained wholly in consonance with DoDD 5000.1 and DoD Regulation 5000.2-R, the JECS process supports a continuing effort to monitor such programs, using the full range of KDs from TABLE 1.

10.6.3 JECS with varied acquisition strategies. When the scope or complexity of a requirement is of a lesser magnitude, the full RD&A cycle is often unnecessary. For lower level projects of simplicity and reduced scope, the state of the art is not ordinarily pressed, and technological risks are low or non-existent. The value of program resources involved is consequently low as well. A common development procedure is to proceed with an approved requirement without a formal Milestone I. Under the conditions described above, the necessity for Phase I, PD&RR, may also be nil, there being no need to demonstrate a concept or ability to utilize a new technology or to validate a choice selected from multiple options. The waiver of a formal Milestone II may also be a reasonable project simplification, initiating the project in Phase II, EMD at the onset. It is not necessary to develop a complex conversion procedure to use JECS in a non-standard, reduced-phase situation. The adaption required is as follows:

a. Retain all JECS coverage corresponding to the portion of the RD&A phase structure which is to be required of the program.

b. Also retain any JECS coverage which supports RD&A actions out of the deleted phase(s) and other structures that, despite waivers, should be accomplished to initiate the project. (The KDs marked in TABLE 1 as prepared for the next phase are usually of this type).

10.6.4 Tailoring and streamlining. The establishment and long-term use of a formal RD&A cycle for which time-regulated procedures and events are carefully structured (i.e., a standardized acquisition strategy), has a conservative effect which resists adaption, abridgement, or variation. These influences have resulted in long developmental efforts of greater cost, without commensurate benefits. Contemporary emphasis has now placed great pressure on efforts to alleviate these problems without exacerbating others further.

a. Tailoring is the umbrella term for an extensive array of measures offering potentially suitable adaption, modifications, and innovations to RD&A procedures. These measures may be suitable for use with a requirement to secure the best possible cost-benefit trade-off in achieving an operationally suitable and effective product item. The performance specifications defined in a requirements document are frequently sensitive and powerful cost drivers, and should be analyzed carefully to avoid overstatement. Other measures include variations in competitive development to minimize the cost of ownership.

b. Streamlining is a procedurally oriented set of measures intended to minimize the burden of oversight on the RD&A process by a well-intentioned but (perhaps) excessive layer of organizational structure. Streamlining manifests itself by limiting program reviews and delegating program approval to lower levels. The impact on the JECS process is to reduce the number of potential forums in which JECS issues may be raised. The practical effect, however, is to reduce the number of forums which may demand support from JECS to a more manageable level.

10.6.4.1 Tailoring with commercial and NDIs. JECS should be thought of more as an acquisition-oriented system rather than as one centering on development, and that the source of the item, developmental, commercial or NDI, is not a JECS issue. JECS does not need to be modified to accommodate commercial or NDI utilization as a tailoring measure.

a. There are no waivers of JECS objectives. They continue to apply to phases not waived. Any KDs from waived phases that should still be prepared for the project also become the start up documents for JECS.

b. The JECS DMN, CE, and PF&OPS objectives/issues remain applicable to commercial and NDI acquisitions; PD&RR may be waived except for project documents that must be prepared for the project start-up and initial contract. In EMD, while the bulk of development activity may be avoidable, testing is not legitimately waived unless the commercial item or NDI has been adequately documented for qualification to acceptable standards. Otherwise, substitute source-selection tests, examinations and demonstrations are necessary. In some manner, a commercial item or NDI component should prove that it meets the specifications of the requirement. E^3 control requirements are implicitly part of the operating performance requirements; to waive them would be to waive the performance requirements themselves. Testing alone verifies claims of capability and qualification. Off-the-shelf military (NDI) hardware should not receive special exemption and should also show certification of qualification or should be qualified.

c. The degree of accommodation for JECS during Phase II (EMD) depends on the character of the commercial or NDI's own development. An engineering adaption is actually a minor development. Integration and adaptive uses may or may not require actual modification, but the degree of compliance should still be demonstrated.

d. Fundamentally, testing to verify compliance with a standard and testing to qualify to the requirements of that standard are essentially the same thing. Tests of MIL-STD-462 or some other Government-approved tests should be performed. Acceptance at levels below full qualification (to requirements) is a decision appropriately reached before a program review forum. The risks to be accepted by the use, or proposed use, of unqualified equipment should be clearly delineated before the project review forum.

10.6.5 Reprocurements. The need to procure quantities of an item, the last contract for which has terminated or which by regulation cannot be extended and increased in scope, results in the necessity to initiate a preprocurement program. JECS may be easily adapted to this situation, with the acquisition essentially opening in Phase III. Some additional work normally performed in an earlier phase of the RD&A cycle should first be brought up to date. DD Form 1494 from the original procurement may still apply, but this should be checked. The Specification, Statement of Work (SOW), and Contract Data Requirements List (CDRL) all should be required to start up the project. Additional considerations which may impact an otherwise straight-forward reprocurement are discussed in the succeeding paragraphs.

10.6.5.1 Requalification for reprocurement. If a reprocurement contract award is made to a new vendor, the new production line should qualify the product by testing, in order to verify compliance with the specifications. A former supplier of the item whose production line has been shut down for only a short period may, however, be reasonably granted a waiver on the need for requalification by the procuring activity. To ensure that the quality assurance for E^3 control requirements has not deteriorated, the duration of the shut-down should not be more than three to six months, if a waiver of requalification is to be granted.

10.6.5.2 Reprocurement to new standards. Occasionally, the standard to which an item is originally qualified will undergo a revision that increases the stringency of some requirements. Subsequently, at reprocurement, the item should be tested to the new higher requirements. However, should the item fail to qualify to the new requirement(s), the procuring activity may accept the item provided it meets the original requirements. Items which meet the new higher requirements become qualified to the revised standard and, in any subsequent reprocurements, should meet the higher requirements now applicable.

10.6.5.3 EMC deficiencies in reprocurement. Any item of hardware which has, in the field, demonstrated EMI problems to or from other equipment should not be supported for reprocurement actions which do not also include corrective design actions (and verifications) to eliminate the EMC deficiencies. Since modifications to an item that is being reproduced are rather severely limited in scope, a redevelopment action instead of a simple reprocurement may be necessary.

10.6.6 An Example: tailored acquisition. To illustrate a reduction in the scope of JECS as applied to a tailored acquisition, consider this hypothetical example: a common electronic modem, a unit item originally developed in the 1940s' vacuum tube era and later transistorized in the mid 60s, has again reached a quarter century mark and is due for replacement. The requirement for a separate, independent unit configuration is still valid. In addition, desired upgrades are: (1) a technology upgrade for the use of CMOS integrated circuit parts to reduce size, weight, and power consumption; (2) high baud rates for operation; (3) an internal module assembly version; (4) crypto module interface ports; and (5) provision for fiber optics path interface. The new modem will represent a much broader, updated capability, and a number of specified operational parameters resulting from Treaty Organization commitments prevent the use of a NDI. A modest development is necessary, but technological risks are very low. For the RD&A process, the waiver of Milestone I, Phase I, and a formal Milestone II is reasonable and logical, the development initiating in Phase II, EMD. The PM should prepare to move forward with an ACAT III project in Phase II. The ENO evaluator performing the JECS project evaluation (going down the Phase I, PD&RR, column of TABLE 1) should reason as follows: The original MNS, STAR, and ORD were updated and accepted under a brief IPS/IPA at an informal Milestone 0 by the authorized MDA; EMC Program Plan Procedures (EMCPP) are not required for ACAT III programs; and this equipment does not require a frequency allocation. A TEMP should be the only document due immediately, and the EDM Specification, a Phase III SOW, and a CDRL should be prepared anyway to initiate a contract in Phase II. When those four KDs are out of the way, the appropriate KDs for Phase II may then be expected at a normal pace.

a. The example above is actually a minor redevelopment. The ENO evaluator should determine what EMI problems have been corrected in the life of the device, and if any EMC deficiencies currently exist in the modem. This information should have been included in the updated MNS and the ORD, and in both the IPS and IPA, the latter recommending a suitably refined JECS objective as the exit criteria. The origin of the last input should be from the evaluator, forwarded by the ENO to the staff supporting cognizant MDA.

10.6.7 Software as a factor.

10.6.7.1 Software intensive systems. There are increasing instances of projects where the system is to be integrated from existing, proven, hardware items and the components are software-controlled. The hardware is only to be mounted and cabled to design-predetermined interfaces. Little or no development, except for software, is to be accomplished by the project.

a. There may be no significant requirements being imposed in an integration, except to cover minor new devices and new interfaces. MIL-STD-461, as a non-system standard, is applied only to complete the aggregate qualification of subsystems and lower level items. These items should be qualified using tests such as those in MIL-STD-462 or, where an item has previously demonstrated extended electromagnetically satisfactory service in comparable environments, be "grandfathered" subject to acceptable performance during an EMI survey of the system. It is reasonable to require the integration contractor to perform surveys and testing at the subsystem level, to isolate and identify any EMI problems, and to recommend or implement corrective actions as provided for in the contract. A contractor, however, cannot be held accountable for the faults of hardware that was not developed by him.

10.6.7.2 Software and EMI. The potential for software to cause EMI may seem to be a non-problem, however this is not always the case. As system and equipment control is being increasingly achieved through the application of computer devices, there is some potential that an EMI problem may be attributed to software rather than just the hardware. As an example, given a transmitter that is under computer-operated control which includes a variable power output in accordance with the selected transmission path, deficiencies (bugs) in the computer program could result in forcing the transmitter to operate beyond its permissible limits and hence EMI is generated through non-linear operation. Software failures have also resulted in EMI. Instead of tests such as MIL-STD-462, a general EMI survey during operational performance testing is an appropriate way of confirming there are no E^3 problems associated with the software.

10.7 Engineering process(EP). The basic aspects of the JECS operation have been covered in this Section, however, this alone will not be an adequate exposition of the day-to-day JECS process for an ENO evaluator. There are two areas upon which elaboration is essential: issues and key documents. These subjects form the input and output vehicles of JECS. Appendix G contains the details of the JECS Engineering Process needed by ENO evaluators to facilitate their work in applying the JECS on a day-to-day basis. ENO personnel should be highly skilled in their own field, but they may have little or no background in DoD acquisition work. The JECS EP is a guide for E^3 assessments of DoD hardware during acquisition. Reviewing Appendix G should help ENO evaluators build an understanding of the acquisition process and assist them in the implementation of JECS.

10.7.1 Primary & corollary issue statements. Appendix G describes briefly, the RD&A cycle and its phases, and the factors and considerations that are common and relatively invariant among the phases. Following that, a discussion of each of the five phases is presented in terms of the key documents associated with it. As each phase is addressed, the objectives and primary issues for the phase are stated. In addition, corollary issues are offered as representative samples of issues that might be derived in support of the primary issues for some of the possible problems. The corollary issues are derived to elevate and illuminate a specific deficiency. The existence of a serious E^3 problem should be expressed in the context of the fundamental JECS objective that is at risk of failure. Through this statement a program impact message of critical importance is either successfully imparted to the MDA, or the opportunity to provide advice on a significant E^3 control issue is lost. The difficulty that needs to be overcome when refining an issue is often the effective translation of an engineering problem statement into the presentation of a relevant program risk so a proper management decision can be obtained.

10.7.2 Evaluation guides for key documents. Appendix G contains a set of evaluation guides. The assessment of projects is accomplished using the evaluations of program documentation. The organization and content of the EP was determined by the nature of and manner in which the day-to-day work of an ENO evaluator could be expected to manifest itself. For practical purposes, information on a project is received, one document at a time. The single most important consideration relative to the circumstances of a project at the time a document is received is: In what acquisition phase is the program?

10.7.2.1 Format. Typically, an evaluation guide starts with a brief description of the format and content of the document being covered. An evaluation guide not only describes the requirement(s) for the KD type itself, but also provides a paragraph addressing the perspective, an insight to the KD in the context of the acquisition phases in which it is expected to be useful. After this, each evaluation guide provides material to aid in the evaluation of the KD. This is usually a series of questions, but regardless of form, it is intended to provoke thought leading to other questions about the item being acquired.

11. EMC VERIFICATION

11.1 General. Compliance with E^3 control/EMC performance requirements should be verified by test, analysis, inspections, or some combinations of these methods. The method(s) selected to demonstrate compliance with a particular requirement is generally dependent on technical appropriateness, degree of confidence attributed to the results, availability of assets, and associated costs.

11.1.1 Verification process. Verification that E^3 control/ EMC performance requirements are being achieved should be a continuing process throughout RD&A. Initial engineering design should be based on analysis and models. As hardware becomes available, testing should be used to validate and supplement the analysis and models. When the hardware is actually produced, inspection, final testing, and follow-on analysis completes the verification process.

11.1.2 Analysis versus testing. Analysis and testing often supplement each other. Prior to the availability of hardware, analysis is often the primary tool used to confirm that the desired level of EMC performance is going to be achieved. Section 12 addresses E^3 analysis and predictions. The balance of this Section addresses testing and evaluations (T&E) as it relates to the verification process. Additional, information concerning T&E considerations is provided in Appendix H.

11.2 Testing. Testing should be mandatory if an item is to be qualified to a specification or performance standard. Until the item is actually tested, whether of commercial, developmental or NDI origin, there is no assurance the item possesses the desired EMC qualities. Measurements should be made in accordance with approved E^3 test procedures and applicable standards such as MIL-STD-462, Measurement of Electromagnetic Interference Characteristics.

11.2.1 Purpose. Testing directly supports the timely development, production and deployment of items. Test results provide the data needed to verify that all of the user's EMC performance requirements have been achieved and to confirm the item is operationally effective and suitable for its intended operational EMEs. Demonstrating the technical capabilities, operational effectiveness, and suitability of an item should be a key requirement before decisions are made to:

a. Commit additional resources to a program.

b. Advance an item from one acquisition phase to another.

c. Deploy an item into its intended operational EMEs.

11.3 Measurement programs. Measurement programs provide the data needed to:

a. Establish the EM characteristics of an item.

b. Establish confidence in the E^3 analysis and predictions that have been performed.

c. Establish confidence in an item's EMC performance and implemented E^3 control measures.

d. Verify an item is in compliance with the specified E^3 control/EMC performance standards.

e. Verify the EMC performance of an item when operating in its intended EMEs.

f. Validate E^3 tools such as modeling, simulations, and analytical processes.

11.3.1 Measurements. Types of measurements that should be preformed and documented prior to the final acceptance of an item include:

a. Electromagnetic emission measurements, both radiated and conducted.

b. Electromagnetic susceptibility measurements.

c. Spectrum signature measurements that include spurious emissions and responses, transmitter and receiver intermodulations, transmitter spectral purity and receiver sensitivity and selectivity.

d. Measurements of the EMEs to determine an item's operational characteristics, compliance with frequency plans, and emission control (EMCON) status.

11.3.2 Parameter measurements. When evaluating an item's performance it is necessary to determine at what level the item becomes susceptible to EM energy. The level of EM energy that will be encountered by an item when operating in its intended EMEs needs to be determined when evaluating its electromagnetic vulnerability. These evaluations require descriptions of the EM energy, both friendly and hostile, which the item may encounter during its life cycle. To completely evaluate the performance of an item in its EME, the item should be tested for its dependency on and response to such factors as:

a. Frequency.

b. Power density.

c. Modulations.

d. Pulse width.

e. Pulse repetition frequency.

f. Polarization of antenna.

g. Antenna scan rate.

h. Dwell time.

11.4 Testing and evaluations (T&E). Development and operational testing and evaluations should be conducted on all defense acquisition items unless waived by the cognizant T&E authority.

11.4.1 Development testing and evaluation (DT&E). DT&E should be conducted to demonstrate that the engineering design and development process is complete, that design risks have been minimized, and that the item will be in compliance with its specifications and designated standards. DT&E should also be used to estimate an item's military utility when it is introduced into its intended EMEs. DT&E, including all preproduction qualification testing, should be conducted on Engineering Development Models (EDMs). Occasionally a project will produce an Advance Development Model (ADM) that is sufficiently similar to the configuration of a follow-on EDM so DT&E may begin as soon as all prototype testing has been completed. DT&E should be planned, conducted and monitored by the developer. DT&E includes Production Acceptance Tests and Evaluation (PAT&E) and 1st article testing after an item has been approved for full-rate production (FRP). DT&E is conducted in factory, laboratory and proving ground environments. A final step in a successful DT&E program is certification that the item is ready for an operational evaluation (OPEVAL).

11.4.2 Operational testing and evaluation (OT&E). OT&E is conducted to:

a. Estimate an item's military utility.

b. Verify an item's operational effectiveness.

c. Verify an item's suitability including compatibility.

d. Determine if there is a need for any modifications.

e. Verify the item meets all of its operational requirements.

The item tested should be sufficiently representative of the expected production model to ensure that the T&E validly supports the production decision. Such a configuration is not normally available in Phase I. However, some OT&E may be useful using ADMs or early prototypes. The data collected may be used to validate concepts of technological applications; help resolve issues of design concepts for the EDM; and assist in the development of tactical employment concepts. After an item is approved for FRP, OT&E should be conducted on production hardware to determine if there is a need to incorporate engineering changes into the production item and to develop and test any proposed engineering changes. These tests should also be used to formulate operational procedures and tactics for the employment of new items. OT&E should be conducted by Service component Test and Evaluation Commands and should be accomplished in as realistic an operational environment as possible.

11.5 Phase I of acquisitions. Phase I, Program Definition and Risk Reduction, is often tailored or deleted from the acquisition process when an item is not very complicated and has low technological risks. Phase I, however, is essential whenever the technology planned is relatively untried, and in general, whenever there is no clearly preferable choice among the concepts proposed for the item. During Phase I a wide variety of analytical work is performed to develop a better understanding for each potential design approach that is under active consideration. Studies and analysis should be conducted to aid in identifying and reducing the risks that are perceived. Other efforts should include examining the proposed designs and identifying the cost-driving factors which are implicit in the performance requirements that have been established for the item. The purpose of these efforts is to determine where the rising costs for increased performance becomes ultimately unaffordable. Also during Phase I an appreciation should be obtained for the types and extent of testing needed and the availability of resources as well as defining the appropriate evaluation criteria. Culmination of Phase I activities at Milestone II should provide an extensive compilation of refined data describing the proposed design approach(es). The Milestone II decision should then be made as to whether the continuation of a program is warranted. The main purpose of Milestone II decision deliberations should be to assess assurances that an item can be brought through low risk development into production in a supportable and affordable form.

11.5.1 Phase I testing. At the project level, the extent of actual hardware fabrication and testing is a function of the degree to which the technology proposed for a design is of an advanced nature. The application of newer technology usually requires a positive demonstration that the critical aspects of the proposed application are feasible. Test data from an ADM provides the first concrete indications of any E^3 problems and the possible impact of the EME on an item. Inability to resolve some uncertainties sufficiently by testing during Phase I may not be a major failure at this time. In some cases, it may be obvious that the early design of the EDM will easily clear up a problem. However, an attempt to validate the application of a technology which failed might well result in the termination of a program. Two (2) areas of significant interest during Phase I are:

a. An appreciation for the scope of potential E^3 problems, the realistic (risk) technical resolutions, and the affordability of accomplishing the resolutions.

b. Specifications for E^3 control/EMC performance requirements that are to be accomplished in an EDM, and the requirements specified for inspecting, testing and demonstrating the achievement of effective E^3 control/EMC performance.

11.6 Phase II of acquisitions. During Phase II, Engineering and Manufacturing Development (EMD), DT&E and OT&E should be conducted to support a decision as to whether the program should move forward into production at Milestone III. The goal of Phase II testing is to confirm that all significant design problems have been identified; that solutions to these problems are available; and that the items are effective and suitable for their designed use. In Phase II, the item's hardware is in the form of an EDM or prototype, and specification qualification testing is appropriate. Through extensive T&E of the EDM it should be shown that a stable, producible, and cost-effective item design is feasible. A major objective for Phase II is to prove that the end-item meets all specified performance requirements and satisfies the mission need(s) by providing minimum acceptable operational performance. In some instances Milestone III may be deferred and Phase II is extended for a period of Low-Rate Initial Production (LRIP) when more extensive testing is required prior to making a commitment for production. Additional testing should be performed on these production models and the results should be used to obtain a Milestone III decision as to whether the program should enter FRP. The final Phase of DT&E in Phase II is a formal technical evaluation of the item's representative hardware and validated software. The final DT&E provides the basis to formally certify that the item is ready for a final dedicated Phase of OT&E before the Milestone III review. The final Phase of OT&E is a formal operational evaluation that is conducted using production-representative hardware, validated software, and maintenance and support equipment planned for operational use. The efforts during Phase II should produce an end-item from which the T&E results support a determination that the item's operational effectiveness and suitability are satisfactory. A Milestone III decision to enter FRP should be made only after the test results from DT&E and OT&E establishes confidence in the item design. The need to document the characteristics of the EDM during Phase II is critical. These results become the criteria for the E^3 testing during PAT&E. The full-rate production model (FPM) should duplicate or surpass the test results recorded for the EDM.

11.7 Phase III of acquisitions. The authorization to continue a program and engage in FRP moves the project into Phase III, Production, Fielding/Deployment and Operational Support. Both DT&E and OT&E are continued in this Phase to identify any potential E^3 problems and design deficiencies. PAT&E is conducted during Phase III unless waived as a result of similar requirements being placed on an LRIP. PAT&E should cover the proof and qualification of the FPM for each E^3 control/EMC performance requirement of the production specification. The overall objective of Phase III is to ensure there is a stable and efficient production and support base established for the item, and to confirm the mission need(s) is satisfied. When deficiencies and defects are discovered, suitable engineering changes should be developed, incorporated, and tested to ensure the correction is effectively accomplished.

11.7.1 E^3 control requirements. During Phase III it is essential that an early serial copy of the item, preferably the first, be effectively tested and demonstrated to meet all of its specified E^3 control/EMC performance requirements. This effort should be accomplished before any other copies of the item are accepted. The necessity to perform such tests stems from the circumstance that the production version of an item is not identical to the EDM version. The EDM is essentially a handmade model, crafted and constructed to meet the specified design requirements. Fabrication techniques and processes are usually re-engineered to obtain the same characteristics as the EDM in the FPM with the advantages of affordable production line practices and skills. Hence the ability of the FPM to replicate the E^3 control achievements of the EDM should be demonstrated by testing.

11.7.2 Operational support (OPS). The last part of Phase III, OPS, begins after the PAT&E for an item is completed and the first unit is delivered and accepted. It is essential during OPS to monitor/test the quality, safety, and supportability of the item for conditions which might require positive corrective action(s) if the useful life and mission need(s) are to be fulfilled and maintained. OPS continues until the item is removed from inventory.

11.7.2.1 Follow-on test & evaluation (FOT&E). Latent force level, joint operational and international E^3 problems may first surface in a deployed item during FOT&E. Also, once an item has been approved for FRP, FOT&E is conducted to evaluate any design or engineering changes that are being considered for the production item. The same provisions for E^3 testing during DT&E and OT&E should be followed during FOT&E.

11.7.2.2 Engineering changes/corrective actions. Compliance with E^3 control/EMC performance requirements should always be verified whenever an engineering change/corrective action is being implemented. Paragraph G.3.15.3 of Appendix G lists a number of E^3 control considerations that should be addressed when the EM characteristics of an item are being altered due to an engineering change/corrective action.

12. E^3 ANALYSIS AND PREDICTIONS

12.1 General. To achieve the required level of EMC, and to permit efficient use of the frequency spectrum, it is essential suitable E^3 analysis and prediction techniques be employed by program managers, engineers, technicians, and users responsible for the planning, design, development, installation and operation of electronic equipment, subsystems, and systems. E^3 analyses and predictions are used to identify, localize, and define potential E^3 problem areas. E^3 analysis and prediction techniques should be employed early in a program before there are significant expenditures of time, effort, and money. More timely and economical corrective measures may be taken when E^3 problems are identified early in the acquisition process.

12.1.1 Type of analyses. Analysis used to derive system E^3 predictions are significantly different from those used for analyzing equipment components. For system E^3 predictions the analyst is interested in determining the EM interactions between various subsystems and equipment, and it is only necessary to define the output characteristics of EM sources and the immunity (susceptibility) of receivers. Consequently, it is not necessary to know the detailed internal EM characteristics of equipment components for an E^3 system analysis. Individual elements can be regarded as black boxes with defined input-output characteristics. On the other hand, when analyzing equipment to determine their EM properties, the analyst should consider the detailed characteristics of all the components and circuits of the equipment.

12.2 E^3 analysis versus acquisition phase. Careful application of E^3 analysis and prediction techniques at the appropriate phases of an item's life cycle should ensure the required level of EMC is defined without having either the wasteful expense of over-engineering or uncertainties of under-engineering.

12.2.1 Phases 0&I. During the first two (2) phases of an acquisition, Concept Exploration (Phase 0) and Program Definition and Risk Reduction (Phase I), the concept is defined in its most basic form. The concept may be the result of an idea that originates at a research laboratory or in response to an operational requirement. Based on the concept and the requirements to be satisfied, the major characteristics of an item, such as size, weight, type of modulation, data rate, information bandwidth, transmitter power, receiver sensitivity, antenna gains and spurious rejection, are defined and specified. Careful consideration should be given to the needed E^3 control requirements when defining and specifying these characteristics. During the first two (2) phases analyses should be conducted to determine if any E^3 problems are likely to be encountered:

a. Within or between elements of the system (intra-system).

b. Between elements of the system or platform and elements of other systems or platforms that are likely to be operating in the same general area (inter-system).

c. Between platforms of a Battle Force.

d. Between elements of a system or platform and the EME in which they are intended to be operated.

12.2.1.1 Inter-system E^3 problems. Inter-system E^3 problems usually result from signals that are coupled from a transmitting antenna of one system to either the receiving antenna or electronic circuitry of another system. Inter-system E^3 problems can be particularly serious when a number of systems are required to simultaneously operate in a limited physical area, such as a ship or aircraft. The types of analyses performed during the first two (2) phases usually rely on either assumed or typical characteristics for the individual elements of a system. At this point in time, concentration should be directed to the manner in which elements interact in the total system with respect to E^3 considerations. Predictions derived from E^3 analyses should provide the program manager and design engineers with the information needed to:

a. Determine the most suitable frequency band(s) and system parameters such as transmitter power, antenna gains, receiver sensitivity, type of modulation, rise times, information bandwidth, etc.

b. Define E^3 control/EMC performance requirements.

c. Identify potential E^3 problem areas and the degree of risk involved if corrective action is not taken.

12.2.2 Phases II & III. During the final two (2) phases of an acquisition, Engineering and Manufacturing Development (Phase II) and Production, Fielding/Deployment, and Operational Support (Phase III), the item progresses from the previously established specifications to the final production end-item. There are a number of decisions that should be made by the program manager and design engineers during the process of designing an item. In general, an item is considered as consisting of a combination of functional stages such as amplifiers, mixers or frequency converters, filters, modulators, detectors, display or readout devices, power supplies, etc. For each item there are a number of important factors, including E^3 considerations, that should be addressed. For example, in the case of receivers, it is necessary to define the number of amplifier and converter stages that will be used, and to establish the gain, selectivity, and sensitivity between these stages. More importantly, an overall block diagram should be developed for the receiver and include a complete description of the gains, frequency responses, input and output impedances, dynamic range, and immunity (susceptibility) levels for each stage. In the past, personnel responsible for the management, design and development of an item were primarily concerned with intra-system E^3 problems. Today these personnel should also be concerned with E^3 problems resulting from signals being externally coupled to the elements of an item as well as internal E^3 problems resulting from cable coupling, case radiation and case penetration.

12.2.2.1 Operational support. During the final phase in the life cycle of an item, the equipment, subsystem, or system is deployed to its intended operational EMEs. At this time E^3 should be considered from various operational aspects such as siting effects, frequency assignment(s), effective radiated power limits, and antenna coverage. Operational inter-system E^3 control/EMC is generally achieved through frequency management and time sharing. Generally E^3 analyses and predictions that are useful during the operational period are similar to those performed earlier. Usually, at this point in time, personnel responsible for compatible system operations should be mostly concerned with the inter-action of system elements, both with each other and with elements from other systems, and not the internal characteristics of the elements. E^3 problems during the operational period generally involve signals that are coupled among elements of either the same or different systems.

12.3 E^3 analysis process. There are a number of different applications for which E^3 analyses are performed. The methods and procedures utilized by an E^3 analysis are dependent upon the application and the results (type of predictions) desired. In general, the E^3 analysis process to be used depends on the specific application, the accuracy and completeness of available data, and the costs to perform the analysis.

12.3.1 Cost of E^3 analysis. Cost is an important factor that should be considered when selecting the specific techniques that will be used for an E^3 analysis. The costs for developing the approach, method, and set of procedures for an E^3 analysis along with the manpower required to conduct the analysis can vary considerably. These costs depend on the specific types of problems being addressed, the number of equipment, subsystems, and systems involved, the accuracy and completeness of the data available for these equipment, subsystems, and systems, and the extent to which it is necessary to evaluate the impact of E^3 on the operational performance of an item or the overall mission.

12.3.2 Automated E^3 analysis process. When a particular E^3 analysis is performed frequently, automating the process should be considered from an economic standpoint. An automated process can be used in conjunction with data available through the FCC, JSC and other databases sources to provide useful results (predictions) at a minimum cost. Mathematical models and analytical processes are already available for a number of applications requiring an E^3 analysis. When a mathematical model or an analytical process exists that is suitable for the E^3 analysis, most of the manpower can than be spent collecting the required data on the transmitter(s), receiver(s), antenna(s) and terrain profiles that are involved in the study. Appendix I, Modeling and Simulations, briefly describes some of the models and computer codes that are available for conducting E^3 analyses. Appendix H, EMC Data, discusses the various types of data that might be needed to conduct an E^3 analysis and the sources (databases) where some of the data can be obtained.

12.4 Applications. E^3 analyses and predictions provide program managers and designers with valuable engineering tools that can be used during the acquisition phases of an item's development. Applications suitable for E^3 analyses and predictions include:

a. Addressing E^3 concerns during the preliminary planning and design of an item.

b. Determining E^3 control/EMC performance requirements that need to be included in an item's specification(s).

c. Preparing E^3 test/verification procedures that will ensure sufficient data is collected to determine an item's compliance with its specification(s).

d. Evaluating test results with regards to E^3 control measures.

e. Determining the appropriate design changes or revisions to the specification(s) of an item that's required to resolve any conditions of non-compliance with regards to E^3 control measures.

f. Evaluating the level of EMC achieved in a specific operational EME.

12.4.1 <u>E^3 problems</u>. Typical E^3 problems that may be addressed by E^3 analyses and predictions include:

a. Examining the EMC of all the equipment within a specified EME and identifying any potential E^3 problems.

b. Determining the impact, with regards to E^3, when the operating frequency of one or more equipment is changed within a specified EME.

c. Determining the impact, with regards to E^3, when one or more transmitters are added to a specified EME.

d. Determining the level of EMC that will be achieved by a receiver being added to a specified EME.

e. Determining which one of several possible locations for a transmitter or receiver will provide the most suitable level of EMC within a specified EME.

f. Determining the source and coupling path of known E^3 problems.

g. Determining the type and level of suppression required to resolve a specific E^3 problem.

h. Determining the propagation losses over specified paths.

i. Determining equipment parameters such as transmitter power, antenna gains, and receiver sensitivity and selectivity which are most suitable for achieving the desired level of EMC.

j. Determining the adequacy of equipment specifications with regards to E^3 control measures.

k. Determining the most suitable frequency band(s) for an item operating in a specified EME.

l. Determining frequency - distance separation requirements, for equipment operating within a specified EME, that will achieve the desired levels of EMC.

m. Determining equipment frequency assignments that will permit compatible operations within a specified EME.

n. Evaluating a system's effectiveness in an operational EME.

12.5 <u>E^3 predictions</u>. Predictions derived from E^3 analyses are dependent upon a number of factors such as:

a. Specific application that an E^3 analysis is to satisfy.

b. Format in which the results are presented and the level of detail required.

c. Methods and procedures utilized during an E^3 analysis.

d. Accuracy and completeness of the data available for conducting an E^3 analysis.

e. Assumptions made while conducting an E^3 analysis.

f. Cost considerations and the time and manpower to be expended on an E^3 analysis.

12.5.1 <u>Types of E^3 predictions</u>. Predictions derived from E^3 analyses differ in terms of the items life cycle at which the E^3 analysis is conducted; the type, accuracy and completeness of data required; the time, manpower, and cost required to conduct the E^3 analysis; and the format and detail of the results desired. Typical types of predictions derived from E^3 analysis include:

a. Preliminary predictions during an item's definition phase. These results are used to identify potential E^3 problem areas and to define the item's E^3 control/EMC performance requirements.

b. Predictions based on statistical summaries of data. The results are used to identify potential E^3 problems between classes of equipment.

c. Predictions based on specification limits. Results are used to determine the adequacy of these limits for an item's intended operational configuration.

d. Predictions of system performance or operational effectiveness. These results are used to define the impact of E^3 on the overall ability of a system to accomplish its objectives or mission.

13. EMC TRAINING

13.1 General. Each military department should be responsible within its own organization for ensuring that sufficient emphasis is placed on E^3 control/EMC and included in all formal courses on the design, development, production, installation methods, test, operational use, and maintenance of their electrical and electronic equipment, subsystems and systems. The program manager should be responsible for making arrangements to train and educate all personnel, involved in the acquisition process, of the importance of achieving and maintaining EMC. Sufficient EMC training should be provided to ensure there is a high level of E^3 awareness. The JSC offers E^3 awareness training to the acquisition community. E^3 awareness reduces the risk of E^3 problems being inadvertently introduced into an equipment, subsystem, or system which have to then be resolved later at a much greater expense, or worse, lived with by the Operational Forces.

13.2 EMC training program. All personnel involved in the design, development, production, procurement, test, operational use, and maintenance of military electrical and electronic equipment, subsystems, and systems should have an awareness of E^3 and the adverse effects that may result from EMC deficiencies. They should also have an awareness of E^3 control/EMC performance requirements and principles, and should be able to apply them to their tasks. An effective EMC training program is essential for developing this awareness and should provide training for:

a. Managers, designers, engineers and technicians in the management techniques and design, production, and installation methods used for controlling E^3 to achieve the desired level of EMC.

b. Test personnel and technicians assigned to engineering duties to detect, measure, analyze, report and correct E^3 problems.

c. Operational and maintenance personnel to recognize performance degradation in their equipment, subsystems and systems that is the result of EM energy, and to use proper operating techniques and maintenance actions to optimize and maintain EMC.

d. Communications, intelligence, and electronic warfare operations personnel assigned to joint and component staffs in the use of automated spectrum management tools to prevent adverse effects from the EME.

13.2.1 Operational procedures. A well-implemented EMC training program can be beneficial in preventing potential E^3 problems from occurring during the acquisition process. There are instances where adequate hardware fixes for E^3 problems are just not available or feasible, either because of the state-of-the-art in EMC technology or because of prohibitive costs. However, for many of these E^3 problems, operational procedures can be used to eliminate or reduce the severity of these problems. Operational procedures that should be considered include the reduction of transmitter power under certain circumstances, avoiding the use of specific frequencies, the use of a different antenna for a communications circuit, etc. Use of operational procedures may be the only way to reduce the adverse effects of some E^3 problems to acceptable limits. Some procedures may be unfamiliar to operators, and even in conflict with what has been considered common operating procedures. Proper training is the only way to ensure the appropriate personnel will understand and use these procedures. Training procedures on E^3 awareness should be included in the Operational Manuals of each electronic equipment, subsystem and system.

13.3 E^3 control. E^3 control consists of actions that eliminate or reduce the adverse, unintentional effects of EM energy. Prerequisites to effective E^3 control should include:

a. A comprehensive understanding of the characteristics and causes of the various types of E^3 problems.

b. An understanding of the various operational EMEs with their specific EM characteristics.

c. Accurately identifying specific E^3 problems which degrade technical and operational performance and E^3 problems which can be a hazard to personnel safety.

d. Implementing E^3 preventive and corrective maintenance procedures and operational procedures for controlling E^3, and electromagnetic spectrum (EMS) management and coordination procedures.

e. Compliance with, and proper application of, E^3 Interface standards and performance specifications.

13.4 Operational and maintenance personnel. Personnel who have been trained to be proficient in the operational use and maintenance of electronic equipment, subsystems, and systems generally lack training in E^3 control. These personnel should also be trained to:

a. Recognize specific E^3 problems when they occur in their equipment.

b. Be aware of any EMC design features built into their equipment.

c. Be aware of any E^3 fixes, such as preventive measures or devices, already installed.

d. Maintain their equipment without causing the removal of any installed E^3 fixes that result in the reintroduction of the original E^3 problems(s).

e. Isolate and correct E^3 problems as they occur.

13.4.1 Operational personnel. Sufficient information should be presented on the different kinds of susceptibility mechanisms to enable operational personnel to identify the source of any equipment/system performance degradation. Operational personnel should be provided with instructions on how to eliminate some types of E^3 problems by using proper operating techniques, and the procedures for reporting unresolved E^3 problems and requesting assistance from maintenance personnel.

13.4.2 Maintenance personnel. Maintenance personnel should be provided with adequate information on the EMC design features and installed E^3 fixes for the equipment/systems they maintain. Maintenance personnel should be made aware of their responsibility for maintenance actions that insures the continued maximum effectiveness of these design features and fixes throughout the equipment/system life. EMC is interrelated with reliability, safety, performance, and other equipment/system characteristics, and EMC maintenance can and should proceed concurrently with them.

14. NOTES

14.1 Intended use. This handbook provides guidance for establishing an effective EMC program.

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

14.3 Subject term (key word) listing.

E^3
EMC
EMCAB
EMC Advisory Board
EMC Bibliography
EMC Data
EMC Program
EMC Performance Considerations
EMC Training
EMC Verification
EME
EMI
EMI Control Procedures
Electromagnetic Compatibility
Electromagnetic Environment
Electromagnetic Environment Effects
Electromagnetic Interference
E^3 WIPT
E^3 Working-Level Integrated Product Team
Hazards of Electromagnetic Radiation to Ordnance
HERO
JECS
JECS Engineering Process
Joint E^3 Control Strategy
Spectrum Management

14.4 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.

CONCLUDING MATERIAL

Custodians:

Army - CR
Navy - EC
Air Force - 11

Preparing Activity:

JSC - JS
(Project EMCS - 0155)

Review Activities:

Army - MI, AV, TE, AT, CR4, CE, MD1
Navy - SH, OS, AS, MC, CG, TD
Air Force - 13, 17, 19, 84, 99
NSA
DISA
DSWA

APPENDIX A

EMC BIBLIOGRAPHY

This appendix provides personnel responsible for the acquisition of platforms, systems and equipment, with a list of pertinent documents relative to EMC/E^3 control requirements.

Part I — Directives, Instructions, Regulations and Manuals - provides the definition of, and authority to incorporate, requirements for E^3 Control and qualification testing.

Part II — Standards - describes, defines, and dictates the EMC/E^3 Control requirements to be included in a Technical Package.

Part III — Data Item Descriptions (DIDs) - defines each item on the Contract Data Requirements List (CDRL).

Part IV — Guidance Documents - provides assistance to personnel in achieving EMC/E^3 Control in the procurement/ acquisition process.

Part V — Service Documents - provides direction and guidance for achieving EMC/E^3 Control.

Part VI — Matrices of EMC Tasks and applicable EMC/E^3 Documents during an item's life cycle.

APPENDIX A

PART I: DIRECTIVES, INSTRUCTIONS, REGULATIONS AND MANUALS

DoD DIRECTIVES

3222.3	DoD Electromagnetic Compatibility Program (EMCP).
4650.1	Management and Use of the Radio Frequency Spectrum.
5000.1	Defense Acquisition.
5000.3	Test and Evaluation.

DoD INSTRUCTIONS

4245.4	Acquisition of Nuclear Survivable Systems.
6055.11	Protection of DoD Personnel from Exposure to Radio Frequency Radiation.

DoD REGULATION

5000.2-R	Mandatory Procedures for Major Defense Acquisition Programs and Major Automated Information Systems.

DoD MANUAL

5000.37-M	DoD Non-developmental Items Acquisition Manual.

OTHER DoD DOCUMENTS

DoD Federal Acquisition Regulations

Clause 257.235-7003	Frequency Authorization.
Supplement, Part 27	Data Requirements.

DODISS	Department of Defense Index of Specifications and Standards.
DoD 5010.12-L	DoD Acquisition Management Systems and Data Requirements Control List (AMSDRL).
OSD JEMI 92-37	JECS Engineering Process Manual (EPM).
USD(A&T) Memorandum	Requirements for Compliance with Reform Legislation for Information Technology (IT) Acquisitions (Including National Security Systems), May 1, 1997.

DEPARTMENT OF COMMERCE

National Telecommunications and Information Administration (NTIA)

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

OFFICE OF MANAGEMENT AND BUDGET (OMB)

OMB Circular A-11	Preparation and Submission of Budget Estimates.

PART II: STANDARDS

MILITARY STANDARDS

MIL-STD-449	Test Method Standard: Radio-Frequency Spectrum Characteristics, Measurement of.
MIL-STD-461	Interface Standard: Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility.
MIL-STD-462	Test Method Standard: Measurement of Electromagnetic Interference Characteristics.
MIL-STD-464	Interface Standard for Systems Electromagnetic Environmental Effects Requirements.
MIL-STD-469	Interface Standard: Radar Engineering Design Requirements, Electromagnetic Compatibility.
MIL-STD-704	Aircraft Electrical Power Characteristics.
MIL-STD-961	Defense Specifications.
MIL-STD-1310	Standard Practice Document: Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety.
MIL-STD-1399	Interface Standard for Shipboard Systems.
MIL-STD-1605	Interface Standard: Procedures for Conducting a Shipboard Electromagnetic Interference (EMI) Survey (Surface Ships).
MIL-STD-1658	Shipboard Guided Missile Launching System Safety Requirements, Minimum.
MIL-STD-2036	General Requirements for Electronic Equipment Specifications.
DoD-STD-2106	Development of Shipboard Industrial Test Procedures.
MIL-STD-2169	High Altitude Electromagnetic Pulse (HEMP) Environment (U).

AMERICAN NATIONAL STANDARDS (ANS) INSTITUTE

ANS C63.12 Standard for Electromagnetic Compatibility Limits-Recommended Practice.

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

ANS C63.2 Standard for Instrumentation - Electromagnetic Noise and Field Strength, 10 KHz to 40 GHz - Specifications.

ANS C63.4 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 C95.1 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields (3 KHz - 300 GHz).

ANS C95.2 Radio Frequency Radiation Warning Symbol.

ANS C95.3 Techniques and Instrumentation for Measurement of Potentially Hazardous Electromagnetic Radiation at Microwave Frequencies.

ANS C95.4 Safety Guide for the Prevention of RF Radiation Hazard in the Use of Electric Blasting Caps.

SOCIETY OF AUTOMATIVE ENGINEERS, INC.

AEHL-87-3 Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lighting.

NATO STANDARD AGREEMENTS (STANAGS)

STANAG 1008	Electrical Power Characteristics for Ships.
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 3731	Design Guide for EMC.
STANAG 3855	Lightning Qualification Test Techniques.
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.

PART III: DATA ITEM DESCRIPTIONS

DATA ITEM DESCRIPTIONS (DID)

DI-R-2055 EMC Test Plan (MIL-STD-469).

DI-R-2056 EMC Control Plan (MIL-STD-469).

DI-R-2057 EMC Test Report (MIL-STD-469).

DI-R-2058 EMCON Test Plan (MIL-STD-469).

DI-R-2059 EMCON Test Report (MIL-STD-469).

DI-R-2060 EMCON Design & Development Plan (MIL-STD-469).

DI-R-2068 Spectrum Signature Test Plan (MIL-STD-449).

DI-R-2069 Spectrum Signature Test Report (MIL-STD-449).

DI-T-3704 EMC Test Plan (MIL-STD-6051).

UDI-R-22550 EMP Hardening Plan.

UDI-R-22551 EMP Hardening Report.

UDI-R-22574 Radiation Hazard Report.

UDI-R-22577 Analysis of Interference Potential Report.

UDI-R-23723 EMI Test Report - Survey (MIL-STD-1605).

UDI-T-30708 Antenna Pattern Report.

DI-EMCS-80157 Suspected RF Radiation Overexposure Report.

DI-EMCS-80199 EMI Control Procedures (MIL-STD-461).

DI-EMCS-80200 EMI Test Report (MIL-STD-461).

DI-EMCS-80201 EMI Test Procedures (MIL-STD-461 & 2).

DI-EMCS-80849 Lighting Protection Plan (LPP) MIL-STD-1795).

DI-EMCS-80850 Lighting Protection Verification Plan.

DI-EMCS-80851	Lighting Protection Verification Report.
DI-EMCS-81528	EMC Program Procedures.
DI-EMCS-81540	E^3 Integration and Analysis Report (MIL-STD-464).
DI-EMCS-81541	E^3 Verification Procedures (MIL-STD-464).
DI-EMCS-81542	E^3 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.

APPENDIX A

PART IV: GUIDANCE DOCUMENTS

MILITARY HANDBOOKS

MIL-HDBK-235	Electromagnetic (Radiated) Environment Considerations for Design and Procurement of Electrical and Electronic Equipment, Subsystems and Systems.
MIL-HDBK-245	Preparation of Statement of Work (SOW).
MIL-HDBK-248	Guide for Application and Tailoring of Requirements for Defense Material Acquisitions.
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.
SD-2	Buying NDI - Nondevelopmental Item Program.

PART V: SERVICE DOCUMENTS

DEPARTMENT OF THE ARMY

AR 5-12	Army Management of the Electromagnetic Spectrum.
AR-70-1	Systems Acquisition Policy and Procedures.
AR-70-10	Test and Evaluation During Development and Acquisition of Material.
AR-71-9	Material Objectives and Requirements.
ADS-37	Electromagnetic Environmental Effects Management, Design, and Test Requirements.
FM-11-490-30	Electromagnetic Radiation Hazards.

DEPARTMENT OF THE NAVY

CHIEF OF NAVAL OPERATIONS

SECNAVINST 5000.2	Major and Nonmajor Acquisition Program Procedures.
OPNAVINST 1500.8	Preparation and Implementation of Navy Training Plans (NTP) in Support of Hardware and Non-Hardware Oriented Developments.
OPNAVINST 2400.20E	Navy Management of the Radio Frequency Spectrum.
OPNAVINST 2410.11	Procedures for the Processing of Radio Frequency Applications for the Development and Procurement of Electronic Equipment.
OPNAVINST 2450.2	EMC Program within the Department of the Navy (DON).
OPNAVINST 3960.10	Test and Evaluation.

OPNAVINST 5000.42 Research, Development, and Acquisition Procedures.

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

OD 30393 Design Principles and Practices for Controlling Hazards of Electromagnetic Radiation to Ordnance.

OP-3565/NAVAIR 16-1-529/SPAWAR 0967-LP-624-6010 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).

NAVSEAINST 8020.7B Hazards of Electromagnetic Radiation to Ordnance (HERO) Safety Program.

NAVSEAINST 8020.17 Navy Explosives Hazard Classification Program.

S9407-AB-HDBK-010 Handbook of Shipboard Electromagnetic Shielding Practices.

DEPARTMENT OF THE AIR FORCE

AFR 55-43 OT&E Management Policies.

AFR 57-1 Operational Needs, Requirements, and Concepts.

AFR 80-14 Test and Evaluation.

AFR 80-23 The US Air Force Electromagnetic Compatibility Program.

AFR 800-2 Acquisition Program Management.

AFMAN 33-120 Radio Frequency Spectrum Management.

TO 31Z-10-4	Electromagnetic Radiation Management.

AIR FORCE SYSTEMS COMMAND (AFSC)

AFSC DH 1-4	Air Force Systems Command Design Handbook, EMC.

AIR FORCE Occupational Safety and Health (AFOSH)

AFOSH STANDARD 161-9	Exposure to Radio Frequency Radiation.

MARINE CORPS SYSTEMS COMMAND (MARCORSYSCOM)

MCO 2400.2	Marine Corps Management of the Radio Frequency Spectrum.
MCO 2410.2	Electromagnetic Environmental Effects Control Program.

PART VI: MATRICES OF EMC TASKS

TABLE A-1. EMC tasks during phase 0 and applicable documents.

EMC TASKS	DoD DIR 4650.1	DoD REG 5000.2-R	DoD DIr 3222.3	MIL-STD-449	MIL-STD-461	MIL-STD-462	MIL-STD-464	MIL-STD-469	MIL-STD-704	MIL-STD-1310	MIL-STD-1377	MIL-STD-1399	MIL-STD-1605	MIL-HDBK-235	MIL-HDBK-237	MIL-HDBK-253	NTIA MANUAL
Prepare and update EMC Program Procedures (EMCPP).			✓												✓		
Organize E^3 WIPT/EMCAB.		✓	✓												✓	✓	
Determine spectrum requirements and submit request for frequency allocation (DD Form 1494).	✓	✓	✓												✓		✓
Define electromagnetic environment which may be encountered during life cycle.							✓			✓		✓		✓	✓	✓	
Perform analyses to determine whether proposed item can operate compatibility in its intended operational electromagnetic environment.		✓	✓				✓							✓	✓	✓	
Establish initial EMC requirements for inclusion in technical package for Advanced Development Model (ADM).				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓

TABLE A-2. EMC tasks during phase I and applicable documents.

EMC TASKS	DoD DIr 4650.1	DoD REG 5000.2-R	DoD DIr 3222.3	MIL-STD-449	MIL-STD-461	MIL-STD-462	MIL-STD-464	MIL-STD-469	MIL-STD-704	MIL-STD-1310	MIL-STD-1377	MIL-STD-1399	MIL-STD-1605	MIL-HDBK-235	MIL-HDBK-237	MIL-HDBK-253	NTIA MANUAL
Continue E^3 WIPT/EMCAB.		✓	✓												✓	✓	
Review and update EM environment.							✓		✓			✓		✓	✓	✓	
Refine analyses to determine if proposed item can satisfactorily operate in intended operational electromagnetic environment.		✓	✓				✓							✓	✓	✓	
Define acceptable performance criteria.					✓		✓	✓	✓			✓		✓	✓	✓	✓
Evaluate EMC standards and predicted electromagnetic environment, and acceptable performance criteria to determine if item will meet general EMC criteria.					✓		✓	✓	✓	✓		✓		✓	✓	✓	✓
Develop tailored EMC performance requirements for technical package for EDM.			✓		✓		✓	✓	✓			✓		✓	✓	✓	✓
Submit request for developmental frequency allocation (DD 1494).	✓	✓	✓														✓
Specify operability analyses and test requirements for TEMP.		✓	✓	✓		✓	✓	✓			✓		✓		✓		
Update EMCPP.			✓												✓		

TABLE A-3. EMC tasks during phase II and applicable documents.

EMC TASKS	DoD DIr 4650.1	DoD REG 5000.2-R	DoD DIr 3222.3	MIL-STD-449	MIL-STD-461	MIL-STD-462	MIL-STD-464	MIL-STD-469	MIL-STD-704	MIL-STD-1310	MIL-STD-1377	MIL-STD-1399	MIL-STD-1605	MIL-HDBK-235	MIL-HDBK-237	MIL-HDBK-253	NTIA MANUAL
Continue E^3 WIPT/EMCAB.		✓	✓												✓	✓	
Review all contractor data items including EMI Control Procedures (EMICP).					✓		✓	✓	✓	✓		✓		✓	✓	✓	✓
Develop/implement program to demonstrate by analysis, emulation and test that the item will perform its mission in the intended EM environment. Include this in TEMP.		✓	✓	✓		✓	✓	✓			✓		✓	✓	✓	✓	
Request assignment of test frequencies.	✓		✓												✓		
Document EMC aspects of maintenance, production and training plans.							✓							✓	✓	✓	
Develop EMC requirements for technical package for Full-rate Production Model.					✓		✓	✓	✓	✓		✓		✓	✓	✓	✓
Submit request for operational frequency allocation (DD 1494).	✓	✓	✓	✓											✓		✓
Develop installation criteria and guidance.							✓			✓					✓		

TABLE A-4. EMC tasks during phase III and applicable documents.

EMC TASKS	DoD DIr 4650.1	DoD REG 5000.2-R	DoD DIr 3222.3	MIL-STD-449	MIL-STD-461	MIL-STD-462	MIL-STD-464	MIL-STD-469	MIL-STD-704	MIL-STD-1310	MIL-STD-1377	MIL-STD-1399	MIL-STD-1605	MIL-HDBK-235	MIL-HDBK-237	MIL-HDBK-253	NTIA MANUAL
Review test procedures and report for acceptance.				✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		
Perform special EMC tests specified in TEMP.		✓		✓		✓	✓	✓			✓		✓		✓		
Finalize EMC aspects of maintenance, production, and training.							✓			✓				✓	✓	✓	
Develop and implement frequency management/usage plan.	✓																✓
Update EMCPP.			✓												✓		
Monitor and review waiver requests and engineering change proposals (ECPs).			✓												✓		✓
Investigate and fix operational electromagnetic problems.			✓														

ACRONYMS AND ABBREVIATIONS

ACAT	Acquisition Category
ADDOC	Additional Document
ADM	Advance Development Model
ADM	Acquisition Decision Memorandum/Memoranda
AE	Acquisition Executive
AFEWC	Air Force Electronic Warfare Center
AFOSH	Air Force Occupational Safety and Health
AFR	Air Force Regulation
AFS	Active Fleet Ships
AFSC	Air Force Systems Command
AI	Articulation Index
AMITS	ASEMICAP Management Information and Tracking System
AMP	Antenna Modeling Program
AMSDRL	Acquisition Management Systems and Data Requirements List
ANS	American National Standards
AR	Army Regulations
ARGUS	A 3-Dimensional FDTD Code
AS	Acquisition Strategy
ASD	Assistant Secretary of Defense
ASEMICAP	Air Systems EMI Corrective Action Program
ATC	Air Traffic Control
BER	Bit Error Rate
BF	Battle Force
BSC	Basic Scattering Code
CAIV	Cost As an Independent Variable
C-E	Communications Electronics
C^2	Command and Control
C^3I	Communications, Command, Control and Intelligence
CDRL	Contract Data Requirements List
CE	Concept Exploration
CFAR	Constant False Alarm Rate
CFE	Contractor Furnished Equipment
CMOS	Complementary Metalized Oxide Semiconductor
CNO	Chief of Naval Operations
COEA	Cost & Operational Effectiveness Analysis
CONUS	Continental United States
DAB	Defense Acquisition Board
DCNO	Deputy Chief of Naval Operations
DID	Data Item Description
DMN	Determination of Mission Need
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction

DoDISS	DoD Index of Specifications and Standards
DON	Department of Navy
DT&E	Development Testing and Evaluation
E-O	Electro-Optical
E^3	Electromagnetic Environmental Effects
E3IAR	E^3 Integration and Analysis Report
E3VP	E^3 Verification Procedures
E3VR	E^3 Verification Report
ECAC	Electromagnetic Compatibility Analysis Center
ECF	Equipment Characteristics File
ECM	Electronic Counter-measures
ECP	Engineering Change Proposal
EDM	Engineering Development Model
EFI	Exploding Foil Initiator
EFIE	Electric Field Integral Equation
EID	Electrically Initiated Device
ELINT	Electronics Intelligence
EM	Electromagnetic
EMC	Electromagnetic Compatibility
EMCAB	Electromagnetic Compatibility Advisory Board
EMCON	Emission Control
EMCP	Electromagnetic Compatibility Program
EMCPP	Electromagnetic Compatibility Program Procedures
EMCTP	Electromagnetic Compatibility Test Procedures
EMCTR	Electromagnetic Compatibility Test Report
EMD	Engineering and Manufacturing Development
EME	Electromagnetic Environment
EMECP	Electromagnetic Environment Control Procedures
EMETR	Electromagnetic Environment Test Report
EMI	Electromagnetic Interference
EMICP	Electromagnetic Interference Control Procedures
EMITP	Electromagnetic Interference Test Procedures
EMITR	Electromagnetic Interference Test Report
EMP	Electromagnetic Pulse
EMR	Electromagnetic Radiation
EMS	Electromagnetic Spectrum
ENO	Engineering Office
EOB	Electronic Order of Battle
EP	Electronic Protection
EP	Engineering Process
EPM	Engineering Process Manual
ER	Error Rate
ESD	Electrostatic Discharge
EU	European Union
EW	Electronic Warfare

EWIR	Electronic Warfare Integrated Reprogramming
FAS	Frequency Assignment Subcommittee (IRAC)
FCC	Federal Communications Commission
FD	Finite Difference
FDTD	Finite Difference Time Domain
FDTD3D	Finite Difference Time Domain 3-Dimensional
FOT&E	Follow-on Test and Evaluation
FP	Frequency Panel
FPM	Full-Rate Production Model
FRP	Full-Rate Production
FRRS	Frequency Resource Record System
FY	Fiscal Year
G3DXL3	Generalized 3-Dimensional eXpandable Lawrence Livermore Laboratory
GEMACS	General Electromagnetic Model for the Analysis of Complex Systems
GFDTD	Version of the FDTD Code
GFE	Government Furnished Equipment
GTD	Geometrical Theory of Diffraction
HDBK	Handbook
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
IEEE	Institute of Electrical and Electronic Engineers
IEMCAP	Intrasystem EMC Analysis Program
IFB	Invitation for Bid
IFF	Identification-Friend-or-Foe
IFRB	Integration Frequency Registration Board
I/N	Interference-to-Noise
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
IPA	Integrated Program Assessment
IPS	Integrated Program Summary
IPT	Integrated Product Team
IRAC	Interdepartment Radio Advisory Committee
ITU	International Telecommunications Union
JCS	Joint Chiefs of Staff
JECS	Joint E^3 Control Strategy
JOERAD	JSC Ordnance E^3 Risk Assessment Database
JROC	Joint Requirements Oversight Council
J/S	Jamming-to-Signal
JSC	Joint Spectrum Center
JSIR	Joint Spectrum Interference Resolution
J-12 WG	Frequency Panel, Allocations Working Group of MCEB

KD	Key Document
KDL	Key Document List
LISN	Line Impedance Stabilization Network
LOS	Line of Sight
LPP	Lighting Protection Plan
LRIP	Low-Rate Initial Production
MARCORSYSCOM	Marine Corps Systems Command
MCEB	Military Communications Electronic Board
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MFIE	Magnetic Field Integral Equation
MIL-STD	Military Standard
MILDEP	Military Department
MNFS	Maximum No-Fire Stimulus
MNS	Mission Need Statement
MOM	Method of Moments
MPE	Maximum Permissible Exposure
NASA	National Aeronautics and Space Administration
NAVAIDS	Navigation Aid Systems
NAVSEA	Navy Sea Systems Command
NDI	Non-Developmental Item
NEC	Numerical Electromagnetic Code
NEC-BSC	Numerical Electromagnetic Code - Basic Scattering Code
NEC-MOM	Numerical Electromagnetic Code - Method of Moments
NSA	National Security Agency
NTIA	National Telecommunications and Information Administration
OIPT	Overarching IPT
OMB	Office of Management and Budget
OPEVAL	Operational Evaluation
OPS	Operational Support
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OT&E	Operational Testing and Evaluation
PAT&E	Production Acceptance Tests and Evaluation
PD&RR	Program Definition and Risk Reduction
PF&OPS	Production, Fielding/Deployment and Operational Support
P_k	Probability of Kill
PM	Program Manager
PMS	Planned Maintenance Subsystem
PSA	Principal Staff Assistant
RADHAZ	Radiation Hazard
RD&A	Research, Development and Acquisition
RDT&E	Research, Development, Test and Evaluation
RF	Radio Frequency

RFP	Request for Proposal
RMS	Root Mean Square
Rpt	Report
RSM	Radar Spectrum Management
RSMCP	Radar Spectrum Management Control Plan
RSMTP	Radar Spectrum Management Test Plan
RTCA	Radio Technical Commission for Aeronautics
SEMCIP	Shipboard Electromagnetic Compatibility Improvement Program
S/I	Signal-to-Interference
SIGINT	Signal Intelligence
SMITS	SEMCIP Management Information Tracking System
SOW	Statement of Work
SPAWAR	Space and Naval Warfare Systems Command
SPEC	Specification
SPICE	Simulation Program with Integrated Circuit Emphasis
STAN	SEMCIP Technical Assistance Network
STANAGS	Standard Agreements (NATO)
STAR	System Threat Assessment Report
STARBOX	A 3-Dimensional Code
T&E	Test and Evaluation
TACDB	Tactical Database
TEMP	Test and Evaluation Master Plan
TEP	Test and Evaluation Procedures
THREDE	3-Dimensional FDTD Code
TP	Test Procedures
TPDA	Test Procedures Development Agent
TPDM	Test Procedures Development Manager
TR	Test Report
TST	Total Ship Tests
TSTD	Total Ship Test Director
TSTP	Total Ship Test Program
UHF	Ultra-High Frequency
USD(A&T)	Under Secretary of Defense (Acquisition and Technology)
VHF	Very-High Frequency
WG	Working Group
WIPT	Working-Level IPT

APPENDIX C

ELECTROMAGNETIC ENVIRONMENT (EME)

C.1 General. The electromagnetic environment (EME) is the resulting product of the power and time distribution, within various frequency ranges, of the radiated and 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. One of DoD's basic objectives is to ensure that all military electronic and telecommunication equipment, subsystems and systems are self-compatible and not adversely affected by the operational EME during their conceptual, design, acquisition, and operational phases. Undesired electromagnetic energy may degrade the performance of an item temporarily, in which case the item will operate in a degraded mode when sufficient electromagnetic energy is present. Alternatively, the electromagnetic energy may cause permanent damage, in which case the item will not operate until it is either repaired or replaced and the E^3 problem has been resolved. Examples of different effects that can be caused by undesired electromagnetic energy, depending on the victim, are:

a. Burnout or voltage breakdown of components, antennas, etc.

b. Performance degradation of receiver signal processing circuits.

c. Erroneous or inadvertent operation of electromechanical equipment, electronic circuits, components, ordnance, etc.

d. Unintentional detonation or ignition of electro-explosive devices, flammable materials, etc.

e. Personnel injuries.

C.1.1 EME effects. The effects of undesired electromagnetic energy on a system, subsystem, or equipment while operating in a specific environment is dependent upon the item's immunity (susceptibility) characteristics and the amplitude, frequency, and time-dependent characteristics of the EME. To prevent E^3 problems from occurring, the possible effects of undesired electromagnetic energy should be considered for each new platform, system, subsystem, and equipment when operating in its intended EMEs. Performance degradation varies for different types of receivers. For example, in a communications receiver, degradation is manifested in the form of reduced intelligibility, increased distortion, or increased bit error rate (BER). In a radar receiver, degradation may occur in the form of range reduction, reduced probability of detection, tracking-errors, or break-lock. In navigation and Identification-Friend-or-Foe (IFF) systems, degradation may occur in the form of range/angle errors, false decodes, or overloads. In some receivers, degradation is related directly to the interference power while in others, it is a function of the number of interfering signals. Determining when degradation may occur and how a receiver's degradation relates to various interference power levels and modulation waveforms is essential before specifying the requirements for E^3 control. Also a requirement to demonstrate satisfactory performance in a defined EME should be included in all system, subsystem and equipment specifications.

C.1.2 Contributors to the EME. The EMEs in which military platforms, systems and equipment must operate are comprised of a multitude of natural and manmade sources.

C.1.2.1 Natural sources. Natural sources consist of:

a. Galactic noise.

b. Atmospheric noise.

c. Solar noise.

d. Precipitation static (P-static).

e. Lightning.

f. Electrostatic discharge (ESD).

C.1.2.2 Manmade sources. Manmade sources for military applications primarily consists of friendly and hostile emitters, both intentional and unintentional, spurious emissions such as motor noise and intermodulation products.

C.1.2.2.1 Intentional emitters. Intentional emitters include, but are not limited to:

a. Communications systems.

b. Navigation systems.

c. Meteorology systems.

d. Rad/IFF systems.

e. Weapon systems.

f. EW systems.

C.1.2.2.2 Unintentional emitters. Unintentional emitters encompass any system, subsystem, or equipment which uses, transforms, or generates any form of electromagnetic energy. Therefore, any electrical, electronic, electro-mechanical, or electro-optic device can be an unintentional emitter. Examples of unintentional emitters include the following:

a. Intentional radiators.

b. Computers and associated peripherals.

c. Televisions, cameras, and video equipment.

d. Microwave ovens.

e. Radio and radar receivers.

f. Power suppliers and frequency converters.

g. Motors and generators.

C.1.2.3 Dominant contributors. Power levels and source locations relative to the item are the two main considerations used for determining which sources are the dominant contributor(s) to the operational EME. For example, during normal noncombat operations the primary sources of electromagnetic energy would be from own and nearby unit's transmissions and spurious emissions. In an attack scenario, enemy transmissions would be another major contributor under some circumstances. Hence, the EME within which an item must operate and survive is both mission-dependent and scenario-dependent.

C.2 Receivers as victims of the EME. There are two (2) basic causes of E^3 problems. One results from undesired electromagnetic energy entering through intended avenues of entry such as antennas and transmission lines into systems, equipment or other devices that by design use electromagnetic energy. The second cause of E^3 problems results from undesired electromagnetic energy entering though unintended avenues of entry such as high levels of electric and magnetic fields coupling directly onto cables or components of a system to produce disruptive or damaging current and voltage surges. Performance degradation is the result of a receiver's response to undesired electromagnetic energy that is either from signals outside the intended frequency band or undesired signals in the operating frequency band. Elimination of E^3 problems resulting from signals outside the intended frequency band is primarily a function of the receiver design. Elimination of E^3 problems resulting from undesired signals within the operating frequency band is much more difficult to resolve, since it involves not only the receiver's design but also the control of frequency use and spurious emissions. Although the resolution of E^3 problems resulting from the unintended reception of electromagnetic energy is primarily a design consideration, it also involves controlling the electromagnetic characteristics of the EME by using appropriate installation practices and imposing, as required, operational constraints.

C.3 Defining the EME. One of the difficulties encountered when specifying the design and performance requirements of an item, from the standpoint of EMC, is that in many cases the characteristics of the intended operational EME(s) are quantitatively unknown. The following factors should be considered when defining the anticipated operational EMEs of an item.

C.3.1 EME profile. Each system, subsystem and equipment in all likelihood will be exposed to several different EMEs during its life cycle. MIL-HDBK-235, Electromagnetic (Radiated) Environment Considerations for Design and Procurement of Electrical and Electronic Equipment, Subsystems and Systems, provides general information on the EM characteristics of different EMEs. Referring to MIL-HDBK-235 can be useful when defining the power levels of representative EMEs to which an item may be exposed. However, some of the Tables in MIL-HDBK-235 should be tailored for specific applications. Specifying EME levels that are too stringent may result in additional costs to the program 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 EMEs during shipment, storage, checkout, launch and the approach to a target. The specified E^3 control performance requirements should ensure the item's performance will not be affected by any of the EMEs that will be encountered.

C.3.2 Configuration. The physical configuration of a system, subsystem or equipment may vary depending on its intended location. An item's immunity (susceptibility) to the EME may also vary depending on its physical configuration and location relative to the intended operational EME. Therefore, when developing performance requirements, both the physical configuration and the location of the item within each of its intended operational EMEs should be considered.

C.3.3 Operational versus survival requirements. There is usually a significant difference between the levels of electromagnetic energy that will temporarily degrade or limit the effective performance of an item and those levels that will permanently damaged an item. The design requirements for achieving EMC under all circumstances should be by necessity much more stringent than those that just ensure the item will not be permanently damaged. When specifying E^3 control requirements, the item's function and how critical it is to the intended 0mission should be taken into account. There are also some precautions that can be taken to protect equipment from being permanently damaged by electromagnetic energy when not in use that are not feasible when they are in an operational mode.

C.3.4 Susceptibility. Electromagnetic susceptibility is the inability of an item to perform its function without degradation while in the presence of an electromagnetic disturbance. The susceptibility characteristics of an item are dependent upon 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 milliseconds 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 the effect EME has on an item.

C.3.5 Future considerations. Possible changes in the intended operational EMEs and future applications of an item also should be considered when defining the EMEs that a system, subsystem or equipment 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.

C.3.6 Conditions precluding EME exposure. When defining the operational environments within which a system, subsystem, or equipment will be required to operate and survive during its life cycle, all operational and installation conditions that can preclude or reduce exposure to the EMEs, and any additional information that may affect an item's exposure to the EMEs should be considered. For example, the complement of designated emitters on a platform or site will provide an indication within which frequency bands high levels of electromagnetic energy will probably be encountered. Dimensional restrictions and intervening structures may exist that causes an item to operate in the near or induction field region of an antenna. Other factors such as the platform usage on which an item is installed and the operational use of the item also should be considered.

APPENDIX D

HERO CONSIDERATIONS

D.1 General. Ordnance containing electrically initiated devices (EIDs) may be susceptible to the electromagnetic energy of an EME. Induced currents from electromagnetic energy can cause inadvertent actuation of an EID or degrade the performance of an ordnance system. Unfortunately, the reaction of an EID to the EME may not be manifested in an obvious way until an inadvertent actuation occurs or the ordnance system has malfunctioned during operation. Either event can have devastating results. Providing HERO protection is best achieved by first identifying the intended EMEs that a system will be exposed to and then implementing proper design procedures to preclude EM energy from entering the system in adequate strength to exceed prescribed safety margins.

D.1.1 EIDs. EIDs are intended to function with the application of electrical energy. Induced currents from RF sources between 10 kHz and 40 GHz in the EME can cause inadvertent actuations. EIDs such as bridge-wire, fusible links and burn-wire devices respond to average power levels, while devices such as exploring foil initiators (EFIs), slapper detonators, laser initiators, conductive composition, or semiconductor bridge devices respond to peak power levels.

D.2. Ordnance performance requirement. As stated in MIL-STD-464, Interface Standard for Systems Electromagnetic Environmental Effects, ordnance with EIDs should not be inadvertently ignited or dudded by the external radiated EME for either direct RF inducted actuation or coupling to the associated firing circuits. Compliance with this requirement should be verified by system, subsystem, and equipment level tests and analysis. Rationale for this requirement and verification is provided in the Appendix of MIL-STD-464.

D.2.1. External EMEs. Two (2) Tables are provided in Mil-STD-464 that defines external EMEs. One Table is for systems capable of shipboard operation and the second Table is for all other applications when the procuring activity has not defined the EMEs.

D.2.2 HERO safety criteria. The HERO safety classification or susceptibility threshold for ordnance systems with EIDs is a function of several factors. The electrical firing characteristics of an EID is one of the most critical factors and is a function of the electrical power available. Systems normally operating on low power sources require EIDs with low actuating power. Another factor is the electrical shielding afforded by the exterior of the system. Systems with RF apertures, intentional or otherwise, allow RF energy to enter the system. Systems with both conditions can be very susceptible to the RF sources in an EME and requires special attention during the design phase to ensure HERO protection. The safety criteria for evaluating an ordnance system containing EIDs are a function of the EID's "maximum no-fire stimulus(MNFS)", and an appropriate "margin" as defined in MIL-STD-464.

D.2.3 Degradation mechanisms. EIDs and their circuits are not intentional RF receivers in weapon systems. Consequently, their inherent response characteristics to RF induced currents is complicated and difficult to evaluate. Frequency, power and polarity are the most important parameters influencing the HERO response of a system. The history of testing weapons for HERO has shown that many other characteristics, such as gain and aspect angle, can also have significant effects, but are nearly impossible to predict by analysis. Proper HERO design considerations are therefore essential.

D.3 HERO design guidance. EIDs may be caused to actuate or dud as a result of induced currents from RF energy. However, it is not necessary to design ordnance systems that are completely immune to these induced currents. The design only needs to reduce the HERO susceptibility of ordnance systems to levels that effectively reduce the risk.

D.3.1 Conceptual/design phase. A proper design to preclude HERO should begin at the earliest phase of development. Significant costs are involved with retro-fitting a HERO fix to a weapon system after it becomes operational. The costs for implementing a HERO fix is not only in dollars. When the dollar cost is too high to correct HERO design deficiencies, operational restriction(s) may have to be imposed on emitter systems (RF sources) as well as on the ordnance system itself. The objective should be to provide HERO safe ordnance with no requirement to imposed operational restrictions on either the ordnance system or emitter systems.

D.3.2 HERO protection. NAVSEA Publication OD 30393, Design Principles and Practices for Controlling Hazards of Electromagnetic Radiation to Ordnance, provides the design methods and techniques that are most applicable for precluding HERO in today's modern weapon systems. Incorporation of methods and techniques such as shielding, filtering, component selection and bonding during the design phase should ensure that an operational system will be immune to HERO. During the design it is essential the methods and techniques being used are well documented so a HERO analysis can be adequately performed.

D.4 HERO control strategy. The objectives that should be accomplished for ensuring HERO will be precluded from a design is summarized in FIGURE D-1. The efforts required to achieve HERO safe ordnance should include:

a. Determining the ordnance systems's EID characteristics and circuit design at the earliest possible time.

b. Determining that the preclusion of HERO can be achieved during the engineering design phase, or remitted in favor of overriding operational necessity.

c. Planning for appropriate HERO evaluation during the PAT&E phase. This includes testing if analysis is found to be inadequate for certification.

d. Establishing administrative or operational control procedures in the event that preclusion of HERO is not possible.

D.4.1 Susceptibility database. A permanent susceptibility database resides at the Joint Spectrum Center (JSC). This JSC Ordnance E^3 Risk Assessment Database (JOERAD) contains all the known susceptibility data for DoD ordnance systems with Joint Service applications. This data is critical for making risk assessments. All susceptibility data derived from an ordnance program should be forwarded to the JSC for inclusion in the JOERAD.

D.5 HERO certification. Weapon systems and devices should be designed to preclude the spurious functioning or degradation of EIDs due to the EMEs that they will be exposed to. Prior to the release of any weapon system for production a determination should be made that the design contains adequate safety provisions for protection against personnel injury, as well as any damage or malfunction of the system, when being exposured to the EMEs. Certification of this determination should be the responsibility of the program manager. The HERO Control Strategy as delineated in FIGURE D-1 can also be used as the process for HERO certification.

D.5.1 Recertification. Whenever a weapon system or electromagnetic emitting system in the EME is being altered, changed or relocated a new determination should be made to ensure there is adequate safety provisions to preclude HERO.

HERO CONTROL STRATEGY FOR CERTIFICATION						
GOAL	**TO DESIGN HERO SAFE ORDNANCE**					
OBJECTIVES	• Establish fund-amental guidance for HERO protection between the desired ordnance system and the intended EMEs.	• Establish in the approved require-ment, that the specified operation-al performance level of the item will be fully achieved in the intended EME. • Ensure that pro-gram and preproject planning addresses the E^3 control organization to provide arrangements for appropriate early HERO assess-ment, analyses, and/or testing during development. • Ensure that significant risks of EM radiation hazards characteristic of or inherent in each solution presented were adequately addressed during the decision process.	• Establish HERO control and testing requirements for engineering development. • Determine that known or projected HERO susceptibility problems of the ordnance system are judged resolvable in engineering development. • Determine that applicable HERO design practices and techniques are being incorporated into the system design. • Obtain HERO representation on the E^3 WIPT/EMCAB when its established.	• Ensure that the developmental model achieves full operational per-formance levels in the intended EMEs without HERO problems. • Ensure that the HERO control design requirements established for the production model will preserve the HERO immunity demonstrated by the approved development model.	• Ensure through analysis or testing that the production model meets all HERO safety requirements established for it.	• Ensure through analysis or testing that redevelopment, upgrading of, or modifications to an ordnance system incorporates the HERO control design requirements needed to correct any existing or newly created HERO problems of the current item.
ACQUISITION PHASE		PHASE 0	PHASE I	PHASE II	PHASE III	
MILESTONE	0	I	II	III	PAT&E	
JECS PHASE	DETERMINATION OR MISSION NEED	CONCEPT EXPLORATION	PROGRAM DEFINITION & RISK REDUCTION	ENG. & MFG. DEVELOPMENT	PRODUCTION, FIELDING/DEPLOYMENT & OPERATIONAL SUPPORT	

FIGURE D-1. HERO control strategy

APPENDIX E

EMC PERFORMANCE CONSIDERATIONS

E.1 General. Experience has shown that the desired degree of EMC can best be achieved by first identifying the operational EME and then defining and adhering to proper design, development, test, production and installation requirements and procedures, and continuing with adequate maintenance and support measures throughout the life cycle.

E.1.1 System design. The trend toward employment of more complex microelectronic circuits is creating a progressively more difficult task for the system developer faced with designing a system to operate in complex EMEs. Given the intended EME, the system designer should determine the EM energy that can be coupled to a system and the potential effects from this energy. From this determination, the design can be established based on the EMC performance requirements. The design may include temporary protection measures if the EM energy at intermediate stages of the life cycle can exceed those which will exist in the operational EMEs of the system. During the operational phase, maintenance activities and aging can result in the deterioration of the system and increase the potential for an E^3 problem. Appropriate maintenance requirements and schedules should be established to ensure that the integrity of the design is maintained throughout the system's life cycle.

E.1.1.1 Principal design parameter. EMC should be considered a principal design parameter with the magnitude, scope, and level of effort tailored to the specific type and mission of the platform, system, or equipment and the program phase. Emphasis should be placed on implementing practical requirements and procedures to meet the desired EMC performance with available resources, while still meeting the intended mission requirements. To accomplish this, an effective program of EMC management, assessment, engineering, and configuration control should be required and integrated into the overall design and engineering effort from early in the conceptual phase and throughout the life cycle of the item.

E.2 Immunity (susceptibility). All electronic equipment, subsystems, and systems are inherently susceptible to EM energy. It is not practical to design a system that is completely immune to the EM energy that can be imposed on it by high-powered transmitters. The degree of immunity required, however, can be achieved to a great extent through engineering practices that incorporate EMI hardening into the design. System design features that reduce system susceptibilities include filtering, shielding, selectivity, component selection, transient limiting devices and signal processing. The goal of EMI hardening is to reduce the susceptibilities of individual equipment and systems to the point that, in the aggregate, exposure of electronic equipment and systems to harmful levels of EM energy can be controlled by frequency management procedures without affecting desired system EMC performance and availability.

E.2.1 Threshold criteria. Identifying the power threshold at which degradation occurs and how receiver degradation relates to various interference power levels and modulation waveforms are very important in the design process. Performance degradation indicators differ for various types of receivers. For instances, in a communications receiver, degradation is manifested in the form of reduced intelligibility, increased distortion, or increased bit error rate; for radar receivers, degradation may occur in the form of range reduction, reduced probability of detection, false alarms, tracking errors, or break-lock; and for navigation and identification-friend-or-foe (IFF) systems, degradation may occur in the form of range/angle errors, false decodes, and overloads. In some receivers, degradation is related directly to the interference power while in others, it is a function of the number of interfering signals.

E.2.2 Degradation mechanisms. The dominant degradation mechanism, such as co-channel, adjacent channel, harmonic, intermodulation, or saturation, depends upon the nature of the interference and varies as a function of geometry and coupling conditions. The threshold at which performance degradation occurs for an equipment or system may vary significantly for different modulated waveforms. In some systems, interference may produce observable degradation throughout the system; while in others, a single component may tend to induce or dominate the overall degradation.

E.2.3 Receiver susceptibility. Receiver susceptibilities are inherent in receiver designs. Susceptibility may result from a single receiver component or from the interactions of two or more components. An EMI problem may occur only when a receiver is exposed to an interfering EM energy source. However, for an EMI problem to occur, there must be sufficient EM energy in the environment with the appropriate waveform and level of power being coupled into the receiver input. Quantifying and understanding the factors that influence the input power level is essential when designing a receiver with built-in immunity. Part of the design process should include determining the effects of deployment geometry, maneuver dynamics, antenna patterns, and propagation factors on the power levels that can be coupled into a receiver.

E.3 <u>EMC performance requirements</u>. Under most circumstances it is impractical to consider after-the-fact fixes for resolving EMI problems. Experience has shown that correction of EMI problems after an electronic equipment or system is designed or in operation always involves considerable expense, and often yields less than optimum results. For this reason, the implementation of specific efforts to deal with EMC matters should be required from the early conceptual and design phases as well as throughout the life cycle of an item. Efforts should include:

a. Early determination of E^3 control/EMC performance requirements.

b. Achievement of system immunity(EMC) in the item's intended operational environment(s).

c. Attainment of built-in EMC in the design of electronic items, rather than resorting to after-the-fact remedial measures.

d. Assurance that EMC can, in fact, be achieved; or if not, duly considered and remitted in favor of overriding operational necessity.

e. Establishment of E^3 control procedures to prevent and correct EM problems that may occur.

E.3.1 <u>Specifications and standards</u>. The complexity of E^3 problems requires the EMC performance requirements in the design and procurement specifications of an item to be tailored specifically to the mission needs, including the end-item's intended operational EMEs. This is normally accomplished through the application and tailoring of E^3 interface specifications and performance standards such as MIL-STD-461 and 464.

E.3.1.1 <u>MIL-STD-461/464</u>. MIL-STD-461, Interface Standard: Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility, and MIL-STD-464, Interface Standard for Systems E^3 Requirements, establishes performance requirements for the control of EM emission and immunity (susceptibility) characteristics of electronic, electrical, and electromechanical equipment and systems designed or procured for use by activities and agencies of the DoD. These performance requirements are the minimum considered necessary to provide reasonable confidence that a particular subsystem or equipment complying with these requirements will function within their designated performance tolerances when operating in their intended EMEs. These requirements are presented as limits for conducted and radiated emissions and conducted and radiated susceptibilities over specified frequency ranges.

E.3.2 Applicable design principles. Applicable design principles that should be followed during the development of an item include:

a. E^3 control/EMC performance requirements should not be developed through trade-offs with other system parameters, such as, reliability, maintainability, cost and safety. The EMC performance requirements should be based on the mission(s) and the specific scenario(s) within which the item is intended to be used.

b. In the early phases of research and development, past experience should direct attention to specific components or circuits which are likely trouble areas from an EMC aspect. Design philosophy should concentrate on these areas to preclude a design in which there is not enough space for shielding or separation, and thus inviting pick-up of unwanted EM energy.

c. In the later phases of research and development, the mechanisms by which one subsystem may possibly interfere with another, whether it is conducted on power leads, signal leads or common antenna, or emitted, should be explored to determine which, if any, are of sufficient strength to pose a problem.

E.4 System protection. The best method for reducing electromagnetic vulnerability in electronic equipment, subsystems, and systems is to preclude the inadvertent EM energy. Application of susceptibility reduction techniques should be considered early in the design process and in each subsystem area so that the entire system hardness requirement does not have to be met by disproportionate efforts in one area. The design goals should be to:

a. Keep unwanted EM energy away from susceptible circuitry.

b. Keep undesired signals which can couple to wires away from intended signal paths.

c. Design circuitry so undesired EM energy in the signal path does not severely disrupt the circuit operation.

Techniques used for hardening circuits from undesired EM energy include shielding, bonding, filtering, grounding, and circuit design.

E.4.1 Shielding. Shielding is essentially a decoupling mechanism used to reduce radiated interactions between equipment, subsystems and systems or portions of a given item. Shielding is used to:

a. Keep radiated EM energy confined within a specific region.

b. Prevent radiated EM energy from entering a specific region.

E.4.1.1 Shielding effectiveness. The shielding effectiveness of an equipment or subassembly enclosure is a complex function involving a number of parameters including:

a. Frequency and impedance of the impinging wave.

b. Intrinsic characteristics and thickness of the shielding materials.

c. Number and shapes of the shield discontinuities.

The equipment design process consists of establishing the undesired signal levels on one side of a proposed shielding barrier, estimating tolerable signal levels on the other side, and evaluating the various shield design options to achieve the necessary effectiveness level. Shielding, however, represents only one method of reducing equipment EM interactions and should not be considered without also considering trade-offs of filtering, grounding and bonding techniques that may simplify or eliminate the requirement for shields.

E.4.2 Bonding. Bonding is the establishment of a low impedance path between two metal surfaces. This path may be between two points on a system ground plane, or between ground reference and a component, a circuit or a structural element. The purpose of the bond is to make the structure homogenous with respect to the flow of RF currents, thus avoiding the development of electric potentials between metallic parts which can produce interference. Surface treatment, corrosion, and bonding resistance are three (3) important factors that should be addressed when establishing good bonds.

E.4.2.1 Bonding effectiveness. The effectiveness of a bond is dependent upon the application, frequency range, magnitude of the current, and environmental conditions such as vibration, temperature, humidity, fungus, and salt content in the ambient environment. There are two (2) basic types of bonding:

a. Direct bonding where there is metal-to-metal contact between the members to be bonded.

b. Indirect bonding where bonding is achieved through the use of conductive jumpers.

E.4.3 Filtering. A well-designed system that incorporates proper shielding and grounding practices can still have undesired EM energy conducted through it which may result in degraded EMC performance of the system, or worst, cause malfunctions. Filters can be used to reduce unwanted conducted EM energy to levels at which the system can function satisfactorily by limiting the magnitude of extraneous currents or confining them to a small physical area.

E.4.3.1 Performance specifications. EMC performance specifications such as those based on MIL-STD-461 limit the conducted emissions that may be introduced on a power line. Tolerable interference levels on critical equipment leads should be defined as early as possible during the design so circuit designers know the conditions that their subassemblies must meet. While filters may be necessary, care should be taken to avoid redundant filtering caused by uncoordinated efforts of separate design groups.

E.4.3.2 Filter parameters. Many parameters should be taken into account when selecting or designing a filter that will be effective for a particular application. Insertion loss versus frequency is the primary characteristic that determines the suitability of a filter for a specific application. Other characteristics that also should be considered include:

a. Impedance matching.

b. Voltage and current ratings.

c. Maximum allowable voltage drop through the filter.

d. Frequencies - both the operating frequencies of the circuit and those that need to be attenuated.

e. Insulation resistance.

f. Size and weight.

g. Temperatures of the intended operational environments.

h. Reliability.

E.4.4 Grounding. Grounding involves the establishment of an electrically conductive path between two (2) points, with one (1) point generally being an electrical/electronic element of a system and the other being a reference point. A good, basic ground plane or reference is the foundation for obtaining reliable, interference-free equipment operation. An ideal ground plane would provide equipment with a common potential reference point anywhere in the system, so that no voltage would exist between any two (2) points. Because of the physical properties and characteristics of grounding materials, no ground plane is ideal, and some potential always exists between ground points in a system.

E.4.4.1 Grounding effectiveness. The extent to which potentials in the ground system can be minimized and ground currents can be reduced determines the effectiveness of the ground system. A poor ground system that enables spurious voltages and currents to couple into a circuit, subassembly, or equipment can degrade the shielding effectiveness of well-shielded units, can essentially bypass the advantages of good filters, and can result in EMI problems that may be rather difficult to resolve after-the-fact. A designer should consider grounding from both inter- and intra-system aspects.

E.4.4.2 Cable shield grounding. The problem of achieving electromagnetic compatibility in a complex electrical or electronic system is in many cases dependent on the treatment of the shielding and the grounding of the shields of interconnecting leads. Poor or incorrect application of a grounded shield to a wire may cause coupling problems that otherwise would not exist. Grounding of the shield may be accomplished as single-point or multi-point grounding. Factors that influence the selection of single-point or multi-point grounding includes the frequencies of the interfering signals, the length of the transmission line, and the relative sensitivity of the circuit to high- or low-impedance fields.

E.4.5 Circuit design. High sensitivity, low signal-level circuitry tends to be prone to interference problems. In most cases, the interference signal produced is proportional to the amount of energy leaking into the circuit. If the desired signal levels are large, circuits are inherently more resistant to interference. When RF leakage into a system cannot be avoided because system constraints prevent the application of sufficient shielding or filtering measures, the designer should choose components and circuit configurations which provide for some degree of hardening. If at all possible, high-sensitivity, low-signal-level circuity should be isolated from probable points of entry of RF energy into the system or circuit.

GUIDE ON THE USE OF CIVILIAN STANDARDS

BY MILITARY AGENCIES

WILL BE PROVIDED IN

FIRST REVISION

APPENDIX G

THE JECS ENGINEERING PROCESS

G.1 General. Section 10 of this handbook describes the purpose and management methodology of the Joint E^3 Control Strategy (JECS). This appendix describes an engineering process (EP) that can be used to facilitate the task of applying the JECS on a day-to-day basis. This appendix addresses the Defense Acquisition life cycle, covering all five (5) major periods in greater depth than in Section 10 and presents evaluation guides for the 15 type of key documents that are listed in TABLE 1 of Section 10.

G.2 RD&A phases and JECS objectives. Major project activities occurring in each acquisition phase are described in the following paragraphs as background information for JECS. Descriptions are often expressed in terms of the sources of information which are used to evaluate a project. In order to facilitate the assessment of programs, a set of objectives is presented with which to measure the effectiveness and adequacy of program E^3 control procedures, measures, and achievements. The presentation of objectives is accompanied by corresponding primary issues, together with several corollary issues. Corollary issues are representative of the tailoring usually required when raising issues of significant E^3 problems for specific program reviews. As circumstances demand, any of the corollary issues presented may be used, modified, or supplanted by an issue derived from the primary issue and varied according to the facts of the E^3 problem. For organizational purposes the write-up for each phase is begun on a new page.

<table>
<tr><td rowspan="2">G.2.1 THE PRE-DEVELOPMENT PERIOD
DETERMINATION OF MISSION NEED
(DMN)</td><td>Starting
Milestone: n/a</td></tr>
<tr><td>Ending
Milestone: 0</td></tr>
<tr><td colspan="2">JECS Gate (at Milestone 0) is DMN</td></tr>
</table>

G.2.1.1 <u>Determination of mission need (DMN</u>). During this initial period before Milestone 0, the need for a capability is surfaced, refined, and developed into a statement of mission-defined need. Documentation used by various DoD Components to develop a mission need may vary widely. These efforts culminate, however, in a document whose format is specified by the Under Secretary of Defense (Acquisition & Technology) (USD(A&T)). This is the Mission Need Statement (MNS).

a. DoDD 5000.1 classifies acquisition programs in three acquisition categories (ACATs). The highest, ACAT I, covers a Major Defense Acquisition Program (MDAP) as defined by DoDD 5000.1. Another term, Major System, is defined by statute. Major Systems are ACAT II programs. These first two categories are usually assigned on the basis of cost thresholds, but an ACAT I may be assigned by the USD(A&T) for other reasons. ACAT III is of still lower value and significance, and encompasses all programs not assigned to a higher category. The USD(A&T) is the designation authority for all proposed MNSs that are assessed as possible ACATs I. While designating a proposal as an ACAT I, the USD(A&T) may delegate its oversight to the Appropriate DoD Component as an ACAT IC (for Component, those retained are known as ACAT IDs). A hierarchy of officials below the USD(A&T) and in the DoD Components act as designation authorities in the assignment of ACATs II and III and as Milestone Decision Authorities (MDA) for programs which may be created.

b. Proposed MNSs are submitted for approval via a validation authority. The validation is performed by the Joint Requirements Oversight Council (JROC) for items that are assessed as potentially of ACAT I magnitude. The proposal is studied to determine if it can be satisfied by non-materiel solutions; i.e., changes in doctrine, operational concepts, tactics, training, organization, etc. If the JROC is satisfied that a non-materiel solution is not feasible, they will forward a MNS to the USD(A&T) together with recommendations and assigned priority.

c. The staff of the USD(A&T), specifically members of a Defense Acquisition Board (DAB) sub-committee, review the proposed MNS and attendant recommendations to determine if a Milestone 0 review is in order. This involves determining that the milestone objectives of DoDI 5000.2-R have been met and that the criteria for the phase are satisfied. When these items have been satisfied, the Acquisition Decision Memorandum (ADM) is prepared with the necessary direction incorporated. For a Milestone 0 decision the requirement would be to perform an appropriate set of Concept Studies. Studies could include a search for commercial and non-developmental items (NDIs) options and, unless a commercial or NDI is particularly promising, a range of options involving development. Identification of the agency to perform these studies and of funding support complete the items for an ADM. Similar actions within the DoD Components by the Military Department (MILDEP) MDA or counterpart confirm and approve ACAT II and III MNSs for candidate programs. The Milestone 0 decision approves the MNS and ends the DMN Period, but does not approve a new program. Phase 0, Concept Exploration (CE) commences at that time.

G.2.1.2 DMN objective and issues. The E^3 control objective for this period and the JECS DMN Gate is to:

> Establish fundamental guidance for bilateral EMC between the desired platform, system, or equipment item and the intended EME.

The primary issue in support of the DMN objective is:

> Has fundamental guidance been established to require the desired platform, system, or equipment item to achieve joint EMC in the intended EME?

Corollary issues are:

a. Does the mission need necessarily mandate use of an EM technology or technology sensitive to EM energy?

b. If, at this early stage, the use of a specific portion of the spectrum is contemplated by the mission need, what prior coordination has occurred with spectrum management agencies?

c. Have the consequences of additional spectrum occupancy resulting from satisfying the requirement been assessed? By an impartial arbiter?

d. Are there any new or unique aspects to this proposed use of spectrum resources? Is the radiated power level unusually high? To a hazardous level?

G.2.1.3 Assessing the DMN period. The importance of the DMN Period to the JECS is that it affords a singular opportunity. The fundamental need for effective E^3 control in the new capability must be stated. The documentation format of an MNS is characterized by significant constraints on length, where even directed considerations are bound by severe limits. The need to achieve required operational performance in the EME, undegraded by EMI, is a minimum acceptable expression in a MNS. A parallel statement requiring electromagnetically compatible operation is also essential as appropriate; the item needed must not itself be the source of interference. Ensuring that follow-on documentation incorporates similar minimum guidance underwrites support for E^3 control considerations in the outyears. The assessment being made at this point seeks to resolve a basic E^3 issue for the current period with regard to the end-item.

G.2.1.4 Resolving DMN issues. The ideal resolution results in suitable E^3 control action(s) being implemented by the project office as soon as the PM becomes aware of an E^3 problem. However, in the DMN period, there being as yet no project office or PM, the need for action devolves to the potential Program Sponsor of the DoD Component. With effective action, the primary issue becomes resolved and the objective for this period is attained. Otherwise, unresolved E^3 problems should be described as issues suitably refined for presentation at the next review level, but not later than the Milestone 0 decision forum. Risk assessments should be prepared for each unresolved E^3 problem.

<table>
<tr><td rowspan="2">G.2.2 Phase 0
CONCEPT EXPLORATION
(CE)</td><td>Starting
Milestone: 0</td></tr>
<tr><td>Ending
Milestone: I</td></tr>
<tr><td colspan="2">JECS Gate (at Milestone I) is CE</td></tr>
</table>

G.2.2.1 Phase 0. With the approval of an MNS at Milestone 0, Phase 0 launches study efforts to investigate alternative means for satisfying the need. Under the acquisition system, various possible concepts to satisfy the need are explored, but performance requirements are maintained in generalized statements until the study efforts and analysis are sufficiently mature to support and justify more detailed refinement. Commercial items and NDIs should be given particular emphasis as possible solutions during the Concept Study efforts. Concepts may propose a mix of commercial items, NDIs and development efforts for some subsystems and systems, and some concepts will be wholly developmental.

a. At this time, an acquisition strategy (AS) should be formulated by the DoD Component who will actually do an acquisition, should a concept be approved. The AS should present acquisition planning for the most promising concepts under study. The AS should show any tailoring of the acquisition cycle that is planned for a particular concept. The AS is not listed as a key document (KD) because it may not be widely circulated or readily available. Moreover its concern for E^3 matters is normally limited to ensuring that necessary frequency allocation(s) have been obtained. However it should be regarded as a possible ADDOC (See TABLE 1) and should present the best available description of planned program and project schedules.

b. Concurrently, Operational Requirements Documents (ORDs) should be prepared for each of the concepts that is to be recommended as suitable for continuance past a Milestone I decision into the next phase. Parameters of each ORD should be tailored to the concept device covered; (e.g., the ORD for a cruise missile would not contain human engineering parameters for a pilot but the ORD for an attack aircraft would; both would, however, have the same maximum effective range parameters). These ORDs are preliminary documents for Milestone I. The ORD for the successful concept should be refined further in the following phase, and should be subject to reapproval at each subsequent milestone. At this time, however, detailed performance requirements should be avoided. The level of detail used should be only sufficient to conduct an early cost and operational effectiveness analysis (COEA) needed for comparisons of concepts.

c. By the end of Phase 0 the threat should have been validated, the advantages and disadvantages of the more desirable concepts should be known and assessed, and the ORD(s) and a proposed Acquisition Strategy (AS) should have been prepared. The Milestone I decision should be based on cost, schedule and performance objectives assessed in conjunction with the projected affordability constraints. The most promising concept(s) should be selected. The AS may continue two (2) or more concepts competitively through one or more phases.

G.2.2.2 CE objectives and issues. There are three E^3 control objectives for Phase 0 and the JECS CE Gate is represented by three subgates.

Subgate CE-1 objective:

Establish, in the approved requirement, that the specified operational performance level of the item will be fully achieved in its intended EME.

The primary issue for Subgate CE-1 is:

Does the requirement specify that the level of operational performance demanded for the item be achieved in the intended joint EME?

Corollary issues are:

a. Will operation of the item result in the radiation of significant EMI in the joint EME?

b. Will operation of the item result in the introduction of significant levels of EM energy resulting in radiation hazards that could affect joint force personnel, ordnance, or volatile fuel stores?

Subgate CE-2 objective:

Ensure that program and preproject planning addresses the organization responsible for E^3 control and provides arrangements for early EME assessment, analyses, and testing during development or acquisition.

The primary issue for Subgate CE-2 is:

Do program and preproject planning considerations include and address means to ensure that the potential for joint EMI will be predicted, analyzed and tested adequately so that effective EMI control is ultimately attained?

Corollary issues are:

a. Have preproject efforts and documentation set forth a clear plan for attaining EMC in the product item?

b. Regardless of source, through development or from commercial and NDI offerings, are the electromagnetic characteristics of emissions or susceptibilities to be calculated or verified by testing?

Subgate CE-3 objective:

Ensure that significant risks of EMI or EM radiation hazards characteristic of or inherent in each solution presented were adequately addressed during the decision process.

The primary issue for Subgate CE-3 is:

Where there are potential risks of Joint EMI or radiation hazards inherent in some solutions proposed for a requirement, have the significant risks been presented?

Corollary issues are:

a. Has the E^3 data provided for use in the process of selecting an alternative solution to the requirement been stated in clear terms (e.g., decreased/

increased cost or time in development, etc., for a particular solution)?

b. Do one or more of the alternatives contemplate the application of power levels significantly above conventional systems? Of high levels of transients?

G.2.2.3 Phase 0 information. TABLE G-1 identifies KD information sources for the objective of each subgate, but should not be followed blindly. Any and all information sources should be explored. Since there are multiple objectives and issues associated with the CE Gate it is normal for some KDs to support more than one subgate.

TABLE G-1. Key Documents for the CE Subgates.

Subgate	Key Document Information Sources
CE-1	STAR, ORD, EMCPP, DD1494, TEMP
CE-2	STAR, ORD, EMCPP, TEMP, SPEC, SOW, CDRL
CE-3	STAR, ORD, EMCPP, IPS

G.2.2.4 Assessing phase 0. The nature of Phase 0 is one of transition. The bilateral requirement for EMC established in the MNS during the DMN Period should now be incorporated into each of the ORDs drafted to support various concepts. In particular the ORDs should carry forward a fundamental need for effective E^3 control, emphasizing the achievement of all operational performance parameters while operating in the intended EME and under the validated threat. As appropriate, each concept should address significant potential risks of EMI, the necessity for, and extent of Electronic Protection (EP) features in the design, the extent and cost of required electromagnetic pulse (EMP) harding measures, the potential for radiation hazards (RADHAZ), and the treatment of other E^3 disciplines. The degree to which these factors are recognized and displayed is indicative of the extent E^3 is understood, and the scope of planning for E^3 considerations. The assessment being made should be to determine that the issue raised for each objective is resolved favorably for E^3 considerations. Each issue corresponds to a particular gate or subgate of the JECS.

G.2.2.5 <u>Resolving CE issues</u>. The ideal resolution results in suitable E^3 control action(s) being implemented by the Project Office as soon as the PM becomes aware of an E^3 problem. The primary issues become resolved and the subgate objectives are attained. Otherwise, unresolved E^3 problems should be refined as issues suitable for presentation at the next program review, but not later than the Milestone I decision forum (or a Milestone II forum where a formal Milestone I and/or a Phase I are waived for lower level, non-major programs). Risk assessments should be prepared for each unresolved E^3 problem.

<table>
<tr><td rowspan="2">G.2.3 Phase I
PROGRAM DEFINITION AND RISK REDUCTION
(PD&RR)</td><td>Starting
Milestone: I</td></tr>
<tr><td>Ending
Milestone: II</td></tr>
<tr><td colspan="2">JECS Gate (for Milestone II) is PD&RR</td></tr>
</table>

G.2.3.1 Phase I. In Phase I the transitional activity of the program continues, bringing the efforts begun during Phase 0, CE, to a higher level of refinement. Phase I emphasizes a wide variety of analytical work which should develop a better understanding of each potential design approach remaining under active consideration. The studies and analysis performed should aid in identifying and reducing perceived risks. Other efforts should examine proposed designs, searching out the cost-driving factors implicit in the performance requirements that have been established. The purpose of these efforts is to determine where the rising curves of costs for increased performance become severe and ultimately unaffordable. At the project level, the extent of actual hardware fabrication and testing should be a function of the degree to which the technology proposed for a design is of an advanced nature. The application of newer technology usually demands positive demonstration that critical aspects of the proposed applications are feasible. By-product data accrued should also support the trade-off analysis noted earlier. The culmination of Phase I activities at Milestone II should bring together an extensive body of refined data describing the proposed design approach(es). The milestone decision should determine if continuation of a program is warranted and, for an affirmative conclusion, should allocate a Development Baseline. The baseline should specify revised and refined costs, schedule, and performance objectives. A central thrust of the Milestone II decision deliberations should be to assess assurances that the item can be brought through low risk development into production in a supportable and affordable form.

G.2.3.2 Phase I objectives and issues. There are two E^3 control objectives for phase I and the JECS PD&RR gate is represented by two subgates:

Subgate PD&RR-1 objective:

> Establish E^3 control and testing requirements for engineering development.

The Primary issue for Subgate PD&RR-1 is:

Have requirements for joint EMI control and testing been established for the engineering development effort?

Corollary issues are:

a. Have critical EMI test issues been defined?

b. Will the critical test issues as stated ensure that testing will be conducted in realistic and representative joint EMEs?

Subgate PD&RR-2 objective:

Determine that known or projected EMI or EM radiation problems of the project item are judged resolvable in engineering development.

The primary issue for Subgate PD&RR-2 is:

Have known or significant projected joint EMI or RADHAZ problems been judged resolvable in engineering development?

Corollary issues are:

a. Is there an approved Developmental Frequency Allocation for any item or component which transmits or receives EM energy?

b. Has the degree of risk associated with the above judgments been clearly presented in the decision process?

c. Does the time duration scheduled for Test & Evaluation appear realistic in consideration of the EME?

G.2.3.3 Phase I information. TABLE G-2 identifies information sources for the objective of each subgate, but should not be followed blindly. Any and all information sources should be explored. There are multiple objectives and issues associated with Phase I, and it is normal for some KDs to support more than one subgate.

TABLE G-2. Key Documents for the PD&RR Subgates.

Subgate	Key Document Information Sources
PD&RR-1	STAR, ORD, EMCPP, DD1494, TEMP, IPS, SPEC, SOW, CDRL
PD&RR-2	STAR, ORD, EMICP/RSMCP/E3IAR, T&E Rpt, EMCPP, DD1494

G.2.3.4 Assessing phase I. Often tailored and deleted from the development cycle for less complex projects of low technological risk, Phase I is nevertheless indispensable whenever the technology planned is relatively untried, and in general, whenever there is no clearly preferable choice among the concepts proposed. Test and measurements data from an Advanced Development Model (ADM) offers the first concrete indications of any E^3 problems and the impact of the EME on an item. Two areas of paramount JECS interest are:

a. An appreciation of the scope of the E^3 problems, their realistic (risk) technical resolution, and the affordability of accomplishment; and, most importantly,

b. The project office specifications for E^3 control requirements that are to be met in an Engineering Development Model (EDM), and the requirements laid down to inspect, test and demonstrate the achievement of effective E^3 control.

The initial manifestation of the end-product should occur in the next phase. At that time, full application of designated standards such as MIL-STD-461, MIL-STD-462 and MIL-STD-464 should be incorporated. The development specification prepared now for use in Phase II should carry positive requirements for the application of MIL-STD-461 (or commercial equivalent) in the EDM at the subsystem level and below. For additional E^3 control requirements that the EDM may need to satisfy, other standards should be consulted; e.g., bonding and grounding, MIL-STD-1310; additional EMP requirements, MIL-STD-2169; etc. The assessment being made for the PD&RR Gate prior to Milestone II seeks to resolve one or more E^3 issues for the current phase of the end-item. Each issue corresponds to a subgate of the JECS.

G.2.3.5 Resolving PD&RR issues. The ideal resolution results in suitable E^3 control actions being implemented by the Project Office as soon as the PM becomes aware of an E^3 problem. When the primary issues become resolved, the subgate objectives are attained. Otherwise, unresolved E^3 problems should be refined as issues suitable for presentation at the next program review, but not later than the Milestone II decision forum. Risk assessments should be prepared for each unresolved E^3 problem.

<table>
<tr><td rowspan="2">G.2.4 Phase II
ENGINEERING & MANUFACTURING
DEVELOPMENT
(EMD)</td><td>Starting
Milestone: II</td></tr>
<tr><td>Ending
Milestone: III</td></tr>
<tr><td colspan="2">JECS Gate (for Milestone III) is EMD</td></tr>
</table>

G.2.4.1 Engineering & manufacturing development(EMD). In Engineering and Manufacturing Development (EMD) a program moves forward with the most promising design approach. The paper requirements should now be translated into the hardware of an engineering development model (EDM). Through extensive testing and evaluation, the EDM should show that a stable, producible, and cost-effective system design has resulted from these efforts. A major development objective should be to prove that the end-item meets all specified requirements and satisfies the mission need by providing minimum acceptable operational performance. The procedures of Phase II emphasizes an often troublesome endeavor in complex technological projects, the transition from development to production. To ensure successful transition to, and readiness for, Full-rate Production the EMD phase as a minimum should demand that the manufacturing or production process be validated. This is frequently accomplished by a Low-rate Initial Production (LRIP). Planned Development Test & Evaluation (DT&E) continues during an LRIP through final Technical and Operation Evaluations at the Phase II level for milestone III.

a. At the project level during EMD, the required platform, subsystem or equipment item is designed, engineered, integrated, tested, and evaluated. These-activities should include the militarization of the design, the start of configuration control, the development of provisioning, and general documentation that will be needed later to support training, maintenance, repair, installations, integrated logistics, and other disciplines. With the start of the design effort, each of the reviews (from the Preliminary through the Critical Design Review) should be closely monitored. Once the latest version of the EMC Program Procedures (EMCPP) has been promulgated and the EMICP/RSMCP/E3IAR approved, E^3 control practices should be in place. Oversight is now necessary to ensure that critical E^3 control measures are not abridged when trade-offs for other design considerations are proposed. As the configuration management discipline is applied to the project item, the mechanism of oversight is made formal and the probability of unexpected changes is reduced. The efforts during EMD should produce an end-item whose test & evaluation (T&E) supports a determination that the item's operational effectiveness and suitability are satisfactory.

G.2.4.2 EMD objectives and issues. There are two E^3 objectives for Phase II and the JECS EMD Gate is represented by two Subgates:

Subgate EMD-1 objective:

Ensure that the developmental model achieves full operational performance levels in the intend EME without generating EMI problems or unresolvable RADHAZs?

The primary issue for Subgate EMD-1 is:

Has the engineering development model demonstrated that it can achieve the required operational performance levels in the joint EME, without causing EMI or radiation hazards?

Corollary issues are:

a. Has operational testing demonstrated the EMC of the item in the joint EME?

b. Has the E^3 control design of the item reached a realistic economic balance between residual EMI protection and suppression by design, installation measures, and techniques?

Subgate EMD-2 objective:

Ensure that the E^3 control requirements established for the production model will preserve the EM performance demonstrated by the approved development model.

The primary issue for Subgate EMD-2 is:

Have requirements for E^3 control and E^3 testing been established for production?

Corollary issues are:

a. Should the item demonstrate further refinements in the degree of designed EMC before receiving approval for production?

b. Have the design parameters, including all late engineering changes needed to achieve the degree of EMC demonstrated in operational testing, been translated into a final production specification and engineering drawing package?

c. Is there an approved Operational Frequency allocation for any item or component which transmits or receives EM energy?

G.2.4.3 Phase II information. TABLE G-3 identifies key document information sources for the objective of each subgate, but should not be followed blindly. The Subgates are supported by a likely time-ordered set of KDs which should ordinarily provide the information leading to a resolution of an issue, and thus the realization of an objective. Any and all information sources should be explored. The EMD phase has more KDs associated with it than any other phase. Since there are multiple objectives and issues associated with the EMD Phase, it is normal for some KDs to support more than one subgate.

TABLE G-3. Key Documents for the EMD Subgates.

Subgate	Key Document Information Sources
EMD-1	EMICP/RSMCP/E3IAR, EMITP/RSMTP/E3VP, EMITP/E3VR, T&E Rpt, ECP
EMD-2	STAR, ORD, EMITR/E3VR, T&E Rpt, ECP, EMCPP, DD1494, TEMP, IPS, SPEC, SOW, CDRL

G.2.4.4 Assessing phase II. Of an importance among phases second to none, Phase II has, however, only two JECS objectives. Nevertheless, the dynamics of the project activities should provide a stream of E^3 concerns that should require careful E^3 control engineering oversight if all potential risks are to receive adequate attention. The reports of design reviews, when available, make useful additional KDs when assessing problems in this area. The overall concerns for the phase, however, should not be obscured by the volume of information that becomes available. Fundamentally, the project item should be acceptable if the test results demonstrate that the E^3 Control/EMC Performance Requirements are met, and the reports of operational tests confirm that the item achieves its performance requirements while operating in its intended EME. The EDM should also exhibit a condition of EMC with co-resident systems, subsystems, and equipment and should not, when properly installed, create unacceptable radiation hazards. It is essential the established E^3 control measures are protected. The production specification should incorporate the same requirements for the Full-rate Production Model (FPM) that were attained in the EDM and LRIP.

G.2.4.5 Resolving EMD issues. The ideal resolution results in suitable E^3 control actions being implemented by the Project Office as soon as the PM becomes aware of an E^3 problem. When the primary issues become resolved, the subgate objectives are attained. Otherwise, unresolved E^3 problems should be refined as issues suitable for presentation at the next program review, but not later than the Milestone III decision forum. (The initial program review if an LRIP is planned). Risk assessments should be prepared for each unresolved E^3 problem.

<table>
<tr><td>G.2.5 Phase III
PRODUCTION, FIELDING/DEPLOYMENT
AND OPERATIONAL SUPPORT
(PF&OPS)</td><td>Starting
Milestone: III</td></tr>
<tr><td></td><td>Ending: N/A</td></tr>
<tr><td colspan="2">JECS Gate is PF&OPS</td></tr>
</table>

G.2.5.1 Phase III. The authorization to continue a program and engage in Full-rate Production (FRP) moves the project into Phase III, Production, Fielding/Deployment and Operational Support (PF&OPS). Production is not a simple turn-key operation. Both developmental and operational test and evaluation (T&E) efforts go forward to expose potential deficiencies and defects. If not waived as a result of similar requirements placed on a LRIP, the first order of business should be conducting Production Acceptance Tests and Evaluation (PAT&E), inspections and demonstrations. PAT&E covers the proof and qualification of the Full-rate Production Model (FPM) for each requirement of the production specification. The PM should monitor these activities to ensure that a stable and efficient production and support base has been established, and to determine that the mission need has been satisfied. When deficiencies and defects are discovered, suitable engineering changes should be developed, incorporated, and tested to ensure that correction is effectively accomplished.

No acquisition cycle milestone marks the end of Phase III. With the delivery and acceptance of the first serial copy, following approval of PAT&E, operational support (OPS) begins. Operational support consists of monitoring the quality, safety, and supportability of the item for conditions which require positive corrective action if the useful life and mission need are to be fulfilled and maintained. The effects of aging on capability should be considered. Phase III continues until the item is removed from inventory.

G.2.5.2 Phase III objective and issues. There are two E^3 control objectives for Phase III and the JECS PF&OPS gate.

Subgate PF&OPS-1 objective:

> Ensure through testing that the production model meets all E^3 control requirements established for it.

The primary issue for subgate PF&OPS-1 is:

> Does the production model meet all E^3 control requirements established for the production model?

Corollary issue is:

> Does the Production Model demonstrate a degree of EMC equal to or greater than that exhibited by the approved engineering development model?

Subgate PF&OPS-2 objective:

> Ensure that documentation supporting redevelopment or upgrading of an item incorporates the E^3 control requirements needed to correct any existing E^3 problems of the current item.

The primary issue for subgate PF&OPS-2 is:

> Has the documentation of reprocurement, redevelopment, and upgrading proposals addressed and incorporated EMI and radiation hazard control requirements necessary for the correction of existing EMI and radiation hazards?

G.2.5.3 Phase III information. TABLE 1 identifies a list of KD information sources for Phase III, but should not be followed blindly. Any and all information sources should be explored.

G.2.5.4 Assessing phase III. The initial interest for Phase III is to ensure that an early serial copy of the item, preferably the first, is effectively tested to demonstrate that it meets the specified E^3 control/EMC performance requirements. This action should be completed before any other copies of the item are accepted. The PAT&E are a common and ideal opportunity for this. A First Article inspection on some contracts is similarly a useful event. The necessity to perform such tests stems from the circumstance that the production version of an item is intentionally not identical to the EDM version. The EDM was essentially a hand-made model, crafted and constructed to meet design requirements. The choice of parts and materials, and the use of processes may not have been ideal from the production standpoint. On a mass basis, the result would be a cumbersome and high-cost production line yielding an expensive product even in large lots. Consequently, fabrication techniques and processes should have been reengineered to obtain the same characteristics as the EDM in the FPM with the advantages of affordable production line practices and skills. The ability of the FPM to replicate the E^3 control achievements of the EDM should be demonstrated. A related aspect of the FPM which will, on occasion, recur throughout the production run is the oversight of engineering change proposals (ECPs) to effect improvements on the item.

The JECS methodology is fundamentally different during OPS. JECS OPS subgate is normally open rather than normally closed. Once an unsatisfactory E^3 condition is confirmed, the OPS subgate closes and remains closed until the condition is corrected. JECS OPS subgate starts with the gate considered as being open, starting with a condition that the EMC design is adequate to have elicited a favorable decision for acceptance at the PAT&E project Milestone. The OPS subgate remains open until an E^3 deficiency is discovered. In the former case, the preparation, approval and implementation of changes to restore EMC would be required to reopen the subgate. Two variations of this case occur:

a. When a production line is still in operation corrective actions are necessary to affect both item serial copies yet to be accepted, and item serial copies already delivered. An approved engineering change proposal (ECP) usually should be sufficient to cover undelivered and future copies. However, for items already delivered/deployed some form of change package will be needed with which to modify the hardware. Variously called Material Change Kits, Field Changes, etc. by the Services, the common purpose is the corrective modification of a hardware item, in this case to restore EMC. Such packages should be based on the factory ECP.

b. When no production contract exists for the item the creation of a change package is an independent effort, but can be monitored and managed as a latent ECP (maintained in the configuration control records for implementation should an additional production be authorized).

G.2.5.5 Reprocurement. In a simple reprocurement, the project reinitiates at Milestone III. During an assessment of a program and its hardware, an update of the requirement(s) may be ordered before proceeding; then reentry after Milestone II is probable. With variations due to the complexity or the introduction of new technology, the redevelopment might be pushed back to entry following Milestone I. The assessment being made should seek to resolve the issue about the end-item for the circumstances that prevail.

G.2.5.6 Resolving PF&OPS issues. The ideal resolution results in suitable E^3 control actions being implemented by the Project Office as soon as the PM becomes aware of an E^3 problem. When the primary issue becomes resolved, the gate objective is attained. Otherwise, unresolved E^3 problem statements should be refined as issues suitable for presentation at the next program review, but not later than the decision to approve and accept the results of PAT&E for the project item.

G.3 Evaluation guides. The assessment of a project for JECS should be accomplished by evaluating program documentation. The following paragraphs present evaluation guides that covers the 45 key documents listed in TABLE 1 of Section 10. There are 15 evaluation guides, one for each type of document. A standard format is used for these guides, the initial item being an organizational description of the document. Next, a discussion of the document is provided to place it in perspective of the acquisition phase(s) in which its receipt is expected. Each guide is completed with a series of E^3 control considerations which are usually stated as questions. Because of the variety of projects which may require assessment, not all questions will be appropriate. Also, no attempt was made to field an exhaustive list of questions. Efforts of the evaluator to find answers for these questions should surface new questions pertinent to the peculiar circumstances of the requirement or project. The experience, education, and knowledge of the evaluator, together with his/her research into potential and actual E^3 problems, should afford the insight necessary to formulate critical statements of issue(s). For organizational purposes, each evaluation guide is begun on a new page.

EVALUATION GUIDE		
Key Document: One-time Preparation	Prep'd in Phase:	For Use in Phase:
G.3.1 MISSION NEEDS STATEMENT (MNS)	DMN	0

G.3.1.1 Description. The Mission Need Statement (MNS) is the first required DoD acquisition document and should be limited to five pages. The MNS is mission-oriented. The MNS should emphasize what is to be done and avoid specifying how it is to be accomplished. Its contents should be organized into five sections, each covering a required aspect of the proposed new start. A MNS may demand a new capability or pursue a significant improvement in either the operational or cost effectiveness of existing items, or both.

a. Defense planning guidance element. Section 1 should identify the objective or that portion of the Defense Planning Guidance to which the MNS responds.

b. Mission and threat analyses. Section 2 should define the need in terms of the mission and objectives of the originator and should identify the threats to which this need responds. This identification should be in terms of validated threats recognized in intelligence analyses. Known Electronic Counter-measures (ECM) capabilities of probable threat forces should be noted.

c. Nonmaterial alternatives. Section 3 should contain a discussion and analysis of the inability of making changes in doctrine, operating concepts, tactics, organization, or training to satisfy the need.

d. Potential material alternatives. Section 4 should identify any potential inter-Service or Allied systems, programs, developments, or potential cooperation or interest which might resolve the need. These avenues should not to be evaluated in the discussion.

e. Constraints. The final Section should cover an extensive array of interface, standardization, support requirements, and other impacts and considerations which may apply. This should include the operational environment. A Minimum statement of bilateral need for EMC should be included here.

G.3.1.2 Perspective. Any DoD Component may originate a proposed MNS. When a need is identified and the MNS is prepared, it should be forwarded to the validating authority. The majority of items acquired for the DoD are obtained by the MILDEPs who also do most of the development work. The appropriate validating authority should be determined by the ACAT level anticipated necessary to fulfill the MNS. If it appears that the ACAT level required will be an ACAT I, the proposed MNS should be forwarded to the JROC for validation. The appropriate MILDEP validates ACAT II and III programs.

G.3.1.3 E^3 control considerations:

a. Does the MNS by direct statements, or by an aggregation of E^3 component concerns (for EMC, Spectrum suitability, Electronic Protection (EP), Electromagnetic Pulse (EMP) hardness, radiation hazard, etc.) establish that the item will meet all performance requirements while operating in the intended EM environment, and that it will neither degrade nor suffer degradation from EMI?

b. Will the required item generate or emit EM energy at significant power levels?

c. Is there a potential that the EM energy emitted will constitute a hazard to personnel? ordnance? volatile fuels?

d. If emitted levels of EM energy are high, is there potential for EMI to cause malfunctions in control systems of other electronic or electro-mechanical devices?

e. Do the victim subsystems of d. include the equipment components of Joint forces? Civil facilities?

EVALUATION GUIDE		
Key Document: Iterative Preparation G.3.2 <u>APPLICATION FOR FREQUENCY ALLOCATION</u> <u>Stages 1 through 4</u> <u>DD FORM 1494</u>	Prep'd in Phase: DMN 0 I II	For Use in Phase: 0 I II III

G.3.2.1 <u>Description</u>. Allocations are required for all equipment which intentionally transmits or receives electromagnetic energy. Such equipment is commonly called telecommunications or communication-electronic equipment. Allocations are certified and approved in four levels designated as Stages 1 through 4. These stages are also respectively named Conceptual, Experimental, Developmental, and Operational, and correspond to Phases 0 through III. As shown in the title block above, their approval is due for the milestones listed. An application for a Frequency Allocation is prepared on DD Form 1494. The form has six sections of one page or less each:

a. DoD general information.

b. Transmitter equipment characteristics.

c. Receiver equipment characteristics.

d. Antenna equipment characteristics.

e. National Telecommunications & Information Agency (NTIA) general information.

f. Foreign coordination general information.

The sections to be completed are those appropriate to the equipment. The level of detail to which the form must be completed and the depth and accuracy of the information provided increases and becomes more demanding at each higher stage. Calculated data will suffice for Stages 1 and 2, however most data in Stage 3 and all in Stage 4 should be measured. DoDD 4650.1, the NTIA Manual, and the appropriate choice from among AR 5-12, OPNAVINST 2400.20 and AFMAN 33-120 provide specific guidance in completing the form.

G.3.2.2 Perspective.

a. General. The purpose of a frequency allocation application in general is to: (1) Confirm that the spectrum will be able to accommodate the item, and (2) elicit guidance from the Military Communications Electronic Board (MCEB) pertaining to the development of the item in such a manner as to achieve acceptable EMC in the item's intended operational EME. Frequency allocation applications should be submitted as early as practical in the development cycle, and updated whenever significant changes are made in the item's technical (electronic) characteristics or planned operational use. Not every developmental item is required to go formally through all phases of the development cycle. Consequently, some projects will not have approved frequency allocations for Stages 1 and 2 of the development cycle. DoDD 4650.1, however, requires frequency allocation applications be submitted and approved before assuming contractual obligations for the engineering and manufacturing development, production or procurement of communications-electronics equipment. This requires a frequency allocation application be submitted and approved for the next stage/phase of development before that phase can be started. Hence frequency allocation applications for the applicable stages should be approved by the Milestone review of the prior phase.

b. Stage 1. An application for a Stage 1 (Conceptual) Frequency Allocation serves to initiate an examination of the request at the earliest possible time in order to isolate those proposals which may result in actual incompatibilities or be contrary to the regulations of radio services permitted in the frequency band in question.

   (1) Timeliness in submission affords a greater opportunity to examine carefully the potential for EM interactions between existing equipment that are current band occupants, and the proposed additional user.
   (2) The examination for potential E^3 degradations resulting from either existing or new spectrum users is becoming increasingly important because of the new, complex and sophisticated types of modulations being applied, along with the general crowding of the spectrum. When a request is not

in accordance with the functions/uses permitted by the ITU and National Tables of Frequency Allocations the submission of extensive analyses may be necessary in order to support a specific request, and even then, the potential for acceptable or unacceptable operation in a band by multiple and differing users may be indeterminate. Final proof by testing may be the only effective means to demonstrate a conclusive answer. A limited allocation, for testing sufficiently to obtain a final resolution of the scope of EM interference, may be the only alternative short of flat rejection of the allocation request.

(3) There is an unfortunate tendency to ignore the Stage 1 allocation. It is appropriate to request this authorization as soon in the formulation process as it is recognized that the capability sought may have E^3 and spectrum considerations. The MNS format, however, stresses capability without solution and is approved at Milestone 0 before the solution of choice is manifested in a formal requirements statement. To default on this prerequisite allocation request until a Stage 2 (Experimental) allocation is needed, however, is an unwise step. Should a serious incompatibility have been postulated or have emerged by the time a delayed request is finally forwarded and reviewed, the consequence could be the loss of resources imprudently committed earlier or the additional cost of physically moving equipment or changing frequencies of the once-isolated victims. It should be clear that the Conceptual Allocation is cheap insurance; the return is a bench mark for an unimpeded development and an agreement in principle that future use of the spectrum as proposed is anticipated to be an acceptable application.

c. Stage 2. An approved Experimental Frequency Allocation Application (Stage 2) is required to ensure there is frequency support for the item. This application also provides a basis for the coordination of necessary prototype testing. In addition to updating those items provided in the previous phase, all applicable data items should be entered as completely and accurately as possible. If there are alternative approaches under consideration, separate frequency allocation applications should be submitted with a notation of the relationship between the systems indicated in the appropriate block. Minor variations, however, may be shown as alternatives on a single application.

d. Stage 3. An approved Developmental Frequency Allocation Application (Stage 3) is required to ensure there is frequency support for the item. This application also provides a basis for the coordination of any needed prototype testing. In addition to updating those items provided in previous phases, all applicable data should be entered as completely and accurately as possible. Most of the data at this stage should have been derived from measurements. If there are still alternative approaches under consideration, separate frequency allocations should be submitted with a notation of the relationship between the items indicated in the appropriate block. Minor variations, however, may be shown as alternatives on a single application. No funds are to be obligated in Phase II for developmental hardware until a Stage 3 Developmental Frequency Allocation is approved.

e. Stage 4. An approved Operational Frequency Allocation Application is required at Milestone III to ensure there is frequency support for the item. At this stage estimated, projected or predicted data is no longer acceptable. Measured data is required and DD Form 1494 should be completed with final data. Funds are not to be obligated in Phase III, PF&OPS, until a Stage 4 Allocation is approved.

G.3.2.3 E^3 control considerations.

a. Has the following minimum data (by calculation or estimation if necessary for Stages 1 or 2) been supplied on DD Form 1494?

(1) Under General Information:
- (a) System nomenclature.
- (b) System component relationships and identification.
- (c) Relationship of other J/F 12 nos. and replacement information.

(2) Under Transmitter Equipment Characteristics:
- (a) Tuning range.
- (b) Power.

        (c) Spurious emission levels.
        (d) Modulation technique.
    (3) Under Receiver Equipment Characteristics:
        (a) Tuning range.
        (b) Power.
        (c) Sensitivity.
        (d) Modulation technique.
    (4) Under Antenna Equipment Characteristics:
        (a) Type.
        (b) Gain.
        (c) Beamwidth.
    (5) Under NTIA General Information:
        (a) Purpose of system and operational concepts.
        (b) System relationships and essentially.

b. Has the cognizant spectrum management office(s) been consulted?

c. What radio services or major joint telecommunications systems are planned or already exist in the selected bands?

d. Are there inherent E^3 problems for the frequency band(s) selected?

e. Are alternate frequency band(s) available?

f. What technical analysis or band-sharing studies should be accomplished to support consideration for the selection of other frequency bands?

g. Should a different frequency band be selected?

h. Has measured data been provided for all appropriate data fields?

    (1) Is the data consistent and unambiguous? Is there sufficient detail to understand the system, its intended usage and planned deployment both during development and testing, and in its intended operational EM environment?
    (2) Have all entries of unclear meaning been explained in the remarks section?
    (3) Have system components and their relationships been identified?
    (4) Have the relationships with other J/F 12 allocations and replacement information been

provided?

i. Is the allocation application responsive to guidance provided by the MCEB on earlier stage allocation applications?

j. Is the measured data close enough to previous estimated and calculated values to validate previous E^3 analyses?

k. Do the measured parameters suggest any unanticipated E^3 problems?

l. Does the information supplied on DD Form 1494 verify resolution of any earlier predicted E^3 problems?

m. Do development item parameters need modification to achieve EMC on a Force Level or joint operational basis?

EVALUATION GUIDE		
Key Document: Iterative Preparation G.3.3 <u>SYSTEM THREAT ASSESSMENT REPORT (STAR)</u>	Prep'd in Phase: 0 I II	For Use at Milestones: I II III

G.3.3.1 <u>Description</u>. The System Threat Assessment Report (STAR) is an iterative document first prepared during phase O, CE, for use at Milestone 1. The STAR is the basic source of intelligence information for a requirement. It should provide an assessment of the threat which confronts the situation addressed by the MNS. The STAR is developed and refined, and when finally validated, becomes the authoritative threat assessment for the Operational Requirements Document (ORD). Each STAR prepared is a threat assessment tailored for and dedicated to a particular program. The initial version of a STAR is subsequently updated at each Milestone. The updated reports should become the primary threat reference for each corresponding update of the ORD. The format of the STAR should open with an executive summary and continue with the following features:

a. An introduction summarizing the MNS.

b. A description of the system/item which the program supports. This should detail the elements of the ORD including performance characteristics and parameters. Pertinent technologies should also be discussed.

c. An overview of the threat environment should be presented together with doctrine and tactics.

d. When useful, potential targets should be described, profiled and discussed, including physical characteristics, Command Control (C^2), order of battle and organizations.

e. A system-specific assessment of the threat should be presented starting with the initial operational capability (IOC) and projecting through ten years of service life.

f. A reactive threat appreciation should be presented last to suggest the interaction(s) to be expected between the item and the threat.

Appendices should be used to supplement the main document as necessary.

G.3.3.2 Perspective. Of the key documents listed in TABLE 1, the STAR is unique in several ways. The STAR is not a program document nor is it prepared within the acquisition arena. It is prepared for the PM rather than by him, and is read more to obtain information useful for an understanding of other documents than it is for its own sake. This is particularly the case where an ORD seeks a device to provide a technical countermeasure having a deceptive response rather than one that is a disruptive or destructive force. Nevertheless the STAR should pass critical review, especially if the intelligence is very new and if the source of information is limited to a single means of collection.

a. The update prepared during Phase I in anticipation of Milestone II should have the benefit of not only having additional data collected, but more importantly of elapsed time during which the body of available refined intelligence has grown.

b. Following the PAT&E project milestone there should be a gradual decline in production & deployment activity. Should a fundamental dissatisfaction occur with the item produced, for any one of a number of reasons, a review can be scheduled to examine the situation. The initial part of such an examination would be to review the ORD to ensure that the stated requirement reflects the true and current need. Consequently, it would also be necessary to take a similar look at the threat as stated by the corresponding version of the STAR.

G.3.3.3 E^3 control considerations. The JECS evaluation provides the PM with observations on the STAR for his information, not with actions or recommendations for his response. The evaluation report in this case should be like a second opinion on the Threat. There are a number of fundamental points to be examined, generally as well as specifically:

a. Is the intelligence upon which the STAR is based current? Is it still timely?

b. Is the assessment essentially based on intelligence from a single source? On multiple sources, but all of the same type (e.g., all Electronics Intelligence (ELINT) intercepts from satellites)? On repeated observations of multiple sources?

c. Is the assessment preliminary and released before a full technical analysis can be made available?

d. Are all parameters presented in the STAR based on values intercepted and measurable from the source used, or are items missing given values representative of those observed in the designs of similar equipment in older intelligence data?

e. If the available information is meager, are the capabilities inferred on the basis of parametric characteristics observed, the only realistic possibilities?

f. If there are separate intelligence assessments available from multiple agencies, are the conclusions reached separately in general agreement? Are there indications of differences that would have a critical impact on the ORD?

g. Are there critical elements of information yet to be collected? Has appropriate prioritization been applied to collection tasking?

h. Has the hardware targeted or resisted by the project item been upgraded?

EVALUATION GUIDE		
Key Document: Iterative Preparation G.3.4 OPERATIONAL REQUIREMENTS DOCUMENT (ORD)	Prep'd in Phase:	For Use at Milestones:
	0 I II	I II III

G.3.4.1 Description. The Operational Requirements Document (ORD) expands the MNS from a limited statement of need into a comprehensive statement of minimum performance requirements expected of a particular conceptual solution. The initial ORD is prepared to support the most suitable concept, judged on the basis of operational effectiveness analysis performed in the Concept Study efforts of Phase O. An ORD should contain the following eight sections:

a. General description of the desired operational capability. Section 1 should include a summary of the MNS as last refined.

b. Threat. Section 2 should present a summarized description of the validated intelligence threat using the STAR as the source. The known Electronic Countermeasures (ECM) capability of a potential enemy to conduct effective Electronic Warfare utilizing means for which current systems have no effective Electronic Protection (EP) is to be indicated in Section 2.

c. Shortcomings of existing systems. If there are significant E^3 problems with a current system that is to be replaced, it should be reported in Section 3.

d. Capabilities required. The subject of Section 4 should be organized into three second-level subparagraphs: System Performance, Logistics & Readiness, and Critical System Characteristics. Some of the more important E^3 considerations and control measures should be included under the third subheading, such as EMC, spectrum management and EMP effects.

e. Integrated Logistics Support (ILS) is another Section with subdivisions. However, none of the five subdivisions concerns E^3.

f. Infrastructure Support and Interoperability, Section 6, has five subdivisions. The first is Command, Control, Communications & Intelligence (C^3I) and requires specific coverage for a number of aspects on this subject. Anti-jamming requirements should be listed and, as a result, permit a third place in which E^3 Control considerations (for EP) are acceptable in an ORD.

g. Force Structure.

h. Schedule Considerations.

There is no limitation placed on the length of ORDs. The preference of the Services in the past has been from three to ten pages for documents accomplishing a similar purpose.

G.3.4.2 Perspective. An ORD is first prepared during Phase 0, CE. At this time there is no program established, only a need. The ORD's originator is usually the potential user or his representative, manifested as an official/cognizant office on the headquarters staff of the interested DoD Component. For the most part, this is an office of a Service staff, and the same office that sponsored the MNS.

a. The Milestone 0 decision which approved the MNS also directed conceptual studies for potential means by which the need might be satisfied. The studies should include a variety of analyses which should be performed in-house, with the assistance of systems command staffs, at Service laboratories, and through contractual support. In this phase, critical system characteristics and affordability become issues in the decision process. The polices and procedures of DoD are such that, while minimum acceptable requirements should be established for all system capabilities necessary to satisfy the Mission Need, the process of establishing an ORD should be an evolutionary one. Detailed performance requirements and mandatory delivery dates should be avoided in the ORD that is prepared in Phase 0. If refinements are carried too far in Phase 0, then the opportunity over the next phase to identify cost drivers, analyze design approaches as functions of variations in risk, and to recognize cost, schedule, and performance trade-offs could be lost. The ORD developed, approved, and validated for Milestone I is thus a first iteration. Over the duration of Phase I, PD&RR, as the results of the analyses become available, the ORD should again be refined. As a practical matter these procedures are applicable to the requirements whose scope and significance identify them as the likely precursors of ACAT I and II level programs or that will otherwise need to follow the path of a full acquisition through Phase I. For the more simple requirements, the utility of an exhaustive iteration of the ORD should be of less potential benefit.

b. Significant changes to an ORD is possible when a clear preference in the selection of concepts is not established. Should this be the case, a separate ORD should be required for each concept that is to continue beyond Milestone I. The existence of multiple ORDs should continue until a preference is established.

c. A complication in program structure may occur when an Acquisition Strategy involves a competitive development. However, unless this circumstance is also a consideration, the final ORD may have been established, and changes to it are not an issue.

d. When a program reaches Phase II, EMD, the ORD is normally a mature document that has reached its ultimate state of refinement. However if competitive developments, using separate ORDs, have been authorized through Phase II, selection of the preferred concept and final ORD will still remain as an outstanding issue with separate developments continuing until a final decision at Milestone III.

e. One reason for delaying completion of an ORD might be an Acquisition Strategy seeking to satisfy a MNS through the application of commercial or NDI hardware which plans on selecting a winner by a competitive test-off. A winner, acceptably close to satisfying the requirements, may still need minor changes in the ORD to qualify.

f. Following the PAT&E project milestone there is a gradual decline of production and deployment activity.

If there is a fundamental dissatisfaction with the item produced, for any one of a number of reasons, a review can be scheduled to examine the situation. The initial part of such an examination should be to review the ORD to confirm the requirement(s) stated reflects the true and current need. Consequently, it may also be necessary to examine the threat as stated by the corresponding version of the STAR.

G.3.4.3 E^3 control considerations.

a. In the description of the need, is the concept and description of the environment, forces, and operations stated clearly so that a realistic EME can be predicted?

b. In the Threat section, is the potential of an enemy jamming capability and the technical sophistication of his jammers referenced in intelligence source documents? Are the parameters specified for which the EP is to counter?

c. Are existing E^3 Control deficiencies, noted in the MNS, carried forward into this current document?

d. Is a fundamental bilateral need for effective EMC stated in the ORD; i.e., does the concept demand that all performance requirements be met while operating in the intended EME, and is the item to operate without suffering or causing degradation by EMI?

e. In the concept, are there to be high levels of radiated EM energy which suggest possible inter-platform E^3 concerns, particularly for joint platforms?

f. Do significantly different E^3 Control considerations exist among alternative solutions for achieving the requirements? Are they highlighted and contrasted in the current document?

g. Does the Forces section include Joint Service Forces that may contributed to the EME?

h. In addition to types, what equipment density is associated with this force level (numbers of same equipment types)?

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<tr><th colspan="3">EVALUATION GUIDE</th></tr>
<tr><td rowspan="2">Key Document:

Iterative Preparation

G.3.5 <u>INTEGRATED PROGRAM SUMMARY</u> (<u>IPS</u>)</td><td>Prep'd in Phase:</td><td>For Use at Milestones:</td></tr>
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I
II</td><td>I
II
III</td></tr>
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G.3.5.1 Description. The preparation of two standard information display documents, the Integrated Program Summary (IPS) prepared by the PM, and the Integrated Program Assessment (IPA), prepared for ACAT ID Programs, by the cognizant Defense Acquisition Board (DAB) Committee, should be required starting with Milestone I. For other ACATs, the staff supporting the DoD Component Acquisition Executive (AE), or supporting the official delegated MDA, should prepare the IPA. The IPA uses the same outline of content used in the IPS:

a. Program Execution Status is presented in Section 1. A description should be given showing how the exit criteria, set forth by decisions at the previous Milestone, have been satisfied. Those exit criteria became the objectives for the phase now ending. Program schedules, performance achieved, funding, current budget, major costs and performance trade-offs, etc. should round out this Section.

b. Threat highlights and inadequacies of current systems should be presented in Section 2.

c. Section 3 covers alternatives considered and considerations resulting in their injection.

d. Section 4 should describe the most promising alternative.

e. The Acquisition Strategy selected should be summarized in Section 5.

f. Cost drivers and major trade-offs should be the subject of Section 6.

g. Risk assessments and plans for their reduction should be presented in Section 7.

h. Section 8 should address affordability of the selected alternative in terms of the overall plans of the DoD Component sponsor.

i. Section 9 should contain recommendations to be considered by the MDA, including whether to proceed into the next phase.

G.3.5.2 Perspective. The IPS is usually the document preferred as a Key Document since its contents reflect the perspective of the prime expert on the program, the PM. The IPA is a useful Additional Document (ADDOC), if available on a timely basis. The JECS evaluator should be required not only to provide issues concerning the satisfaction of the phase objectives for the current phase now ending, but also to recommend exit criteria for the immediate milestone up for review. For E^3 control considerations, the appropriate input for new exit criteria should be the JECS objective(s) for the Phase into which the Program will be approved to enter. The central program issue(s) should be carefully prepared and will vary as the development and acquisition proceeds.

a. At the end of Phase 0, the issues of particular interest at a Milestone I review should be the progress made in the selection of the most suitable alternative concept and the results of studies and analyses for the concepts under consideration.

b. At the end of Phase I, the issues of particular interest at a Milestone II review should be the progress made by the program since Milestone I; the results of early T&E; for the most promising design concept, identity of those components requiring some development and the background, with analysis, as to why existing military NDIs or commercial items cannot be employed.

c. At the end of Phase II, the issues of particular interest at a Milestone III review should be the progress made in the development, the project's readiness for production and, most importantly, the results of T&E.

G.3.5.3 <u>E^3 control considerations</u>.

a. Is a fundamental bilateral need for effective EMC stated in the requirements statement?

   (1) That the item is to meet all performance requirements while operating in the intended EME?
   (2) That the item will not degrade nor suffer degradation from EMI?

b. Are E^3 control deficiencies in current systems noted in the ORD or otherwise documented, carried forward into the IPS for resolution, and is there confidence that they will be resolved?

c. Will there be high levels of radiated EM energy which suggest possible inter-platform concerns, particularly joint platforms?

   (1) Have analysis investigated this potential?
   (2) Has T&E investigated this potential?
   (3) Has Operational Test & Evaluation (OT&E) investigated this potential?

d. E^3 control objectives for each phase were presented with their fundamental issues. Some of these may have been selected at the previous Milestone as exit criteria. Have these issues received adequate attention in the current IPS/IPA to ensure E^3 control objectives will be met?

EVALUATION GUIDE		
Key Document: Iterative Preparation	Prep'd in Phase:	For Use in Phase:
G.3.6 TEST & EVALUATION MASTER PLAN (TEMP)	0 I II	I II III

G.3.6.1 Description. The Test & Evaluation Master Plan (TEMP) is the most fundamental of the Defense program documents. A TEMP should be required for all ACAT I & II programs, and the initial edition should be available at the first occurring milestone (formally or not). Subsequently, at each succeeding milestone and annually on projects whose phases are significantly longer than a year, a revision should be required updating, revising, and correcting earlier information and plans.

a. The TEMP should describe the item to be acquired and the expected system characteristics, define and establish test objectives and critical issues, assign responsibilities, identify resources, and present schedules for test and evaluation. Test resource requirements should be addressed in the TEMP along with an analysis of impediments, plans to correct test resource limitations, and a listing of approved evaluation criteria.

b. The Format for a TEMP is prescribed in DoD 5000.2-R. The document has five parts:

(1) Part I should contain the mission, threat assessment capsule, list of minimum acceptable operational requirements, system description, and critical technical parameters.
(2) Part II should be an integrated test program summary.
(3) An overview of all DT&E should be presented as Part III, including a listing of all DT&E conducted to date, planned future DT&E and live fire T&E when required.

(4) Similarly, Part IV should present an overview of all OT&E, a list of critical test issues, a listing of all OT&E conducted to date, and planned OT&E remaining.

(5) Part V should present a detailed T&E resource summary.

c. Whereas the TEMP is an overall planning and scheduling document, the actual conduct of developmental and operational tests are specified in their respective detailed test procedures. The TEMP should not exceed 30 pages, but the three required appendices and any annexes deemed essential by the DoD component are not included in this page limit.

G.3.6.2 Perspective. Of the fifteen types of KDs, twelve pertain to what an item is to achieve (the requirements), two report test results, but only the TEMP addresses the critical aspects of how the item performed or should have performed. The degree of influence a TEMP has in securing a desirable decision for E^3 Control requirements is a function of the Critical Operational Issues found in Part IV of the TEMP. These statements, covering items of the highest concern, are usually phrased as questions and are established in the TEMP in order to facilitate evaluation of operational effectiveness and operational suitability. The derived corollary issues of JECS may be a useful source of critical operational issues for E^3 concerns, and their insertion in the TEMP is recommended during the JECS review process of the initial draft TEMP.

a. A TEMP initiated for Milestone I should control all DT&E and OT&E and should also control Follow-on Test and Evaluation (FOT&E). Major changes in program requirements, schedules, or funding should be accommodated as routine updates of the TEMP later in the life of the program. The TEMP should be updated at least annually to ensure that T&E requirements are current.

b. A TEMP initiated for Milestone II or an existing TEMP which during Phase I becomes overtaken by major events and changes, can be prepared/updated for approval at Milestone II. The major portion of DT&E and OT&E that can be realistically scheduled, can still be accommodated since little DT&E and almost no OT&E is ever accomplished during Phase I. Phase II efforts should ensure that the completed T&E will support a decision for project transition into Full-rate Production (FRP) at Milestone III. The goal of EMD testing is to confirm that all significant design problems have been identified; that solutions to these problems are available; and that the item is effective and suitable for its designed use. To accomplish this goal a series of tests in both DT&E and OT&E may be appropriate. The EMD item hardware should be in the form of either an EDM or prototype and preproduction qualification testing is appropriate.

c. The final element of DT&E in EMD should be a formal technical evaluation of representative hardware and validated software. The final element of OT&E during EMD should be a formal operational evaluation, conducted using production-representative hardware, validated software, and maintenance and support equipment planned for operational use.

d. In those instances when more extensive testing is necessary prior to making a commitment for FRP, a decision may be made to start LRIP in an extended Phase II. Additional testing should be performed on these production models. A Milestone III decision to enter FRP should only occur after additional testing (both DT&E and OT&E) establishes confidence in the item design.

e. Moving into Phase III after approval for FRP, DT&E includes Production Acceptance Test & Evaluations (PAT&E) (or 1st Article Testing); OT&E should be conducted on production hardware to verify the absence of additional problems, wring out the engineering design of newly proposed engineering changes, to complete and verify the adequacy of approved engineering changes, and to determine if production items incorporate all approved ECPs. Additionally, these tests should be used to formulate operational procedures and tactics for the employment of the new items. Latent force level, joint operational, and international EMI problems may first surface in the deployed item during FOT&E.

f. As time passes, the TEMP may require extensive changes to incorporate information covering completed DT&E and OT&E. The TEMP gradually takes on the attributes of a major technical history.

G.3.6.3 E^3 control considerations.

a. In projects where there is a significant probability that there will be difficulty in attaining an acceptable level of EMC or adequate control over other E^3 concerns, has the appropriate JECS primary issue(s) been refined into an appropriate corollary issue(s) and incorporated into the TEMP as a critical issue(s) for effectiveness or suitability?

b. DT&E to date:

(1) Have all E^3 T&E requirements been adequately addressed?
(2) Has EME simulation been adequately addressed?
(3) Have any required E^3 tests been by-passed as a result of waivers or for any other reasons? What is the potential operational impact of not having this E^3 test data?
(4) Has there been any evidence of susceptibility? Have susceptibilities been properly evaluated in terms of performance according to evaluation criteria provided in the TEMP?

c. OT&E to date:

(1) Have any E^3 tests or tests involving E^3 been by-passed?
(2) Has there been any evidence of Radio Frequency (RF) susceptibility, operational ineffectiveness, or unsuitability because of E^3?

d. Future DT&E:

(1) Will DT&E retest for E^3 failures or shortcomings detected in DT&E?
(2) Have acquisition items been modified from the configuration on which E^3 T&E was performed? If so, does the modification require E^3 T&E? Has the acquisition item passed E^3 T&E?
(3) Have all E^3 T&E requirements been adequately addressed?
(4) Will planned DT&E retest for E^3 failures or shortcomings detected during DT&E?
(5) Has evaluation of E^3 Control at the next higher level of design been addressed to a sufficient degree that installation requirements are adequately recognized?

(6) Will PAT&E E^3 control testing be conducted and accepted before any deployment is permitted?

e. Future OT&E:

(1) Are tests planned to evaluate the effect of modifications implemented to correct previous E^3 problems? To evaluate the effects of correcting non-EM problems?
(2) Are tests being planned to evaluate the acquisition item under realistic EME conditions?
(3) Have results of DT&E been used for planning OT&E?
(4) Will transmitters and receivers be operated simultaneously on adjacent channels with minimum required frequency separations?
(5) Will OT&E demonstrate the degree to which EMC is attained between the acquisition item and its intended environment under realistic operating conditions?

f. Follow-on Test and Evaluation (FOT&E). If required for FOT&E, are there provisions for E^3 control testing and evaluation at the next higher level of design for additional operational uses such as in other aircraft or ship types, etc?

EVALUATION GUIDE		
Key Document: Iterative Preparation G.3.7 <u>ELECTROMAGNETIC COMPATIBILITY PROGRAM PROCEDURES</u> (<u>EMCPP</u>)	Prep'd in Phase: 0 I II	For Use in Phase: I II III

G.3.7.1 <u>Description</u>. It is essential a document for managing the E^3 control effort of a program be prepared and implemented at the earliest possible time so the greatest benefit can be derived from the effort.

a. The EMCPP should establish the sum total of direction and efforts required to achieve EMC in the end-item. The EMCPP should set forth the series and sequences of surveys, analyses, design efforts, test planning, and testing for the project on a time-phased basis. The EMCPP should present technical details only in the depth essential to establish clearly the technical policies that are to be in effect and what technical options are desired. Policy statements for E^3 control measures and techniques forego detailed descriptions, relegating the details of these subjects to detailed control procedures.

b. The EMCPP should be an essential document for Major Systems which, for an end-item at the platform level, provides organization and direction on problems of otherwise overwhelming complexity. For projects of lesser scope, the EMCPP should be as useful, even though scaled down according to the scope of the project and its needs.

c. Every program designated as, or meeting the criteria for, ACAT I or II that is without the benefit of a suitable EMCPP should be regarded as being deficient in planning. The inclusion of commercial and NDI components as part of, or all of, the hardware in no way minimizes the importance of this document. Commercial items and NDIs only represent an alternate solution. Commercial items and NDIs should be considered no better than the newest untested design until its capabilities have been demonstrated through testing. Prior tests, properly documented, should be acceptable. A verifiable, documented history of trouble-free service in a fully comparable EME may suffice in non-critical applications.

d. A DID is available for ordering the EMCPP on contracts as standard deliverable documentation. The form and format of the EMCPP is specified by the DID. The individual DID is:

DI-EMCS-81528 - EMCPP

G.3.7.2 Perspective. The EMCPP is an iterative document, and ideally is initially written before Milestone I in Phase 0, concurrently with the first iteration of the TEMP, and early enough to influence the technical package (Specification, SOW, and CDRL) for the ADM. Subsequently, during Phases I and II, the EMCPP should be updated as appropriate, and early enough to influence the technical packages being prepared for the follow-on phases.

a. For projects that are tailored and initiated in a phase later than Milestone I, it is important that the EMCPP be prepared as a first order of business. Projects that are initiated later than Milestone II (i.e., in Phase II, EMD) still require and benefit from the effort needed to produce a timely and carefully prepared EMCPP. As the complexity of a project increases, the span of a PM's direct involvement in any facet of the project is reduced. Nevertheless, the more intimately a PM is involved in the preparation of this document the greater should be his E^3 control awareness.

b. Deferring the preparation of this document until the prime hardware developing contractor becomes available could seriously diminish the effectiveness of the EMCPP. A developer or vendor usually does not have a perspective or knowledge base that qualifies him to prepare this type of document. More importantly, such a document would then be unsuitably late. The EMCPP should have been written and approved, and should have influenced the preparation of the technical package for the developer's contract. If it is not practical to prepare the EMCPP in-house, a suitable consultant can be contracted to provide the needed support.

G.3.7.3 E^3 control considerations.

a. Does the EMCPP cover normal administrative matters adequately? Are the following covered:

(1) Purpose, background, scope?
(2) Updating instructions and provisions?
(3) Joint systems and force level relationship?
(4) Is there a general project description and overview?
(5) Are all basic reference documents listed?

b. Does the EMCPP make a clear and orderly presentation of the project and procedures? Does it cover:

(1) E^3 WIPT/EMCAB responsibilities and role for a major subsystem project?
(2) Procedures for identifying and resolving potential E^3 problems?
(3) Configuration control and E^3 control considerations?
(4) Implementing resources?

c. Is there a section(s) covering the identification and scoping of the EME and planning for the use of prediction and analysis techniques? Are the following specifically addressed:

(1) Determination of the intended EME?
(2) Predictions of potential E^3 problems?
(3) Determination of degradation criteria?
(4) Determination of safety margins?
(5) The need for tailoring E^3 control requirements?

d. The EMCPP should establish technical policy on the application of various techniques and technical measures. Is there a section that addresses the identification and application of E^3 control requirements for the appropriate parts of the technical package, installation plans, and technical documentation? Are the following addressed:
(1) Frequency management?
(2) Applicability of standards?
(3) Bonding and grounding?
(4) Installation criteria?
(5) Government-Furnished Equipment (GFE) and Contractor Furnished Equipment (CFE) considerations?

(6) Use of special materials or techniques?

e. Does the EMCPP establish a workable E^3 test program? Are there sections/provisions to:

(1) Confirm suspected EM environmental conditions?
(2) Isolate/identify EMI problems?
(3) Develop & review formal E^3 test/verification procedures?
(4) Review DT&E and OT&E?
(5) Conduct acceptance and qualification tests?
(6) Conduct platform EMI surveys and inter-platform tests?

f. Does the EMCCP have a provision for becoming the design history of/for the project item? Will appendices be added covering/containing:

(1) Current E^3 control specifications?
(2) Most recent data/results of formal testing?
(3) Current recommended E^3 control installation practices?

g. When a EMCPP is acquired by invoking the DID, have all the requirements of the DID been achieved?

EVALUATION GUIDE		
Key Document: Counterpart Document Preparation	Prep'd in Phase:	For Use in Phase:
G.3.8 ADM, EDM & FPM SPECIFICATION	0 I II	I II III

G.3.8.1 Description. Preparing an equipment specification is a key part of the acquisition process. DoD policies and guidelines for the preparation of specifications emphasize that requirements should be stated in terms of performance or "what-is-necessary" rather than telling a contractor "how-to" perform a task. 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 define the functional requirements of the item, the environment(s) in which it must operate, and its interface and interchange characteristics. A performance specification should state the requirements in terms of required 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. A properly constructed performance specification should assure the Government of a quality product at reduced cost, and greatly reduce Government oversight and contract administration.

G.3.8.2 Perspective.

a. Following program approval at Milestone I, a contract for the hardware of an ADM is needed as a matter of priority to push the new project forward into Phase I, PD&RR. Ideally, the specification should be prepared in Phase 0 prior to Milestone I. This may be practical despite the lack of a formal program by using the concept study resources and the support of a system command or departmental laboratory. The proposed concept baseline, the general E^3 control requirements of the ORD, and the EMCPP when available, should be used for guidance. In additional to invoking standards such as MIL-STD-461 and 464 (when applicable) to achieve EMC, other appropriate measures for spectrum management, E^3 control, EMP and lighting protection, radiation hazards concerns, etc., should be specified. Standards covering these and other aspects of E^3 are addressed elsewhere in this handbook.

b. Following program approval at Milestone II, a contract for the hardware of an EDM is needed as a matter of priority to push the project forward into Phase II, EMD. For maximum efficiency, the specification should be prepared in Phase I prior to Milestone II. The baseline for the project advances from the Concept Baseline to that of the Development Baseline. The specification should impose the minimum acceptable performance requirements from the mature ORD, and in addition, impose requirements that the item should perform under specific environmental conditions, including the EME. These additional requirements physically harden the EDM against the degrading and often destructive effects of the environments in which it has to perform and when measures are incorporated to achieved these requirements the EDM is said to be militarized. The EDM should demonstrate the items's ability to meet all performance requirements under operational as well as factory conditions, and successfully complete all scheduled DT&E and OT&E.

c. Following program approval at Milestone III, a contract for the hardware of an FPM is needed as a matter of priority to push the project forward into Phase III. For maximum efficiency, and usually to meet the schedule of the project's POA&M, the specification should be prepared during EMD prior to Milestone III. The FPM to be produced should be a production engineered version of the approved EDM. Latitude allowed the designer in the EDM specification should be eliminated and the performance requirements should now be narrowly stated to ensure the characteristics of the EDM are incorporated or improved in the FPM. Changes made in the EDM specification by approved ECPs should be incorporated as a part of the new product baseline into the FPM specification. The standards and specifications referenced earlier in the EDM specification will usually be repeated in the new specification.

G.3.8.3 <u>E^3 control considerations</u>.

a. Prior to the evaluation of a specification, program documentation received to date should be reviewed to determine the following (as applicable):

(1) What is the acquisition item intended to do?
(2) Is the item tactical? mobile? transportable? for a fixed-plant installation? strategic? target-dependent?
(3) Does the item stand alone, or is it part of a larger system?
(4) What are the signal inputs and outputs, and their range of frequency and associated power levels?
(5) What are the Radio Service constraints and requirements?
(6) What are the basic power support/supply requirements?
(7) What are the range and power requirements?
(8) What are the sensitivity requirements for the receiving equipment?
(9) Where will the acquisition item be used?
(10) What is the characteristics of the platform EME?
(11) Is the acquisition item required to operate continuously or intermittently?
(12) Are there any location, size, or weight restrictions?
(13) When is the acquisition item to be operative?
(14) How will the acquisition item be maintained, operated, and supported?
(15) To what extent is the acquisition item manned during operation? Are there any operating stations with personnel located in the vicinity of transmission lines, couplers, or antenna subsystems?
(16) What are the classification aspects of the acquisition item and its application?
(17) Will classified information be accessible in clear-text form at any point?
(18) Is the acquisition item critical to some military operation, and if so, what? Are joint forces involved?
(19) Are there critical sequences for operations involving this acquisition items?

(20) To what extent will malfunctions affect mission success or personnel safety?
(21) What is the medium (radio, wire, cable) of the transmission?
(22) How is the acquisition item matched and coupled to the medium?
(23) If antennas are part of the subsystems involved, what special characteristics should be considered?
(24) Is the acquisition item active or passive (that is, does it transmit, receive, or both)?
(25) Is signal processing equipment required?
(26) With what equipment does the acquisition item interface directly?
(27) What modulation techniques are being used?
(28) What waveforms are involved?
(29) What are the spectrum requirements?
(30) What sensitivity and resolution are required?
(31) What are the minimum threshold responses, in both amplitude and duration?
(32) What are the requirements for stability and accuracy?
(33) Is this equipment of analog or digital design?
(34) Are there any special remote control requirements?
(35) In what type of facility is the equipment to be installed?
(36) What other equipment will be in the same installation?
(37) Are there any inherent, definable E^3 problems expected as a result of the grounding systems used?
(38) Are there any space-available problems anticipated?
(39) Are there any special co-site problems anticipated?
(40) What are the inherent shielding characteristics of the installation?
(41) Will the acquisition item be exposed to enemy electronic countermeasures (ECM)?

b. Evaluation considerations for the specification include:

(1) Are there existing E^3 problems with this or similar equipment?
(2) Are performance requirements specified for the anticipated EME?
(3) Are any tests required to confirm or assess highly probable or known E^3 problems?

(4) Do bonding and grounding measures comply with applicable standards such as MIL-STD-1310.

(5) Have the basic requirements of MIL-STD-461 and 464 been invoked for systems, subsystems and equipment items? Is self-compatibility specifically required?

(6) Have omissions or relaxations been applied to the requirements of MIL-STD-461 and 464? If so, are these reductions supported by appropriate calculations based on acceptable data? Are they formally documented with approved ECPs that have been subsequently applied by modification to the contract?

(7) Is there a potential for severe levels of electromagnetic fields in the EME? If so, have the requirements of MIL-STD-461 been increased?

(8) Have appropriate tests of MIL-STD-462 been invoked to match the requirements of MIL-STD-461?

(9) Have additional tests based on requirements of other standards been required?

EVALUATION GUIDE		
Key Document: Counterpart Document Preparation	Prep'd in Phase:	For Use in Phase:
G.3.9 <u>STATEMENT OF WORK (SOW)</u> SOW Type II & SOW Type III	O I II	I II III

G.3.9.1 <u>Description</u>. The Statement of Work (SOW) is one of three principle parts of the technical package that is used in a DoD hardware contract. The format for a SOW is roughly the same as that used by specifications. In Section 1 the scope of the SOW should be established. Section 2 should be used to list applicable documents. In Section 3, supporting work requirements should be presented in successive subsections.

a. A specification alone is permitted to state the qualitative and quantitative design and performance requirements for an item. A SOW should establish all the other work that is to be accomplished on the contract and describe this work in tasks that should be accomplished if the necessary deliverable documents and data are to become available.

b. The range of SOW tasks which may be levied upon the hardware contractor is very broad. It varies with the development phase being covered as well as with the needs of the hardware item and program.

G.3.9.2 <u>Perspective</u>. It is essential, for the development of an item, that the contractor be tasked in the SOW to perform the non-specification work that leads to the creation of the data itself and other types of deliverables. These deliverables will only be available if the work to prepare or obtain them is specified (tasked) in the SOW.

a. The SOW, however, should not be used to order the delivery of data items under any circumstances. The CDRL is the only proper vehicle for describing and ordering non-hardware deliverables that result from work tasked in the SOW.

b. The preparation of a SOW ideally occurs during the latter stage of the Phase prior to the one in which the SOW will be used (e.g., late in Phase I if the SOW is intended to be used during EMD).

c. Major E^3 tasks that should be called for in the SOW are the establishment of contractor control programs, control procedures, test procedures, and test/ verification reports.

d. It is important to recognize the significance and difference between tasking to perform activities, and the preparation and delivery (via the CDRL) of many unnecessary and expensive documents. The direction of activity and ordering of data essential to the formulation of decisions or which constitute vital records is, of course, a necessary measure. The acquisition of records and documents having no long term value, that are based on preliminary designs, that are collected prior to environmental and qualification tests, is a pointless and expensive act. For example, the requirement for a contractor to develop an E^3 control program during Phase I is very justifiable; however the preparation and delivery of documented control procedures that will need extensive changes in the future can not be justified.

G.3.9.3 E^3 control considerations. The following questions relate to provisions of the SOW:

a. Will the contractor have an adequate E^3 control program that is in accordance with the guidance provided in MIL-HDBK-237?

b. If a E^3 WIPT/EMCAB is an appropriate measure for the project, is the role of the contractor defined?

c. Does the E^3 program provide for an EMICP in accordance with MIL-STD-461? A E3IAR in accordance with MIL-STD-464?

d. For radar development projects, does the E^3 program provide for an EMCCP in accordance with MIL-STD-469?

e. For aircraft systems projects, does the E^3 program provide for an EMCCP/E3IAR in accordance with MIL-STD-461/MIL-STD-464?

f. If any standard tests are to be performed with commercial or NDI components of partially developed subsystems, does the E^3 program provide for:

   (1) An EMITP/E3VP and EMITR/E3VR in accordance with MIL-STD-462/MIL-STD-464?
   (2) An EMCTP and EMCTR for radar projects in accordance with MIL-STD-469?
   (3) An EMCTP/E3VP and EMCTR/E3VR for a aircraft system in accordance with MIL-STD-461 and MIL-STD-464?

g. If specific types of analyses or predictions need to be performed, does the E^3 program identify them?

h. Does parametric measurements provide the data needed for the preparation of a frequency allocation application?

EVALUATION GUIDE		
Key Document: Counterpart Document Preparation	Prep'd in Phase:	For Use in Phase:
G.3.10 CONTRACT DATA REQUIREMENTS LIST CDRL for ADM Demonstration CDRL for EDM Development, or CDRL for FPM Manufacturing	0 I II	I II III

G.3.10.1 Description. The Contract Data Requirements List (CDRL) is the third of three principal parts of the Technical Package for a hardware contract. Displayed on DD Form 1423 or an automated version thereof, the list(s) is the data ordering vehicle accompanying a hardware contract. To simplify the problem of preparing orders for data, and of preparing and formatting the data itself, a Data Item Description (DID) utilizing DD Form 1664 is used to define each item on the CDRL. DD Form 1664 establishes a standard requirement for a data product, often specifying merely "the Contractor's format" but at times giving a range of detail. 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. 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.

G.3.10.2 Perspective. The E^3 community uses DIDs for ordering various data items associated with hardware development. The most commonly ordered documents are EMI Control Procedures (EMICP)/E^3 Integration and Analysis Report (E3IAR), EMI Test/ Verification Procedures (EMITP)/(E3VP), and EMI Test/Verification Reports (EMITR/E3VR).

a. Data preparation and delivery are very expensive activities frequently aggregating costs higher than that of a complete hardware system. Data which will later be invalidated or changed by anticipated follow-on development activities should seldom be ordered; e.g., the ADM built in Phase I will usually have little in common with the EDM or FPM of later phases. SOW tasking for routine EMI test/verification procedures and EMI test/verification reports on the ADM, and orders for these CDRL products in Phase I may be very hard to justify. On the other hand, an early effort in the project to prepare an EMICP/E3IAR is a sound measure. Having obtained a basic EMICP/E3IAR in Phase I is not a lost effort when the project moves on into EMD. The contractor for Phase II, even if its a new company, should be tasked to use the ADM EMICP/E3IAR as a base line and to update and expand the procedures for additional use in Phase II. Similarly, an EMITP/E3VP developed for factory acceptance testing in EMD, may be wholly or at least substantially useful for the PAT&E tests in Phase III.

b. CDRL entries other than DIDs can be tailored on DD Form 1423 as well as the DIDs themselves. When applicable, data items should be tailored to buy only what is actually need for a project while at the same time requiring essential efforts be performed and critical data be delivered.

G.3.10.3 E^3 control considerations.

a. Does the CDRL order and require updates of sufficient E^3 technical data and reports to support the evaluation of the E^3 control effort?

b. Specifically, does the CDRL order, as applicable:

(1) DI-EMCS-80199 - EMI Control Procedures?
(2) DI-EMCS-80201 - EMI Test Procedures?
(3) DI-EMCS-80200 - EMI Test Report?
(4) DI-EMCS-81540 - E^3 Integration Analysis Report?
(5) DI-EMCS-81541 - E^3 Verification Procedures?
(6) DI-EMCS-81542 - E^3 Verification Report?

c. For radar equipment, aircraft systems, or other special items, have the substitute or additional plans & reports been ordered?

d. Where clearly established EMP requirements exist, does the CDRL order, as applicable:

(1) DI-NUOR-80156 - Nuclear Survivability Program Plan?
(2) DI-NUOR-80926 - Nuclear Survivability

Assurance Plan?
(3) DI-NUOR-80928 - Nuclear Survivability Test Plan?
(4) DI-NUOR-80929 - Nuclear Survivability Test Report?

e. Are appropriate offices listed on the CDRL (DD Form 1423) distribution Section (Blocks 14 and 15) for each of the above items?

f. Are appropriate offices listed on the CDRL distribution Section (Blocks 14 and 15) for:

(1) Preliminary installation or installation control drawings?
(2) Review copies of manuscripts (for technical manuals)?
(3) Specifications?

EVALUATION GUIDE		
Key Document: G.3.11 TEST & EVALUATION (T&E) REPORTS	Prep'd in Phase:	For Use in Phase:
	I II III	I II III

G.3.11.1 Description. Test and Evaluation (T&E) reports cover two types of testing:

a. Development Testing and Evaluation (DT&E) is conducted to demonstrate that the engineering design and development process is complete, that design risks have been minimized, and that the system will meet specifications. DT&E should also be used to estimate the system's military utility. DT&E should be planned, conducted and monitored by the developer. DT&E is accomplished in factory, laboratory and proving ground environments.

b. Operational Testing and Evaluation (OT&E) is conducted to estimate a prospective system's military utility, operational effectiveness, operational suitability (including compatibility) and the need for any modifications. OT&E should be conducted by Service Component Test and Evaluation Commands and is accomplished in as realistic an operational environment as possible. Formal test reports should be prepared by the testing agency. They should contain the data obtained from the test, a description of the actual conditions which prevailed during the test, and an analysis of the test results which should be compared to the test objectives. Test report requirements should be specified in the Test & Evaluation Master Plan (TEMP).

G.3.11.2 Perspective. DT&E and OT&E should be conducted on all defense acquisition systems unless waived by the cognizant T&E authority. By law, the cognizant T&E authority is an independent command or agency within each MILDEP.

a. T&E prior to Phase II. The ability to conduct DT&E and OT&E during Phase I beyond demonstrating new applications and validating advance concepts is problematical. Technically, T&E is conducted only on developmental (EDMs), Low-rate Initial Production (LRIP) hardware, or production (FPMs) models so the results can be representative of equipment that are in final operational form. Consequently, T&E in Phase I is usually limited to demonstrations for the Phase I needs. On occasion, a project will produce an ADM that is sufficiently similar to the configuration of a follow-on EDM and DT&E to resolve critical issues may begin as soon as all Phase I testing has been completed.

(1) The availability of a suitable ADM, after completion of Phase I tests & demonstrations, may facilitate commencement of either DT&E or OT&E.
(2) For large complex systems, it is not unusual that while the program as a whole is in Phase I, some lesser components are ready with EDM grade hardware for DT&E and even OT&E.

b. T&E in Phase II and III.

(1) DT&E testing, including all preproduction qualifications testing, is conducted on an EDM to confirm that all significant design problems have been identified, that solutions to these problems are available, and that the items tested are effective and suitable for their intended use. The final DT&E should provide the basis to formally certify that the system is ready for a final dedicated phase of OT&E before the Milestone III review.
(2) OT&E should be conducted to verify the item's operational effectiveness and suitability and to ensure that it meets operational requirements. The item tested should be sufficiently representative of the expected production model to ensure that the T&E results validly supports a production decision.
(3) The nature of the test(s) themselves are almost as varied in number as there are items. In Phase I or early EMD, the tests should favor the low end of complexity. Inability to resolve some

uncertainties sufficiently by testing may or may not be a major failure at this time. In some cases, it may be obvious that the early design of the EDM may easily clear up a problem. An attempt to validate the application of a technology which failed, however, might well result in the termination of a program.

(4) At the low end of complexity, the items may merely be placed in service, on line, monitored, instrumented, and operated as they would day in and day out when finally accepted. On the other end of significance, a main battle force may be required to perform a series of scenarios in order to generate data for evaluations. In a successful development, the report conclusions from the final dedicated phase of OT&E should recommend proceeding into production. The report does not itself approve production but should be the principal consideration in obtaining approval for full-rate production.

c. Inability to resolve any uncertainty sufficiently during testing of the EDM may result in Milestone III being delayed. In this instance Low Rate Initial Production (LRIP) may be authorized or extended in order to obtain more data from additional units of the item. Such a decision results in scheduling another round of DT&E and final OT&E to obtain more conclusive demonstrations of operational suitability and operational effectiveness before Milestone III approval is sought.

G.3.11.3 E^3 control considerations.

a. Have all the critical E^3 test issues identified in the TEMP been addressed?

b. Are there other identifiable critical E^3 test areas which need to be noted for incorporation in future testing?

c. For DT&E reports:

(1) Did the test data demonstrate compliance with E^3 control requirements of the specifications?

(2) Did testing verify the effectiveness of proposed spectrum control and utilization techniques?

(3) Were the E^3 control installation requirements adequate for the installation problems encountered?
(4) Have all the critical E^3 test issues been addressed?
(5) Were all the planned E^3 tests performed?
(6) Is there any evidence of performance degradation due to the EME?
(7) Has the effectiveness of proposed spectrum control and utilization techniques been demonstrated?
(8) Did the development item demonstrate minimum acceptable performance?

d. For OT&E reports:

(1) Were the tests conducted in a realistic operational EME?
(2) Does the report identify results, actions required, proposed corrective actions (if any),and characteristics that may influence the ability to meet E^3 control requirements in the operational environment?
(3) Can observed E^3 deficiencies be resolved:
    (a) By installation measures at the next higher level of design?
    (b) Through operational restrictions?
(4) Are all critical E^3 test issues addressed?
(5) Based on the reported information, what is the overall force level impact on warfare systems?

EVALUATION GUIDE		
Key Document: Iterative Preparation	Prep'd in Phase:	For Use in Phase:
G.3.12 <u>EMI CONTROL PROCEDURES (EMICP)/E^3 INTEGRATION AND ANALYSIS REPORT (E3IAR)</u>	I II III	I II III

G.3.12.1 <u>Description</u>. E^3 control procedures are the technical policy documents of engineering projects. E^3 control procedures provide important direction and guidance on projects which involve, or whose components are subject to, exposure to EM energy. The purpose of these documents is to define the appropriate E^3 tasks/actions and include: analysis, prediction, design, engineering, fabrication, cabling, assembly, integration, checkout, testing, troubleshooting, redesign, and data collection.

a. DIDs are used to order E^3 Control Procedures on contracts as standard deliverable documentation. The purpose of each document is specified by the appropriate DID. The DIDs associated with MIL-STD-461 and 464 are:

DI-EMCS-80199	-	EMI Control Procedures (MIL-STD-461).
DI-EMCS-81540	-	E^3 Integration and Analysis Report (MIL-STD-464).

G.3.12.2 <u>Perspective</u>. E^3 control procedures reveal the extent of a contractor's E^3 awareness and his understanding of E^3 control measures.

a. In Phase I a contractor should be required, for a project of any significance, to initiate formal E^3 planning even if there is no requirement for an ADM. Emphasis should be placed on establishing procedures for the reduction of potential E^3 problems. Unless some assemblies, or groups of a large subsystem, are ready for Phase II it is probably premature to go to the expense of testing during Phase I.

b. In Phase II, EMD, the E^3 Control Procedures from Phase I should be updated and expanded. The contractor should be directed (in the SOW) to revise the E^3 control procedures used for Phase I into a document suitable for EMD coverage. Testing should be conducted to establish an appropriate range of E^3 control measures.

c. The E^3 control procedures used in Phase II should have governed the development of the EDM with respect to E^3 considerations. The same EDM, judged acceptable, operationally suitable and effective, should be produced in full rate production. It is usually appropriate for the Full-Rate Production Model (FPM) to be governed by an extension of the E^3 Control procedures used for the EDM. An essentially cosmetic update of the E^3 control procedures to cover Phase III should be obtained at minimal expense. Should there be a new contractor for production, the SOW and CDRL for the production contract can direct the contractor (working from a Government Furnished Information (GFI) copy of the Phase II (EMD)E^3 control procedures document) to prepare only an amendment which establishes the old document as the effective E^3 control procedures for production during Phase III.

G.3.12.3 E^3 control considerations.

a. The EMICP is ordered by requesting DID DI-EMCS-80199. The EMICP is prepared in accordance with E^3 control/ EMC performance requirements such as those of MIL-STD-461. The EMICP is ordinarily required for all project items that either emit or are susceptible to EM energy. The EMICP should identify how all of the E^3 control requirements are to be implemented with emphasis on the specific techniques that are to be employed. The EMICP should establish the appropriate EMC measures and E^3 control practices for the item. Does the EMICP include the following:

    (1) An organization and administrative section showing:
        (a) Organization - lines of authority & control?
        (b) Implementation - milestones & schedules?
        (c) Requirements on subcontractors?
        (d) Equipment/subsystem description & installation?

(2) Procedures for spectrum conservation?
(3) An Electrical/Electronic Circuit Design section?
  (a) Alternative circuits & their advantages & disadvantages?
  (b) Trade-offs for EMC?
(4) Wiring Design?
  (a) Cable separation?
  (b) Routing?
  (c) Grounding?
  (d) For naval platforms, have cable categories been assigned in accordance with NAVSEA S9407-AB-HDBK-010?
(5) Mechanical Design?
  (a) Compartmentalizing and layout arrangement?
  (b) Filtering of openings?
  (c) Shielding?
  (d) Corrosion control?
(6) Analysis (prediction of EMI levels)?
(7) Discussion of E^3 testing?
(8) Discussion of E^3 problem resolution?
(9) Method and frequency of planned EMICP revisions?

b. The E3IAR is ordered by requesting DID DI-EMCS-81540. The E3IAR is prepared in accordance with E^3 control/ EMC performance requirements such as those of MIL-STD-464. The E3IAR should describe the application of the E^3 control/EMC performance requirements and the translation of these requirements into system software and hardware to achieve a cost-effective system. The E3IAR should address the overall integration of the various requirements into a single system design which complies with the interface and performance requirements. Does the E3IAR include the following:

(1) An introduction?
  (a) System description?
  (b) Statement of the EM environments for the system and their impact on the item being developed?
  (c) Statement of any assumptions?
(2) Applicability of each requirement to the system?
(3) System design features associated with meeting each imposed requirement?
(4) General methodology for verifying each requirement?
  (a) Analyses?
  (b) Bench tests?

(c) Component - piece parts test?
(d) Full system tests?
(e) Inspections?

(5) Technical descriptions for each of the following areas included in contractually imposed requirements:
(a) Margins?
(b) Intrasystem Electromagnetic Compatibility (EMC) including where applicable: ship hull intermodulation interference, internal electromagnetic environments, and powerline transients?
(c) Intersystem EMC?
(d) Lightning?
(e) Electromagnetic pulse?
(f) Subsystem and equipment electromagnetic interference, including where applicable: non-developmental items, commercial items, electromagnetic spectrum compatibility, and DC magnetics?
(g) Electrostatic charge control, including where applicable: vertical lift and in-flight refueling, precipitation static, and explosive subsystems?
(h) Electromagnetic radiation hazards, including where applicable: hazards of electromagnetic radiation to personnel, hazards of electromagnetic radiation to fuel, and hazards of electromagnetic radiation to ordnance?
(i) Life cycle E^3 hardness?
(j) Electrical bonding, including where applicable: power current return path, antenna installations bonding, and EMI bonding?
(k) External grounds, including where applicable: aircraft grounding jacks?
(l) TEMPEST?
(m) Emissions control?
(n) Electronic protection?

c. A systems EMC Control Plan (EMCCP) is ordered by requesting DID UDI-T-21330. The EMCCP is specifically for air platform systems and is prepared in accordance with requirements of MIL-STD-461 and MIL-STD-464. The applicable E^3 control considerations (Questions) of Paragraph G.3.12.3a and 3b can also be used to evaluate the EMCCP.

d. For radar acquisitions, a Radar Spectrum Management Control Plan (RSMCP) can be ordered by requesting DID DI-MISC-81114. The RSMCP is prepared in accordance with the requirements of MIL-STD-469. Does the RSMCP include the following:

   (1) Identify, responsibility, and authority of the individual who will implement the contractor's design program?
   (2) Number and experience of full-time and part-time radar design and EMC engineers assigned to the program?
   (3) Organizational chart of all program personnel?
   (4) Design aspects of the acquisition item as related to the requirements specified in MIL-STD-469? Are the following specific items discussed:
      (a) General design philosophy and reasons for the proposed approach?
      (b) Anticipated E^3 problems and proposed methods for resolution?
      (c) Method(s) of implementing the design?
   (5) Detailed description of facilities, available and to be procured (identified separately) that will enable a contractor to demonstrate compliance with MIL-STD-469 requirements?
   (6) Methods of accomplishing design reviews with subcontractors, if any?
   (7) Considerations (Questions) of Paragraph G.3.12.3a and 3b where appropriate?

e. A EME Control Plan (EMECP) may be required in situations where a specification places limitations on the impact that a system's EM emissions may have on an environment. The impact to the EME can be controlled by limiting the system's power levels and field strengths. The applicable considerations (Questions) of Paragraph G.3.12.3a and 3b may be useful when evaluating the EMECP.

<table>
<tr><th colspan="3">EVALUATION GUIDE</th></tr>
<tr><td rowspan="2">Key Document:

Iterative Preparation

G.3.13 E^3 TEST/VERIFICATION PROCEDURES</td><td>Prep'd in Phase:</td><td>For Use in Phase:</td></tr>
<tr><td>I
II
III</td><td>I
II
III</td></tr>
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G.3.13.1 Description. Three (3) different DIDs are available for ordering E^3 Test Procedures on contracts as standard deliverable documentation. The form and format specified for the test procedures varies, and in some cases allows for use of the contractor's format. Selecting this option usually reduces the cost without jeopardizing the validity or usefulness of the data. The individual DIDs are:

DI-EMCS-80201	-	EMI Test Procedures (MIL-STD-461 & 462).
DI-MISC-81113	-	Radar Spectrum Management Test Plan (MIL-STD-469).
DI-EMCS-81541	-	E^3 Verification Procedures (MIL-STD-464).

G.3.13.2 Perspective. There is no substitute for performing an actual test on an item that is controlled with predetermined conditions. The tests can be repeated endlessly to demonstrate the net impact of small design changes or other conditions.

a. In Phase II an initial, or updated from Phase I, EMICP/E3IAR is supported by E^3 Test/Verification Procedures and a E^3 Test/Verification Report. Testing is mandatory if an item is to be qualified to a specification or standard (e.g., MIL-STD-461/464). Until the item is actually tested, whether of developmental, commercial or NDI origin, there is no assurance the item possesses the desired EMC qualities.

b. Reuse of the EDM E^3 Test/Verification Procedures during Phase III is usually feasible if the developing contractor is retained for production. However, it will probably be necessary to order new test/ verification procedures for use during production when there is a change in contractors. The differences in facilities and available equipment would in all likelihood make an attempt to reuse the E^3 test/ verification procedures very difficult and ultimately may not be a cost savings.

c. The FPM being produced in Phase III should demonstrate its qualification to the requirements of the specification just like its predecessors did.

G.3.13.3 E^3 control considerations.

a. EMI Test Procedures (EMITP) is ordered by requesting DID DI-EMCS-80201. The EMITP is prepared in accordance with the requirements of MIL-STD-461 & 462 for EMI and EMP testing during any phase in which formal tests are required. These test procedures provide the fundamental range of required testing for an item. The usefulness of well a prepared EMITP does not necessary end at the end of the phase. The EMITP can be revised, expanded, and updated at minimal cost, for reuse in EMI/EMP testing of the next phase as appropriate. Does the EMITP include the following features or requirements:

(1) An introduction?
   (a) Description of the document's purpose and relationship to the overall EMC program?
   (b) Table of EMI tests required with corresponding paragraph numbers and test methods from MIL-STD-462?
(2) An applicable EMC document list?
(3) A test site description?
   (a) Description of facility?
   (b) Description of facility groundplane and method of grounding and bonding of test sample?
   (c) Evidence of spot-check measurements of ambient EM emissions (radiated and conducted)?
(4) Test Instrumentation?
   (a) Nomenclature and bandwidth?
   (b) Scan speeds?
   (c) Matching transformer and band-rejection characteristics?
   (d) Antenna factors, current probe impedances, line impedance stabilization networks (LISN), impedances and insertion losses, and impedances of 10 uF capacitors?

(5) Test Sample Physical Layout Description?
(6) Test Sample Operation Description?
   (a) Operational mode for each test frequency?
   (b) Test sample control settings?
   (c) Test set control settings or characteristics of input signals?
   (d) Test frequencies at which oscillators and clocks may be expected to approach their limits?
   (e) List of performance checks which demonstrate the equipment meets minimal working requirements?
   (f) Enumeration of circuits, outputs, or displays to be monitored and criteria specified to be monitored for degradation of performance?
(7) Measurements Descriptions?
   (a) Block diagram of test setup?
   (b) List of test equipment with method of grounding, bonding or isolation?
   (c) Procedures for probing test sample; determining placement and orientation of probes and antennas; and selecting measurement frequencies and detector functions?
   (d) Required information to be recorded? (Sample data sheets, test logs and graphs, and test limits should be given).
   (e) Modulation characteristics?

b. E^3 verification procedures (E3VP) is ordered by requesting DID DI-EMCS-81541. The E3VP is prepared in accordance with the requirements of MIL-STD-464. The E3VP should describe the overall verification procedures (test, analysis, and inspection, as appropriate) for each E^3 control/EMC performance requirement specified in the contract for the system being developed. Does the E3VP include the following:

(1) An introduction?
   (a) System description, including any pertinent information regarding verification issues?
   (b) Statement of assumptions and limitations associated with verification?
   (c) General objectives?
(2) A general description of an overall verification matrix being used to demonstrate compliance with requirements, including relative role of analyses, tests and inspections?

(3) Methods of verifications?
  (a) Abstracts of the procedures used for verifying each E^3 control/EMC performance requirement?
(4) Engineering factors affecting verification procedures?
  (a) Facilities?
  (b) Resources?
  (c) Safety?
  (d) Reports?
  (e) Security?
(5) Verification methodology used to verify compliance for each of the following interface requirement areas that are contractually imposed:
  (a) Margins?
  (b) Intrasystem Electromagnetic Compatibility (EMC) including where applicable: ship hull intermodulation interference, internal electromagnetic environments, and powerline transients?
  (c) Intersystem EMC?
  (d) Lightning?
  (e) Electromagnetic pulse?
  (f) Subsystem and equipment electromagnetic interference, including where applicable: non-developmental items, commercial items, electromagnetic spectrum compatibility, and DC magnetics?
  (g) Electrostatic charge control, including where applicable: vertical lift and in-flight refueling, precipitation static, and explosive subsystems?
  (h) Electromagnetic radiation hazards, including where applicable: hazards of electromagnetic radiation to personnel, hazards of electromagnetic radiation to fuel, and hazards of electromagnetic radiation to ordnance?
  (i) Life cycle E^3 hardness?
  (j) Electrical bonding, including where applicable: power current return path, antenna installations bonding, and EMI bonding?
  (k) External grounds, including where applicable: aircraft grounding jacks?
  (l) TEMPEST?
  (m) Emissions control?
  (n) Electronic protection?

(6) Detailed procedures?
  (a) Analyses?
  (b) Tests?
  (c) Inspections?
(7) Objective of each verification?
  (a) References?
(8) Verification items?
  (a) Identification of the physical configuration, such as structural features, mechanical and electrical equipment installed, and software status?
  (b) Description of system functions (or subsystem/ equipment functions) that are required or available?
  (c) Description of provisioned equipment (items that are part of the resultant system operation but are not necessarily developed under the contract) such as weapons, pods, and payloads that are required?
  (d) Operating details of the system?
(9) Elements of verification?
  (a) Models, techniques, and tools used for analysis and predictions and their specific application to this system?
  (b) Step by step procedures?
  (c) Determination of applicable margins and the methods to be used for demonstration?
  (d) Selection of critical circuits, functions, and subsystems?
  (e) Pass or fail criteria and methods of quantifying and evaluating degradation?
  (f) Description of test articles, test facilities, test equipment (including instrumentation on and off the system), support equipment, and calibration techniques?
  (g) Method of simulating operational performance when actual operation is impractical?

c. A Radar Spectrum Management Test Plan (RSMTP) is ordered by requesting DID DI-MICS-81113. The RSMTP is prepared in accordance with the requirements of MIL-STD-469. Does the RSMTP include the following:

(1) Test conditions and procedures for the system, and the sequence of operation during the tests?
(2) Implementation and application of test procedures, including modes of operation, control settings, monitored points, and related information?

(3) Nomenclature and general characteristics of test equipment to be used?
(4) Types of measurement standards and methods of calibration and calculations to show the expected accuracy of each?
(5) Dummy loads, filters, dummy antennas, and signal samplers that are to be used and their descriptions?
(6) Readout and detector functions to be used?
(7) Details of test setups and test site procedures?
(8) Maximum use of photographs and drawings?
(9) Expected accuracy of measurements?
(10) Nomenclature and description of test sample?
(11) Personnel required, both designated Government and contractor representatives?

d. An EME Test Plan (EMETP) may be required in situations where a specification places limitations on the impact that a item's EM emissions may have on an environment. Does the EMETP include the following:

(1) An administrative section describing the contractor's organization, E^3 engineering personnel, their responsibilities and authorities for preparing the EMETP?
(2) Description of the desired emission profile of the item, the predicted harmonic and spurious responses and their levels?
(3) Discussion on the application of MIL-STD-462 and industry standard (ANS, IEEE, EIA, etc) test methods and procedures as applied to the requirements of the specification?
(4) Description of the test sites and test procedures?
(5) Considerations (questions) of Paragraph G.3.13.3a and b where appropriate?

EVALUATION GUIDE		
Key Document: Iterative Preparation	Prep'd in Phase:	For Use in Phase:
G.3.14 <u>TEST REPORTS FOR EMC, EME, EMI & OTHER E^3 DISCIPLINES</u>	I II III	I II III

G.3.14.1 <u>Description</u>. Only two (2) DIDs are currently available for ordering E^3 Test/Verification Reports on contracts as standard deliverable documentation. The form and format of these reports are specified by the DIDs. In some cases the contractor's format is accepted. The individual DIDs are:

DI-EMCS-80200 - EMI Test Report (MIL-STD-461).
DI-EMCS-81542 - E^3 Verification Report (MIL-STD-464).

G.3.14.2 <u>Perspective</u>. Test reports present a project's "bottom Line". When test results are properly documented and clearly explained, the information provided forms conclusive evidence of the project's success or failure.

a. The test results of a package of properly selected tests performed in accordance with standards such as MIL-STD-462 and MIL-STD-464 provide an EM baseline profile of an item. The test results should describe the susceptibility and emitted interference levels of the item as compared to the requirements of MIL-STD-461 and MIL-STD-464.

b. The EMITR/E3VR is the most important source of E^3 control information that is readily available. Without the information provided by an EMITR/E3VR, analyses would be very difficult to perform, and the EMC of the project item could not be accurately assessed.

c. The need to document the EM characteristics of the EDM during Phase II is critical. These results become the criteria for E^3 testing during PAT&E. The Full-rate Production Model (FPM) should later duplicate or surpass the test results recorded for the EDM.

G.3.14.3 <u>E^3 control considerations</u>.

a. A EMITR is ordered by requesting DID DI-EMCS-80200. The EMITR should be prepared in accordance with the requirements of MIL-STD-461 & 462. Commencing with the earliest phase in which formal tests are conducted, the EMITR is used to record and evaluate progress toward achieving E^3 control objectives and to formulate future testing requirements in the succeeding phase. Does the EMITR include the following:

- (1) Administrative Data?
  - (a) Contract number?
  - (b) Procuring activity authentication and certification of test performance?
  - (c) Disposition of test item?
  - (d) Description of test sample, including function and intended use, if known?
  - (e) The Root Mean Square (RMS) value of line phase current?
  - (f) List of tests performed and any authorized changes in limits or test references?
- (2) Appendices (one for each test)? Does each appendix contain:
  - (a) Testing equipment nomenclatures?
  - (b) Testing equipment serial numbers?
  - (c) Testing equipment calibration date, procedures used and traceability?
  - (d) Photographs or diagrams of test setups?
  - (e) Transfer impedance of current probes?
  - (f) Antenna factors, line impedance stabilization network (LISN) impedance and insertion losses, and impedance curve of 10 uF capacitors?
  - (g) Identification of EMI suppression measures, if used?
  - (h) Test data before and after the application of EMI suppression measures?
  - (i) Graphs of X-Y recordings of limits and measured data?
  - (j) Data showing compliance with requirements, thresholds or limitations?
  - (k) Sample calculations?
- (3) Recommendations and Conclusions?
  - (a) Results of test given?
  - (b) Remedial actions already initiated, if any?
  - (c) Proposed corrective actions, if any?

(d) Characteristics of the test sample that may influence equipment's ability to meet contractual EMI control requirements?

b. A E^3 verification report (E3VR) is ordered by requesting DID DI-EMCS-81542. The E3VR is prepared in accordance with the requirements of MIL-STD-464. The E3VR should describe the overall verification results (test, analysis, and inspection, as applicable) for each E^3 control/EMC performance requirement specified in the contract for the system being developed. Does the E3VR include the following:

(1) Introduction?
   (a) System description?
   (b) Pertinent information regarding verification issues?
   (c) Assumptions and limitations associated with verification efforts?

(2) General description of the results for the verification of each E^3 interface and performance requirement?
   (a) Synopsis of verification procedures and reference to detailed procedures?
   (b) Successes and failures?
   (c) Impacts of failures on operational performance?
   (d) Recommendations to resolve failures?
   (e) Lessons learned?

(3) Detailed information covering the results of the analysis, tests, and inspections used to verify compliance with each of the following interface requirement areas that were contractually imposed:
   (a) Margins?
   (b) Intrasystem Electromagnetic Compatibility (EMC) including where applicable: ship hull intermodulation interference, internal electromagnetic environments, and powerline transients?
   (c) Intersystem EMC?
   (d) Lightning?
   (e) Electromagnetic pulse?
   (f) Subsystem and equipment electromagnetic interference, including where applicable: non-developmental items, commercial items, electromagnetic spectrum compatibility, and DC magnetics?

(g) Electrostatic charge control, including where applicable: vertical lift and in-flight refueling, precipitation static, and explosive subsystems?
(h) Electromagnetic radiation hazards, including where applicable: hazards of electromagnetic radiation to personnel, hazards of electromagnetic radiation to fuel, and hazards of electromagnetic radiation to ordnance?
(i) Life cycle E^3 hardness?
(j) Electrical bonding, including where applicable: power current return path, antenna installations bonding, and EMI bonding?
(k) External grounds, including where applicable: aircraft grounding jacks?
(l) TEMPEST?
(m) Emissions control?
(n) Electronic protection?

(4) Objective of each verification?
(a) References, including source of detailed verification procedures?

(5) Verification items?
(a) Identification of the physical configuration, such as structural features, mechanical and electrical equipment installed, and software status?
(b) Description of system functions (or subsystem or equipment functions) that were exercised?
(c) Description of provisioned equipment (items that are part of the resultant system operation but are not necessarily developed under the contract), such as weapons, pods, and payloads that were used?

(6) Results?
(a) When verification was conducted?
(b) Where verification was conducted?
(c) Who conducted the verification?
(d) Documentation of setup, including the verification article, facility, test equipment and calibration?
(e) Verification observations, such as plots, measurements, photos, drawings, logs, checklists, data sheets, ratings, and comments?
(f) Demonstration of margins?

(g) Description of any deviations from the verification procedures?
(h) Status and disposition of verification article?

(7) Conclusions?
(a) Status of compliance with requirements (pass or fall)?
(b) Impact of the results on system operational performance?

(8) Recommendations?
(a) Required corrective actions, modifications, or changes to operational procedures, manual, or processes?
(b) Additional verification actions, investigations, resolutions, or studies?

c. A EMC Test Report (EMCTR) may be required for radar acquisitions. The EMCTR should be prepared in accordance with the requirements of MIL-STD-469. Does the EMCTR include the following:

(1) The data required by TABLES I and II of MIL-STD-469?
(2) Discussion on how any observed deficiencies reported in the EMCTR can be resolved:
(a) During Phase II, EMD?
(b) By installation measures?
(c) At the next higher level of design?
(d) Through operational restrictions?
(3) Discussion on how out-of-specification conditions are related to the performance of an item? Degradation at the mission level?
(4) Discussion on cost-performance trade-offs for each possible method of resolving an E^3 problem?
(5) Considerations (Questions) of Paragraph G.3.14.3a and 3b where appropriate?

d. A EME Test Report (EMETR) may be required in situations where a specification places limitations on the impact that a item's EM emissions may have on an environment. The applicable considerations (Questions) of Paragraph G.3.14.3a and 3b may be useful when evaluating the EMETR.

EVALUATION GUIDE		
Key Document: One-Time Preparation G.3.15 <u>ENGINEERING CHANGE PROPOSALS, DEVIATIONS, & WAIVERS</u>	Prep'd in Phase:	For Use in Phase:
	II III	II III

G.3.15.1 <u>Description</u>. This evaluation guide addresses (3) types of documents whose uses are very similar despite apparent differences. The three (3) types of documents are Engineering Changes, Deviations, and Waivers. All three (3) documents are covered together under a single KD for consideration within JECS. These documents are used to authorize changes in hardware (or software) from that specified in current documentation. The Engineering Change Proposal (ECP) is the most important and has the most extensive requirements for information. The ECP data requirements covers all the data needed for a Deviation or Waiver. DD Form 1692 is the prescribed standard format that is intended specifically for an ECP (including emergency submission follow-ups). The ECP after approval becomes an Engineering Change that authorizes the implementation of the actions it proposed.

a. <u>Engineering change</u>. Better known by its preapproval name, ECP, the Engineering Change is part of a formal procedure for developing, reviewing, and approving requests for changes to an item that is under configura-tion control. When an ECP is approved, the Engineering Change results in a permanent departure from the approved baseline configuration of the item. The ECP may propose a change to the electrical or mechanical design, or software, or it may request a change in the specification or drawings of the existing configuration. Either way, the item as defined by the specification or drawings, becomes changed, and the changes resulting from an approved ECP become permanent. All items manufactured subsequently should conform to the revised configuration.

b. <u>Deviation</u>. In some circumstances an item may be unable to qualify or may be otherwise found deficient when compared to requirements of the specification. In this condition, the item does not meet a requirement(s) and hence cannot be accepted. However, if the item remains useful at some lower level, "failed delivery" may not be in the Government's best interest. The Deviation is a specific written authorization, granted prior to the manufacture of an item, to depart from a particular requirement(s) of an item's current approved configuration for a specific number of units or a specified period of time. The Deviation is not a permanent change. Moreover, according to the terms of the Deviation or the contract, the item serial copies affected may ultimately be reworked to bring them into compliance with the approved configuration. The approval of a Deviation may include a contingent clause requiring the deficiency be corrected by the manufacturer at no cost, or for a price established in the approval documentation.

c. Waiver. The term Waiver as used in this context is a formal (written) authorization to accept an item, which during manufacturing, or after having been submitted for Government inspection or acceptance, is found to depart from a specified requirement(s), but nevertheless is considered suitable for use "as is" or after repair by an approved method. (The other usage of the term "Waiver", generally associated with Spectrum Management, refers to the confirming of relief from a Radio Service band regulation and, although at times seemingly the same, has a different impact altogether). The Waiver is a one-time action, and the serial units covered by the waiver do not necessarily have any lower level of usefulness. The Waiver is not a permanent change in the configuration.

G.3.15.2 Perspective. ECPs are seldom used prior to Phase II, EMD, since formal baseline configurations are normally not established before this time. However, once configuration control is imposed, the use of ECPs is essential. The potential requirement for ECPs continues in Phase III, Production, Fielding/Deployment and Operational Support, so long as a production line is active. Engineering Changes, Deviations, and Waivers all apply to hardware that has not yet been accepted by the Government. Equipment units that have already been delivered and accepted (except for hardware covered by latent defect clauses) are not subject to control in this manner. Each Service has its own terminology (Material Modification Kits, Field Changes, etc) and procedures that enable changes to be incorporated into equipment that has already been delivered and deployed in the field. Configuration control of an item can have a number of subtle consequences to disciplines such as E^3 control and EMC, that are not always immediately apparent.

a. ECPs should always be evaluated for changes to the item's EM characteristics. An ECP may be used to alter and improve the E^3 control capabilities of an item, or alternately, a ECP having an entirely different objective unrelated to E^3 may have collateral E^3 control consequences.

G.3.15.3 <u>E^3 control considerations</u>. When considering documents which authorize changes:

a. What is the impact of a change on the total system performance when the change is made and the modified item is operated in the intended EME?

b. What is the E^3 impact of the change on the next higher level of design?

c. If adverse E^3 are suspected, is testing planned to confirm or deny their existence?

d. If an ECP, Deviation, or Waiver is proposed for the correction of an E^3 control deficiency, will it achieve its purpose without generating other problems? If performance trade-offs are required, have they been evaluated?

e. Does the change result in a requirement for operational restraints or installation limitations (e.g., loss of/change in inherent shielding by substitution of fiberglass for steel partitions to save/lower weight)?

f. Can Observed E^3 control deficiencies be resolved:

(1) By installation measures?
(2) At the next higher level of design?
(3) Through operational restrictions?

g. Can out-of-specification E^3 control conditions be related to performance degradation at the mission level?

h. Have cost-performance trade-offs been identified for each significant method of resolving an E^3 problem?

JOINT E^3 CONTROL STRATEGY (JECS)						
GOAL	**TO ELIMINATE DURING ACQUISITION THE DEGRADATION OF JOINT OPERATIONAL CAPABILITIES BY ELECTROMAGNETIC ENVIRONMENTAL EFFECTS**					
OBJECTIVES	• Establish fund-amental guidance for bilateral EM compatibility between the desired platform, system, or equipment item and the intended EM environment (EME).	• Establish, in the approved requirement, that the specified operational performance level of the item will be fully achieved in the intended EME. • Ensure that program and preproject planning addresses the E^3 control organization and provides arrangements for appropriate early EME assessment, analyses, and testing during development or acquisition. • Ensure that sign-ificant risks of EMI or EM radiation hazards character-istic of or inherent in each solution presented were adequately addressed during the decision process.	• Establish E^3 control and testing requirements for engineering development. • Determine that known or projected EMI or EM radiation problems of the project item are judged resolvable in engineering development.	• Ensure that the developmental model achieves full operational performance levels in the intended EM environment without generating EMI problems or unresolvable EM hazards. • Ensure that the E^3 control requirements established for the production model will preserve the EM performance demonstrated by the approved development model.	• Ensure through testing that the production model meets all E^3 control requirements established for it.	• Ensure that documentation supporting redevelopment or upgrading of an item incorporates the E^3 control requirements needed to correct any existing E^3 problems of the current item.
ACQUISITION PHASE		PHASE 0	PHASE I	PHASE II	PHASE III	
MILESTONE	**0**	**I**	**II**	**III**	**PAT&E**	
JECS PHASE	DETERMINATION OF MISSION NEED	CONCEPT EXPLORATION	PROGRAM DEFINITION & RISK REDUCTION	ENG. & MFG. DEVELOPMENT	PRODUCTION, FIELDING/DEPLOYMENT & OPERATIONAL SUPPORT	

FIGURE G-1. JECS goal & objectives summary

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APPENDIX H

T&E CONSIDERATIONS FOR EMC

H.1 General. T&E should be started as early as possible in the acquisition process in order to reduce acquisition risks and to estimate the capability of the item under development being able to achieve all of its technical and operational requirements. Critical T&E issues, objectives, methodologies, and evaluation criteria should be defined during the initial phase of an item's acquisition. These criteria serve to define the testing that should be required for each phase of the acquisition process and provides the structure for the measurements program. Test procedures should be developed to test and verify the critical E^3/EMC issues. All significant changes to an item's configuration, and each major milestone, should trigger a review of the EMC T&E requirements in order to determine if individual steps need to be modified or updated.

H.2 Planning the T&E approach. The following factors should be considered when planning the overall T&E for a project:

a. DT&E should be planned to resolve E^3 risks, evaluate alternative design approaches and assist in the selection of hardening components such as shielded cables, filters, etc.

b. DT&E and OT&E activities that should be considered include:

   (1) EMC tests as specified in applicable standards such as MIL-STD-449, MIL-STD-462, MIL-STD-464, MIL-STD-469 and MIL-STD-1605.
   (2) Verification of effectiveness of proposed spectrum control and frequency utilization techniques.
   (3) Demonstration of an item's satisfactory operation in its intended EMEs. Emphasis should be placed on an item's utilization in locations where it will be subjected to high levels of EM energy.
   (4) T&E for EMP should be conducted when the operational requirements document (ORD) states that the item is to survive and operate in nuclear environments.

c. HERO tests should be planned for those items containing Electro-Explosive Devices (EEDs) or other types of electronically or electrically initiated hardware.

d. Ensure there is sufficient data available to assess an item's compatibility. If required, test procedures should be prepared to acquire additional data during DT&E.

e. Have an approach that establishes the relationships between test data and operational effectiveness.

f. Confirm test results will provide sufficient data to perform a vulnerability analysis. This may be accomplished by establishing rationale that relates specific test data to the various steps in the process. Vulnerability analyses should be presented in terms of operational performance parameters such as time between false alarms, detection ranges, etc.

g. Items should be tested with all transmitters and receivers being operated that are normally required for simultaneous operation. This includes all receivers and transmitters on the item's platform as well as those on nearby platforms.

h. For those systems which cannot be protected from all operational environments, OT&E tests should be performed with the item in those EMEs to determine if its EMC performance is acceptable.

i. Ensure adequate test facilities are available and special training is provided, when required, with regards to the operation of the equipment, subsystem or system being tested.

j. Costs for analysis of test results in terms of expected operational performance. This is often equivalent in scope to the data collection effort itself.

k. Any observed deficiencies in EMC should be weighed against operational performance in terms of need, urgency, risk and worth. When there is a need for more effective control the application of alternative design techniques should require additional T&E.

H.3 Feasibility studies during the conceptual phase. Although feasibility studies are not truly T&E, it is during these studies that the greatest impact can be made on the future status of EMC. The use of previous T&E results, operational information on similar E^3 problems, studies, and references to corporate memory of lessons learned can have a profound impact upon the future control of the EM environment. It is during these studies that important decisions can be made relative to critical configuration arrangements and dimensional relationships.

H.4 Analytical studies. Whenever possible, maximum use should be made of data acquired from previous E^3 predictions and operational experiences, although in many areas, changes to the design may have rendered the previous predictions invalid. Previous E^3 predictions should be analyzed in relation to the current design to determine which predictions are still applicable and which require revisions, and to identify those areas requiring further predictions and analysis.

H.4.1 Changes. As the design changes from the baseline configuration, additional E^3 predictions may be required to provide inputs for the preparation of an EMC Impact Statement addressing these changes. Additionally, it is probable that changes will continue to be made to the design until the time of, and even after, an item's delivery. The need for E^3 predictions is, therefore, continuing, and these predictions should be required whenever a major change to the design, or configuration, is anticipated.

H.4.2 Testing. E^3 predictions may also be used to initiate early testing to verify the existence of a major problem and to permit an early start on developing technically sound engineering solutions.

H.5 Model studies. Modeling study techniques have been refined to the point where they constitute accurate and reliable prediction tools. As the design changes from the baseline configuration, it may be necessary to update model studies. It is vital that management procedures ensure that all participants, from the analyst to the equipment installer, are operating with the same and latest information.

H.6 Test and evaluation master plan (TEMP). The TEMP, or for smaller programs, the TEP, is the controlling (planning) document for T&E. The TEMP prescribes the T&E requirements, including EMC testing, for an acquisition program. The TEMP contains the integrated requirements for DT&E and OT&E. As such, it describes the end-item to be acquired and the expected system characteristics, defines and establishes the test objectives and identifies critical issues, assigns responsibilities, identifies resources, and presents schedules for development and operational test events for each of the test phases during an item's acquisition. Test resource requirements are addressed in the TEMP along with an analysis of impediments, plans to correct test resource limitations, and a listing of approved evaluation criteria. Where as the TEMP is an overall planning and scheduling document, the actual conduct of developmental and operational tests are specified in their respective detailed test procedures. The TEMP is prepared early in the acquisition process, ideally prior to the Milestone 1 decision for each new item being developed, and should be reviewed at least once annually. The TEMP should be updated, as required, to incorporate significant T&E results and any changes that occur in the acquisition plan or milestones.

H.6.1 TEP. The TEP format is generally the same as that prescribed for a TEMP, except that all elements need not be included. OT&E, as well as other selected elements, depending on the nature of the product, may be excluded from TEPs.

H.6.2 EMC testing. The TEMP (or TEP) should provide for appropriate EMC testing. Approval of the TEMP (or TEMP revision) constitutes direction to conduct the T&E program and includes the commitment of the Research, Development, Test and Evaluation (RDT&E) support. Failure to update the TEMP, as required, can result in inadequate T&E resources. Procedures for DT&E and PAT&E should be drawn up directly from the TEMP or TEP.

H.6.3 Review guidelines for TEMP. A TEMP Evaluation Guide is presented in Appendix G, Paragraph G.3.6.

H.7 Development test and evaluation (DT&E). During DT&E there is a need to identify OT&E requirements, obtain required test data, and prepare associated EMC analysis. DT&E is conducted in factory, laboratory and proving ground environments. A final step in a successful DT&E program is certification that the system is ready for OPEVAL.

H.7.1 Preinstallation testing. Preinstallation testing is conducted to ensure the integral components of a system function as specified in their intended EMEs. Test programs should be designed to verify compliance with contractual EMC performance requirements. Test procedures should indicate measurement objectives, test configurations, test points, detailed measurement procedures, and the formats for recording data. Specific test techniques should be based on the general procedures in the EMC standards. Preinstallation testing, as applicable, includes the following:

- Engineering development testing.
- First article testing.
- Acceptance testing.
- Integration testing.
- Spectrum signature testing.

Preinstallation testing may be conducted by Government laboratories, centers, or facilities, or it may be required of prime contractors, subcontractors, or vendors.

H.7.2 Land-based test sites testing. Land-based test site testing of entire systems can be an important part of DT&E. A system's complexity determines whether construction of a land-based test site is warranted. Insofar as possible, testing at land-based test sites should include EMC considerations. For systems whose complexity does not warrant construction of a land-based test site, DT&E and Initial Operational Test and Evaluation (IOT&E) will frequently consist only of T&E of individual unproven systems. For these situations E^3 considerations should be addressed through engineering analysis, mathematical and brass modeling, specific system-to-system interface tests, and planning for the earliest possible EMC testing of the complete platform.

H.7.3 Ship construction testing. Ship construction testing is conducted by the prime contractor. It is important that management procedures provide for appropriate observations of critical tests and that installation check out testing provides for EMC demonstration tests in the EME. Builders trials are conducted by the prime contractor and should be observed by Government personnel. They should include the requirement for EMC demonstration tests of complete systems.

H.7.4 Aircraft flight safety testing. Aircraft flight safety testing is conducted by the prime contractor and is mandatory for acceptance of the aircraft by the Government.

H.8 Production acceptance test and evaluation (PAT&E). PAT&E is defined as testing that is conducted on production items to demonstrate a system meets all of its requirements. Specific objectives of the PAT&E should be included in the TEMP.

H.9 Total ship tests (TST). Completion of the Total Ship Test Program for Active Fleet Ships (TSTP/AFS) provides for comprehensive tests which should determine the readiness status of equipment, single systems, or integrated ship systems during the life cycle of a ship. Test programs should be developed, verified, and proven under the direction of the Total Ship Test Director (TSTD), Test Procedures Development Managers (TPDMs), and Test Procedures Development Agents (TPDAs). The TSTP should be designed to provide Fleet personnel and industrial activities with the capability, utilizing standard tests developed in the Planned Maintenance Sub-System (PMS), for determining the condition of material readiness of shipboard equipment and systems. Each TSTP should provide for appropriate EMC testing. The Project manager should be responsible for supporting the development of the TSTP, with the objective of providing a complete set of PMS procedures at the time of Fleet introduction.

H.10 Aircraft testing. The purpose of this test is for the contractor to demonstrate the performance and EMC of the aircraft as well as its ability to perform its mission.

APPENDIX I

E^3 MODELS AND SIMULATIONS

I.1 General. E^3 analysis ranges from simple estimates through computationally intensive solutions of electromagnetic field equations. Simplified coupling analyses are useful for feasibility studies, and for general trade-off assessments of alternative system designs, and can often be performed with only handbook references and manual computations. Analytic models and simulation-based computer codes are often required for detailed calculations.

I.1.1 Models. A model is a representation of an actual or conceptual system that involves mathematics, logical expressions, or computer simulations that can be used to predict how a system might perform or survive under various conditions or in a range of hostile environments.

I.1.2 Simulations. Simulation involves the process of conducting experiments with a model(s) for the purpose of better understanding the behavior of the system being modeled under selected conditions or of evaluating strategies for the operation of the system under selected conditions or limits imposed by the development of operational criteria. A simulator provides the acquisition manager, analyst, or planner with the ability to easily and inexpensively study the impact of variations in configuration, performance, or tactics. Simulation provides the mechanism for an extrapolation from existing or planned performance characteristics to projected operational performance characteristics.

I.2 Analytical tools. Numerous analytical, modeling, and simulation tools for E^3 analysis have been developed by the services and DoD agencies such as the JSC (formerly ECAC). The following paragraphs provide an overview on some types of models that are available at the JSC for E^3 analysis.

I.2.1 Transmitter models. These models can be used to predict the spectra of desired and undesired emissions. For in-band emissions, the JSC maintains a handbook containing models of the spectra of desired emissions for a wide variety of modulations. These models vary: some give the equation of the spectrum; some provide a normalized plot of the spectrum; some provide rules to identify the bounds of the spectrum. There are also models for out-of-band emissions which have been derived empirically. In many cases these models have been incorporated into automated analysis models.

I.2.2 Propagation models. There are a number of models for predicting propagation from very low radio frequencies through E-O frequencies. These models are designed to analyze groundwave, diffraction, and tropospheric scatter propagation through an atmosphere whose refractivity may vary with height. These models may be adapted to account for variability in conductivity, permittivity, terrain, and frequency. Special-purpose propagation models are also available that provide the capability to consider earth-space links, tropospheric ducting, rain-scatter coupling between antenna beams, foliage attenuation, millimeter wave, and E-O propagation effects.

I.2.3 Frequency assignment models. Automated frequency assignment models are available to satisfy communications requirements. These models are applicable to single-channel, multichannel, and frequency-hopping radios. The models have applications in the frequency bands from HF to SHF. Operational applications include tactical units, air-ground-air links, HF long-haul links, and large-scale theater operations.

I.2.4 Receiver models. There are numerous receiver EMI analysis models. Basically, a receiver analysis is done to predict the extent of performance degradation on a receiver system, resulting from interfering signals. JSC maintains an extensive collection of technical manuals and automated models that are used to:

- Calculate frequency dependent rejection as a function of frequency offset.
- Predict spurious response frequencies and levels.
- Determine the effects of automatic gain control capture, filter ringing, and loss of synchronization.
- Simulate both time and frequency domain receiver processing by using time sampling, digital filtering, and fast Fourier transform techniques.
- Model a variety of receiver terminal devices and error correction codes.
- Compare output performance measures such as bit error rate to the characteristics of the desired and interfering signals at the detector input.

I.2.5 Environmental analysis models. Models are available to analyze interference power levels, power-density levels, and interference-to-noise (I/N), signal-to-interference (S/I), or jamming-to-signal (J/S) ratios of equipment in selected environments. Some of these models have an interactive histogram display capability that enables the user to graphically summarize the resulting data. Models are also available to predict and to display electromagnetic radiation (EMR) data for environments containing vast numbers of equipment. These models can be used to perform near-field corrected power-density analyses and can be used in conjunction with other models to perform analyses to identify E^3 interactions, using such parameters as received interference power, I/N and S/I. The analysis results can be plotted graphically as a function of frequency. These plots depict the EMR environment in specific geographic areas such as the ones encountered by an aircraft, a missile, or a spacecraft traversing an area or any user-defined EMR environment.

I.2.6 Cosite analysis models. Unique interference interactions occur when a large number of undesired signals with high-power levels are present in a cosite environment (i.e., on the same platform or near other systems). Models are available to assist the project engineer in performing a cosite analysis. A cosite analysis capability needs to be supported by a data base of applicable equipment characteristics. Cosite analysis capabilities include:

- Determining the performance of existing collocated C-E systems.
- Evaluating the design of system configurations in terms of cosite performance.
- Determining constraints on frequency assignments.
- Evaluating a variety of equipment types including conventional communications receivers and transmitters, frequency-hopping receivers and transmitters, and radars.

I.2.7 Electro-optical systems analysis models. There are a number of analysis capabilities that apply to E-O systems such as infrared sensors, laser communication links, and missile seekers. These models are used to perform systems analyses relating to target signatures, atmospheric transmittance, optics off-axis patterns, sensor performance, and dynamic target engagement. Analysis techniques have also been developed for predicting low-level interference and jamming thresholds of E-O receivers and for estimating the higher threshold levels to sensor overload and damage.

I.2.8 Coverage contour models. These models enable the user to interactively generate area coverage contours of path loss, terrain elevations, line of sight, and jamming-to-signal ratios. The overlays can then be displayed on a workstation along with digitized maps. This capability uses the Arc/Info geographic information system to manipulate, analyze, and display the geographic data.

I.2.9 Radar analysis models. There are a number of analytical models and computer programs for analyzing the EMC of radar systems in the presence of undesired signals. The overall performance of a radar system, as well as the performance of functional components, such as search, track, or track-while-scan, can be evaluated. The models can be readily adapted to evaluate the performance of special function radars, such as imaging radars. Automated capabilities exist that are tailored for the levels of analyses and types of environments commonly encountered. These environments may contain a large number of potential interference sources, including various types of surface and volume clutter.

I.2.10 ATC, IFF, and NAVAIDS models. These models provide capabilities to assess the performance of air traffic control (ATC), identification friend or foe (IFF), and navigation aid systems (NAVAIDS) in user-defined interference environments. Scenario databases are used to define hypothesized environments, and includes definitions of equipment characteristics such as antenna parameters, transmitter power, receiver sensitivity, and processing capabilities. Drawing information from the scenario databases, the ATC/IFF/NAVAIDS models are then used to predict systems performance relative to the system design and the intended environment. These models can be used in support of the acquisition process, systems engineering, and systems integration.

I.2.11 Space system analysis models. These models can be used to analyze electromagnetic interactions of large constellations of satellites and terrestrial systems. Friendly, neutral, and/or threat systems can be included in the analysis. The models determine the incident power density or the received signal power at uplink, downlink, and crosslink receivers. A graphics interface capability enables the analyst to view the satellite orbits and the power levels calculated for various points along the orbital path.

I.3 Computer codes. There are a large number of computer programs available for use as tools for solving a variety of analysis and modeling problems. These computer codes are capable of providing very useful interpretations to rather complex problems. In general, a detailed understanding of the theory of the analysis method is not required in order to be able to use the codes effectively. The theory has already been implemented in the codes; however, the user has to be sure that the selected code is applicable to the particular problem at hand and that the problem definition does not violate any of the constraints dictated by the code's algorithm. E^3 analysis codes can be broadly categorized into three major areas: (1) computational EM codes, (2) system simulation codes, and (3) circuit simulation codes. Computational EM codes are used to compute the fields radiated from a driven structure; to calculate the currents induced on a structure when illuminated by an incident field; to compute the fields scattered from an illuminated structure; to compute the fields coupled through an aperture in the surface of an illuminated structure; and/or combinations of the above. System simulation codes can be used to calculate the response of systems to complex EMEs. System codes may address either intersystem interactions, intrasystem interactions, or both. E^3 analyses and predictions are concerned with both types of interactions. Circuit simulation codes are used to perform detailed analyses of the responses of electronic circuits to both desired and undesired inputs. These codes incorporate linear and nonlinear component models in an analysis.

I.3.1 Computational electromagnetic codes. There are computational EM codes that can calculate approximations for the electromagnetic fields about, and coupling to, structures in both the frequency and time domains. Frequency domain models are usually separated into two groups. One is low frequency where the structure under analysis is not greater than a few wavelengths in maximum dimension. The other is high frequency where the structure is large compared to the wavelength. There are also hybrid codes which can connect both the low frequency and high frequency groups to provide an overall frequency coverage approximation. Time domain methods are also available for finding the electromagnetic response of a system. With Fourier Transforms, frequency domain models can often be used to solve many time domain problems and vice versa.

I.3.1.1 Fundamental codes. The fundamental types of computational EM codes are wire (method of moments, - MOM) codes, scattering (geometrical theory of diffraction - GTD) codes, and finite difference (FD) codes. The MOM technique uses either the electric-field or the magnetic-field integral equation (EFIE or MFIE, respectively) solution to Maxwell's equations, converts the EFIE or MFIE to a matrix equation using numerical analysis techniques, and solves the matrix equation using numerical analysis techniques. Wire codes are restricted to electrically small structures (i.e., relatively low frequency interactions) since extremely large matrices are generated for structures exceeding a few wavelengths and the computer time and storage requirements become prohibitive. Scattering codes, on the other hand, solve the integral form of Maxwell's equations in the high frequency limit. The lower frequency limit for scattering codes is limited by the spacing between the scattering centers of the principal objects which comprise the model. The minimum spacing between scattering centers is typically required to be at least one wavelength resulting in a lower frequency limit of approximately 100 MHZ. FD codes solve the differential form of Maxwell's time-dependent curl equations using a volumetric zoning scheme. This technique allows an easy method for incorporating regions of complex material properties (permittivity and permeabilty) and can be applied to analyses of both 2- and 3-dimensional structures in the time domain.

I.3.2 Wire codes. The Numerical Electromagnetic Code - Method of Moments (NEC-MOM) is a computer code for analyzing the electromagnetic response of an arbitrary structure consisting of wires and surfaces in free space or over a ground plane. The code NEC-2 is the latest in a series of codes, each of which was built upon the previous one. The NEC-MOM EM code provides:

- The ability to compute scattering by arbitrary thin-wire configurations.
- The capability to model structures over a ground plane.
- A surface modeling option.
- A simplified approximation for large interaction distances.
- The use of the Numerical Green's Function for partitioned-matrix solutions.
- A treatment for lossy grounds which is accurate for antennas very close to the ground.
- An option to compute the maximum coupling between antennas.

I.3.2.1 <u>NEC-MOM code</u>. The NEC-MOM code contains an integral equation solution (MFIE) specialized for smooth surfaces with one (EFIE) specialized for thin-wire structures to provide convenient and accurate modeling of a wide range of structures. The integral equation approach is best suited to electrically small structures (i.e., dimensions up to several wavelengths). Although there is no theoretical size limit, the numerical solution requires a matrix equation of increasing order as the electrical size of the structure is increased. Hence, modeling structures with dimensions exceeding several wavelengths may require more computer time and file storage capability than is practical. In such cases, standard high frequency approximations such as geometrical or physical optics, or GTD techniques are more suitable than the integral equation methods used in NEC-MOM.

I.3.2.2 <u>NEC-M0M models</u>. A model for NEC-MOM may include nonradiating networks and transmission lines connecting parts of the structure, perfect or imperfect conductors, and lumped-element loading. A structure may also be modeled over a ground plan that may be either a perfect or imperfect conductor. The excitation may be either voltage sources on the structure or an incident plane wave of linear or elliptic polarization. The output may include currents and charges, near electric or magnetic fields, and radiated fields. Thus, the code may be used for antenna analysis, RF/EMP/lightning coupling analysis, or scattering studies.

I.3.2.3 <u>NEC-M0M summary</u>. NEC-MOM is a useful tool for performing antenna, coupling, or scattering analyses. NEC-MOM is most appropriate for use during validation and demonstration when sufficient data becomes available to generate accurate and detailed system models. Because NEC-MOM is a method-of-moments code, the program is typically limited to VHF frequencies and below.

I.3.3 <u>Scattering codes</u>. The Numerical Electromagnetic Code - Basic Scattering Code (NEC-BSC) is a user-oriented computer program which can be used to perform EM coupling and scattering analyses at UHF frequencies and above. Examples of analysis problems which NEC-BSC addresses include near and far zone pattern calculations of antennas in the presence of scattering structures, coupling predictions between antennas in the presence of scatterers, and radiation hazard predictions.

I.3.3.1 NEC-BSC. The analysis techniques used in NEC-BSC are based on uniform asymptotic techniques formulated in terms of the GTD. In NEC-BSC (Version 2), complicated structures can be simulated using perfectly conducting finite elliptic cylinders or using arbitrarily oriented flat plates that can be perfectly conducting or dielectric. Any object that can be modeled with a reasonable number of flat plates and elliptic cylinders of sufficient electrical size is a candidate for analysis. In NEC-BSC (Version 3), perfectly conducting finite elliptic cylinders, elliptic cone frustrum sections and finite composite ellipsoids can also be used to model the structure. In some instances, it is not necessary to build a complete model of the scatterer. In the case of a narrow beam antenna, only the part of the object that lies near the main beam needs to be modeled in detail. The rest of the object can be only roughly modeled or left out completely which results in a savings of the execution time while allowing a detailed structure to exist near the significant scattering centers.

I.3.3.2 NEC-BSC models. NEC-BSC, which is essentially a GTD code, is generally useful at UHF frequencies and above. Each plate in the model should have edges at least a wavelength long. If a dielectric slab is present, the source should be at least a wavelength from the surface and the incidence angle should not be too close to grazing. Each antenna element should also be at least a wavelength from all edges. The number of plates and cylinders that can be used in a model is limited only by the size that arrays can be dimensioned on the computer. The orientations of the plates and cylinders are arbitrary; however, second order interactions can only be used for parallel cylinders and for a pattern cut in a plane perpendicular to the axis of the cylinder. The input section of the code is based on a command system which is designed to make the definition of a given problem convenient. The commands are grouped into four broad classifications: (1) geometry definition commands; (2) pattern control commands; (3) program control commands; and (4) output commands. The geometry definition commands form the largest group, with subgroups that define units, coordinate definitions, structure definitions for plates, ground planes and cylinders, and antenna information for sources and receivers. The pattern control commands allow the user to choose fixed or swept frequency, type of pattern cut (near or far zone), and bistatic scatter options. The program control commands define when to execute the given data set, when to initialize a new data set, when to end the program, and special considerations such as limiting the number of scattering mechanisms operating at any one time. The output commands control the type of output generated.

Normalization values are defined in the output commands which determine whether the output represents directive gain, power gain, absolute antenna coupling values, or radar cross section.

I.3.3.3 NEC-BSC summary. NEC-BSC is a useful tool for analyzing electromagnetic radiation, scattering, and coupling problems. NEC-BSC is most appropriate for use during validation and demonstration when sufficient information becomes available to generate accurate and detailed system models as required to perform meaningful E^3 analyses. Because NEC-BSC is a GTD code, the program is typically limited to UHF frequencies and above.

I.3.4 Finite difference codes. Finite Difference Time Domain (FDTD) techniques provide a direct solution to Maxwell's time-dependent curl equations by treating the illumination of a structure (containing conductors and dielectrics) as an initial boundary value problem. At t = 0, a plane wave source is assumed to be turned on. The propagation of waves from this source is simulated by solving a finite difference analog of the time-dependent Maxwell's equations on a lattice of cells, including the structure. By time stepping, i.e., repeatedly implementing a finite difference analog of the curl equations at each cell of the corresponding space lattice, the incident wave is tracked as it first propagates to the structure and then interacts with it via surface current excitation, diffusion, penetration, and diffraction. Time stepping is continued until the desired late-time or sinusoidal steady state behavior is achieved at each lattice cell. The field envelope, or maximum absolute value, during the final half-wave cycle of time-stepping is taken as the magnitude of the phasor of the steady-state field at each cell.

I.3.4.1 FDTD. The FDTD technique has two key advantages relative to other available modeling approaches. First, it is simple to implement for complicated metal/dielectric structures because arbitrary electrical parameters can be assigned to each lattice cell. Second, the computer memory and running time requirements for FDTD techniques are not prohibitive for many complex structures of interest. With FDTD techniques, the required computer storage and running time increases linearly with N, the total number of unknown field components. Computer techniques which require the solution of simultaneous equations, such as MOM techniques, usually have a storage requirement proportional to N and running time proportional to N^2 or N^3. Also, since all FDTD operations are explicit and can be performed in parallel, rapid array-processing techniques can be readily applied which enable 10^5 to 10^6 field components to be solved in a single FDTD problem, as opposed to about 10^3 field components for conventional approaches using simultaneous equation solutions.

I.3.4.2 <u>FDTD models</u>. A large number of FDTD computer codes have been developed. Some of the more documented codes include THREDE, G3DXL3, FDTD3D, GFDTD, ARGUS and STARBOX.

a. THREDE is a 3-dimensional FDTD code developed primarily for solving EMP propagation, coupling, and scattering problems. The incident field may either be propagating in the form of plane waves or spherical harmonics, or may be locally generated by a gamma flux. THREDE can also treat surface-current injection testing by imposing the incident field only at the injection cells. A nonideal ground plane may be located arbitrary close to the scatterer, which may also have arbitrary parameters. One version of THREDE is a total-field code which can treat problems including nonlinear phenomena such as field-dependent air conductivity. A second version of THREDE is a scattered-field code in which only the scattered field is solved by the finite-difference algorithm.

b. G3DXL3 (Generalized 3-Dimensional eXpandable Lawrence Livermore Laboratory) is a lineal descendent of THREDE, augmented with an expansion technique and the ability to handle lossy dielectrics. G3DXL3 uses a first-order absorbing boundary condition, optimization techniques, and a different indexing scheme to achieve a 50% improvement in operating speed. G3DXL3 has been experimentally validated using a cylindrical cavity with variable size apertures.

c. FDTD3D is a 3-dimensional finite difference time domain code for closed surfaces. The code is primarily used for cavity coupling and scattering analyses. FDTD3D allows for the modeling of volume and surface impedance and can handle Dirichlet, Neumann, impedance, and radiation boundary conditions. The code uses a finite difference solution with pulse basis functions and the total field quantity is used for the formulation. Curved surfaces are modeled by linear approximations.

d. GFDTD is an FDTD code similar to FDTD3D but with considerably less capacity. GFDTD is also used for cavity coupling and scattering analyses. The code uses a finite difference algorithm with separate field quantities.

e. ARGUS is a 3-dimensional FDTD code used principally for plasma, cavity, and scattering analyses. The code has an automatic mesh generation capability. ARGUS uses finite difference and particle-in-cell (proprietary) methods and must be run on a Cray-class computer for efficient execution.

f. STARBOX is a 3-dimensional Maxwell's equation solver with the capability of treating complex geometries, shadowing effects, varying surface emissivities, and arbitrary illumination angles. The code also treats arbitrary cable configurations within cavities. STARBOX uses an equi-grid, time centered, space centered algorithm that incorporates a Meeking routine to define internal structures.

I.3.5 Hybrid codes. The General Electromagnetic Model for the Analysis of Complex Systems (GEMACS) is a program that can be applied to the investigation of almost any electromagnetic phenomenon associated with radiating or scattering systems. GEMACS is a practical tool that can be applied to major systems during design, development, and production to investigate and compute antenna parameters, radar cross sections, field coupling, etc. in the frequency domain. Version 4.0 of the code incorporates three different solution techniques: (1) MOM; GTD; and FD. The MOM, GTD, and FD formulations in GEMACS can be utilized separately or combined to solve a wide class of problems efficiently and accurately. The MOM formulation can be applied to structures that are small in terms of a wavelength; the GTD formulation can be applied to structures that are large in terms of a wavelength; and the FD formulation can be applied to field solutions internal to a cavity.

I.3.5.1 GEMACS. In order to perform a complete analysis of a system, all regions of the system must be considered (i.e., exterior surfaces, apertures, and interior cavities). The built-in hybridization capability of GEMACS can analyze the complete system in all regions of interest. This hybridization process is totally invisible to the analyst once the types of interactions and the output data of interest have been defined. The use, coupling, and interactions of the various modules, as well as the transfer of data among the modules in the proper dimensions, are automatically handled by GEMACS.

a. The MOM formulation in GEMACS was originally derived from the Antenna Modeling Program (AMP). The primary differences are in the geometry and excitation processes and in the use of the Banded Matrix Iteration technique. The MOM technique is based on a numerical solution of Maxwell's integral equations. Two integral equation forms are widely used: (1) EFIE and (2) MFIE. The EFIE expresses surface currents in terms of Green's function and incident electric fields. The EFIE is well suited to one dimensional geometries such as thin wires or geometries which are composed of thin wires. The MFIE expresses surface currents in terms of the derivative of a Green's function and the incident magnetic fields. The MFIE is well suited for smooth, closed surface geometries which are composed of surface patches. Up to 20,000 wire segments and patches can be used. However, a typical analysis of a structure with a few hundred segments at a single frequency requires on the order of one hour of computer time. An MOM analysis of the same structure at 10 frequencies would require approximately 10 hours of computer time. Thus, the actual limit is typically dictated by computer resources. To analyze a structure the size of a fighter aircraft with 700 segments in a reasonable amount of computer time, the upper frequency is limited to approximately 60 MHZ. If only part of the aircraft structure is modeled, the upper frequency limit can be extended.

b. Many of the GTD formulations in GEMACS were derived from the BSC developed by the Ohio State University in 1979. The BSC was extended in GEMACS so that reflected and diffracted fields in the near zone of a structure could be computed. The GTD technique is based on an extension of geometrical optics. Geometrical optics by itself fails near surface discontinuities (e.g., plate edges). GTD corrects the scattered field by the amount geometrical optics is in error by defining additional scattering centers at points on surface discontinuities. The field diffracted from these edges is related to the incident field by a diffraction coefficient. The GTD models must be constructed within the limits of one cylinder, two end caps, and 14 plates which may have at most six corners. GTD, like geometrical optics, is a high frequency asymptotic technique and solution accuracy degrades as the wavelength increases. Thus the plates used in the model should be at least one wavelength long and the antenna elements should be at least one wavelength from all edges. If the smallest edge length on the structure is two feet, the GTD model would be useful down to approximately 500 MHZ.

c. The FD formulation in GEMACS is a direct solution of Maxwell's equation which divides the structure being analyzed into unit cells to create a lattice representation of the structure and its interior volume. The interactions between these unit cells are then solved using numerical solutions. The unique feature of the FD method is its ability to model the propagation of an electromagnetic wave in a volume of space containing a dielectric or conducting structure. GEMACS hybridizes an FD algorithm with the MOM and GTD formulations in the frequency domain to solve both the interior and exterior problems, coupling them by finite difference models of connecting apertures. The apertures themselves are treated as interior cavities such that every geometry is represented by at least three regions: the exterior, the aperture, and the interior. All regions are solved simultaneously so that all interactions are properly considered in relationship to each other.

I.3.5.2 <u>GEMACS summary</u>. GEMACS is a powerful and versatile tool for analyzing electromagnetic radiation, scattering, and coupling problems. GEMACS is most appropriate for use during validation when sufficient information becomes available to model structures and conductors as necessary to preform meaningful E^3 analyses. Because GEMACS combines MOM, GTD, and FD techniques into a single hybrid analysis tool, the program is applicable to a wide variety of system E^3 analysis problems and may be used over an extremely broad frequency range.

I.4 <u>System simulation codes</u>. The Intrasystem Electromagnetic Compatibility Analysis Program (IEMCAP) can estimate electromagnetic compatibility margins for platform located systems. IEMCAP utilizes a data file describing the basic platform geometry, system complement (and associated antenna, power, frequency and rejection characteristics) and calculates the extent to which systems may interfere with each other as a function of frequency. The program uses simplified coupling techniques from the general theory of diffraction to obtain bounded limits to the expected coupling of electromagnetic signals between systems. The system descriptors are then used to calculate how the coupled signals effect the desired system response. In general, absolute accuracy is sacrificed for computational speed, allowing various "what if" scenarios to be performed in a short amount of time.

I.5 Circuit simulation codes. Electronic circuit simulation has been possible since the late 1960's when the Berkeley Simulation Program with Integrated Circuit Emphasis (SPICE) software was developed. Since then, SPICE has evolved to include high speed logic and microwave circuit modeling. Circuit simulators are available that can simulate most circuit topologies (digital and analog).

I.5.1 System simulators. Other codes are available which can simulate system block diagrams. Since these codes are relatively new to the engineering software market, their capabilities and availability are changing rapidly. Simulators for radio frequency and microwave block system simulators provide an assortment of similar capabilities such as:

a. Analyze System Performance for:

- Gain and Phase.
- Group Delay.
- Impedance Match.
- Dynamic Range.
- Signal to Noise Ratio.
- Non-Linear Characteristics.

b. Analyze System Intermodulation Characteristics.

c. System Power versus Frequency.

d. Communications Link Noise Budget.

e. Circuit Optimization.

System simulators require a data file description of the system block diagram. This data file may use "canned" models of each block or models developed for other circuit simulation tools that are compatible with the system simulator.

J. EMC DATA

J.1 General. The significance and applicability of using E^3 analysis tools such as modeling is dependent upon the detail and accuracy of the available data. The data available to support E^3 analyses varies greatly across the lifetime of an item. Early in the Concept Exploration Phase, information available to an analyst is primarily found in statements pertaining to the functional goals and mission objectives of an item and may be supplemented with additional information based on an analyst's experience with similar systems and equipment. As an item's acquisition advances through the phases of its life cycle, specific platform geometry, equipment EM characteristics, antenna placements, cable layout, etc. are more accurately defined and thus the ability to perform detailed analyses grows as the item matures.

J.2 Types of data. Accurate data describing the EM characteristics of all devices, equipment, subsystems, and systems and the probable EMEs in which they are intended to operate are required when conducting detailed E^3 analysis. The information required to perform various E^3 analysis can be categorized into the following seven (7) groups:

J.2.1 Platform inventory data. Platform inventory and configuration data for aircraft, ships, subsurface ships and vehicles are contained in this category. Platform inventory information is required for both currently installed equipment and equipment planned for future deployment/installation.

J.2.2 Equipment characteristics data. This includes radio frequency (RF) parametric data containing technical characteristics for transmitters, receivers, and antennas for equipment identified in the Platform Inventory databases. The level of detail of this data varies depending on it’s intended use. Design engineers require detailed data while operational personnel may only be interested in general data.

J.2.3 Frequency assignment data. Frequency assignment data includes information on the authorization of specific users to use discrete frequencies or bands of frequencies for specific purposes with specific equipment. The required data includes both Government and non-Government frequency assignment information. A large portion of this data is already resident at the Joint Spectrum Center (JSC).

J.2.4 Equipment employment data. This information includes the procedures and methods by which the equipment is used. This is operational doctrine and employment information regarding actual usages. Some of this data is contained in the Electronic Order of Battle (EOB) information.

J.2.5 Topographic data. Topographic data includes both geopolitical boundary data and digitized terrain information.

J.2.6 EMI problem/resolution history data. EMI problem data includes a description of the E^3 problem, how the problem was resolved (when applicable), affected platforms, and the status of the fixes for each affected platform. Sources for obtaining data on E^3 problems include:

a. The Joint Spectrum Interference Resolution (JSIR) Program.

b. The Shipboard Electromagnetic Compatibility Improvement Program (SEMCIP) Technical Assistance Network (STAN).

c. The SEMCIP Management Information Tracking System (SMITS).

d. The Air Systems EMI Corrective Action Program (ASEMICAP) Management Information and Tracking System (AMITS).

J.2.7 Test results data. This data includes the results from various equipment EMI/EMC tests and measurements that were conducted in accordance with specified EMC/EMI standards.

J.3 Databases. DoD components conducting E^3 analysis may request data from the JSC. The JSC maintains extensive database resources to support DoD E^3 analyses. These database resources include the following:

J.3.1 Background environmental database. This database contains automated and nonautomated records of the electromagnetic environment of military and registered civilian communication-electronics (C-E) operations worldwide. The environmental file includes data from:

- Allied Radio Frequency Agency.
- Canadian Department of Transportation.
- Department of Defense.

- Defense Mapping Agency.
- Federal Communications Commission.
- National Academy of Sciences.
- National Telecommunications and Information Administration.
- International Telecommunication Union.
- North American Aerospace Defense Command.
- Satellite and Microwave Engineering Link Data Sources.

J.3.2 Equipment characteristics database. The equipment characteristics database contains more than 80,000 records of basic technical characteristics of military and commercial C-E systems. These data records have been created from a variety of sources such as technical orders and manuals; manufactures brochures; and frequency allocation, commercial, and measurement documentation. Extensive data are available for most DoD systems. Technical data for foreign equipment are also available.

J.3.3 Frequency resource record systems database. The Frequency Resource Record System (FRRS) database contains more than 180,000 DoD frequency-assignment records. Each record includes administrative and technical data such as the type of assignment, the assigned frequency, organizational information, and the equipment locations.

J.3.3.1 FRRS data. FRRS data are provided by DoD components to support worldwide frequency-management activities, Joint Chiefs of Staff (JCS) contingency requirements, and EMC analysis requirements to the extent that the data are applicable.

J.3.4 Tactical database. The Tactical Database (TACDB) contains data on C-E configurations of military units and platforms such as aircraft, ships, and tanks and commercial aircraft and ships. In addition, the TACDB contains data on representative C-E deployments (e.g., locations and use of C-E equipment) based on currently approved military scenarios.

J.3.5 Space systems database. The JSC Space Systems database contains C-E characteristics of radio frequency equipment associated with space systems which are extracted from satellite launch notifications, NASA, and other government agency publications. In addition, this database contains parameters for orbiting spacecraft. These parameters are provided by the US Space Command; whereas, parameters for future spacecraft, which reflect the projected orbit, are extracted from technical documents such as the International Frequency Registration Board (IFRB) notifications and entered into the database. The JSC also maintains a hard-copy file of orbital parameters that contains data from numerous sources.

J.3.6 Electro-optical systems database. In support of the Air Force Electronic Warfare Center (AFEWC), the JSC compiles both US and friendly country electro-optical (E-O) system characteristics in the Electronic Warfare Integrated Reprogramming (EWIR) format. This database forms the E-O portion of the US Non-Communications systems database established by the Joint Chiefs of Staff.

J.3.7 Topographic database. This JSC database contains digitized terrain-elevation data, obtained from the Defense Mapping Agency, for approximately half of the earth's land surface. Current coverage includes all of CONUS, Europe, the Middle East, Asia and portions of Canada, Africa, and South America.

J.4 Equipment data elements. Data needed for assessing the electromagnetic compatibility of communication, radar, and EW/SIGINT equipment includes the following:

J.4.1 Transmitter information.

- Transmitter power.
- Modulation type and techniques.
- Emission bandwidths (3,20,60 db).
- Harmonics/levels.
- Intermodulation products/levels.
- Spurious emission/levels.
- Noise pedestal/broadband noise.
- Pulse rate, width, rise and fall time, compression ratio.

J.4.2 Receiver information.

- RF bandwidths (3,20,60 db).
- IF bandwidths (1st, 2nd, 3rd).
- Filters (3,20,60 db).
- Sensitivity.
- Dynamic range.
  - Processor gain/jamming ratio.
- Susceptibility.
  - Cable/case penetration.
  - Front end burnout level.
- Noise figure.
- Local oscillator frequency.
- Degradation threshold criteria.
  - Signal to interference ratio.
  - Interference to noise ratio.
  - Synchronization threshold.
  - Articulation Index (AI).
  - BIT Error Rate (ER).
  - Residual error rate.
  - Constant False Alarm Rate (CFAR).
  - Gain compression.

J.4.3 Antenna information.

- Effective radiated power.
- Antenna type (parabolic, phased array, etc.).
- Antenna height.
- Main beam gain.
- Average sidelobe/backlobe gain.
- Horizontal/vertical beam width.
- Angular coverage.
- Sector scan rate.
- Polarization (Horiz/vert/circular).

J.5 JSC home page. Information on JSC operations and capabilities can be obtained from their Home Page, www.jsc.mil.