CHAPTER 2

SYSTEM CONSIDERATIONS

2.1 SYSTEM VIEWPOINT

Although many specifications and standards exist which may be applied against individual electronic equipments for the purpose of interference control, these documents do not necessarily insure electromagnetic compatibility when a multiplicity of equipments are located in a common electromagnetic environment. Many cases have been recorded where a well-designed piece of equipment failed to perform its intended function because of electromagnetic incompatibility with another equipment at the intended location. A classic example is the case of the prime contractor who developed, at great expense to himself, a very sensitive, high-frequency communications receiver for a missile system. Special tubes had been developed, waveguides and antennas had been designed, and packaging configurations were complete. Unfortunately, this system was to be collocated with a doppler navigation radar working at exactly the same frequency. Design changes necessitated by a shift in frequency proved to be an expensive lesson. The application of interference control measures to individual equipment, without regard for those measures already applied at interfacing equipment, can also result in redundancy, with associated increased cost, weight, and design time.

The system design approach avoids these problems because system design for EMC/RADHAZ means approaching the problem at the very beginning of project activity, wherein a detailed functional design study is made of the overall system, its constituent subsystems and equipments, and the intended operational environment. At that time, the EMC/RADHAZ problem is defined, possible contributory factors are analyzed, and necessary goals are established. In general, the four desired goals in the achievement of optimum compatibility are:

o Minimization of electromagnetic emissions which may affect other equipment (effects of the system upon external elements - inter-system).

o Minimization of susceptibility to emissions (e.g., effects of external elements upon the system - inter-system).

o Minimization of emissions and susceptibility between equipments within a system (internal effects - intra-system).

o Elimination of potential radiation hazards to both personnel and materiel.

System designs also mean that EMC must be integrated into all project activities throughout the project life to assure the accomplishment of these goals from a preventive-measures approach rather than the use of inefficient, costly, after-the-fact remedies.

The implementation of EMC/RADHAZ, therefore, calls for the establishment, by both government and industry management, of a formal program having well-defined objectives and controls. Such a program is discussed in the following paragraphs.

2.2 EMC/RADHAZ PROGRAM OBJECTIVES

EMC programs and their objectives have been described in detail in the literature. A summary of the salient features follows.

The establishment of an EMC/RADHAZ program within the framework of an overall project must include a clear statement of the objectives of such a program. In general, a formal program will have the following objectives:

o Gathering of information and data, including spectrum signature measurement data on the equipment or system and on the intended operational electromagnetic environment.

o Selection, interpretation and application of EMC/RADHAZ specifications and standards, engineering methods, and testing procedures which may be applied toward the selection or design of equipments.

o Selection and application of methods of prediction of both interference and radiation hazards in the intended environment, based on information gathered.

o Dissemination of gathered information to all personnel concerned with the planning, design, or installation of the equipment or system.

o Generation of an EMC/RADHAZ program plan when required, which states the specific practices, procedures, design criteria, etc., to be used (and to be avoided) to achieve EMC/RADHAZ throughout all phases of a program. Details of such a plan are presented in Appendix A.

o Establishment of an EMC/RADHAZ educational program.

A well-conceived and executed EMC/RADHAZ program will preclude difficult after-the-fact field fixes or crises which may arise at the installation and checkout phases and which, while costly in terms of time and dollars, usually are not amenable to satisfactory solution. Cases have been recorded where entire systems had to be redesigned to meet the mission requirements. Since the EMC/RADHAZ program forms one facet of an overall project, the EMC/RADHAZ program plan will be integrated with and become a part of the main project plan, the Base Electronics System Engineering Plan (BESEP). The general requirements of the BESEP for systems compatibility and radiation hazards, as outlined in NAVELEXINST 11000 series, will thus be met.

2.3 EMC/RADHAZ FUNCTIONS

The EMC/RADHAZ program plan is the heart of the program and establishes the philosphy for the project. From it comes the detailed documentation for electromagnetic interference control, grounding, bonding, shielding, wiring and cable routing, suppression and filtering, and criteria for protection from EMR hazards. In addition, the plan outlines the approach to meet the EMC/RADHAZ requirements and the test program required to meet specified limits. The program plan is a dynamic document, changing as information from the EMC reviews is fed back, and as it receives updated information from the prediction function.

2.3.1 Input Functions

a. Environmental Data and Siting Criteria. The electromagnetic environment in which the equipments are to function should be defined by the field activity in order to achieve a realistic EMC/RADHAZ program plan. Attention should be paid to:

(1) Site survey for determination of ambient levels.

(2) Collocated systems/equipments.

(3) Possible sources of interference, such as power lines and industrial activity.

(4) Site layouts.

b. Specifications and Standards. Documents which may have been selected and incorporated for the specific system/equipments provided for installation include: MIL-STD-461 and MIL-STD-469 for equipments, MIL-E-6051 for systems, and other applicable documents. These are discussed further in Chapter 3.

c. Preliminary Design and Prediction Data. Preliminary design includes the gathering of technical data for planning purposes, defining of the overall system performance characteristics, including selection frequencies and waveshapes, and analysis of interference and RADHAZ possibilities, both within the system and contributed to the external environment by the system (Prediction Process). Technical data may be acquired from:

(1) Technical manuals

(2) Technical orders

(3) Handbooks and other publications

(4) Reports to military agencies for similar or identical equipments used in other systems

(5) ECAC

(6) Equipment qualification reports.

Information acquired or produced from gathered data should include:

(1) Co-channel and adjacent channel interference

(2) Harmonics

(3) Spurious radiation

(4) Equipment susceptibility

(5) Transients

(6) Circuit impedances and coupling

(7) Frequency responses

(8) Propagation data

(9) Potentially hazardous areas or conditions.

2.3.2 Test Plans

A test plan should be prepared to outline those tests required to demonstrate system compatibility and the presence of potential RADHAZ. It is a written plan which may include equipment tests, subsystem tests, and finally, tests at the system level. Techniques and measuring equipment to be employed may be based upon the pertinent military standards described in Chapter 3.

2.3.3 Engineering Functions

a. System Concepts.

b. Selection and interpretation of specifications and the gathering of technical data.

c. Analysis, prediction, and modelling.

d. Equipment considerations.

e. Equipment and system testing.

f. Packaging, bonding, grounding, shielding, and supression techniques.

2.3.4 Installation Functions

a. Location and orientation of equipments.

b. Equipment interfacing.

c. Cable routing, ground connections, bonding, and shielding implementation.

d. Equipment configuration (e.g., consoles, panels, etc.).

2.3.5 Hazards Functions

a. Prediction of potential hazards to personnel and materiel.

b. Site measurements of antenna patterns, power densities.

c. Implementation of protective measures as required, e.g., installation of radar fences, warning signs, interlocks, etc.

2.4 SUMMARY OF EMC/RADHAZ CONTROLS

In order to achieve the objective of compatible, hazard-free operation of equipment within an overall project program, controls must be applied at each of the major functional activities.

2.4.1 Management Controls

a. Establishment of a group or individuals responsible for EMC/RADHAZ program within the project team.

b. Preparation of formal program plan.

c. Designation of applicable documents.

d. Designation of authority in all EMC/RADHAZ matters.

e. Analysis of skills and abilities required for each project phase.

f. Documentation and dissemination of all activities accumulated and generated data.

g. Design and test review, with approvals, at each project phase.

h. Establishment of training programs for the various job categories involved in the project.

i. Integrate data into the ECAC and other data centers to receive, compile, and analyze.

j. Prepare significant summaries of EMC/RADHAZ data, such as EMC/RADHAZ trends, spectrum signatures, and possible troublesome areas.

k. Provide for interchange of pertinent information with government agencies.

2.4.2 Design and Engineering Controls

a. Requirements

(1) Establish system requirements.

(2) Provide information on operational compatibility, mission and time compatibility, and minimum acceptable degradation for the mission, when requested.

(3) Perform spectrum studies to evaluate the validity of frequency assignments and submit recommendations.

(4) Develop alternate methods to perform the same function.

(5) Develop the necessary information studies and guidelines for achieving compatibility and stability.

(6) Perform tradeoff studies.

(7) Translate EMC/RADHAZ requirements into optimum installation.

(8) Prepare installation specifications for contractors.

(9) Prepare lists of equipments to be installed with their equipment characteristics.

(10) Promulgate and maintain environmental criteria on handling, storage, ground operations, and the definitions of environmental test limits.

b. Analyses

(1) Conduct analyses to determine criticality, system identification of potential interference, susceptibility, and hazards.

(2) Analyze operating procedures and instructions to ensure that interference and susceptibility modes are not introduced.

c. Controls for Improvement Studies

(1) Initiate and prepare recommendations for improvement when information indicates the allocated requirements will not be attained.

(2) Conduct improvement studies to predict the compatibility of potential interference, susceptibility modes, and potential hazards.

(3) Provide results of EMC/RADHAZ studies for use in other programs/projects.

2.4.3 Prediction and Testing Controls

a. Observe out-of-tolerance effects of potential emission generators.

b. Provide information that would allow logical test procedures.

c. Formulate an EMC/RADHAZ test plan.

d. Evaluate prototype demonstration tests.

e. Use test results to determine EMC and presence of EMR hazards.

2.4.4 Installation Controls

a. Utilize established siting criteria for equipment installation.

b. Provide rules for grounding, bonding, shielding, cable runs, and equipment mounting and interfacing.

c. Use manuals, technical orders, etc., which fully describe the proper methods and procedures for setting up, checking, adjusting, aligning, calibrating, and operating the equipment.

d. Inspect and approve installation to assure that the desired emission, susceptibility, and hazard modes are not introduced.

2.4.5 Hazard Controls

a. Apply RADHAZ prediction methods.

b. Apply appropriate protective methods for personnel and materiel.

c. Implement medical surveillance program, as required.

d. Conduct measurements of field patterns and power densities at the intended environment.

2.4.6 System Test and Operation Practices and Standards

a. Make available field manuals and technical orders which fully describe the proper methods and procedures for setting up, checking, adjusting, aligning, calibrating, and operating equipment prior to test or operational use.

b. Implement policies and procedures to ensure adherence to prescribed safety measures for the repair and maintenance of equipment.

c. Apply testing procedures to determine equipment/system performance degradation from storage or use.