

# CHAPTER 1

## INTRODUCTION

### 1.1 PURPOSE

This document ( one of a series of Naval Shore Electronics Criteria Handbooks ) contains technical data related to the fields of Electromagnetic Compatibility (EMC) and Radiation Hazards (RADHAZ). The purpose of the handbook is to provide technical guidance to system planners, engineers, and other personnel concerned with the planning, design, and installation of base electronic equipment and systems. Therefore, data and information in this handbook is organized and structured to achieve overall system compatibility by minimizing equipment interplay (cross-coupling), and to provide a RADHAZ-free environment for both personnel and materiel. To accomplish these goals, the handbook contains informative material and general design criteria covering the nature of Electromagnetic Radiation (EMR) and its effects upon biological systems (personnel) and materiel (electronic equipment, fuels, ordnance), interference reduction techniques, measurements and instrumentation, controlling the effects of EMR from a systems viewpoint, prediction and modeling techniques, and methodology for protection of materiel and personnel from radiation hazards. The handbook may be used both in new-site planning and in existing-site expansion efforts for the following purposes:

- o Identify potentially interfering systems and potentially hazardous areas.
- o Establish a control program slanted towards the elimination or minimization of such areas.
- o Implement the control program by means of standardized techniques.
- o Provide safety precautions based on the given criteria in those cases where hazardous areas cannot be eliminated.

### 1.2 IMPORTANCE AND SIGNIFICANCE OF EMC AND RADHAZ

The importance of EMC and RADHAZ becomes apparent when one considers the possible effects of electromagnetic energy upon people and materiel in light of the development and use of unprecedented high radiated power outputs, increase in equipment complexity and siting density, and the critical over-crowding of the electromagnetic frequency spectrum. Some of the known effects include:

- o Total or partial destruction of electronic equipment.
- o Inadvertent fuel explosions.
- o Inadvertent ordnance triggering.
- o Physiological damage to the human body.
- o Degradation of equipment functions.

Thus, it appears appropriate that a uniform, coordinated body of knowledge be applied toward the study and reduction of the effects of electromagnetic energy in its interactions with functional systems and components. In this regard, people may be thought of as biological functional systems, with the RADHAZ problem then considered simply as the incompatibility between radiation-producing equipment and personnel.

### 1.3 BACKGROUND

#### 1.3.1 Electromagnetic Compatibility

Prior to World War II, reports of interference problems were infrequent mainly because of the limited types of equipment in use during that period: radar and communications sets operating at relatively low power outputs and spaced far apart formed the major classes of electronic equipment then in general use.

World War II fathered the technological explosion resulting in more complex radar, sonar, communication systems, navigation, and countermeasures equipment. Increasing transmitter powers and receiver sensitivities brought increasing reports of "radio frequency" (as it was then called) interference at shore activities, including reports of interference from "new" sources such as fluorescent lights, rotating machinery, etc.

The problems created, spurred work during the 1940's aimed at determining the nature of radio frequency interference and achieving "after-the-fact fixes" by trial and error methods.

In the 1950's, studies of a more theoretical nature were undertaken, leading to experimental work on such interference reduction techniques as grounding, shielding, and filtering. New test equipment was developed at an accelerated pace. The interference problem became more acute with the appearance of megawatt systems and the problem of radiation hazards to personnel, ordnance and fuels greatly increased, as well.

The late 1950's and the 1960's brought a new phase, which may be called the beginning of Electromagnetic Compatibility, in which there was an awareness that the problem should be attacked at the planning and design stages of both sites and equipment, rather than after installation of the equipment. Initiation of attempts to predict potential interference and hazard problems during the planning stages began at this time, e.g. the Department of Defense Electromagnetic Compatibility Program, and its focal point, the Electromagnetic Compatibility Analysis Center (ECAC) were established to help coordinate efforts in these areas for the military services. Other groups concerned with EMC were formed, such as the IEEE EMC Group, the Electronic Industries Association, and the Society of Automotive Engineers (SAE) EMC Groups.

Current activity in EMC is centered on the use of modern computer analyses for modelling and prediction, management of the frequency spectrum, and control of electromagnetic radiation and conduction from an overall systems viewpoint.

#### 1.3.2 RADHAZ

The radiation hazards problem has gone hand-in-hand with the trend towards higher output power and increasing equipment siting densities. Average radiated power has increased from about ten watts in 1940 to today's megawatt powers.

Early workers in the field of microwaves first noticed the heating effects on people by microwave radiation. Experiments with animals exposed to radiation subsequently demonstrated the insidious effects on tissue; some of the more pronounced effects being the formation of cataracts and testicular deterioration. As a result of these findings, attempts were made by many researchers to determine and establish safe hazard levels.

By 1958 a general agreement was reached establishing a power density level of ten milliwatts per square centimeter as the upper limit for constant exposure to microwave radiation, independent of the radiated wavelength. Further research (and experience) revealed that electromagnetic fields could cause inadvertent detonation of explosive devices, explosion of fuels, and damage to electronic equipment.

To control these hazards, programs were established within the Department of the Navy to define potential hazards, determine the degree of equipment susceptibility, and provide protection criteria and techniques.

Today, a new awareness exists that EMR is a national problem concerning commercial enterprise and the public at large, as well as the Military. This is emphasized by the recent establishment of a new Federal Agency, the Environmental Protection Agency. Of its many responsibilities, one will be to monitor and apply standards to define and control the inadvertent emissions by microwave devices used by the U.S. public.

#### 1.4 DEPARTMENT OF DEFENSE ELECTROMAGNETIC COMPATIBILITY PROGRAM

The DOD Electromagnetic Compatibility Program (EMCP) was established to ensure EMC of all military Communication-Electronic (C-E) equipments, subsystems, and systems from conception and design through acquisition and operational phases. The program is an integrated DOD effort that assigns specific and joint responsibilities to DOD components in each of the program areas of standards and specifications, measurement techniques and instrumentation, education for EMC, data base and analysis capability, design, concepts and doctrines, operational problems, and test and validation capability. DOD DIRECTIVE 3222.3, OPNAVINST 2410.31, NAVMATINST 2410.1, and NAVELEXINST 2410.1 describe the various Navy programs which implement and support the DOD program, state Navy policy, and assign responsibilities for accomplishing the program objectives.

#### 1.5 ELECTROMAGNETIC COMPATIBILITY ANALYSIS CENTER (ECAC)

This joint DOD activity, managed and operated by the Air Force, maintains the data bases and mathematical and computer analysis techniques for investigation of DOD and interservice EMC problems. It provides DOD components convenient and rapid access to the data bases and analysis techniques and assists in intraservice problems. As the DOD focal point of joint analysis for the EMCP, this facility analyzes C-E equipment and equipment under development, or proposed for development, to determine its EMC with other equipments in present and projected environments.

##### 1.5.1 Data Base Files

The data base is a compilation of environmental information regarding both military and non-military fixed and mobile C-E equipments, selected technical characteristics of such equipments, and selected terrain elevation information.

a. Environmental File. This file represents a large part of the data base and contains technical information, operating characteristics, and site information related to government and non-government fixed site C-E equipments. The file is developed from military and non-military field surveys and from data provided by such agencies as the Federal Communications Commission (FCC) and the Interdepartment Radio Advisory Committee (IRAC). It contains the geographical location of the equipment, the operating agency to which it is assigned, operating frequency, operational duty cycle, antenna orientation, carrier modulation characteristics, and items of a similar nature.

b. Equipment Characteristics File. This file contains general technical performance and nominal characteristics data on specific equipments in both the military and non-military inventory. It is compiled by the ECAC from technical manuals, technical orders, test reports, and other sources, and includes such information as transmitter power output, receiver sensitivity, transmitter and receiver modulation and bandwidth capabilities, tuning ranges, etc.

c. Terrain Data File. Effective analysis of certain types of EMC problems requires the availability of digitized topographic data, that is, topographic data in a digital data format for computer accessibility. This information is stored at ECAC on magnetic tapes in the form of rectangular arrays representing elevations recorded at spacings varying from approximately 100 to 3000 feet.

1.5.2 Data Base Services

a. Environmental File Summary Listings. Listings of environmental file data for the Continental United States (CONUS) and Alaska are updated and published approximately once a year. In addition, special listings can be provided for any area where ECAC has data. These can be provided either as computer printouts, on punched cards, or on magnetic tape.

b. Equipment Characteristics Summary Listings. Equipment characteristics listings are published periodically in multiple-volume directories. Listings of such information as military C-E equipment, military electronics (including navigational) equipment, and commercial C-E equipment are available. Magnetic tape copies and punch cards of this file can be provided upon request, on a need-to-know basis.

c. Special Computer Output Listings. In addition to the listings, there are other ways in which the environmental file data may be selected and sorted to provide special listings as to the amount, type, and order of information, and may also contain selectable file information beyond that contained in the standard listings.

1.5.3 Analytical Services

The availability of an extensive data base at ECAC and the development of expertise and specialized analysis techniques enable ECAC to provide a unique service in studying and investigating EMC problems.

a. The Center provides assistance primarily in system-to-environment and environment-to-system compatibility situations, with some capability for intersystem analysis.

NOTE

Intersystem compatibility for this purpose refers to interactions between several systems in a restricted area. System-to-environment and environment-to-system compatibility involves the mutual interactions between all users of the electromagnetic spectrum over large physical areas.

b. The following are examples of analyses provided by ECAC:

- o Development of a list of equipments possibly causing interference to, or experiencing interference from, equipments proposed for development, acquisition, modification, and installation.

- o Guidance to selecting locations for satellite communications system ground station terminals.

- o Evaluations and implications of various advanced system design parameters on operational performance in the system's intended environment.

- o Guidelines for making frequency assignments to various communications and radar mobile/tactical systems, and guidance for interference-free deployment and use.

- o Determination of expected in-band and out-of-band performance characteristics of planned transmitters and receivers.

- o Map overlays showing the power density contours in a geographic area containing one or more transmitters.

- o Map overlays showing the areas in which an airplane cannot be detected by a ground-based radar because of shielding by topographic features.

o Spectrum occupancy displays (computer printouts) showing the number of C-E equipments assigned to specified frequency bands and channel increments. The information is obtained from the ECAC environmental data base.

c. Since each compatibility analysis task has its own special objectives and requirements, it is not practical to specify "Standard" outputs or formats which ECAC would provide as a result of a study. Outputs can range from narrative discussion of interference effects and possible remedial techniques, to tabulations of expected performance levels, to graphs and curves suitable for use in further analysis of the situation.

#### 1.5.4 Procedures for Requesting Summary Listings

Documents such as C-E directories and environmental file listings are available at the National Technical Information Service, Department of Commerce, Springfield, Virginia 22151. Also available are ECAC publications relating to analytical techniques. When requesting these documents, the user will complete DDC Form 55 and send it through the necessary approval channels to ECAC. If approved by CNO (OP-941F/N64), ECAC, as the releasing agency, will certify and return the form to the user who, in turn, must submit the form according to established procedures.

#### 1.5.5 Requests for ECAC Services

Requests for analytical services or data base information as outlined in OPNAVINST 2410.29, should be addressed through military channels to include CNO(OP-941F/N64) in the routing chain to:

Navy Deputy Director ECAC  
North Severn, Annapolis, Maryland 21402

The following information should be included with the request:

- o The agencies and organizations that will use the outputs.
- o An explanation of the information desired with as much detail as possible.
- o An indication of the application for which the information is desired.
- o A complete and clear justification of the need to know, and authority for access to classified information.

