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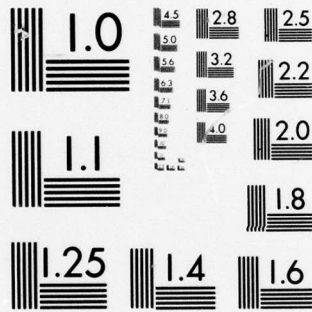
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ENGINEERING AND DEVELOPMENT PROGRAM PLAN - FREQUENCY SPECTRUM MANAGEMENT

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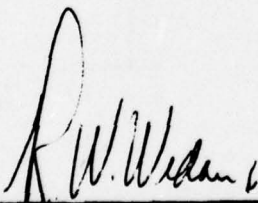
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, D.C. 20590

FOREWORD

This document describes the engineering and development plan for the FAA E&D Program 21 Frequency Spectrum Management Program Element. It provides an overview of the function of the Spectrum Management Staff and the tasks which must be performed to assure adequate electromagnetic spectrum for operation of the National Airspace System. Program objectives, development activities and relationships with other FAA, national and international spectrum management organizations are described.

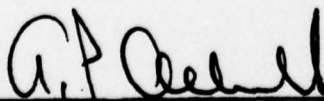
The plan is intended to provide guidance to personnel actively involved in spectrum management. The plan also serves as a basis for estimating and programming the resources required to perform the tasks of spectrum management.

APPROVED:



Director, Systems Research and
Development Service

APPROVED:



Associate Administrator for
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16. Abstract As an element of the 21 Program, Support, this program plan describes spectrum management activities supporting aviation's use of the frequency spectrum. Long range spectrum planning is provided through coordination with national and international organizations. Policy, criteria, and standards are provided to spectrum users to ensure efficient spectrum utilization. Electromagnetic compatibility analyses and representation in national/international forums are provided to ensure the suitability of available spectrum. New measurement and analysis techniques are provided to improve overall spectrum management. The Frequency Spectrum Management element is divided into three subprograms. The Radar/Beacon Spectrum Planning subprogram includes projects for radar, ATCRBS, and DABS. The Communications/Navigation Spectrum Planning subprogram includes projects for navigation, CAS, communications, MLS, and satellites. The Spectrum Applications Engineering subprogram includes projects for RF propagation, spectrum surveillance, spectrum coordination, electromagnetic radiation measurements, and the exercising of specialized models and computer programs developed as functional tools of spectrum management.					
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0.0 EXECUTIVE SUMMARY

0.1 The Issue

The radio frequency spectrum is a highly contested, limited resource and the situation is getting steadily worse. Serious consequences await those agencies/nations which do not maintain an active, progressive program to protect its existing operations and to provide for accommodation of its planned systems. Competition for this vital resource has already reached the point where the Federal Aviation Administration's (FAA) vast communications, navigation, and surveillance systems in use today are threatened by encroachment from other spectrum users. In addition, any plans on the part of the agency to introduce new systems into the National Airspace System (NAS) will confront spectrum availability as a formidable problem.

0.2 Overall Frequency Management Policy and Intentions

It is Government policy to provide the necessary level of support to manage the ever increasing demands upon the finite spectrum resource (this is covered in an October 21, 1975, General Accounting Office report, No LCD-74-122). It is intended that such support prevent or alleviate deficiencies such as those listed below:

- (1) Systems that do not function reliably or accurately due to interference or poor propagation.
- (2) The denial of telecommunications services because of the unavailability of suitable spectrum.
- (3) The inability to protect and advance United States (U.S.) objectives internationally.
- (4) Burdensome regulations resulting from unnecessarily wasteful use of the spectrum.
- (5) A de facto default on the provisions of the Communications Act of 1934 (establishing the FCC to regulate non-government users) and Executive Order 11556 (establishing the Office of Telecommunications Policy to regulate government users)

0.3 Program Objectives

Program Element 213, Spectrum Management, consists of a wide variety of contract and in-house efforts involved in the discharging of the Spectrum Management Staff's overall responsibility. Its general objectives are

- (1) to provide long-range planning of the acquisition and retention of sufficient, suitable radio frequency spectrum to meet the needs of the agency;
- (2) to provide spectrum management policy and technical guidance to all agency elements;

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- (3) To provide spectrum management expertise and electromagnetic compatibility analyses in the national/international forums (where FAA must compete for radio frequency spectrum allocations) to improve overall spectrum management.

0.4 Interfacing Programs/Organizational Support

Interfaces are primarily with supporting organizations such as the National Bureau of Standards (NBS), Institute for Telecommunications Sciences (ITS), and the Electromagnetic Compatibility Analysis Center (ECAC); with the Office of Telecommunications Policy, Department of State, and the Federal Communications Commission; international organizations such as the International Civil Aviation Organization (ICAO) and the International Telecommunications Union (ITU); NAFEC and the Transportation Systems Center and other programs such as program areas 02, 03, 04, 05, 06, 07, 08, 13 and 17.

0.5 Operations Versus Engineering and Development Responsibilities

This Program Plan does not deal with the day-to-day operational frequency management activities (AAF-30 activities) concerning the routine assignment and coordination of radio frequencies (assignments for an individual site; for example, an assignment to support the addition of a new sector in an ARTCC, and notification of military and civil users). This also includes the routine resolution of operational interference problems, and maintenance of the agency's frequency assignment records. This Program Plan covers only those Engineering and Development activities required to meet the objectives outlined in Section 0.3, Program Objectives.

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1.0 INTRODUCTION/BACKGROUND

1.1 Background

The radio frequency spectrum is a highly contested, finite resource which, like other resources, is susceptible to oversubscription. Both national and international regulation is required because of the intense competition for its use. Therefore, it is essential that adequate spectrum support be provided to ensure the protection and assignment of radio frequencies required by various programs, systems, services, and equipment of an experimental, operational, or developmental nature.

1.1.1 General

The FAA is engaged in a wide variety of operations and projects in which the use of radio frequencies is essential. Radio frequency utilization by non-Government entities plays a vital role in all aspects of air, sea, highway, and rail transportation. Moreover, through grants-in-aid, the FAA is supporting a number of projects which require the use of frequencies by non-Government entities and are therefore under cognizance of the FCC. The FAA is, therefore, concerned with both Government and non-Government aspects of radio frequency management. Furthermore, non-Government facilities and users of select aeronautical frequency bands are licensed by the FCC even though the frequencies are engineered by the FAA.

1.1.2 Spectrum Allocations

By international agreement, the usable radio frequency spectrum has been sub-divided into a number of frequency bands. Each of these bands has, in turn, been allocated to (or designated for use by) one or more of the several recognized categories of radio-frequency users, known as radio services. Those of particular interest to the Department of Transportation (DOT) include fixed, mobile, and satellite radio communication and radionavigation services of concern to aeronautical, maritime, and land transportation modes. Within the relatively broad framework of these frequency band allocations to radio services, frequency assignments to specific radio stations (or radio-frequency-using devices) are made by the responsible national spectrum management authorities. In the United States, this responsibility is divided with separate, co-equal authorities being responsible for Government and non-Government frequency management matters.

1.1.3 Communications Act of 1934

The Communications Act of 1934, as amended, provides for the regulation of communications by radio. The Act established the Federal Communications Commission (FCC) and vests in that agency responsibility for the regulation of all radio frequency spectrum utilization by non-Federal Government entities. In recognition of the Constitutional power of the President, the Act provides that radio stations belonging to and operated by the United States "shall use such frequencies as shall be assigned by the President." This provision is now interpreted to include leased radio facilities provided they remain under operational control of a Federal Government agency. The term "radio station" includes all telecommunications (communications-electronics) equipment designed for the purpose of radiating and/or receiving radio-frequency energy; such as radars, radionavigation devices, altimeters, sensors, telemetry, etc.

1.1.4 Executive Order 11556

All functions relating to the assigning of radio frequencies to Federal Government Radio stations conferred upon the President by provisions of the Communications Act of 1934, were transferred to the Director, Office of Telecommunications Policy, Executive Office of the President, by Reorganization Plan No. 1 of 1970. The Plan was implemented by Executive Order 11556, signed by the President on September 4, 1970.

1.1.5 FAA Functions

The radio frequency spectrum is used to support virtually all of the FAA's guidance, communication, and surveillance systems. In order for this agency to meet its statutory obligations and accomplish its mission, the use of the radio frequency spectrum is required. The Spectrum Management Staff, ARD-60 serves as the agency focal point in dealing with the Office of Telecommunications Policy (OTP), Executive Office of the President (EOP) for obtaining spectrum assurance and the certification of system support as required. This is covered in Order 6050.19B, Radio Frequency Spectrum Utilization and Management.

1.2 Policies, Regulation, Technical Standards, and Procedures

1.2.1 OTP Regulations and Procedures

Policies, regulations, and technical standards governing the use of the radio frequency spectrum by Federal Government agencies, and the administrative procedures to be followed in frequency management matters, are promulgated by the Office of Telecommunications Policy (OTP) in the Manual of Regulations and Procedures for Radio Frequency Management (OTP/RP-RFM). The OTP/RP-RFM stipulates:

- (1) Prior authorization by OTP is required for the use of any portion of the radio frequency spectrum by a Government agency, whether for experimental, developmental, or operational purpose.
- (2) Requests from Government agencies for radio frequency assignments, or other frequency management actions, are processed through the Interdepartment Radio Advisory Committee (IRAC). The IRAC has been given responsibility for assisting the OTP in assigning frequencies to Government radio stations and in developing the executive policies, programs, procedures, and technical criteria pertaining to the allocation, management, and use of the radio spectrum.
- (3) The obligation of funds by Government agencies for the development or procurement of telecommunications equipment requiring the assignment and protection of radio frequencies for their use must be withheld pending the assurance of the availability of appropriate radio frequency assignment support by OTP.
- (4) In the case of a Government-funded study by non-Government interests, wherein the use of radio frequencies is foreseen, the Government agency concerned should, as far as practicable, apprise the contractor(s) of the need for ensuring that radio frequency support appears feasible.

1.2.2 Spectrum Support Requirements

OMB Circular No. A-11, governs policy for the funding of procurements which require the use of the spectrum. It states, "Estimates for the development or procurement of major communication-electronics systems (including all systems employing satellite (space) techniques) will be submitted only after certification by the Office of Telecommunications Policy that the space in the radio frequency spectrum required for such systems is available." OTP Circular 11 states that "executive agencies will ensure that no funds are obligated for either development or procurement of communication-electronics system requiring the use of the frequency spectrum until the availability of appropriate spectrum support is assured." This review of telecommunications systems includes all space systems operating throughout the spectrum; and all new, major terrestrial systems, or modifications to such systems, operating above 420 MHz.

1.2.3 Development Cycle Review Points

There are four stages of development for which OTP notification is required:

- (1) Stage 1 - Planning (Conceptual) Stage
- (2) Stage 2 - Experimental Stage
- (3) Stage 3 - Development Stage
- (4) Stage 4 - Procurement Stage

FAA Order 6050.19B should be consulted for detailed processing procedures. DOT Order 5420.1, and DOT Order 5420.2, establish the Department's policy concerning the subject and fix responsibilities within the modal agencies. These responsibilities are vested in the FAA Interdepartment Radio Advisory Committee (IRAC) Representative.

1.2.4 Reviews for Spectrum Availability

Spectrum reviews are necessary for the following reasons:

- (1) New telecommunications systems and major changes (those changes which create potential EMC problems or expand spectrum usage) in the technical characteristics or operational applications of existing systems or subsystems are subject to the procedures prescribed in Chapter 8 of the Office of Telecommunications Policy's "Manual of Regulations and Procedures for Radio Frequency Management." The approval to grant or obligate funds for any agency effort which requires the assignment and/or protection of radio frequencies is dependent upon OTP's determination of appropriate spectrum support. This requirement applies to both contractual and non-contractual efforts involving either government or non-government entities.
- (2) Specification documents, as defined in the current edition of FAA STD-005c, receive consideration and evaluation from a spectrum standpoint when the system, service, or equipment being specified will depend on spectrum support. Revisions, granting of waivers, or alterations of specification documents which impact in any way on the use of the radio spectrum, including the subsequent increase of quantities of goods or services being procured under contract in accordance with an existing specification, requires reexamination from a spectrum standpoint.

- (3) Frequency spectrum availability regarding proposals for new, improved, or expanded systems, services or equipments must be determined prior to submission to management for decision making, whether or not there is a budget implication, if the service, system, or equipment will depend upon spectrum support.

1.2.5 Utilization of Spectrum Reviews

Information concerning the planned use of the spectrum and OTP/EOP spectrum support assurances are maintained by the Spectrum Management Staff of the Systems Research and Development Service (SRDS). Long range plans, technical guidance, electromagnetic compatibility analyses, and new measurement techniques are developed in support of planned spectrum utilization. This information is utilized under the following circumstances:

- (1) When it becomes necessary to provide the information required by the OTP to obtain spectrum support for systems and equipments prior to initiating budgetary actions.
- (2) When necessary to provide rapid response capability for any query made by the OMB or OTP.
- (3) When integrating the planning, programming, funding, and budgeting actions.
- (4) When it becomes necessary to establish compatibility with other Government equipment, systems, or services, existing or planned.

1.3 Program General and Specific Objectives

The general objective of this program is to ensure that the aeronautical services are provided adequate spectrum support. This includes providing assistance to the Department of State, Office of Telecommunications Policy, and the Federal Communications Commission in assuring sufficient protected Radio frequency spectrum for the needs of the FAA and the nation's aviation interests. The program will provide the following specific objectives:

- (1) Long range planning of the acquisition and retention of sufficient radio frequency spectrum to support the aeronautical interests of the nation, at home and abroad, and active support of spectrum standardization for the world's aviation community.

- (2) Research, analysis, engineering, and evaluation in support of the development of spectrum related policy, planning, standards, criteria, measurement equipment, and measurement techniques.
- (3) Electromagnetic compatibility analyses to determine intra/inter-system viability, to define design parameters and to assure certification of adequate spectrum support for present and future requirements of the system.
- (4) Automated frequency selection systems to provide frequency planning, assignment, and analysis capabilities.
- (5) Spectrum management consultation, assistance, and guidance to all aviation interests both national and international.
- (6) More efficient use of the allocated RF spectrum through the minimization of bandwidth requirements, retransmissions due to interference or poor propagation, and increased numbers of channels.
- (7) Spectrum support for existing and planned FAA facilities.
- (8) Protection of aeronautical operations from interference from all other spectrum users.
- (9) Up to date handbooks containing policy, assignment criteria and standards.
- (10) Improved methods of resolving interference problems.

1.4 Program Structure and Interfacing Programs

1.4.1 Program

This program plan covers the Frequency Spectrum Management portion of program area 21, Support. It consists of three subprograms: subprogram 213-061, Radar/Beacon Spectrum Planning; subprogram 213-062, Communications/Navigation Spectrum Planning; and subprogram 213-060, Spectrum Applications Engineering.

1.4.2 Interfacing Programs

The Frequency Spectrum Management program interfaces with other programs such as the Radar, Beacon, Navigation, Airborne Separation Assurance, Communications, Approach and Landing Systems, Airport/Airside, Flight Service Station, and Satellite Programs. This includes projects concerning the performance and electromagnetic compatibility of systems such as ASDE, ATCRBS, DABS, MLS and AEROSAT.

2.0 TECHNICAL APPROACH

2.1 Technical Approach Selected

2.1.1 General

The primary approach contained in this plan concerns the use of in-house effort and contracted effort from various organizations concerned with frequency spectrum management. This includes a number of efforts such as data base maintenance, computer models, software development, development of measurement devices for flight check aircraft, and the formulation of directives. A significant portion of the in-house workload of the Spectrum Management Staff is supplemented by outside (contract) support. An efficient utilization of in-house, NAFEC/TSC, contractor, and interagency facilities is maintained through an appropriate distribution of the required work.

2.1.2 Data Base Maintenance (Example)

The development of various data bases is a clear example of an area where an outside organization rather than in-house capabilities are used. As an example, terrain data is obtained from the Army Map Service as opposed to conducting in-house mapping of terrain around FAA facilities. A similar situation exists with the frequency assignment data base maintained by the Office of Telecommunications of the Department of Commerce.

2.1.3 Alternative Approach to Data Base Maintenance

An alternative approach would be to establish in-house capabilities to maintain data bases and automated systems. This would greatly improve FAA control of these resources, but would be costly both in implementation time and funds. Although the long-range goal should be directed towards becoming more autonomous in these areas, the most cost effective approach at present is to contract for the use of these existing capabilities. In-house efforts are primarily directed towards the management of supporting contracts, essential supporting activities to determine the performance

of equipment operating within the National Airspace System, the coordination of the use of the frequency spectrum, and the generation of necessary directives concerning spectrum management. Any change of in-house capabilities will be accomplished in an evolutionary manner with careful cost versus benefit analysis prior to each decision to expand an existing capability, or add new capabilities.

2.1.4 Approach Selected

The approach selected is to make cost effective use of capabilities available in other government agencies and industry. The services of the Institute for Telecommunications Sciences of the Department of Commerce are used in projects involving the propagation of radio waves, the radio properties of the environment, the characterization of noise and interference, information transmission and antennas. The services of the Electromagnetic Compatibility Analysis Center of the Department of Defense are used in projects involving automated analyses of spectrum utilization, electromagnetic compatibility, site coverage, and the determination of predicted performance levels. Other contractual support is obtained as required. In-house efforts include the development of technical guidance such as handbooks, the management of contractual efforts, and the provision of representation for various national and international organizations.

2.2 Major Tasks

2.2.1 General

The major spectrum management tasks are oriented toward several goals. First, the increased demand placed on available spectrum creates a need to improve efficiency in the use of this resource. Second, suitable spectrum allocations are needed for existing and planned facilities. Third, protection of present aeronautical operations from other spectrum users must be maintained. To reach these goals, the major tasks are distributed among three sub-programs: Spectrum Applications Engineering; Radar/Beacon Spectrum Planning; and Communications/Navigation Spectrum Planning. In general, these tasks provide outputs of the following types:

- (1) Policy, standards, and criteria.
- (2) Handbooks and directives implementing policy, standards, and criteria.
- (3) Propagation and ground conductivity charts.
- (4) Computer programs and services.
- (5) Measurements.

- a) Field measurements - air and ground.
- b) Empirical data reduction.
- c) Frequency assignment criteria validation.

Tasks have been generated in support of numerous activities. The following are typical support activities:

- (1) The resolution of field problems.
- (2) Frequency band analyses in support of spectrum allocations .
- (3) Aircraft accident investigations.
- (4) Proposal evaluation panels.
- (5) Frequency change plans.
- (6) Consultation
 - a) Agency
 - b) Aviation community

An important activity is the issuance of handbooks. The following handbooks are currently under preparation:

- (1) VORTAC/ILS
- (2) Air-Ground Communications
- (3) MLS/ISMLS
- (4) L/MF - Ground Conductivity
- (5) VHF/UHF/Microwave Links
- (6) Radar/ATCRBS/DABS/PRF
- (7) Measurement Techniques/Standards
- (8) Frequency Management Principles - General

2.2.2 Example of Short Term Tasks

Tasks have been initiated in response to specific requirements supporting activities both external and internal to the FAA. These include EMC analysis and testing of the Joint Tactical Information Distribution System (JTIDS), the development of radar threshold criteria, SHF-SATCOM compatibility analysis and testing, preparation for the 1979 General

World Administrative Radio Conference of the ITU, the validation of VOR and ILS separation criteria, and the examination of the effects of cable television and high power TV and FM broadcast stations upon airborne avionics.

2.2.3 Examples of Continuing Tasks

Other tasks are of a continuing nature. These include obtaining spectrum approval for FAA systems under development, the issuance and revision of frequency engineering standards and criteria, providing representation to national and international spectrum management organizations, review of relevant FCC documents such as type acceptance applications for new aeronautical equipment, and the investigation of new spectrum measurement techniques.

2.2.4 Examples of Critical Tasks

A number of time critical and cost associated tasks are involved in attaining the objectives of this program plan. These include the development and refinement of computer models and data bases needed in performing frequency band studies to determine the degree of congestion involved in each band utilized by the FAA, and the associated remedial actions. Another task is the development and refinement of agency handbooks containing geographical separation criteria for use by the operations elements of the FAA in engineering frequency assignments for the various navigation, communications, and surveillance systems employed in the NAS. A third task is the development of timely proposals and suitable technical justifications for changes to the national and international allocation tables that are needed to support the evolutionary growth of the NAS. These allocations are established by organizations such as the International Telecommunications Union of the United Nations. One such effort concerns a General World Administrative Radio Conference (GWARC) scheduled for Geneva in 1979 to review and update regulations concerning the entire radio spectrum. A GWARC is held approximately once each 20 years. A fourth task is the judicious review of the new systems proposed by other spectrum users to determine their impact on FAA operations.

2.2.5 Trend Toward Encroachment

The National and International trend toward sharing of radio frequency bands between different types of services; e.g., aeronautical radionavigation and cable television or satellite services and radars in the same frequency band, is a departure from the old approach of exclusivity for safety services. This new philosophy will require much more rigorous EMC studies and demonstration of efficient use of those portions

of the spectrum available to the aeronautical interests. In this regard, our spectrum is considered a candidate for use by all other services with unsatisfied requirements. Action to avoid adverse encroachment or reallocation actions, national and international, has become critical.

2.2.6 Future Emphasis

The future emphasis will be in the following areas:

- (1) Support to the development divisions
- (2) Present and defend aeronautical spectrum requirements
 - a) before the OTP, including OTP Circular 11/8.3 submissions
 - b) before the FCC
 - c) before international forums
- (3) EMC studies
- (4) Handbooks, criteria, standards, and policy
- (5) Automated frequency selection programs

2.2.7 Spectrum Applications Engineering Subprogram

2.2.7.1 Objectives

The objectives of this subprogram are to continue the development of technical expertise in the highly specialized field of RF propagation; to develop the sophisticated test equipment and measurement procedures needed to more accurately certify facility operation and resolve interference situations in a more timely manner; and to obtain/retain spectrum support for new/existing FAA systems in the OTP/IRAC and ICAO/ITU/CCIR forums. Propagation computer models will be developed/refined for solving a wide variety of day-to-day spectrum management problems (field and Headquarters). Propagation studies will be conducted as required in support of GVARC 1979 preparation. Standardized measurement and test procedures for EMC analyses and spectrum signatures will be developed for use by Regional and Headquarters frequency management personnel. National and International spectrum management forums will be participated in to the extent necessary to satisfy the spectrum needs of the agency.

2.2.7.2 Typical Products

Examples of efforts nearing completion are an RML propagation path study, refinements to an ITS propagation model and the development of an initial remote terminal capability with the Electromagnetic Compatibility Analysis Center. The results of two recent studies of the impact of the earth's magnetic field in the polar regions have been published in report FAA-RD-75-136 entitled "Effects of High Latitude Geophysical Events on VHF Aeronautical Navigation Aids," and report FAA-RD-75-198 entitled "Effects of High Latitude Geophysical Events in the Aeronautical Radio Frequency Bands." In addition, power density surveys will be performed in and around FAA facilities, airport environment and the interior of aircraft in support of OTP's Electromagnetic Radiation Management Advisory Council (ERMAC). ERMAC's goal is the assessment of biological and non-biological hazards of non-ionizing electromagnetic radiation. The National Bureau of Standards is performing the field measurements with emphasis on the techniques and instrumentation necessary for accurate power density surveys.

2.2.7.3 Typical Project (OMEGA and VLF System Studies)

The propagation and spectrum studies relating to OMEGA and VLF navigational systems have been a typical part of the Spectrum Applications Engineering effort. Studies of these systems are contained in report number FAA-74-75, II, Multipath in Air Traffic Control Frequency Bands, Volume II, dated July 1974. The severe problems created by noise, diurnal variations in propagation, impact of weather and solar disturbances, the complexity of processing, errors created by the relatively high velocity of aircraft, mountainous terrain, etc. are addressed in these reports. Should difficulties arise in the future in regard to propagation or the electromagnetic compatibility of VLF and OMEGA systems, studies will be undertaken to resolve such problems.

2.2.8 Radar/Beacon Spectrum Planning Subprogram

2.2.8.1 Objectives

The objectives of this subprogram are to conduct studies and make recommendations for improving the overall electromagnetic compatibility (EMC) of existing and new radar and radar beacon (ATCRBS and DABS) systems; to upgrade the existing capability for predicting ATCRBS performance in a given environment and validate the resultant model; and to develop the capability for predicting DABS performance in a given environment. An EMC analysis has been performed to support the introduction of the ASDE-3 radar into the 15.7 to 16.2 GHz band. Frequency band studies will be conducted as

required to insure continued spectrum support for the agency's ASR and ARSR operations (existing and planned). Specific problems at terminal and enroute ATCRBS sites will be investigated and proposed solutions will be developed utilizing the latest performance prediction models. EMC studies will be performed to support the development of DABS.

2.2.8.2 Typical Products

Some of the outputs from this subprogram include the development of the DABS Performance Prediction Model, an ARSR EMC analysis, an ASDE-3 EMC analysis, a study to determine the impact of DABS upon TACAN/DME, and EMC analysis of ATCRBS/BCAS, and an analysis of select ATCRBS problem sites. An ATCRBS Airborne Antenna model has recently been developed for use in various analyses. The results of a recent study of the impact of DABS upon X and Y mode TACAN have been published in report FAA-RD-75-109 entitled "Interference Potential of the Discrete Address Beacon System (DABS) Provisional Signal Formats on X and Y Mode TACAN Equipment."

2.2.9 Communications/Navigation Spectrum Planning Subprogram

2.2.9.1 Objectives

The objectives of this subprogram are to develop a frequency assignment/station selection model for RNAV routes; to perform computer analyses/studies to support the continued implementation of 25 kHz VHF air/ground frequency assignments; to develop an implementation plan for 25 kHz UHF air/ground frequency assignments; to refine frequency assignment criteria for both communications and navigation facilities; and incorporate the results of these tasks in the appropriate handbooks.

2.2.9.2 Typical Products

A computer model will be developed which takes into consideration existing frequency protected VOR/TACAN/DME service volumes in evaluating proposed RNAV routes. An existing computer model at ECAC will be exercised, as required, in providing "real world" frequency assignment and frequency change guidance to AAF-30 and Regional Frequency Management Offices. A new model has been developed to select UHF assignments in a manner similar to the existing VHF model. Existing propagation prediction models will be exercised considering new hardware characteristics, to provide the basis for refined navigation/communications frequency assignment criteria. Criteria developed for MLS installations will include factors such as collocated DME systems. This will include frequency/distance separation

criteria based upon equipment design factors such as pulse shape and operational factors such as volume size. In addition, a data report has resulted from recent NAFEC testing to determine ILS antenna patterns.

2.3 Support Organizations

2.3.1 NAFEC Support

The primary source of in-house support is NAFEC. NAFEC is involved in projects to develop RML and radar interference threshold criteria, TACAN/DME testing in support of the MLS program, DABS-TACAN/DME EMC measurements, AEROSAT/MLS EMC measurements, Joint Tactical Information Distribution Systems (JTIDS) test support, validation of new NAVAIDS separation criteria, and testing of the effects of high power TV and FM broadcasting upon avionics equipment.

2.3.2 Other Support

Support outside the FAA is obtained primarily through inter-agency agreements with organizations such as the National Bureau of Standards, the Institute for Telecommunications Sciences, and the Electromagnetic Compatibility Analysis Center. Financial support is provided through either Program 21 funding or funding under the specific program area being supported by the associated spectrum analysis project. Operational support such as data base validation and computer model testing is provided through the Airway Facilities Service, the Air Traffic Service, the Flight Standards Service, and regional personnel.

2.4 Critical Technologies for Selected Systems

There are several areas in which critical technologies affect the spectrum assignment process. For example, propagation characteristics, the cost of improving airborne and ground equipment EMC performance, output power limitations associated with solid state devices, size and weight constraints for avionics equipment, and siting effects must all be taken into consideration in developing a viable frequency assignment criteria/plan. These affect the degree of freedom one has in the choice of frequency assignments and spectrum allocations and that in turn increases the problem of spectrum congestion. The critical technologies can be roughly divided into those that affect the ability of a system to provide satisfactory performance in a real world environment and those that permit operation compatible with a large variety of other spectrum users.

Typical examples of critical technological areas are as follows:

- (1) In the area of propagation, the consideration of factors such as ground conductivity and terrain effects is essential for the accurate modeling of propagation characteristics.
- (2) Although it is theoretically possible to create a device capable of measuring the intelligibility of a voice transmission as received, measurement of the many parameters involved requires such an intricate and large amount of processing that no equipment suitable for "live" use has ever been developed. Such a measurement technique would be needed if voice quality standards were to be imposed upon spectrum users.
- (3) Many technologies have been used to alleviate various electromagnetic compatibility problems that occur when quantities of equipment are colocated at a single site. Critical technologies have been encountered in obtaining accurate characterizations of spurious responses and emissions of equipment, and accurate determinations of the levels of coupling between different units.
- (4) Critical technologies in the area of automated frequency assignment techniques have been encountered in the maintenance of accurate, up to date bases, and computer security. In the case of transmitters operating on an intermittent basis, records of the hourly annual utilization are not even available in most cases, and have to be estimated.
- (5) Although accurate low drift crystal controlled oscillators are within the state-of-the-art, a critical technological issue is the poor performance that can result from the large numbers of off-frequency equipment in use.
- (6) When new systems such as MLS or DABS are proposed, a band-sharing problem is created concerning compatible operation with other users of the same spectrum. This problem is particularly severe in the case of satellites since terrain cannot be relied upon for shielding. Antenna directivity and the disparity in the power levels used by different systems have been critical technological problems in this case.
- (7) A critical technological issue in the case of equipment used for spectrum measurement has been miniaturization without the sacrifice of performance so that the necessary instrumentation for a complete and accurate analysis can be carried in a single vehicle.

- (8) Because of the extremely high power levels used by certain ground facilities, it is impractical to design equipment that is not affected when aircraft come within several miles of such facilities. This includes FM broadcast stations affecting the 118-136 MHz aeronautical band, and certain military facilities such as low frequency transmitters interfering with Loran-C reception in aircraft.

2.5 Basis of Comparisons

There are many factors that form a basis for comparing the effectiveness of solutions to a particular spectrum management problem. While not all of these will apply to any given situation, the following is a general list of the factors considered:

- (1) Compatibility on an international basis.
- (2) Impact upon operating/maintenance/system costs, and efficiency in operation and spectrum utilization.
- (3) Time requirements (implementation schedule) and compatibility with planned spectrum utilization.
- (4) Human factors and safety.
- (5) Interference susceptibility:
 - a. man-made and natural noise.
 - b. channel loading.
 - c. spurious emissions and responses.
 - d. propagation anomalies and effects of terrain.
- (6) Impact upon equipment performance.
- (7) Availability (present and future) and suitability of spectrum.

- (8) Legal and political requirements.
- (9) The requirement to account for spectrum usage and to document system operating characteristics.
- (10) The accuracy and utility of measurement and analysis techniques that have been developed.
- (11) Long term viability and the ability to support predicted growth patterns.

3.0 END ITEM PRODUCTS/SCHEDULE

ITEM

Revised VOR/ILS/TACAN/DME Handbook	Sep 78
Radar Interference Threshold Criteria Report (Phase I)	Feb 78
ATCRBS Performance Prediction Model	Jan 78
Report on RML Interference Thresholds	Sep 79
ATCRBS Problem Site EMC Analysis Report	Jan 78
Radar Frequency Engineering/Assignment Technique	Oct 79
Revised Communications Frequency Handbook	Apr 78
Revised Handbook On EMC Measurement Techniques	Jun 78
DABS Performance Prediction Model	Mar 78
25 kHz Air/Ground Implementation Plan (Phase II)	Jul 78
ATCRBS/BCAS EMC Analysis	Nov 78
Revised RML Frequency Engineering Handbook	Feb 79

4.0 FUNDING REQUIREMENTS

FUNDING REQUIREMENTS (Thousands)

Support, Program 21	Appropriation	FY-76	FY-77	FY-78	FY-79	FY-80	FY-81	FY-82 & Later
All Elements	R, E&D	302	954	1648	1500	2500	2500	2500
All Elements	F&E	1865	1420	2266	2266	2266	2266	2266
Frequency Spectrum Management, P.E 213	R, E&D and F&E							
SRDS: In- House		250	285	479	479	500	500	500
Contract		500	370	470	845	1700	1600	1650
NAFEC: In- House		0	0	136	106	150	150	150
Contract		0	0	0	0	0	0	0

Funding estimates reflect planned program milestones and are subject to the availability of funds. Current year estimates are consistent with the fiscal Program. Projected estimates are consistent with the NAS ten year plan.

APPENDIX A

COORDINATION

An elaborate set of interrelationships exists between the various organizations involved in spectrum management activities. Figure A-1 depicts the various relationships affecting international and national coordination of spectrum use. Figure A-2 depicts relationships within the United States. The FAA must participate directly in numerous Government groups to obtain spectrum support.

By agreement in 1967, between DOT and the predecessor of OTP, and subsequently ratified by OTP, DOT is authorized two representatives on the IRAC: one representative, provided by the Federal Aviation Administration (FAA) is responsible for the frequency management interests of that agency and for the Transportation Systems Center; the second representative, provided by the U.S. Coast Guard is responsible for the frequency management interests of that agency and for all other surface-mode operating elements (FHWA, FRA, NHTSA, UMTA, SLSDC, and MTB) as well as internal frequency requirements for the Office of the Secretary. By agreement, the Coast Guard also is responsible for frequency management interests of the Department of Health, Education, and Welfare (DHEW) dealing with the coordination and assignment of radio frequencies, protection from radio frequency interference and maintenance of radio frequency records, but does not represent DHEW at IRAC meetings.

Although the number of subgroups is fluid, at this printing the Office of Telecommunications Policy activities affecting the FAA include ten Ad Hoc groups and ten Working Parties of the Interdepartment Radio Advisory Committee, two Working Groups of the Spectrum Planning Subcommittee, and five Working Groups and nine Working Parties of the Technical Subcommittee. The following responsibilities have been imposed in regard to IRAC:

- (1) The Interdepartment Radio Advisory Committee (IRAC) was organized by mutual agreement of the Government departments concerned on June 1, 1922 and was continued by the Office of Telecommunications Policy (OTP) pursuant to Executive Order 11556 of September 4, 1970. The IRAC serves in an advisory capacity to the Director, OTP.
- (2) The IRAC consists of a representative appointed by each of 18 member departments and agencies that are major users of radio. The Spectrum Management Staff has been delegated authority by the Administrator to represent FAA.
- (3) Liaison between the IRAC and the Federal Communications Commission (FCC) is effected by the representative appointed by the Commission to serve in that capacity.

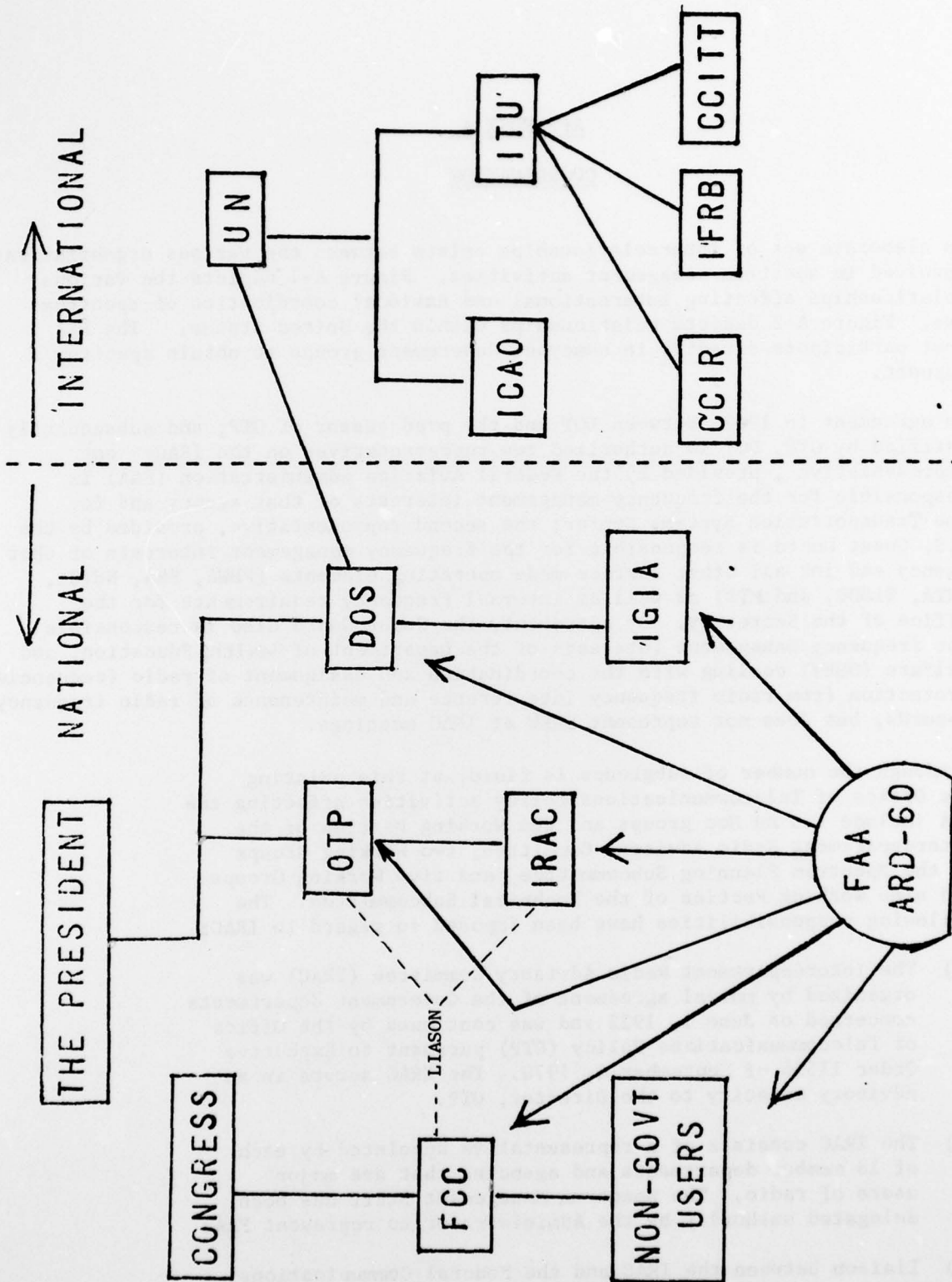


Figure A-1, INTERNATIONAL SPECTRUM MANAGEMENT

SPECTRUM MANAGEMENT IN THE UNITED STATES

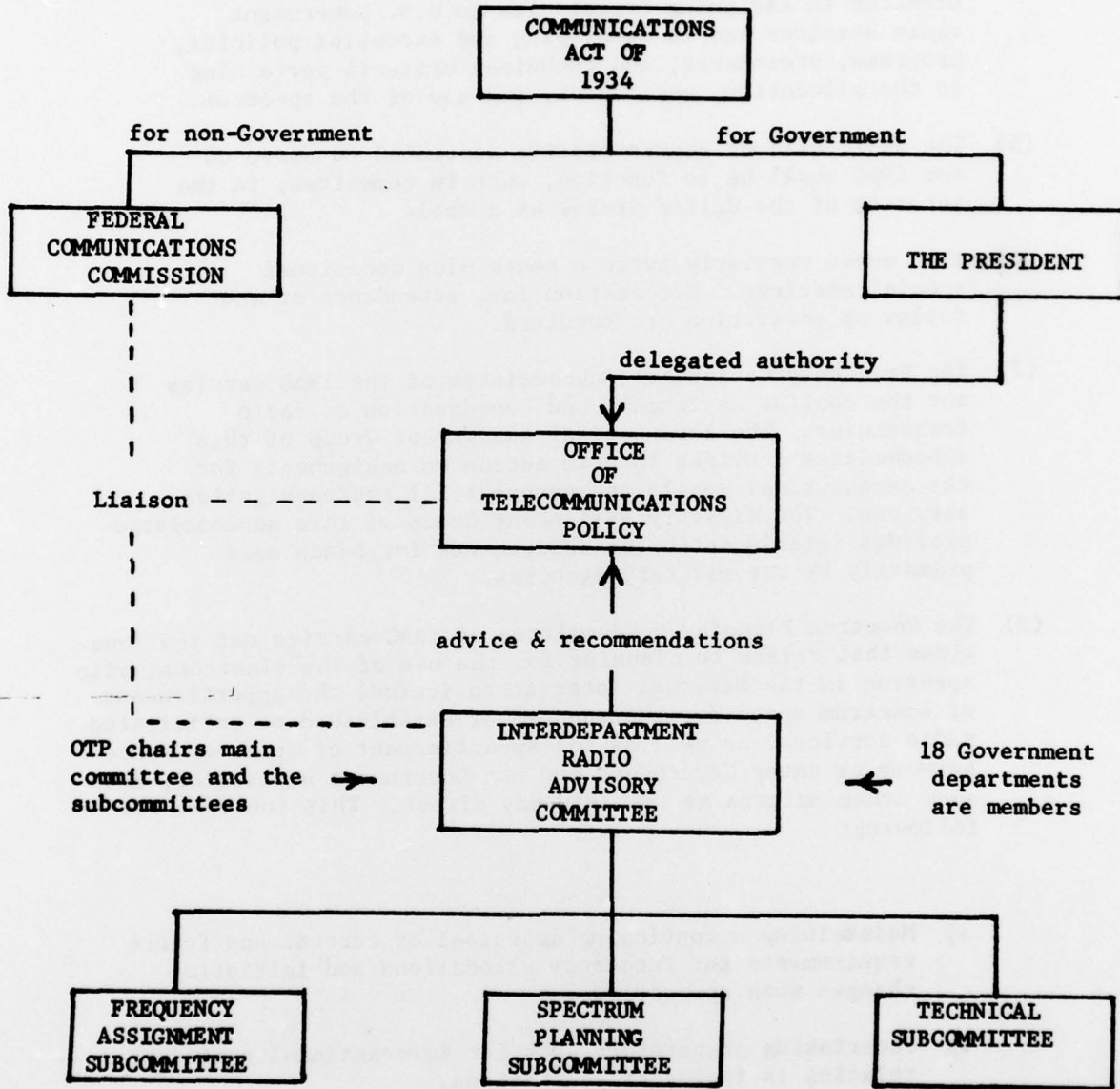


Figure A-2

- (4) The basic function of the IRAC shall be to assist the Director in assigning frequencies to U.S. Government radio stations and in developing and executing policies, programs, procedures, and technical criteria pertaining to the allocation, management, and use of the spectrum.
- (5) The basic role of representative appointed to serve on the IRAC shall be to function, when in committee, in the interest of the United States as a whole.
- (6) IRAC meets regularly twice a month plus occasional special meetings. Preparation for, attendance at and follow up activities are required.
- (7) The Frequency Assignment Subcommittee of the IRAC carries out the routine assignment and coordination of radio frequencies. The Aeronautical Assignment Group of this subcommittee provides interim action on assignments for the aeronautical mobile and aeronautical radionavigation services. The Military Assignment Group of this subcommittee provides interim action on assignments for bands used primarily by the military agencies.
- (8) The Spectrum Planning Subcommittee of IRAC carries out the functions that relate to planning for the use of the electromagnetic spectrum in the National interest to include the apportionment of spectrum space for the support of established or anticipated radio services, as well as the apportionment of spectrum space between or among Government and non-Government activities, and such other matters as the IRAC may direct. This includes the following:
 - a) Maintaining a continuing appraisal of current and future requirements for frequency allocations and initiating changes when appropriate.
 - b) Undertaking preparatory work for international conferences relating to frequency allocations.
 - c) The consideration of current and planned spectrum usage, including new development, techniques and services. The long range needs of all radio services are also considered, including specific proposals for changes to spectrum allocations and possible International implications.

d) The development of procedures to maintain pertinent documentation on all planned and operational satellite systems including their technical and operational characteristics; ascertain in the early stages of system concept development, where compatibility may not exist; make recommendations as to potential electromagnetic compatibility problem areas, and proposed courses of action to resolve these problems; make recommendations as to technical parameters necessary to facilitate sharing between systems; and review the effectiveness of existing systems with a view toward rectifying compatibility deficiencies.

(9) The Technical Subcommittee of the IRAC carries out functions that relate to the technical aspects of the use of the electromagnetic spectrum, and such other matters as the IRAC may direct. This subcommittee has five permanent working groups as follows: Standards, Propagation, Techniques, Side Effects and Electromagnetic Compatibility. This subcommittee is required to:

- a) develop recommended new standards and improve existing standards pertaining to use of the radio spectrum;
- b) maintain awareness of the radio propagation (including natural radio noise) programs and needs of the Government for purposes of evaluating and making recommendations leading to a better utilization of the radio spectrum;
- c) evaluate and make recommendations, in the form of technical reports, on new and existing techniques from the standpoint of their ability to optimize use of the radio spectrum (recommendations to include implementation steps);
- d) provide a coordination and evaluation mechanism for activities within the Government dealing with the biological and non-biological effects of nonionizing electromagnetic radiation; and
- e) evaluate and make recommendations, in the form of technical reports, regarding the EMC capabilities and needs of the Government in support of spectrum management, including techniques and criteria leading to greater inter and intra-radio service sharing of available spectrum and the reduction of man-made radio noise.

Department of State imposed activities affecting the FAA include the following:

- (1) Treaty preparation and negotiation..
- (2) The requirement for International Frequency Registration Board (IFRB) notifications of spectrum use.
- (3) Participation in the International Telecommunication Union (ITU) of the United Nations.
- (4) Participation in seven Study Groups and eight Working Groups of the International Radio Consultative Committee (CCIR).
- (5) Participation in International Civil Aviation Organization (ICAO) division/regional/panel meetings; and preparatory work through the Interagency Group on International Aviation (IGIA).

FCC activities affecting the FAA include type acceptance of ground and avionic equipment and proposed rule making involving bands of interest to the aeronautical services. FCC rule making activities provide regulations prescribing the conditions under which and the manner in which spectrum can be used by non-government entities. These may be generated by the FAA, the FCC, or user groups. Advice and consultation is provided to the FCC when required.

In addition, spectrum management expertise on behalf of the agency is provided in non-Government forums such as the Radio Technical Commission for Aeronautics, the Aerospace Flight Test Radio Coordination Council and the Airlines Electronics Engineering Committee..

Specific coordination requirements are imposed by Office of Management and Budget (OMB) and Office of Telecommunications Policy (OTP) directives (examples are given in section 1.2).

Coordination with organizations performing work under contract/interagency agreement is standard. Progress reports, interim reports, design reviews, redirection when necessary, etc. are all performed through the respective contracting offices. Maximum use is made of informal coordination (briefings, meetings, etc.) prior to initiating formal action.

APPENDIX B

REFERENCES

1. The Radio Frequency Spectrum, United States Use and Management, Executive Office of the President, Office of Telecommunications Policy, Washington, D. C., August 1975.
2. Manual of Regulations and Procedures for Radio Frequency Management, Executive Office of the President, Office of Telecommunications Policy, Washington, D. C., current edition.
3. Further Opportunities to Improve Radio Spectrum Management in the Federal Sector, U.S. General Accounting Office, Logistics and Communications Division, report No. LCD-74-122, October 21, 1975.
4. Radio Regulations, General Secretariat of the International Telecommunication Union, Geneva, Switzerland, current edition.

APPENDIX C

ACRONYMS

AAG	Aeronautical Assignment Group, a part of the IRAC Frequency Assignment Subcommittee making frequency assignments in the aeronautical bands.
AEROSAT	Aeronautical Satellite, a program to develop satellite systems for transoceanic flights.
ARSR	Air Route Surveillance Radar.
ASA	Aircraft Separation Assurance, a program to investigate airborne systems for collision avoidance.
ASDE	Airport Surface Detection Equipment, a radar system for detecting aircraft on the airport.
ASR	Airport Surveillance Radar.
ATCRBS	Air Traffic Control Radar Beacon System.
CCIR	International Radio Consultative Committee, a subgroup of the ITU of the UN that issues recommendations concerning technical and operational radiocommunications issues.
CCITT	International Telegraph and Telephone Consultative Committee, a subgroup of the ITU of the UN that issues recommendations concerning technical, operational, and traffic issues relating to telegraphy and telephony.
DABS	Discrete Address Beacon System.
DHEW	Department of Health, Education, and Welfare.
DME	Distance Measurement Equipment, a system providing range data to aircraft.
DOS	Department of State.
DOT	Department of Transportation.
ECAC	Electromagnetic Compatibility Analysis Center, an EMC software support facility of the Department of Defense.
EMC	Electromagnetic Compatibility.
EOP	Executive Office of the President.
ERMAC	Electromagnetic Radiation Management Advisory Council, a council established to investigate and make recommendations to the OTP concerning possible harmful side-effects of electromagnetic radiation.

FAA Federal Aviation Administration.

FAS Frequency Assignment Subcommittee, a subgroup of the IRAC.

FCC Federal Communications Commission.

FHWA Federal Highway Administration.

FM Frequency Modulation, used in reference to FM broadcasting in the 88 to 108 MHz band.

FRA Federal Railroad Administration.

GWARC General World Administrative Radio Conference, an international conference convened by the ITU of the UN for the purpose of revising the complete set of international radio regulations, held at 20 year intervals.

ICAO International Civil Aviation Organization.

IFRB International Frequency Registration Board, a subgroup of the ITU of the UN that records frequency assignments for the purpose of minimizing harmful interference on an international basis.

IGIA Interagency Group on International Aviation, a committee chaired by the FAA to provide recommendations to the Department of State concerning international aviation matters.

ILS Instrument Landing System.

ITS Institute for Telecommunication Sciences, a part of the Department of Commerce specializing in radio propagation research and related fields.

ITU International Telecommunication Union, an element of the UN that establishes international radio regulations.

IRAC Interdepartment Radio Advisory Committee, manages the use of radio frequencies by U.S. Government radio stations.

ISMLS Interim Standard MLS, a limited capability microwave instrument landing system providing only one predetermined landing pattern and would be phased out upon implementation of full performance MLS systems.

JTIDS Joint Tactical Information Distribution System, a joint military information distribution system utilizing the same portion of the spectrum as ATCRBS.

L/MF Low/Medium Frequency, 30 to 3000 kHz.

MAG Military Assignment Group, a part of the IRAC Frequency Assignment Subcommittee making frequency assignments in military bands.

MLS Microwave Landing System.

MTB Materials Transportation Bureau.
 NAFEC National Aviation Facilities Experimental Center.
 NAS National Airspace System.
 NAVAID Navigational Aid.
 NBS National Bureau of Standards.
 NHTSA National Highway Traffic Safety Administration.
 OMB Office of Management and Budget.
 OTP Office of Telecommunications Policy.
 PRF Pulse Repetition Frequency.
 RML Radar Microwave Link.
 RNAV Area Navigation.
 SCAM Spectrum Characteristic Analysis and Measurement.
 SHF-SATCOM Super High Frequency-Satellite Communications, a high power military satellite communications link using the same portion of the spectrum as RML systems.
 SLSDC Saint Lawrence Seaway Development Corporation.
 SPS Spectrum Planning Subcommittee, a subgroup of the IRAC.
 TACAN Tactical Air Navigation, a military navigational aid providing range and azimuth relative to the ground site.
 TSC Technical Subcommittee, a subgroup of the IRAC.
 TV Television, in reference to commercial broadcast television.
 UHF Ultra High Frequency, 300 to 3000 MHz, in reference to the 225-400 MHz aeronautical band.
 UMTA Urban Mass Transit Administration.
 UN United Nations.
 US United States.
 VHF Very High Frequency, 30 to 300 MHz, in reference to the 118 to 136 MHz aeronautical band.
 VORTAC VHF Omni-Range and TACAN, a combined VOR and TACAN facility.
 WARC World Administrative Radio Conference, an international conference convened by the ITU for the purpose of revising specific international radio regulations, held at several year intervals.