


## LETTER OF PROMULGATION

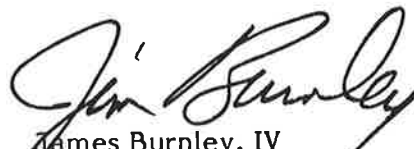
This letter promulgates the fifth edition of the Federal Radionavigation Plan, which was prepared jointly by the Departments of Defense and Transportation. It supersedes the 1986 Federal Radionavigation Plan.

The Federal Radionavigation Plan is published to provide information on the management of those Federally-provided radionavigation systems used by both the military and civil sectors. It supports the planning, programming and implementing of air, marine, land and space navigation systems to meet the requirements shown in the President's budget submission to Congress. This plan is the official source of radionavigation policy and planning for the Federal Government, and has been prepared with the assistance of other Government agencies.

The Federal Radionavigation Plan is revised biennially. Your suggestions for the improvement of future editions are welcomed.



Frank C. Carlucci  
Secretary of Defense



James Burnley, IV  
Secretary of Transportation



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16. Abstract  The Federal Radionavigation Plan (FRP) delineates policies and plans for radio-navigation services provided by the U.S. Government to ensure efficient use of resources and full protection of national interests. Developed jointly by the U.S. Departments of Defense and Transportation, the FRP sets forth the Federal interagency approach to the implementation and operation of radionavigation systems.  The FRP is updated biennially. This fifth edition describes respective areas of authority and responsibility, and provides a management structure by which the individual operating agencies will define and meet requirements in a cost-effective manner. Moreover, this edition contains the current policy on the radionavigation systems mix. The constantly changing radionavigation user profile and rapid advancements in systems technology, combined with delays in the U.S. space program, require that the FRP remain as dynamic as the issues it addresses. This edition of the FRP builds on the foundation laid by previous editions and further develops national plans towards providing an optimum mix of radionavigation systems for the foreseeable future.					
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## PREFACE

The Department of Defense (DOD) and the Department of Transportation (DOT) have developed the fifth edition of the Federal Radionavigation Plan (FRP) to ensure efficient use of resources and full protection of national interests. The plan sets forth the Federal interagency approach to the implementation and operation of Federally provided, common-use radionavigation systems.

The FRP is a review of existing and planned radionavigation systems used in air, land, and marine navigation and for purposes other than navigation in terms of user requirements and current status. The FRP contents reflect DOT responsibilities for public safety and transportation economy, as well as DOD responsibility for national security.

The plan is updated biennially. The established DOD/DOT interagency management approach allows continuing control and review of U.S. radionavigation systems. Your inputs on this plan are welcome. Interested parties and advisory groups from the private sector are invited to submit their inputs to the Chairman of the DOT Navigation Working Group (Attn: DRT-20), Department of Transportation, Research and Special Programs Administration, Washington, DC 20590.

## METRIC CONVERSION AND OTHER MEASURES

### Length

1 centimeter	= 0.3937 inch	
1 inch	= 2.54 centimeters exactly	
1 foot	= 0.3048 meter	
1 meter	= 3.280 feet	
1 yard	= 0.9144 meter	
1 kilometer	= 1,000 meters	
1 fathom	= 6 feet	= 1.828 meters
1 statute mile	= 1,609.3 meters	= 5,280 feet
1 nautical mile	= 1.852 kilometers	= 1.151 statute miles
1 degree of latitude	= 60 nautical miles	

### Speed

1 knot	= 1 nautical mile per hour	
Mach 1	= 661.5 knots at standard sea level	= 1116.5 ft/sec
1 kilometer per hour	= 0.5399 knot	
1 mile per hour	= 1.47 feet per second	

### Area

1 square inch	= 6.5 square centimeters	
1 acre	= 43,560 square feet	= 4,047 square meters
1 hectare	= 2.47 acres	= 10,000 square meters

### Standard Sea Level

Temperature	= 15° Celsius	= 59° Fahrenheit
Atmospheric Pressure	= 29.92 inches of mercury	(14.696 psi)

### Angular Measure

Degree	= 1/360th of a circle
Mil	= 1/6,400th of a circle

### Radio Frequency Bands

Very low	= (VLF)	Below 30 khz
Low	= (LF)	30 to 300 khz
Medium	= (MF)	300 to 3,000 khz
High	= (HF)	3,000 khz to 30 MHz
Very High	= (VHF)	30 MHz to 300 MHz
Ultra High	= (UHF)	300 MHz to 3 GHz
Super High	= (SHF)	3 to 30 GHz
Extremely High	= (EHF)	30 to 300 GHz
L Band	= L	390 to 1,550 MHz
S Band	= S	1,550 to 5,200 MHz
X Band	= X	5.2 to 10.9 GHz
K Band	= K	10.9 to 36 GHz

### Temperature

Fahrenheit	= 9/5 Celsius + 32
Celsius	= 5/9 (Fahrenheit - 32)

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## EXECUTIVE SUMMARY

The Federal Radionavigation Plan (FRP) delineates policies and plans for Federally-provided radionavigation services. It also discusses privately operated radiodetermination systems recognizing that these systems may impact Government radionavigation planning in the future. This plan describes areas of authority and responsibility and provides a management structure by which the individual operating agencies can define and meet radionavigation requirements in a cost effective manner. It is the official source of radionavigation policy and planning for the Federal Government. This edition of the FRP updates and replaces the 1986 FRP and incorporates common-use radionavigation systems (i.e., systems used by both civil and military sectors) covered in the DOD Joint Chiefs of Staff's (JCS) Master Navigation Plan (MNP). The MNP covers many radionavigation systems used exclusively by the military, and has not been replaced by the FRP.

This document describes the various phases of navigation and other applications of the radionavigation services, and provides current and anticipated requirements for each. As requirements change, radionavigation systems may be added or deleted in subsequent revisions to this plan.

The FRP covers common-use, Federally-operated systems. These systems are sometimes used in combination or with other systems. Privately-operated systems are recognized in the interest of providing a complete picture of U.S. radionavigation.

The systems covered in this plan are:

- Radiobeacons
- LORAN-C
- OMEGA
- VOR, VOR/DME, VORTAC
- TACAN
- ILS
- MLS
- TRANSIT
- GPS

A major goal of DOD and DOT is to select a mix of these common-use civil/military systems which meets diverse user requirements for accuracy, reliability, availability, integrity, coverage, operational utility, and cost; provides adequate capability for future growth; and minimizes unnecessary duplication of services. A significant portion of this plan is devoted to the Global Positioning System (GPS) since it has the potential to replace many existing radionavigation systems.

Selecting a radionavigation systems mix is a complex task, since user requirements vary widely and change with time. While all users require services that are safe, readily available and easy to use, military requirements stress unique defense capabilities such as performance under intentional interference, operations in high-performance vehicles, worldwide coverage and operational capability in severe environmental conditions. Cost remains a major consideration which must be balanced with a needed operational capability.

Navigation requirements range from those for small single-engine aircraft or small vessels, which are cost-sensitive and may require only minimal capability, to those for highly sophisticated users, such as airlines or large vessel operators, to whom accuracy, flexibility, and availability may be more important than initial cost. The selection of an optimum mix to satisfy user needs, while holding the number of systems and costs to a minimum, involves complex operational, technical, institutional, international and economic trade-offs. This plan establishes a vehicle for DOD and DOT to address these questions and arrive at an optimum mix determination. This edition of the FRP attempts to build on the foundation laid by previous editions and further develop national plans toward providing an optimum mix of radionavigation systems for the foreseeable future. The constantly changing radionavigation user profile and rapid advancements in systems technology, as well as delays in the U.S. space programs, require that the FRP remain as dynamic as the issues it addresses. This issue of the FRP contains the current policy on the radionavigation systems mix.

This document is composed of the following sections:

- Section 1     Introduction to the Federal Radionavigation Plan: Delineates the purpose, scope and objectives of the plan, presents the DOD and DOT authority and responsibilities for providing radionavigation services, and the DOD/DOT policy and plan for the radionavigation system mix.
- Section 2     Radionavigation User Requirements: Provides civil and military requirements for air, land and marine navigation.
- Section 3     Radionavigation Systems Plans: Describes how the various radionavigation systems are used in meeting civil requirements, and the status and plans for each system.
- Section 4     Research, Engineering and Development: Presents the research, engineering and development efforts to be conducted by DOT and DOD.
- Appendix A    System Characteristics: Describes present and planned navigation systems in terms of ten major parameters: signal characterization, accuracy, availability, coverage, reliability, fix rate, fix dimension, capacity, ambiguity, and integrity.
- Appendix B    Chart Reference Systems: Discussion of chart reference systems.
- Appendix C    Definitions
- Glossary



## 1. INTRODUCTION TO THE FEDERAL RADIONAVIGATION PLAN

This section describes the background, purpose, and scope of the Federal Radionavigation Plan (FRP). It summarizes the events leading to the preparation of this document and the national objectives for coordinating the planning of radionavigation services. The remaining contents of Section 1 set forth National Policy, Radionavigation Authority and Responsibility, and Radionavigation System Planning.

### 1.1 BACKGROUND

The first edition of the FRP was released in 1980 as part of a Presidential Report to Congress, made in response to the International Maritime Satellite (INMARSAT) Act of 1978. It marked the first time that a joint Department of Transportation/Department of Defense (DOT/DOD) plan for common-use systems (i.e., systems used by both the civil and military sectors) had been developed. Now, this biennially-updated plan serves as the planning and policy document for all present and future Federally-provided radionavigation systems. This edition also reflects input obtained at air, marine, and land radionavigation users' conferences in 1986 and 1988.

The 1979 DOD/DOT Interagency Agreement for joint radionavigation planning, as well as for the development and publication of the FRP, was renewed in August 1984. This agreement recognizes the need to coordinate all Federal radionavigation system planning and to attempt, wherever consistent with operational requirements, to utilize common systems. Since the publication of the first edition of the FRP there have been significant changes in the radionavigation environment. Although the Global Positioning System (GPS) is a principal driving force in the FRP, other external factors such as breakthroughs in low cost Long Range Navigation (LORAN-C) receiver technology, marketplace pressures, delays in the space program, and increasing private sector involvement have affected the evolution of the FRP.

The FRP also has an impact on international radionavigation planning. This has been recognized in the process of selecting the future radionavigation systems mix. The FRP has been distributed to working groups within the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO), the International Association of Lighthouse Authorities (IALA) and other organizations.

Radionavigation users' conferences held in 1986 and 1988 indicated strong support for the LORAN-C system by air, marine and land users. Marine radiobeacons continue to be important to small boaters, and aeronautical beacons serve many airports without any other navigational aid. Very High Frequency Omnidirectional Range/Distance Measuring Equipment (VOR/DME), an international aviation standard, serves as the basis for the current airway structure and has a very high degree of acceptance among aviators. OMEGA has a small marine user population but continues to be used by business aviation and air carriers throughout the world as well as some specialized users involved in electromagnetic propagation and atmospheric wind studies. The TRANSIT satellite navigation system has a large population of maritime users throughout the world. Users also reported that safe, prudent navigation requires that a backup system be available.

Many users of radionavigation services are anticipating the operational availability of GPS. Civil users, however, are reluctant to state when they might equip with GPS due to operational uncertainties and concerns about receiver costs. Unfortunately, delays in the space program make it difficult to determine a firm operational date for GPS.

The need to consolidate and reduce the number of systems is a major objective of DOD and DOT. The constantly changing radionavigation user profile and rapid advancements in systems technology, as well as delays in the U.S. space programs, require that the FRP and the policies stated therein remain as dynamic as the issues they address. The current DOD/DOT policy on the radionavigation systems mix is presented in Section 1.6.

## 1.2 PURPOSE

The purpose of this FRP is to:

- o Present an integrated Federal policy and plan for all common-use civil and military radionavigation systems.
- o Provide a document for specifying radionavigation requirements and addressing common-use systems and applications.
- o Outline an approach for consolidating radionavigation systems.
- o Provide Government radionavigation system planning information and schedules.
- o Define and clarify new or unresolved common-use radionavigation system issues.
- o Provide a focal point for civil user input.

## 1.3 SCOPE

This plan covers Federally-provided, common-use radionavigation systems, acknowledging that these systems can be used for other purposes. It also briefly addresses privately-owned systems such as racons, radio determination satellite systems and others that interface with or impact on Federally-provided systems. The plan does not include systems which mainly perform surveillance and communication functions.

The major radionavigation systems subject to the planning process described in this FRP are:

- o Radiobeacons
- o LORAN-C
- o OMEGA
- o VOR, VOR/DME, VORTAC
- o TACAN
- o ILS
- o MLS
- o TRANSIT
- o GPS

#### 1.4 OBJECTIVES

The radionavigation policy of the United States has evolved through statute, usage, and in the interest of national defense and public safety. The objectives of United States Government radionavigation policy are to:

- o Support national security
- o Provide safety of travel
- o Promote efficient transportation services

#### 1.5 POLICIES AND PRACTICES

The following policies and practices implement the above objectives:

- A. Implementation and operation of radio aids to navigation. Services which contribute to safe, expeditious, and economic air and maritime commerce and which support United States national security interests are provided.
- B. Installation and operation of radionavigation systems in accordance with international agreements.
- C. Recognition of electromagnetic spectrum planning requirements and avoidance of unnecessary duplication of navigational systems and services. The highest degree of commonality and system utility between military and civil users is sought through early considerations of mutual requirements.

- D. Promotion of transportation safety and environmental protection by requiring certain vessels and aircraft to be fitted with navigational equipment as a condition for operating in the controlled airspace or navigable waters of the United States.
- E. Direction to ensure that radionavigation services available to civil users meet projected demand, performance, safety, and environmental protection requirements considering economic constraints on radionavigation systems providers and users.
- F. Evaluation of domestic and foreign radio aids to navigation, with support for the development of those systems having the potential to meet unfulfilled operational requirements; offering major economic advantages over existing systems; and providing significant benefits in the national interest.
- G. Promotion of international exchange of scientific and technical information concerning radionavigation aids.
- H. Guidance and assistance in siting, testing, evaluating and operating radio aids to meet unique aviation requirements not supported by the Federal Government.
- I. Promotion of national and international standardization of civil and military radionavigation aids.
- J. Establishment, maintenance, and dissemination of system and signal standards and specifications.
- K. Development, implementation, and operation of the minimum special radionavigation aids and services for military operations.
- L. Operation of common-use radionavigation systems as long as the United States and its allies accrue greater military benefit than potential adversaries. Operating agencies would cease operations or change characteristics and signal formats of radionavigation systems only during a dire national emergency.
- M. Control of LORAN-C stations by DOT to optimize utilization by non-marine users, within the constraints imposed by the need to provide quality service to maritime navigation.
- N. Provision of the GPS Standard Positioning Service (SPS) for continuous, worldwide civil use at the highest level of accuracy consistent with U.S. national security interests. It is presently projected that a predictable and repeatable accuracy of 100 meters (2 drms) horizontally and 156 meters (2 sigma) vertically will be made available during the first year of full GPS operation. During the development phase of the GPS program, the satellites will be transmitting both Precise Positioning Service (PPS) and SPS signals in the clear in support of government sponsored tests. Civil users are cautioned that the system is under development, and signal availability and accuracy are subject to change without advance warning, at the discretion of the DOD. Therefore, until the system is declared operational, any use of the system is at the user's own risk.

- O. Equipment of military vehicles, as appropriate, to satisfy civil aviation and maritime navigation safety requirements. U.S. military vehicles and users will be equipped with navigation systems which best satisfy mission requirements. In general, a combination of radionavigation and self-contained navigation aids is required. Standardization, although important, may be disregarded when unique military systems provide the capability to operate safely without reference to civil radionavigation systems.
- P. Establishment of mechanisms, where practical, for users of Federally-provided radionavigation aids to bear their fair share of the costs for development, procurement, operation, and maintenance of these systems.
- Q. Provision, through DOD/DOT interagency agreements, of comprehensive management for all Federally-provided common use radionavigation systems.
- R. Ensure in accordance with established national policy, reliance on the private sector to support the design, development, installation, operation, and maintenance of all equipment and systems required to provide common-use radionavigation aids in support of this FRP (within the constraints of national security).

#### 1.6 DOD/DOT CURRENT POLICY ON THE RADIONAVIGATION SYSTEM MIX

The Department of Transportation (DOT) is responsible for ensuring safe and efficient transportation. Radionavigation systems play an important role in carrying out this responsibility. The two main elements within DOT that operate radionavigation systems are the United States Coast Guard (USCG) and the Federal Aviation Administration (FAA). The agency responsible for coordinating navigation planning within DOT is the Research and Special Programs Administration (RSPA).

The USCG has the statutory responsibility to define the need for, and to provide aids to navigation and facilities required for safe and efficient marine navigation. The FAA has the responsibility for the development and implementation of radionavigation systems to meet the needs for safe and efficient air navigation, as well as control of all civil and military aviation, except for military aviation needs peculiar to warfare and primarily of military concern. The FAA also has the responsibility to operate aids to air navigation required by international treaties.

The Department of Defense (DOD) is responsible for developing, testing, evaluating, implementing, operating, and maintaining aids to navigation and user equipment required for national defense and ensuring that military vehicles operating in consonance with civil vehicles have the necessary navigational capabilities.

All common-user systems currently operating or planned were considered in developing the current policy on the mix of Federally-provided radionavigation systems. The statement that follows is the current DOD/DOT radionavigation policy for the period 1988-1990.

**DOD/DOT POLICY AND PLANS  
FOR THE  
FUTURE RADIONAVIGATION SYSTEMS MIX  
1988 - 1990**

PURPOSE:

This statement sets forth the policy for Federally provided radionavigation systems to be supported for the remainder of this century and into the early part of the next.

OBJECTIVES:

The Federal Government operates radionavigation systems as one of the necessary elements to enable safe transportation and encourage commerce within the U.S. It is a goal of the Government to provide this service in a cost effective manner. In order to meet both civil and military radionavigation needs, the Government has successively established a series of radionavigation systems over a period of years, each utilizing the latest technology available at the time, and each designed to meet an existing unfulfilled need, usually in terms of improved accuracy and/or expanded coverage. This policy statement addresses how and for what period each system should be part of the Federal radionavigation system mix. To date few systems have been discontinued.

DOD is currently introducing a new high-technology radionavigation system, the Global Positioning System (GPS), which will have wide civil application on a global basis. This system has the potential to meet or better the accuracy and coverage capabilities of most other radionavigation systems. Consequently, if the full civil potential of GPS is realized, the Department of Transportation will consider phasing out some of the existing radionavigation systems.

Any decision to discontinue Federal operation of existing systems will depend upon many factors including: (a) resolution of GPS accuracy, coverage, integrity and financial issues; (b) determination that the systems mix meets civil and military needs currently met by existing systems; (c) availability of civil user equipment at prices that would be economically acceptable to the civil community; (d) establishment of a transition period of 10-15 years; and (e) resolution of international commitments.

## INDIVIDUAL SYSTEM PLANS:

RADIOBEACONS: Maritime and aeronautical radiobeacons serve the civilian user community with low-cost navigation. They will remain part of the radionavigation mix into the next century.

LORAN-C: LORAN-C provides positioning and timing services for both civil and military air and surface users. It is the Federally provided navigation system for the U.S. Coastal Confluence Zone (CCZ). LORAN-C is approved as a supplemental air navigation system and is being implemented as a non-precision approach aid. Signal monitors necessary for LORAN-C nonprecision approaches will be operational in 1989. By 1990, additional transmitting stations will be installed to complete signal coverage over the 48 conterminous states. The LORAN-C system serving the continental United States (including Alaska) and the coastal areas will remain a part of the navigation system mix into the next century. DOD will not have a requirement for LORAN-C after December 1994.

OMEGA: OMEGA is a global navigation system serving maritime and aeronautical users. OMEGA is expected to remain part of the radionavigation system mix through the remainder of the century. It is a sole means of air navigation in some oceanic areas. Recapitalization of equipment and antennas, required at several stations in the mid-1990's, will be based on cost benefit analyses that may lead to elimination or reduction of service in some areas. The normal transition period of 10 to 15 years may be shortened due to escalating maintenance costs and availability of alternative navigation systems such as GPS. DOD will phase out military air use of OMEGA by December 1994; however, some naval receivers may continue in operation after that date.

VOR/DME: VOR/DME provides users with a sole means of air navigation in the National Airspace System (NAS). VOR/DME, as the international standard for civil air navigation in controlled airspace, will remain a short-range aviation navigation system into the next century. DOD will phase out military support and use of VOR/DME by 1997.

TACAN: TACAN is a short-range navigation system used primarily by military aircraft. When DOD determines that GPS, properly integrated with other onboard aircraft systems, is an acceptable radionavigation system for military use in controlled airspace, the DOD requirement for land-based TACAN will terminate. Based upon the planned GPS operational date of 1992, the DOD requirement for land-based TACAN should terminate by December 1997. The requirement for shipboard TACAN will continue until a suitable replacement is operational.

ILS; MLS; DME/P: These are precision approach systems for aircraft. MLS will replace ILS, and will be completely installed at civil airports by 2003.

TRANSIT: TRANSIT is a satellite-based radionavigation system operated by DOD. The DOD requirement for TRANSIT will terminate and system operation will be discontinued by December 1996.

GPS: GPS is a DOD developed, worldwide, satellite-based radionavigation system that will be the DOD's primary radionavigation system well into the next century. The constellation will ultimately consist of 24 operational satellites (21 plus 3 operating spares). The GPS constellation will be declared fully operational by DOD when 21 satellites are functioning in their assigned orbits, planned to occur in 1992. If current R&D satellites remain functional beyond their design life, this could occur before 1992.

GPS Precise Positioning Service (PPS), the service that requires the use of cryptographic keys, will be primarily limited to military and official Government users. GPS Standard Positioning Service (SPS) will be made continuously available, without charge to all users worldwide, and will provide 100 meter (2 drms) or better positioning accuracy.

AIR USE: GPS has the potential to become a sole means air navigation system. Approval of civil air navigation receivers to operate with the GPS is expected initially to be on a supplementary basis. Resolution of coverage and integrity issues is needed to certify GPS as a sole means system.

SURFACE USE: GPS will satisfy the requirements for the ocean phase of maritime navigation, some coastal phase requirements and some land user requirements. At the 100-meter accuracy level planned, however, GPS will not meet the requirements for some coastal phase maritime applications or the requirements for harbor/harbor approach navigation. Additionally, some land navigation requirements, as stated by the users, demand accuracy in the 10-meter range. It is possible that an enhanced form of GPS, such as differential GPS, could satisfy these more stringent requirements.

DIFFERENTIAL: The Coast Guard and the DOD are investigating the capabilities of differential GPS. Although there are currently no Federal Government plans to provide a differential GPS service for common use, the DOD in coordination with the DOT will control differential GPS transmissions to prevent interference with GPS satellite transmissions and to protect U.S. national security interests.