AN OVERVIEW OF THE FEDERAL RADIONAVIGATION PLAN

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Abstract

The 1986 Federal Radionavigation Plan (FRP) is significantly different from previous editions, although the content is essentially the same. A brief review of FRP history will be presented. Current and future federal requirements for radionavigation systems and the status of the Global Positioning System (GPS) and its possible impact on existing systems will be addressed. Issues such as "the role of the private sector" and "uses other than navigation," that appeared for the first time in the 1986 FRP will be highlighted. The radionavigation users' conference held in Washington, D.C. in March 1988 and other user oriented actions will be discussed.

Introduction

The formation of the Department of Transportation (DOT) in 1967 set the stage for development of a coordinated national navigation plan. The Federal Aviation Administration and the U. S. Coast Guard were providing navigational services in the aeronautical and maritime environments respectively. Early, long range, radionavigation systems were all ground based. The Transit system's enormous success showed the potential for a full coverage, satellite based system. The emergence of the GPS provided the push for better planning and control over the presumed proliferation of radionavigation systems and became the driving force behind the FRP. With the Department of Defense (DOD) setting the pace for the GPS for national defense purposes, users and manufacturers began to rally and demand a mix of radionavigation systems that would include ground based as well as satellite systems.

Radionavigation Plan History

The Federal Aviation Administration and the U.S. Coast Guard completed studies in 1969 that were used by the DOT in the development of a national navigation plan. The first edition of this plan was the DOT National Plan for Navigation (NPN), published in May 1970. Military navigation requirements were published separately in the Joint Chiefs of Staff Master Navigation Plan and were not included in the NPN. The first NPN set national policy, established requirements and presented a basic operating plan for civil radionavigation systems. The last NPN (third edition) was published in 1977 and was a major refinement of the 1970 and 1972 NPN's and the 1974 NPN annex.

A General Accounting Office (GAO) report to the Subcommittee on Coast Guard and Navigation, Committee on Merchant Marine and Fisheries, U.S. House of Representatives, in March 1974, titled "Summary of GAO Study of Radionavigation Systems: Meeting Maritime Needs" gave a lukewarm endorsement to Coast Guard plans that would designate:

- o Omega as the most cost-effective solution to the medium accuracy and worldwide coverage requirements for all users on the high seas.
- o Loran-C as the radionavigation system that can best satisfy the precision navigation requirements resulting from heavy traffic in the coastal confluence and harbors and

estuaries, thereby, eliminating the requirement for Loran A.

This report also noted that space satellite systems were not economical or readily available for civil users. With Loran-C satisfying civil maritime navigation requirements, Loran-A would be phased out, with a period of two years dual Loran-A and Loran-C operations being reasonable for equipment amortization and changeover! This GAO study was undertaken because of the presumed proliferation of radionavigation systems. The report recognized the differences in requirements between aviation, maritime and military users, and acknowledged the potential number of land users to highlight the need to standardize on the minimum number of long-range radionavigation aids.

The NPN Annex of July 1974, announced the designation and implementation of Loran-C as the government provided radionavigation system for the U.S. coastal/confluence zone and the deactivation of the Loran-A radionavigation system. The annex provided for a five year phase out period for Loran-A and a two year dual operation of Loran-A and Loran-C.

The NPN promulgated in November 1977 was the last NPN edition. Based on recommendations in the March 1974 GAO report and the work being done by the Office of Telecommunications Policy, this last NPN came closest to being a national radionavigation plan for civil users than those previously. The plan was prepared and approved by the Departments of Transportation, Defense and Commerce and the National Aeronautics and Space Administration. The emerging technology of the GPS was included because it showed great promise as an all weather, truly worldwide, radionavigation system.

The March 1978 GAO report "Navigation Planning--Need for A New Direction," was more comprehensive than the 1974 study and recommended a government-wide radionavigation plan along with a reduction in the number of federally operated systems. The report relied heavily on the potential of the DOD Navigation System using Timing and Ranging (GPS) to replace most existing long-range radionavigation systems. Some systems judged unneeded included VOR, Loran-C, and Transit. This was a major shift from the GAO report of March 1978, just 4 years before. The potential of the GPS was fully recognized. However, the operational dates for GPS were too optimistic.

The International Maritime Satellite Telecommunications Act, Public Law 95-564 of November 1978, required the President to submit a government-wide navigation plan to the Congress. An interagency working group, already studying radionavigation planning, developed the first edition of the FRP, jointly published by DOD and DOT in 1980. This new national plan contained civil sector as well as national defense radionavigation policy for common use systems. The most significant goal of the plan called for a 1986 decision on an optimum radionavigation system mix. This 1986 decision was to be based on the GPS becoming operational in 1987. The system mix decision was to be made based on coordination and consultation with all groups affected by the planned 1986 decision.

The second edition of the FRP was published in

1982 and recognized the need for input from sources other than the Federal Government. Liaison with the private sector was initiated by the Research and Special Programs Administration (RSPA) of DOT.

The 1984 edition of the FRP provided the following preliminary policy on an optimum system mix:

- DOD phase out military air use of Omega and overseas Loran-C by 1992, VOR/DME and land-based TACAN by 1997 and cease TRANSIT operation in 1994
- Civil user phase out of Loran-C and Omega after certain problems with GPS were resolved
- A 15 year transition period for phase out of Loran-C and Omega as GPS became operational
- Resolution of international commitments.

The 1986 Edition of the FRP

The 1986 FRP, the fourth edition, is a major revision of the 1984 edition. The 1986 FRP consists of one volume containing four chapters and several appendices. The 1986 FRP is better organized and easier to read. Most redundant material has been eliminated. However, the basic content of the FRP remains consistent with previous editions. To encourage wider audience participation in the civil review process of the FRP, the request for private sector input was placed in the preface.

In the discussion to follow, only those areas where FRP content has changed significantly from the 1984 edition will be covered. Editorial changes or differences in presentation not accompanied by substantial information additions or deletions will not be addressed. Therefore, the reader should consult the FRP directly to clarify specific areas of interest or concern.

Major Objective of the FRP

The need to consolidate and reduce the number of

radionavigation systems is still recognized as the major objective of the FRP. However, due to delays in the GPS program and comments from radionavigation system users, a recommendation on an optimal mix of systems is deferred until after GPS becomes operational and significant questions relating to GPS operation are satisfactorily resolved for all classes of users. The 1986 FRP updated the 1984 preliminary decision based on current system plans.

Policy Considerations

A major change in selecting systems to be part of the system mix is shown in figure 1. Previous editions of the FRP referred to a DOD/DOT final recommendation on selection of navigation systems of the future. The current policy is more dynamic since no final recommendation will be made, but each revision of the FRP provides an updated decision on the current system mix. This process now allows systems to be selected based on user need rather than forcing an artificial selection of systems based on GPS availability. Improvements to existing systems are not precluded since user requirements may force the need for some modernization of systems.

Indeed, the 1986 FRP refers to a "long-term goal to establish, through an integrated DOD/DOT planning and budgeting process, a cost-effective, user-sensitive, mix of systems for the post-2000 time frame." Thus, a mix of systems implies that a need for redundancy will be taken into consideration when warranted by user requirements. Although not explicitly stated in the FRP, redundancy of radionavigation systems, strongly expressed during the 1986 and 1988 users' conferences, is considered extremely important for safety of navigation. Figure 1 is noteworthy also because of the lack of a time line driving the distinct phases of the planning process. The planning process now extends over the two year period between editions of the FRP.

* A national decision occurs upon approval of requested budget authority

FIGURE 1 DOD/DOT RADIONAVIGATION SYSTEMS PLANNING PROCESS

The current policy goals are:

- DOD phase out military air use of Omega and overseas Loran-C by 1994, VOR/DME and land-based TACAN by 1997, and cease TRANSIT operation in 1996. Additionally, DOD will phase out military use of ILS
- Civil user phase out of VOR/DME, Loran-C and Omega continues to depend on resolution of certain problems with GPS
- Establishment of a 15 year transition period
- Resolution of international commitments.

There are no plans by DOT to discontinue any existing radionavigation system in the near term, only the DOD has decided to phase out their usage of certain systems.

Factors Affecting Selection of the System Mix

A final selection of the system mix has not been made for several reasons. The GPS is not operational and will not be operational for several more years. A decision on whether to phase out a radionavigation system can have serious consequences, including increased costs for the users of the system. When other factors are considered, such as GPS satellite launch schedule delays, changes in user profiles, changes in dynamic radionavigation technology, and input received during the 1986 civil radionavigation users' conferences it becomes readily apparent that the government's concern for maintainable, economical, and accurate navigation systems to meet user requirements would force a delay in selection of the system mix. Any recommendation on an optimal system mix would be premature before GPS operation for all user classes is verified.

GPS satellite launch delays are a direct result of the shuttle accident. The changes in users' profiles are attributable to: an expansion of the role of Loran-C in aviation, vehicle location, and timing synchronization applications. Dynamic electronics technology has resulted in the largest increase in users because of the ease of operating newer receivers. Automation of receiver functions, dramatic decreases in receiver costs, internal receiver databases, and use of software to provide additional capabilities (automatic calculation of latitude and longitude, way point calculations, course to steer, etc.) has resulted in a significant increase in the number of users, especially in the marine and land community. Navigation management systems have introduced additional complexity into the system mix selection process, especially for aviation applications. Digital signal processing has resulted in easier receiver operation, less need and demand for operator training, and a quantum improvement in receiver performance.

Role of the Private Sector

Private sector involvement in radionavigation services is briefly discussed in the 1986 FRP. There are no recommendations on the role of the private sector in providing radionavigation services, but several factors are mentioned for consideration. The Federal Communications Commission (FCC) has authorized commercial Radiodetermination Satellite Service (RDSS) and such a service could provide navigation capability, although it is unlikely that RDSS will replace the federal government's role in providing radionavigation services for basic safety of navigation. RDSS systems differ from federal radionavigation systems in that a one or two way communications channel is generally supplied by the RDSS system, thus providing fleet management capabilities, the major RDSS advantage over

a pure radionavigation system. Some of the factors remaining to be examined to ensure the appropriate future roles of private and federally operated radionavigation systems are:

- o Privately-operated service's impact on usage and resultant demand for federally operated services.
- o Resolving competition related questions between private sector services and a federally provided free service.
- o Possible private sector operation of federally-operated services.
- o RDSS liability in providing navigation services and the federal government's regulatory role.

These factors could have a significant impact on future radionavigation policy and a detailed examination of the relationship between federal systems and RDSS must be undertaken. However, since RDSS is not presently fully operational, questions relating to these factors cannot be properly answered at this time.

Land Navigation

Land navigation applications are recognized in the 1986 FRP, however requirements are still in the developmental stage. Also, there is no designated federal agency to represent the land navigation users. The Research and Special Programs Administration is coordinating these requirements with other federal agencies and civil users. The application with the largest number of users appears to be in vehicle navigation systems, however requirements have not been fully developed. Automobile manufacturers are studying the use of GPS or Loran-C based systems for intra-city navigation of automobiles.

Uses Other than Navigation

The FRP recognizes applications other than navigation: these applications include radiolocation in two forms (surveying/site registration and automatic vehicle monitoring/location) and time/frequency dissemination. These applications will further enhance transportation safety, especially in applications dealing with shipments of hazardous cargoes and improved coordination and response to accidents or disasters. Other areas of radionavigation use showing definite economic benefits include wildlife migratory, forestry conservation and crustal motion studies.

Current and Future Radionavigation Systems

Loran-C

The domestic Loran-C system expansion in the mid-continent continues on schedule, with full operation planned by 1990. Military requirements for overseas Loran-C will cease in 1994 and present plans are to turn operation of these overseas stations over to host nations and to phase out the Hawaii Loran-C chain. However, the domestic Loran-C system should remain in operation well into the next century. Loran-C user population is expected to increase substantially by 1991 as a result of new land based applications and an increased acceptance by the aviation community. This increase in users is a direct result of lower receiver costs. Comments from the 1986 and 1988 users' conference indicates an increased interest and acceptance of the Loran-C system, especially in land based and timing applications. Differential Loran-C systems are in use today. The Coast Guard is using differential Loran-C to set aids to navigation. State governments

are using such systems to monitor ocean dumping practices and procedures.

Congressional interest in Loran-C remains at a high level and several studies have been funded over the next several years. Interoperability of Loran-C and GPS is the ultimate goal of the studies, with potential application of a sole means integrated system being provided for aviation users.

GPS

The first GPS block II satellite is scheduled to be launched in late 1988 or early 1989. A 21-satellite constellation (18 operational plus 3 spares) is scheduled to be in place by 1992. Thus, GPS should be fully operational in 1992 in three dimensions for military and civil users.

Studies have shown that a constellation of 24 operational GPS satellites can meet civil aviation requirements for sole-means navigation in the national air space. Funding for additional satellites has been recommended by DOD. A request from the GPS timing and frequency community to leave several GPS satellites on orbit with no selected availability is being considered by the GPS Steering Committee.

Developments for civil sector use are proceeding, although at a slower than expected pace. The DOT has agreed to a request from the DOD to establish a Civil GPS Service (CGS) to provide civil user access to Standard Positioning Service (SPS) data and information. Initial studies indicate that GPS/SPS information would be provided through a computer bulletin board service. The CGS will also manage the program for providing the Precise Positioning Service (PPS) to certain approved users; details of PPS access are still being formulated.

Current And Future Radionavigation Planning

GPS will become operational in 1992 when 18 satellites and three spares are on orbit. Since GPS receivers are not currently economical for most general aviation and the majority of marine users, civil use of GPS will be limited initially to special user groups. When economical GPS receivers are available, probably within three to five years of GPS being declared operational, the number of GPS users is expected to increase dramatically. Discontinuance of federal funding for domestic Loran-C or worldwide Omega service, in lieu of GPS service, is not likely to occur until sometime in the twenty-first century and not until the following issues are resolved:

- o Resolution of GPS accuracy, integrity and financial issues
- o GPS meeting the needs of civil air, marine, and land users currently met by existing systems
- o Economical GPS receivers becoming available
- o Resolution of international commitments
- o Designation of an appropriate transition period for any phased out system (currently 15 years).

Another matter which must be reconciled is the selection of radionavigation systems by DOT to meet civil requirements. Although the FRP policy statement has, for several issues, indicated that DOT might decide to discontinue federal operation of Loran-C and Omega, recall that the selection process calls for a cost-effective, user-sensitive, mix of systems for the post-2000 time frame. Thus one cannot rule out a civil user requirement for redundant systems based on the

fundamental rule that the prudent navigator not depend on one system or method for all navigation needs.

The selection process provides for biennial reviews of the current national decision, with any changes being promulgated in the next edition of the FRP. This process was applied to the preliminary decision in the 1984 FRP to reach the current decision on the mix of systems. Because the questions relating to GPS issues cannot be fully answered until the early 1990's, no change in policy for the current mix of systems is anticipated prior to 1992.

Only one users' conference has been held to obtain civil user input to the 1986 FRP. This public hearing was held in conjunction with the annual FAA user conference in Washington, DC during March 1988. Comments from civil users of radionavigation systems can have a significant impact on the contents of the FRP and accordingly, active participation by the civil sector in providing input into the FRP is highly encouraged. Although private sector input cannot be guaranteed to directly influence the national decision on radionavigation policy, consideration of civil user comments and opinions are very important in the overall planning process to ensure that all user requirements are properly satisfied.

Projection of user populations can markedly affect decisions relating to continued operations of any radionavigation system. User equipment costs will continue to have a direct impact on any future recommendations relating to an optimal radionavigation system mix. The effect of an operational GPS on radionavigation systems will not be fully known until after several years of GPS operation; even then, redundancy requirements could preclude the shutdown of particular systems.

Conclusions

The 1986 FRP did not recommend a final optimum mix of radionavigation systems because of the rapid changes occurring in today's technology. This rapid technological change is evident in the availability of lower cost radionavigation receivers. For GPS to successfully compete as a civil radionavigation system, receivers comparable in cost to Loran-C receivers must be readily available to civil air and marine users. The decrease in receiver costs has been of significant importance in fostering the large increase in Loran-C users. Reduction in receiver costs for the other radionavigation systems is probably imminent. Economical receivers will attract more users to a particular system, causing further difficulties in the decision making process to reduce the number of radionavigation systems. With the selection process calling for a mix of systems to meet user requirements, the number of users of a particular system will be a major factor in deciding on the final system mix.

With a dynamic process for formulating policy decisions for selection of the optimal mix of federally funded radionavigation systems, civil user populations will play a major role in shaping the biennial FRP policy statement for domestic systems. The FRP will continue to be updated every two years, allowing for civil review and influence in the radionavigation system selection process. Decisions on the phasing out of current radionavigation systems will not occur until after GPS has been operational for several years and a solid base of GPS users is in place, along with a concurrent decrease in users of other systems. Thus, the mid 1990's is the earliest possible date to validly change the current radionavigation system mix for the post year 2000 time frame.

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