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DOT SHOULD TERMINATE FURTHER LORAN-C DEVELOPMENT AND MODERNIZAT--ETC(U)
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BY THE U.S. GENERAL ACCOUNTING OFFICE

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Report To The Secretary Of Transportation

AD A107768

LEVEL II

DOT Should Terminate Further LORAN-C Development And Modernization And Exploit The Potential Of The NAVSTAR/Global Positioning System

The U.S. Coast Guard is planning to modernize its existing LORAN-C navigation system, even though LORAN-C can potentially be replaced by the Department of Defense's NAVSTAR/Global Positioning System (GPS) in the early 1990s. The Coast Guard and the Research and Special Programs Administration have also devoted little effort to evaluating and developing GPS' capability as a civil marine and land navigation system.

Because LORAN-C can be effectively maintained and reliably operated at least until the early 1990s and because the Coast Guard has not been able to validly demonstrate the cost effectiveness of the replacement program on a station-by-station basis, GAO recommends that the Coast Guard terminate its planned replacement of existing LORAN-C equipment. GAO also recommends that the Coast Guard discontinue developing new LORAN-C applications and focus efforts and resources on demonstrating GPS' potential as a marine and land navigation system.

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UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

MISSION ANALYSIS AND
SYSTEMS ACQUISITION DIVISION

B-203651

The Honorable Drew Lewis
The Secretary of Transportation

Dear Mr. Secretary:

We have completed a followup review on our March 21, 1978, report entitled "Navigation Planning--Need for a New Direction" (LCD-77-109). That report concluded that the Department of Defense's (DOD's) satellite based NAVSTAR/Global Positioning System (GPS) could be a national asset and could replace many existing navigation systems at substantial savings. The report considered these systems, including the Department of Transportation's (DOT's) LORAN-C system, to be unneeded by the early 1990s, and cautioned against further investment in LORAN-C. It also recommended that the Secretary of Transportation become more involved in the GPS program to ensure the timely availability of low-cost civil receivers.

Since that report was issued 3 years ago, DOT has continued to develop, expand, and improve navigation systems which GPS could replace. Further, DOT has devoted little effort to evaluating GPS' capability as a marine and land navigation system and has not initiated a program to develop and demonstrate the technology necessary to ensure the availability of low-cost receivers for marine and land users.

More specifically, we found that the Coast Guard:

--Plans to make a recommendation in 1982 to the Secretary of Transportation which should clarify the future role of GPS versus LORAN-C, without adequately developing the technology necessary to ensure the availability of low-cost GPS receivers that are essential to effect widespread acceptance of GPS by the civil marine community.

--Plans to continue operating LORAN-C until at least the year 2000, at a cost of approximately $35 million a year currently and escalating to approximately $60 million a year by 1984, although GPS is scheduled to provide coverage equivalent to LORAN-C as early as 1986. DOD plans to discontinue its use of LORAN-C in the early 1990s.

--Plans to spend at least $25 million to replace certain existing LORAN-C transmitters without adequately demonstrating either the need for or the cost effectiveness of the replacement.

Also, DOT's Research and Special Programs Administration (RSPA) has devoted little money and resources to evaluating GPS' potential as a land navigation system. At the same time, it has spent greater effort and funds to develop and demonstrate LORAN-C's potential as a land navigation system, which would require further LORAN-C expansion costing at least $22 million to provide total land coverage. This would further duplicate GPS' global coverage. RSPA plans to submit a coordinated recommendation by the end of 1982 to the Secretary of Transportation on the potential use of GPS versus LORAN-C for land applications. In 1983 DOT and DOD will jointly make a preliminary decision on the best future mix of radionavigation systems for air, marine, and land use.

Over the past 4 years, the Coast Guard and RSPA, combined, have funded approximately $6.7 million to develop and demonstrate LORAN-C for new marine and land applications, while funding only $1.2 million to evaluate GPS' potential for similar applications. In our opinion, the continued emphasis on developing new LORAN-C applications and the limited efforts to evaluate GPS could bias future decisions toward further expansion and operation of LORAN-C longer than necessary. As stated in our 1978 report, GPS has the potential to replace LORAN-C by the early 1990s. Further development efforts should be redirected to ensure a more adequate evaluation of GPS' potential as a marine and land navigation system, especially the low-cost receiver technology necessary for wide civil acceptance and use.

Also, if the Coast Guard's recommendation in 1982 is supportive of GPS, the Coast Guard should, at that time, propose to the Secretary of Transportation a tentative schedule for phaseout of LORAN-C. If DOT's 1983 preliminary decision supports GPS, DOT should, at that time, announce the tentative schedule. An early announcement will ease the transition for the user community.

Based on our review, we believe that the Coast Guard's plan to operate LORAN-C until at least the year 2000 is based on questionable assumptions and that the Coast Guard could phase out LORAN-C for civil use by the early 1990s. Phaseout of LORAN-C by the early 1990s would be consistent with DOD's plans to phase out its use of LORAN-C in the early 1990s.

Also, the Coast Guard was not able to validly demonstrate on a station-by-station basis, the cost effectiveness of the transmitter replacement program or the necessity of new transmitters to improve navigation safety. Thus, in our opinion, the planned improvement of LORAN-C is not needed at this time.

Accordingly, we recommend that you direct the Coast Guard to:

--Discontinue developing new LORAN-C marine applications which GPS has the potential to satisfy and focus efforts and resources on developing and demonstrating low-cost GPS user equipment technology which is essential to civil acceptance and use of GPS.

--Develop a tentative timetable to phase out LORAN-C by the early 1990s, and if DOT's preliminary decision in 1983 supports GPS, inform the public at that time of the tentative timetable so as to allow users to make informed decisions on replacement of current LORAN-C receivers.

--Terminate its planned replacement of certain existing LORAN-C transmitters with new solid-state transmitters, unless the Coast Guard can validly demonstrate on a station-by-station basis that this upgrade will be cost effective by the early 1990s.

We recognize that our recommendations are dependent on GPS being deployed and providing appropriate coverage by 1986. In the past, the Congress has strongly supported GPS, although the House and Senate Armed Services Committees have disagreed over the system's funding for fiscal year 1982.

Because of GPS' great potential to replace existing systems, the fiscal year 1980 Appropriations Committees Conference Report directed DOD to avoid buying any new equipment that GPS could replace. The DOD 1981 Authorization Act Conference Report recommended increased funding for GPS and strongly urged DOD to preserve the program's integrity and provide GPS capability as early as possible. The Senate Armed Services Committee 1982 report again strongly endorsed GPS. However, the House Armed Services Committee 1982 report recommended that DOD's fiscal year 1982 budget request for GPS not be funded. Thus, the Committee of Conference must resolve this issue.

If adequate GPS coverage is not available until after 1986, the Coast Guard could revise its tentative LORAN-C phaseout schedule to allow users a sufficient transition period. Also, ample time would remain for the Coast Guard to assess the need for and cost effectiveness of any LORAN-C modernization activities, including the replacement of existing transmitters.

Appendix I contains details which support the above conclusions and recommendations and describes the objectives, scope, and methodology used in performing this evaluation. We have obtained agency comments and, to the extent possible, incorporated them in the report along with our evaluation of those comments.

B-203651

As you know, section 236 of the Legislative Reorganization Act of 1970 requires the head of a Federal agency to submit a written statement on actions taken on our recommendations to the Senate Committee on Governmental Affairs and the House Committee on Government Operations not later than 60 days after the date of the report and to the House and Senate Committees on Appropriations with the agency's first request for appropriations made more than 60 days after the date of the report.

Please send us copies of your statements that were sent to congressional committees.

Sincerely yours,

W. H. Sheley, Jr.
Director

DOT SHOULD TERMINATE FURTHER LORAN-C DEVELOPMENT AND MODERNIZATION AND EXPLOIT THE POTENTIAL OF THE NAVSTAR/GLOBAL POSITIONING SYSTEM

BACKGROUND

Within DOT, the U.S. Coast Guard is authorized to establish and operate civil marine radionavigation systems. Also, RSPA is coordinating the identification of land navigation requirements. LORAN-C and GPS are both candidates for meeting civil marine and land navigation requirements in the future.

LORAN-C is the Government-provided, Coast Guard-operated marine radionavigation system for the U.S. Coastal Confluence Zone. It provides approximately 1 quarter nautical mile accuracy to users equipped with the proper LORAN-C receiver and charts. Also, the Coast Guard operates LORAN-C in selected overseas areas for DOD use. However, DOD plans to phase out most of its use of LORAN-C in the early 1990s, since GPS is scheduled to begin operation in 1986.

GPS is a DOD satellite navigation system which will provide a highly accurate (less than 20 meters) worldwide navigation capability. Although DOD requires an extremely precise navigation capability for improved mission effectiveness, the signals made available to civil users will be less precise. Accuracies of approximately 1 quarter nautical mile or better will be available to civil users when GPS becomes operational. This accuracy level was chosen by DOD because it protects national security interests, while satisfying the majority of civil navigation requirements, including those of oceanic and coastal navigation. Also, the accuracy provided to users may improve each year following initial operation. DOD may also initially allow better accuracies to selected civil users based on benefits derived. Thus, GPS has the potential to replace most radionavigation systems, including LORAN-C, that are used for such purposes as oceanic and coastal marine navigation, and may eventually satisfy harbor and land navigation requirements. GPS is scheduled to begin two dimensional, latitude and longitude, coverage in 1986, with three dimensional, latitude, longitude, and altitude, coverage available in 1987. Marine and land navigation require only two dimensional coverage.

Our March 21, 1978, report "Navigation Planning--Need for a New Direction" (LCD-77-109), concluded that navigation systems had proliferated, adding to Government costs, but that DOD's GPS offered the potential to replace numerous existing systems, including DOT's LORAN-C, at substantial savings. The report also concluded, however, that better planning and management were needed if GPS' benefits as a national asset were to be realized, and that strong navigation management at the executive level of

the President was needed to overcome agency parochialism and to develop and carry out a Government-wide plan for navigation.

Subsequent to our March 21, 1978, report, section 507(a) of the International Maritime Satellite Telecommunications Act, Public Law 95-564, required the President, in conjunction with the appropriate Government agencies, to develop a Government-wide navigation plan. The President was to forward the plan to the Congress by no later than November 1, 1979. On January 6, 1981, the Director of the Office of Management and Budget transmitted the Federal Radionavigation Plan, signed jointly by the Secretaries of DOT and DOD, to the Congress.

This plan points out that the Coast Guard and DOT will recommend, by the end of 1982, the future mix of radionavigation systems for marine and land use, respectively. According to the plan, these recommendations should clarify the future need and role of both GPS and LORAN-C for marine and land navigation. In 1983 DOT and DOD will jointly make a preliminary decision on the best future mix of radionavigation systems. From 1983-86, DOD and DOT will coordinate and consult with groups affected by the preliminary decision, issuing a national decision in 1986.

GPS' role in that mix will depend upon when it is deployed. As mentioned, GPS is scheduled to provide two dimensional coverage in 1986. In the past, the Congress has urged DOD to keep GPS on schedule. However, for fiscal year 1982, the House Armed Services Committee has recommended that DOD's fiscal year 1982 request for GPS not be funded, while the Senate Armed Services Committee has expressed support for GPS. The Committee of Conference must resolve this issue.

OBJECTIVES, SCOPE, AND METHODOLOGY

The objectives of this assignment were to

--evaluate DOT's efforts to develop and demonstrate the NAVSTAR/GPS's potential as a civil marine and land navigation system;

--evaluate DOT's effort to develop tentative plans for LORAN-C phaseout; and

--evaluate the necessity of DOT expenditures to further develop, modernize, and expand LORAN-C.

This review was a followup to our March 21, 1978, report entitled "Navigation Planning--Need for a New Direction" (LCD-77-109). Our April 30, 1979, report to the Congress "Should NAVSTAR Be Used for Civil Navigation? FAA Should Improve Its Efforts to Decide" (LCD-79-104), addresses the Federal Aviation Administration's (FAA's) efforts to evaluate GPS as a civil air navigation system. Since our earlier reports contained an evaluation of GPS

as an air navigation system, GPS' use for this purpose was not included in this evaluation.

This evaluation was performed primarily at the following locations.

--U.S. Coast Guard, Washington, D.C.

--U.S. Coast Guard Supply Center, Brooklyn, New York.

--RSPA, Washington, D.C.

--FAA, Washington, D.C.

--DOD, Washington, D.C.

--Department of the Air Force, Washington, D.C.

--Air Force Systems Command/Space Division, Los Angeles, California.

We reviewed the Federal Radionavigation Plan, including the past results and projected plans of the Coast Guard's program to evaluate GPS. To learn the status of GPS, we examined current system development and acquisition plans as well as recent test results. To evaluate the potential for phasing out LORAN-C and the necessity of procuring new LORAN-C equipment, we

--examined the Coast Guard's development and modernization plans for LORAN-C,

--examined the Coast Guard's cost/benefit analysis for the LORAN-C replacement program,

--collected and analyzed reliability and operational cost data for the stations to be modernized,

--collected and analyzed reliability and operational cost data for existing solid-state stations, and

--examined reported results of recently completed LORAN-C experiments.

To identify user needs and concerns, including the future availability of low-cost GPS receivers, we participated in selected seminars attended by users and Government and private industry officials, talked to selected manufacturers of navigation equipment and officials of the National Aeronautical and Space Administration, and examined DOT's studies related to the low-cost user equipment issue.

COAST GUARD'S GPS EVALUATION LACKS PRIORITY

The Coast Guard is evaluating GPS to determine its capability to satisfy the requirements of oceanic, coastal, and harbor navigation. Coast Guard officials explained that two major issues must be resolved before GPS can be accepted as the primary marine navigation system: (1) the availability of low-cost GPS receivers that offer adequate performance and (2) the level of GPS accuracy that DOD will make available to civil users. However, the Coast Guard has devoted little staff and funding to evaluating GPS and has made little progress in resolving these issues, which are critical to widespread acceptance and use of GPS by civil users. At the same time, the Coast Guard has devoted several times more staff and funding to develop and demonstrate new, additional LORAN-C applications.

Our March 1978 report recognized GPS' potential as a national asset and pointed out that wide civil acceptance of GPS depended heavily on the availability of low-cost GPS receivers. Because the early availability of low-cost GPS receivers could curtail unneeded spending on existing systems and allow their phaseout several years sooner than if receiver development were simply left to market demand, the report pointed out that the Government may have to take action to ensure the availability of a low-cost shipboard GPS receiver. According to the Federal Radionavigation Plan, to resolve the low-cost user equipment issue, the Coast Guard should, among other things, develop and demonstrate low-cost GPS receiver technology and develop a realistic cost estimate for a low-cost GPS civil marine receiver.

However, the Coast Guard has made little progress in developing and evaluating low-cost GPS receiver technology. Proposed project plans indicate that in fiscal year 1982, approximately 4 years since our last report and 3-1/2 years since receiving congressional guidance, the Coast Guard will begin a project to specifically study and demonstrate low-cost GPS receiver technology for marine use. This project will provide information on low-cost receiver design and performance trade-offs critical to resolving the low-cost equipment issue. However, the final project report will not be completed until 1985. On the other hand, since 1979 FAA has been pursuing low-cost aviation receiver technology, including the development and testing of a low-cost GPS general aviation receiver. Coast Guard officials explained that although the Coast Guard has made progress in resolving some GPS issues, the low-cost user equipment issue remains an obstacle and that a lack of resources limits their progress in resolving this issue. However, program plans show that since 1977, the Coast Guard has spent approximately $1.5 million and 6-1/2 staff years to develop and demonstrate low-cost LORAN-C user equipment for harbor navigation.

Without any documentation to support the estimate, the Coast Guard informed us that a low-cost GPS receiver comparable to a good quality LORAN-C receiver would cost approximately $10,000. This estimate is extraordinarily high compared to some private

manufacturers and other DOT estimates. Representatives from several companies that produce navigation equipment and have developed various low-cost receiver designs explained that if the Coast Guard's 1982 recommendation supports GPS, their companies could manufacture, by 1986, GPS receivers which would sell to the user in a price range from $2,000 to $3,000 and would provide equivalent performance to a high quality LORAN-C receiver. A DOT study estimates a GPS civil marine receiver will cost approximately $3,100. A high quality LORAN-C receiver can cost as much as $8,000 to $9,000 while a good quality LORAN-C receiver costs approximately $2,500.

As for the Coast Guard's concerns over the level of accuracy GPS will provide to the civil marine user, DOD's current policy, as previously stated, is to allow civil users a level of GPS accuracy that is very similar to LORAN-C and therefore capable of supporting oceanic and coastal navigation. DOD will decide on improvements to this accuracy by 1983 which is 3 years before GPS begins providing two dimensional coverage. According to DOD officials responsible for developing GPS, differential GPS could provide very high accuracies in a localized geographic area, such as a harbor. Such accuracy represents a significant improvement over existing LORAN-C coverage. DOD's early tests of differential GPS indicate that it does provide much higher accuracies. Yet, the Coast Guard has not initiated any projects to evaluate the potential of differential GPS for harbor navigation.

Coast Guard officials explained that insufficient resources have hindered the Coast Guard's overall efforts to evaluate GPS. Yet, the Coast Guard has used greater resources to develop LORAN-C than it has to evaluate GPS. Since the project's start in 1978, the Coast Guard has spent approximately $1.2 million and 1-1/2 staff years to evaluate GPS. Results thus far are encouraging. However, since 1977 the Coast Guard has spent approximately $5.4 million and 49 staff years to develop new LORAN-C applications, primarily for harbor navigation. Results of this work indicate that high accuracies are potentially achievable, but implementation costs and the work involved may be prohibitive when compared to the benefits derived.

Conclusions and recommendations

The Coast Guard has devoted little money and resources toward evaluating GPS' potential as a marine navigation system, especially the low-cost GPS receiver technology that is essential to the wide acceptance of GPS by the civil marine community. Early availability of low-cost GPS receivers could allow an early phaseout of LORAN-C resulting in significant operational savings to the Coast Guard.

At the same time, the Coast Guard has continued its emphasis on developing and demonstrating new, additional LORAN-C applications. In our opinion, proceeding in this manner could bias

future decisions toward further expansion and operation of LORAN-C longer than necessary.

Accordingly, we recommend that the Secretary of DOT direct the Coast Guard to discontinue developing and demonstrating new and additional LORAN-C marine applications which GPS has the potential to satisfy and focus efforts and resources on developing and demonstrating GPS' potential as a marine navigation system, especially the low-cost GPS user equipment technology essential to civil acceptance and use of GPS.

Agency comments and our evaluation

DOT strongly disagrees with these conclusions and recommendations and, more specifically, commented that (1) it is premature and possibly not in the best interest of the Government to develop low-cost GPS receivers for civil use, (2) based on DOD's current policy on signal accuracy, GPS will not meet certain existing and potential requirements, while differential GPS may not help to provide higher accuracies, and (3) the Coast Guard has spent $1.6 million to evaluate GPS.

As our prior report pointed out, the Government may have to take action to ensure the availability of low-cost GPS marine receiver technology so as to curtail the planned spending for unneeded systems and permit their phaseout several years sooner than if receiver development were simply left to market demand. Also, contradictory to DOT's comment, since 1979, FAA has been developing and testing a low-cost GPS receiver that will be suitable for low budget general aviation users. Also, at the time of the transition from LORAN-A to LORAN-C, the Coast Guard was instrumental in developing a low-cost LORAN-C receiver acceptable to civil users.

Regarding DOT's comment that GPS may not satisfy certain marine navigation requirements, according to the Federal Radionavigation Plan, discussions with DOD navigation planning officials, and an August 1980 Coast Guard study, even with reduced accuracy, GPS will satisfy existing navigation safety requirements currently met by LORAN-C and could satisfy future requirements. DOD navigation planning officials explained that DOD is currently developing policy regarding the civil use of differential GPS to obtain the higher accuracies needed for applications such as harbor navigation.

Finally, included in DOT's estimate of $1.6 million for GPS evaluation are projects whose purpose, according to the Coast Guard's master project plans, is to develop and demonstrate LORAN-C as a precision aid for harbor navigation. Consequently, we do not believe these projects can be included as work to evaluate GPS. According to these plans, through fiscal year 1981, the Coast Guard has funded approximately $1.2 million to evaluate GPS.

COAST GUARD COULD POTENTIALLY PHASE OUT LORAN-C BY THE EARLY 1990s

Our March 1978 report pointed out that GPS could replace LORAN-C by the early 1990s. However, the Coast Guard plans to continue operating LORAN-C until at least the year 2000. This plan to continue the operation of LORAN-C until at least the year 2000 is based on questionable assumptions. Based on our review, if DOT's 1983 preliminary decision supports GPS, the Coast Guard could phase out LORAN-C by the early 1990s. This would be consistent with DOD's plans to phase out its use of LORAN-C in the early 1990s.

The plan to operate LORAN-C until at least the year 2000 is based on (1) the adoption and use of LORAN-C by a large user population and (2) the absence of any near-term prospect for its replacement. Also, Coast Guard officials explained that LORAN-C should be operated until the year 2000 because of uncertainty over if and when GPS will be available for civil use, unsatisfactory GPS accuracy to be allowed civil users by DOD, the high cost of GPS receivers, and problems associated with telling users who have just switched from LORAN-A to LORAN-C that they must now switch to GPS. We note that during the transition from LORAN-A to LORAN-C, the Coast Guard gave little regard to similar problems which were cited by LORAN-A users against the transition from LORAN-A to LORAN-C.

According to the Federal Radionavigation Plan, the projected large LORAN-C user group refers to new and expanded applications, including harbor, aviation, and land navigation. However, GPS has the potential to satisfy these same applications, and according to a recent DOT study of LORAN-C expansion into the Caribbean, some marine operators intend to defer their acquisition of any additional radionavigation receivers until GPS is available. Thus, a projected large user population does not justify the operation of LORAN-C until at least the year 2000 because the projection is based on new and expanded applications which GPS has the potential to satisfy.

Regarding the absence of any near-term replacement, GPS is currently scheduled to provide, in 1986, accuracies equivalent to LORAN-C for oceanic and coastal navigation, and greater accuracies could be allowed if justified. The GPS accuracy levels allowed for civil users were selected based on stated requirements and national security issues.

Concerning the cost of GPS receivers for civil users, we interviewed industry representatives and engineering groups who are directy involved with the development and demonstration of GPS receiver technology. These officials explained that a GPS civil marine receiver, comparable in price to a good quality LORAN-C receiver, could be available when GPS is phased in if GPS is designated as the Government-provided marine radionavigation

system. The previous section of this appendix on the Coast Guard's program to evaluate GPS addresses this issue in more detail.

We also recognize the potential hardship which could be imposed on some civil users if they are required to switch from LORAN-C to GPS. Conversely, operating duplicative systems also imposes a hardship on the general taxpayer. While the Government is responsible for providing safe and adequate navigation coverage to users, it should do so in the most economical manner. At the same time, the Government could minimize the impact on the user of transitioning to a new system by informing the users as early as possible of the proposed phaseout schedule and by dual operation of both systems long enough for users to plan their equipment procurements.

By announcing in 1983 a tentative schedule to phase out LORAN-C by the early 1990s, the Coast Guard could provide civil marine users approximately a 10-year period to accomplish the transition from LORAN-C to GPS and amortize their investment in LORAN-C equipment. A 10-year transition period should be adequate. The LORAN-A to LORAN-C transition period was only 6 years with dual system operation of 2 to 4 years.

Also, LORAN-C receivers are typically replaced every 7 years. One equipment manufacturer stated that receivers were replaced every 5 years. Thus, even those users who purchased new LORAN-C equipment as late as 1987 could recoup most of their investment by 1992. By that time, user equipment costs could, according to private manufacturers, fall even further as technology advances and demand rises, as was the case when users transitioned to LORAN-C. Thus, if adequate steps are taken, DOT could phase out LORAN-C and achieve significant savings while minimizing the impact on users which should be less than the impact of the shorter LORAN-A to LORAN-C transition.

These plans are dependent on the availability of low-cost GPS user equipment and GPS' two dimensional operation in 1986. As pointed out earlier, the Coast Guard has done little to ensure the availability of low-cost user equipment. However, approximately 5-1/2 years remain before GPS begins providing two dimensional coverage and approximately 11-1/2 years remain before the potential phaseout of LORAN-C. Sufficient time remains to develop the necessary low-cost GPS receiver technology if the Coast Guard makes the work a priority. Also, if GPS' operational time frame is revised, the Coast Guard could revise its phaseout schedule for LORAN-C to allow a sufficient transition period for users.

Conclusions and recommendations

In our opinion, the Coast Guard's plan to operate LORAN-C until at least the year 2000 is based on questionable assumptions and the Coast Guard could potentially phase out LORAN-C by the early 1990s. By announcing in 1983 its tentative plans to phase

out LORAN-C by the early 1990s, the Coast Guard can ease the transition for the user community as well as avoid the high future operating costs of LORAN-C.

Accordingly, we also recommend that the Secretary of DOT direct the Coast Guard to develop a tentative timetable to phase out LORAN-C by the early 1990s and, if DOT's preliminary decision in 1983 supports GPS, inform the public at that time of this tentative timetable so as to allow users to make informed decisions on replacing current LORAN-C receivers.

Agency comments and our evaluation

DOT strongly disagrees with these conclusions and recommendations and commented that because of numerous national commitments and international agreements and a growing number of marine users, it would be premature to decide today to terminate LORAN-C and choose a replacement. Also, DOT believes a 10-year transition period should begin with the 1986 national decision on the future mix of navigation systems, thus extending the phaseout of LORAN-C to the late 1990s.

The recommendations in this report do not call for a decision today on terminating LORAN-C. Rather, our recommendations are structured around DOT's preliminary decision in 1983 and also consider the timing of GPS' availability. Neither are there any formal national or international commitments which require the continued operation of LORAN-C through a set date, similar to that for the FAA's VOR/DME aviation system. According to the Federal Radionavigation Plan, VOR/DME is protected until January 1, 1985, under agreement with the International Civil Aviation Organization. The plan does not identify any such agreements for LORAN-C.

Also, as pointed out in the above section, a projected large user population does not justify the operation of LORAN-C beyond the early 1990s because the projection is based on new and expanded applications which GPS has the potential to satisfy. Finally, if the DOT and DOD joint preliminary decision in 1983 supports GPS, DOT can announce at that time its tentative plans to phase out LORAN-C by the early 1990s. This would allow users approximately a 10-year period to plan their equipment procurements and amortize the cost of their LORAN-C equipment. In our opinion, this transition time frame is reasonable, considering that DOT transitioned from LORAN-A to LORAN-C in 6 years with dual system operation for only 2 to 4 years.

COAST GUARD REPLACEMENT OF EXISTING TRANSMITTERS IS UNNECESSARY

Our March 1978 report questioned the need for any expenditures to modernize existing navigation systems which GPS could replace, unless such expenditures were cost effective or justified on a navigation safety basis. The Coast Guard, however, plans to modernize from 10 to 17 LORAN-C stations by replacing the existing

AN/FPN-42 vacuum-tube transmitters with new AN/FPN-64 solid-state transmitters. Total program costs for procurement and installation were estimated to be approximately between $25 and $42.5 million for 10 and 17 transmitters, respectively. Because existing equipment will be able to provide effective and reliable navigation until the early 1990s and because the Coast Guard was unable to validly demonstrate the cost effectiveness of the replacement program on a station-by-station basis, in our opinion, the replacement program is not necessary at this time.

Currently, LORAN-C satisfies navigation safety requirements and operates at a reliability level of greater than 99 percent a year and, according to operations and headquarters officials, should continue to do so until at least the early 1990s. Based on our review of operational reliability reports and discussions with personnel responsible for operating and maintaining LORAN-C, the major causes of any off-air time at the vacuum-tube LORAN-C stations are personnel error and interruptions and inconsistencies in commercially provided electric power, not the AN/FPN-42 transmitter. At the existing solid-state LORAN-C stations, the major causes of off-air time are the AN/FPN-64 solid-state transmitter itself as well as personnel error. The amount of unusable time caused by problems with the solid-state transmitters can be attributed to the greater sensitivity of solid-state transmitters to commercial power failure.

In its fiscal year 1982 budget material, the Coast Guard stated that spare parts critical to LORAN-C operation were becoming increasingly difficult to obtain. However, Coast Guard officials in charge of maintenance and supply explained that there is currently no problem obtaining those parts for any existing LORAN-C transmitter. They also said, as did headquarters and station personnel, that given present conditions, LORAN-C could be effectively maintained until the early 1990s.

Since LORAN-C could be phased out by the early 1990s, the Coast Guard should demonstrate the cost effectiveness of the solid-state transmitter investment on a station-by-station basis. At the time of our review, however, the Coast Guard was unable to provide any documentation which demonstrated the cost effectiveness of the vacuum-tube transmitter replacement program. Subsequently, during fiscal year 1982 appropriations hearings before the House Appropriations Subcommittee on Transportation, the Coast Guard submitted material that indicated the solid-state transmitters would, through operational and maintenance savings, pay for themselves by 1996. However, as Coast Guard officials later agreed, the installation costs for each station were excluded from the analysis. When these are included, we estimate that the program will not pay for itself until 2004.

Since the appropriations hearings, the Coast Guard has significantly revised both the costs of the replacement program and the savings that would result from the program. The current Coast Guard economic analysis estimates that the replacement program

will pay for itself by approximately 1987 to 1993. However, in our opinion, the analysis and its results are highly questionable because the Coast Guard did not evaluate the costs and benefits of the replacement program on a station-by-station basis. Consequently, operational savings were overstated, while projected savings due to staff reductions may not occur. Also, the Coast Guard understated the solid-state transmitter installation costs and excluded certain equipment procurements, while including costs for unnecessary refurbishments to existing equipment.

The Coast Guard estimated operational savings by comparing annualized operational and maintenance costs of one solid-state station to those of one vacuum-tube station. We found, however, that several of the vacuum-tube stations have lower operating costs than that used in the Coast Guard's analysis while the operating costs at the Coast Guard's other existing solid-state stations are greater than that used in the analysis. For example, the Coast Guard estimated that electrical power for a vacuum-tube transmitter costs approximately $30,000 a year and $13,000 a year for a solid-state transmitter. We found, however, that electrical power costs for the AN/FPN-42 vacuum-tube stations have run as low as approximately $10,000 a year, while electrical power costs for existing solid-state stations have run as high as approximately $37,000 a year. The Coast Guard also estimated that spare parts for the AN/FPN-42 vacuum-tube transmitters cost approximately $28,000 a year. We found that spare parts for these transmitters could run as low as $16,000 a year. Thus, the Coast Guard's projected payback time frame for this program is based on overstated operational savings.

Based on an ongoing experiment at a Canadian solid-state LORAN-C station, the U.S. Coast Guard has projected that by installing solid-state transmitters, it can reduce the staffing level at these stations from 11 to 4 people. The Coast Guard was unable to provide any documentation demonstrating the results of the Canadian experiment thus far. In our opinion, however, because it is unknown to what extent the staffing level can be reduced at a U.S. Coast Guard owned and operated facility and because the Coast Guard is currently initiating a 2-year experiment to explore the issue, the Coast Guard has yet to adequately demonstrate it will achieve large personnel savings as a result of the replacement program.

According to personnel responsible for operating and maintaining LORAN-C stations, because of differences in operation and maintenance procedures, the Canadian staffing level may not be effective for U.S. stations. Coast Guard operations personnel agreed that if station staffing levels were reduced, certain support functions would be contracted for, and these costs would partially offset the personnel savings. The Coast Guard's current analysis does not include any adjustments for these potential costs.

To evaluate the feasibility of staff reductions at U.S. LORAN-C stations, identify and evaluate those support activities which must be contracted out, and specifically identify what level of staff is required for effective operations, the Coast Guard is initiating an experiment at one of its four existing solid-state stations. This experiment will evaluate, through actual operation, staffing levels of 6 to 8 people and will last approximately 2 years. The remaining 3 solid-state stations will be staffed with 11 or more people, the same as the vacuum-tube stations.

Also, the Coast Guard's analysis did not include the personnel costs for installing the new solid-state transmitters. According to operations and maintenance personnel as well as headquarters staff, the solid-state transmitter installation will take approximately 2 to 3 months and will require four to five engineers in addition to the station staff.

The analysis also excluded costs for new generator sets and switchgear, as the Coast Guard stated this would be accomplished with or without new solid-state transmitters. However, none of the AN/FPN-42 stations are scheduled for new generators at the present time. According to operations personnel, the existing generators can provide reliable service until the 1990s.

Also as part of its economic analysis, the Coast Guard assumed that extensive refurbishments of the existing vacuum-tube LORAN-C stations would be required to operate effectively until the year 2000. The costs for these refurbishments offset a significant portion of the costs to buy and install new solid-state transmitters. However, as previously pointed out, the Coast Guard could phase out LORAN-C by the early 1990s. According to personnel responsible for operating and maintaining LORAN-C, it should provide reliable navigation coverage, without major refurbishment, until the early 1990s.

Conclusions and recommendations

The Coast Guard has been unable to validly demonstrate on a station-by-station basis, the cost effectiveness of the replacement program. Because the existing equipment is satisfying navigation safety requirements and should continue to do so until the early 1990s, and because of GPS' potential as a replacement for LORAN-C, the inability to demonstrate the replacement program's cost effectiveness negates the need for the program at this time.

Accordingly, we further recommend that the Secretary of Transportation direct the Coast Guard to terminate its planned replacement of certain existing LORAN-C vacuum-tube transmitters with new solid-state transmitters, unless the Coast Guard can validly demonstrate on a station-by-station basis that this upgrade will be cost effective by the early 1990s.

Agency comments and our evaluation

DOT commented that the replacement of the vacuum-tube transmitters is necessary to provide reliable LORAN-C service through the late 1990s and because the transmitters cannot be effectively maintained due to their age and the lack of reliable sources for certain spare parts. Also, solid-state transmitters offer economic benefits such as reduced operations and maintenance costs and reduced staffing levels.

As discussed previously, if DOT's 1983 decision supports GPS, LORAN-C can be phased out by the early 1990s. According to personnel responsible for operations and maintenance, LORAN-C can provide safe and reliable navigation until the early 1990s. The existing equipment has undergone various upgrades over the years, and Coast Guard maintenance and supply officials said that there is very little danger of any contractor discontinuing those parts which support the vacuum-tube transmitters. In fact, one manufacturer of vacuum-tubes recently signed a new contract. Although solid-state transmitters can potentially provide certain benefits over the vacuum-tube transmitters, we do not believe that the Coast Guard has adequately demonstrated that these benefits will occur at each station or that the benefits will offset the solid-state transmitter investment. In light of DOT's 1983 preliminary decision on the future use of LORAN-C and the lack of a valid station-by-station cost/benefit analysis, the solid-state transmitters are not necessary at this time.

RSPA'S GPS EVALUATION PROGRAM LACKS PRIORITY

RSPA is conducting a multiyear program to research, develop, and demonstrate radionavigation land applications. RSPA officials agree that GPS' accuracy can potentially satisfy most land navigation applications. However, they have said that two critical issues must be resolved before GPS can function as the primary land navigation system: (1) the development and availability of low-cost user equipment and (2) the adequacy of coverage in "urban canyons." However, RSPA has devoted little effort to evaluating GPS and has made little progress resolving issues critical to the land application of GPS, while emphasizing the development and demonstration of LORAN-C as a land navigation system. However, to implement LORAN-C as a nationwide land navigation system, three to five additional midcontinent LORAN-C stations would be needed. According to a 1979 DOT study, estimated costs for this expansion would be at least $21.8 million.

Thus far, RSPA's evaluation program for GPS land applicability has been limited to the development of a digital computer simulation of GPS receivers to permit evaluation of alternative receiver structures. RSPA is also monitoring FAA's and the Coast Guard's efforts to evaluate GPS. However, the Coast Guard's GPS evaluation lacks emphasis and monitoring it may not yield the information necessary to resolve the above issues.

One method that would yield such data is to design and test low-cost GPS land receivers. Professionals and industry officials involved in navigation research and development said that receiver technology has advanced to the point that actual hardware development of a receiver is well within the state of the art. As mentioned earlier, FAA is developing and testing a low-cost GPS general aviation receiver. One major manufacturer has been developing and testing a low-cost GPS land receiver since 1977. Also, actual testing of a GPS receiver could be done to evaluate the extent of GPS coverage in urban areas. The manufacturer mentioned above has achieved up to 20 meter accuracy in urban areas with a GPS receiver comprised mainly of a desktop calculator and a commonly used microprocessor. RSPA officials explained that limited resources preclude them from taking this type of approach. However, through fiscal year 1981 RSPA will have spent approximately $1.363 million to develop and demonstrate LORAN-C as a land navigation system, while spending only $40,000 to evaluate GPS' applicability to land navigation.

In contrast to its GPS evaluation program, RSPA's development program for LORAN-C land applications has concentrated on the development and demonstration of LORAN-C user equipment specifically for land use and various projects to demonstrate LORAN-C applicability to land navigation. The program includes actual testing of LORAN-C receivers in urban areas to determine the amount of distortion of the LORAN-C signal and evaluation of differential LORAN-C as a technique to obtain better accuracy.

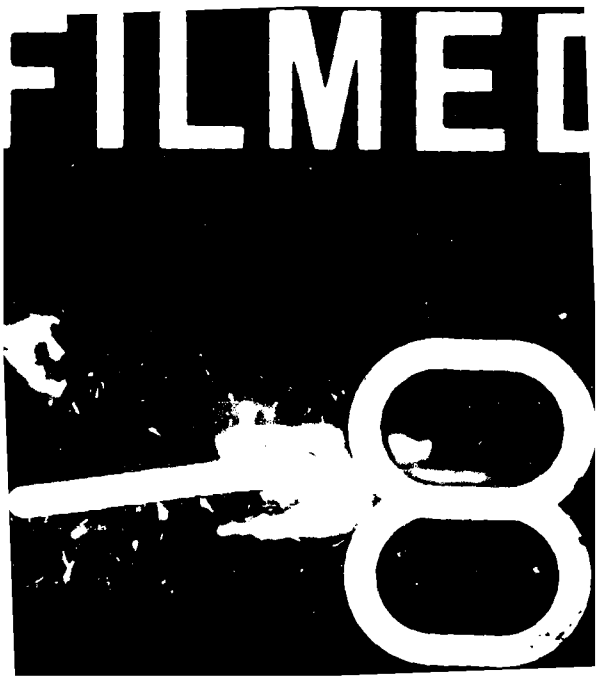
RSPA's approved fiscal year 1982 budget request included $500,000 to continue the LORAN-C evaluation, but RSPA officials were unable to identify any amount of money to be used to evaluate GPS as a land navigation system. However, because of the President's proposed reduction of the Federal budget, RSPA's original fiscal year 1982 budget request was decreased. In implementing these cuts, RSPA reduced the funding for LORAN-C development to $150,000 and programed $100,000 to GPS evaluation. Such actions are necessary to increase the emphasis on the evaluation of GPS' land applicability.

Conclusions

Until recently, RSPA has devoted little resources toward evaluating GPS' potential as a land navigation system. At the same time, RSPA continued its emphasis on developing and demonstrating LORAN-C for land application. It would cost the Government at least $21.8 million to provide total land coverage with LORAN-C, and this would duplicate GPS land coverage. In our opinion, proceeding in this manner could bias future decisions toward further expansion and operation of LORAN-C longer than necessary. DOT subsequently told us that RSPA had recently discontinued all research on the land applications of LORAN-C.

Agency comments and our evaluation

DOT also pointed out that RSPA has spent $874,000 on its LORAN-C research and $833,000 on GPS. However, according to RSPA's multiyear program plan, RSPA spent $1.363 million to research LORAN-C and $40,000 to evaluate GPS. The variance of the LORAN-C figures is due to RSPA's exclusion of one expenditure and reprograming of other funds. Included in RSPA's estimate of GPS expenditures are programs whose purpose was not directed specifically toward the evaluation of GPS' land applicability. Thus, we do not believe these expenditures should be included as work to evaluate GPS.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