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an evaluation of alternative policies

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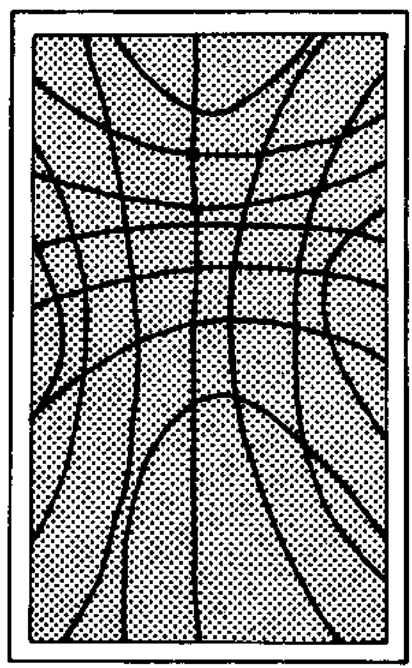

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acknowledgment

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We especially wish to offer thanks to those who assisted us:

- Mariners using Loran-A who cheerfully and generously responded to our many questions;
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- Representatives from the Coast Guard and other agencies;
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related publication

SURVEY OF COMMERCIAL SPORTFISHING BOATS IN THE COASTAL UNITED STATES. Michael B. Fraser, James A. Henderson and John F. McManus. 1977. Publication no. ORESU-T-77-009. $2.00. A survey of charterboat owners and operators, taken as part of the project "Termination of Loran-A", revealed numerous characteristics of the charterboat industry.

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executive summary

The research project, "Termination of Loran-A: An Evaluation of Alternative Policies," analyzed problems associated with the planned termination of Loran-A service and expansion of Loran-C service in U.S. coastal waters. Coast Guard implementation of the project's recommendations will assist civilian users of Loran-A with orderly conversion to Loran-C, while keeping costs to the taxpayer reasonable.

Marine users of Loran-A number about 50,700. There are about 32,000 recreational boaters and 15,000 commercial fishermen. Other large groups of Loran-A users are the marine commercial sportfishing, merchant marine, tug and towboat, and offshore petroleum service industries. All of these users are generally satisfied with the quality of Loran-A service, and their number has grown steadily in recent years.

Most Loran-A users are resigned to the coming changeover to Loran-C: some are enthusiastic, a few are opposed. Users value Loran service highly, and therefore 77-98% (in the various groups) of Loran-A users have made a decision plan to switch to Loran-C. However, many users plan to delay their switch until close to the time set for Loran-A termination, and the Loran-C receivers they plan to use are inconsistent with the superior results they expect.

Even though Loran-C will provide superior navigational service, the changeover will be burdensome. For example, the loss of useful life of presently installed Loran-A sets, the selection and cost of Loran-C receivers, timely availability of needed charts, reconfiguration, coordinate conversion, and tax and other financial questions will cause significant problems for users.

The benefit-cost analysis sought sets of actions that would reduce the financial burdens of Loran-A termination for users by an amount greater than these actions' cost to the Coast Guard, and hence to taxpayers. Based on the results of the analysis the best options are for the Coast Guard to conduct the Loran-C Education Program that is described in Appendix V and to extend Loran-A service by one year in Washington, Oregon, and California; these two actions constitute the project's first two recommendations. Closely related are recommendations for development with Canada of a coordinated Loran plan and for an alternate approach to East Coast reconfiguration.

Other recommendations emerge from analysis of issues beyond the scope of the benefit-cost model: terminate Loran-A service at a time of year when marine activity is minimal; ensure that nautical charts fully support Loran-C service; and publish Loran-C system specifications. The final recommendation reaffirms the necessity for two years of overlapping service, during which Loran-C is *fully* operational and the *full* quality of Loran-A service is maintained.

The changeover from Loran-A to Loran-C can benefit users, but it will be neither easy nor automatic. The Coast Guard is to be commended for its competent technical performance to date. Nonetheless, users need assistance and the total Loran system needs attention. Voluntary conversion to Loran-C is vastly preferable to forced and reluctant conversion. If the Coast Guard undertakes the eight recommendations described in this report, we anticipate that users will switch to Loran-C sooner and purchase receivers that can match their expectations. As a result, burdens of conversion will be reduced, the transition will be smoother, and the Loran-C system will serve the U.S. mariner well.

purpose and introduction

The project, "Termination of Loran-A: An Evaluation of Alternative Policies," pursued the following objectives:

1. To determine the impact upon U.S. civilian mariners using Loran-A of the scheduled termination of Loran-A service and the coinciding expansion of Loran-C service over U.S. coastal waters.

2. To estimate the private and public benefits and costs of conversion from Loran-A to Loran-C under:

a) The published Loran-A termination schedule together with those Coast Guard actions planned at present for the changeover; and

b) The published Loran-A termination schedule together with additional Coast Guard actions that could be designed to lessen the impact on mariners of Loran-A termination.

3. To recommend:

a) Actions that the Coast Guard can undertake, sponsor, or request to minimize the impact of the published Loran-A termination schedule; and, if the residual impact is excessive,

b) That combination of minimum overlap period with other Coast Guard actions that will reduce the conversion's impact to a level that will produce a reasonable balance between private and public costs and private and public benefits.

Accomplishing these objectives required examination of many problems associated with conversion from Loran-A to Loran-C. As an initial research task, we developed a conceptual framework and methodology appropriate for evaluating the conversion. To conduct the necessary benefit-cost analysis of alternative Coast Guard actions, we undertook three major investigations to obtain data. First, the number, location, needs, and plans of existing Loran-A users were determined. Second, supply conditions in the Loran receiver manufacturing industry--past, present, and future--were assessed. Third, the costs of continuing Loran-A service nationally and regionally were estimated in detail. Full reports on the results of the three investigations may be found in the technical appendices of this report, as may reports of other investigations that profile Loran-C users, examine impacts on Canada and on search and rescue activities, and describe the recommended education program.

We then evaluated the alternative Coast Guard actions on the basis of their relative benefits and costs. Finally, we developed the recommendations presented here that seek to minimize the impact of conversion, including recommendations that emerge from nonquantifiable considerations.

background

Loran, an acronym standing for Long Range Navigation, is a pulsed hyperbolic radionavigation system that uses shore-based transmitters and shipboard receivers. Hyperbolic navigation assumes that the difference in distance from two fixed points on shore can be determined by measurement of the time interval between reception of synchronized signals from transmitters at the two points. The lines of constant time difference, and hence constant difference in distance, are hyperbolas (3).

This discussion deals with problems encountered in replacing the older Loran-A system with Loran-C with the impact of the changeover on U.S. civilian mariners who use Loran-A at present.

U.S. LORAN-A SERVICE

Loran-A was developed during World War II to aid in wartime navigation. At the end of the war, Loran-A service covered a good portion of the northern hemisphere. Since authorities recognized that Loran-A had widespread potential for a variety of applications in marine navigation, Loran-A service in the United States was continued after World War II. This service was augmented by additional tranmitting stations to fill gaps in coverage, a process that continued into the early 1970s. (Loran-A service in the western Gulf of Mexico started in 1968, and the Loran-A transmitting station at Marshall Point, Maine, was added in 1972).

Loran-A operates at a frequency of 1850-1950 kHz and has a ground-wave range of 500-700 nautical miles (nm). Its geodetic fix accuracy (the accuracy with which a geographic position can be determined from electronic coordinates) is 0.5-5nm, and its repeatable accuracy (the accuracy of returning to a position for which the electronic coordinates are known), is 0.05-1 nm.

NATIONAL PLAN FOR NAVIGATION

The *National Plan for Navigation of 1972* specified the requirement for a radionavigation system capable of providing 0.25 nm geodetic fix accuracy within U.S. coastal waters to a distance of 50 nm offshore (26). However gaps exist in Loran-A coverage for U.S. coastal waters, most notably off the western coast of Florida and for much of the West Coast and Alaska. Little engineering development of Loran-A has taken place during the last 20 years, the Loran-A transmitters are aging, and it is unclear if the requirement for accuracy could readily be achieved. Because of the expense and technical risk involved in upgrading and expanding the system, Loran-A was rejected.

On 16 May 1974, the Secretary of Transportation announced the selection of Loran-C as the government-provided radionavigation system for the coastal waters of the United States. The announcement was confirmed in the *Annex to the National Plan for Navigation* that was published in July 1974.

The *Annex* reaffirmed Department of Transportation policy on avoiding unnecessary duplication of navigation systems, and listed the following dates for implementation of Loran-C service and for termination of Loran-A:

U.S. LORAN-C SERVICE

Loran-C was developed during the 1950s to meet military needs. The first chain of transmitters started operation in the late 1950s. Loran-C shares many basic similarities with Loran-A, but is technically superior because of its transmission at a much lower frequency (100 kHz) and such technical improvements as multiple-pulse transmissions, phase coding, cycle matching, freedom from skywave contamination, and use of more sophisticated receivers. As a result Loran-C provides longer range and greater accuracy than Loran-A. It has a ground-wave range of 1200-1500 nm, geodetic fix accuracy of 0.1-0.5 nm, and repeatable accuracy of 0.01-0.05 nm.

In 1974, at the time of its selection as the government-provided radionavigation system, Loran-C service in the United States existed only in portions of Alaskan and East Coast waters. At the time of this writing, in June 1977, U.S. West Coast, Canadian West Coast, and Gulf of Alaska Loran-C chains have been constructed. The U.S. West Coast chain has commenced operation, but the Canadian West Coast and Gulf of Alaska chains have not. Construction is currently under way to reconfigure the existing East Coast chain into two chains, Southeast and Northeast. When completed, these U.S.

Implementation of Loran-C Service

West Coast	1 January 1977
Gulf of Alaska Expansion	1 January 1977
East Coast Reconfiguration	1 July 1978
Gulf of Mexico Expansion	1 July 1978
Great Lakes Expansion	1 February 1980

Termination of Loran-A Service

Aleutian Islands	1 July 1979
Gulf of Alaska	1 July 1979
Hawaiian Islands	1 July 1979
West Coast	1 July 1979
Caribbean	1 July 1980
East Coast	1 July 1980
Gulf of Mexico	1 July 1980

Loran-C chains will provide full coverage of U.S. coastal waters to a distance of more than 200 nm offshore.

The technical superiority of Loran-C allows provision of useful navigational service in harbors, sounds, and other restricted waters. Loran-C will also be useful for land and air navigation. Loran-A was not suitable for such uses because of its lesser accuracy, shorter range, and poor propagation over land.

LORAN-A USERS

Loran-A users are numerous and varied: for instance, just within the U.S., the range of Loran-A users includes civilian and government mariners, foreign civilian and government mariners, and both U.S. and foreign aircraft that operate over the ocean.

The scope of the present study further limits consideration to only one of these Loran-A user communities, U.S. civilian mariners, a large and diverse group. Table 1 duplicates Table I-1 in Appendix I, and shows both the major groups of U.S. civilian mariners using Loran-A and our best estimate of the number of Loran-A users in each group. Appendix I presents detailed information on these user groups, their use of Loran-A, and their plans for adopting Loran-C. As well as being numerous and diversified in their marine activities, these users are generally satisfied with the quality and coverage of Loran-A service, and their number has grown steadily in recent years.

PROBLEMS OF CONVERSION

The decision to terminate Loran-A and to implement Loran-C as the government-provided marine radionavigation system for U.S. coastal waters imposes a significant impact on the user of Loran-A. On the one hand, the user will receive technically superior navigation service: longer range, greater accuracy, more complete coverage. On the other hand, the user faces what may be a difficult and expensive choice. If Loran is essential to his or her marine operations, the user must switch to Loran-C before termination of Loran-A in order to retain continuous service.

Many users acknowledge Loran-C's superiority, but feel that Loran-A is satisfactory for their needs. At current prices, Loran-C receivers are expensive, compared to Loran-A receivers in common use. Most fully automatic Loran-C receivers cost from $3000-5000, whereas serviceable Loran-A receivers are available for less than $1000, and few cost more than $2000. In addition, many Loran-A users face the complication of purchasing a Loran-C receiver and of retiring an already installed Loran-A receiver before the end of its useful life. The conversion process will also cost the user time: he or she must learn the operational characteristics of a new system, must become familiar with new Loran charts, and in many cases must convert Loran-A coordinates to Loran-C.

For almost all Loran-A users, the basic navigational reference system at sea consists of Loran coordinates, rather than latitude and longitude. They think in terms of Loran; their navigational world is one of Loran. Loran-C may be a better system, and will be valuable to many mariners, but Loran-A is familiar and functional. For the user, conversion to Loran-C represents a profound change, which resembles in a very fundamental way the conversion from English to metric measurements.

Specific problems exist both with the Loran system and for the individual mariner. Not every user will encounter every problem. The extent and severity of the problems that will exist for a given user are further determined by his or her location, economic circumstances, and type of marine operation. These problems may be summarized as follows:

System Problems

1. Coverage. Whereas Loran-C coverage will be excellent for U.S. coastal waters, users nonetheless wish to have a navigation system that provides service wherever they operate. Loran-C does not provide worldwide service, and cannot be used for the full extent of many long trips. At a regional level the Loran-C chains planned at present will not serve the Caribbean area, as Loran-A did.

2. Chart Coverage. Users need charts. Under current plans, large-scale Loran-C charts will not be printed for a number of areas before the termination of Loran-A. In addition, many users desire charts that provide overlapping Loran-A and Loran-C grids for transposing electronic positions; these are not being produced for some areas. Finally, the charts do not incorporate complete Additional Secondary Phase Factor corrections so that Loran-C charts will reflect

User Group	Estimated Number of Loran-A Users (Rounded to Nearest Hundred)
Commercial Fishing	15,000
Marine commercial sport-fishing	1,800
Merchant marine	500
Tug and towboat industry	300
Offshore petroleum service vessel industry	600
Marine recreation	32,000
Other Loran-A users	500
Total	50,700

Table 1. Estimated Number of U.S. Civilian Marine Loran-A Users

fully the inherent accuracy of the system.

3. System Reliability and Performance. Along portions of the West Coast, the available signal is weaker than has been predicted. In some locations on the East Coast, cycle-selection problems exist. Some users of Loran-C make the wry observation: "Loran-C is great for tracking, but I have to use Loran-A to tell my Loran-C receiver where it is for initial setup."

4. Receivers. Many users do not know what kind of Loran-C receiver is required to produce the navigational results advertised for Loran-C. Even though the Coast Guard recommends a fully automatic receiver, it has not specified in detail the characteristics of such a receiver. Many fully automatic receivers are on the market, and their performance varies widely. In addition, many other types of Loran-C receivers are available, and their performance is even more variable. The current Loran-C receiver situation is complex and confusing.

5. Reconfiguration. East Coast reconfiguration will improve coverage and signal strength. Unfortunately, few users understand the details and implications of reconfiguration. As currently planned, East Coast reconfiguration will be extremely disruptive: those users who have switched to Loran-C early and voluntarily will be penalized through their subjection to a second conversion from existing Loran-C coordinates to reconfigured Loran-C coordinates. This second conversion will be operationally far more difficult for the user than the original Loran-A to Loran-C conversion. Furthermore, the present reconfiguration schedule provides only one year of overlapping Loran-A/Loran-C service for the coastal area off North Carolina, South Carolina, Georgia, and Florida.

Individual User Problems

1. Selection of proper Loran-C receiver.

2. Relatively high cost of Loran-C receivers as compared to Loran-A receivers.

3. Correct installation of Loran-C receiver.

4. Proper operation of Loran-C receiver.

5. Availability of competent repair and maintenance service.

6. Timely availability of needed charts.

7. Uncertainty about tax and financial treatment pertinent to Loran conversion.

8. Conversion of Loran-A coordinates to Loran-C.

9. General and widespread misinformation and lack of information on Loran-C characteristics and capabilities, the reasons for the switch from Loran-A to Loran-C, and the content and timing of the schedule for implementation of Loran-C and termination of Loran-A.

The marine Loran-A user most severely affected by the changeover is the private, small business operator. He or she typically has less information, fewer technical resources, and limited economic flexibility. For this user, the Loran changeover must be viewed in the context of his or her business's many dimensions: financial, especially insurance, taxes, loans, and general business climate; government regulations; engineering, marine equipment, and electronics; safety; and general operations. These many factors are themselves complex, and interact in complex ways. Government intervention is increasing, and required changes are frequent and far-reaching; examples include VHF/SSB radios, marine sanitation devices, increased fuel costs, disposal of oily bilge wastes, moorage policies and rates, coastal zone management, and Occupational Safety and Health Act regulations. These changes are seemingly disparate, but their effect is cumulative. Each is at least initially burdensome for mariners and especially for the small business operator. Conversion from Loran-A to Loran-C is one of these many changes.

approach

The objectives of this study were to identify the problems for U.S. civilian mariners associated with termination of Loran-A service, to measure and evaluate the benefits and costs of possible Coast Guard actions to lessen the adverse impact of termination, and to recommend (1) those Coast Guard actions that would minimize the private costs to Loran-A users of termination and (2) those actions that would maximize the net social benefits from the termination of Loran-A and conversion to Loran-C. The problems involved with termination and conversion have been identified and described. This section presents the conceptual approach used to measure and evaluate the effects of alternative Coast Guard actions to reduce the private costs and increase the social benefits of Loran-A termination.

The approach derives from literature on benefit-cost and policy analysis, and features:

(1) an economic model to predict the behavior of Loran manufacturers and existing Loran-A users under alternative Coast Guard actions;

(2) a conventional benefit-cost framework to measure and place a value on the results of the predicted behavior; and

(3) a policy analysis that recognizes the simplicity of the economic model, the unquantifiable benefits and costs, the equity consequences of alternative actions, and the relevant constraints on the Coast Guard.

This approach starts from the premise that choice among possible Coast Guard actions must ultimately be a matter of judgment, which will require integration of the objectively determined merits and subjectively evaluated other effects of each alternative action. This premise is appropriate, since the Coast Guard's decision to undertake particular actions must be made within the framework of the political process.

PERSPECTIVE AND METHOD

One goal of government actions is to improve the national well-being. In evaluating a particular action--the presently scheduled termination of Loran-A and conversion to Loran-C, for example--the government must identify how the well-being both of particular groups and the nation will be improved, and determine whether some better means exists for achieving the same end. If other Coast Guard actions appear superior to the presently scheduled actions, the "best" among them deserves careful consideration before implementation of the currently planned actions. On the other hand, if possible alternative actions appear inferior, then the Coast Guard can undertake its currently scheduled actions with greater confidence.

Therefore, the first step for evaluating the scheduled termination of Loran-A service and conversion to Loran-C was to review the areas of concern that prompted this study. These concerns include the burdens of termination and the benefits of conversion for existing U.S. Loran-A users, as well as the higher costs involved in larger scale Coast Guard actions to lessen the burdens.

The second step involved assessment of the impact of alternative Coast Guard actions on the behavior of these groups that benefit or are burdened by the termination of Loran-A and conversion to Loran-C. An economic model capable of estimating the benefits and costs of possible actions was the vehicle chosen for accomplishing this task.

The benefit-cost model developed for this study links the private and public benefits and costs of the Loran-A/Loran-C conversion to Coast Guard budgets, actions, and policies during the Loran-A/Loran-C overlap period. The levels, timing, and regional distribution of benefits and costs to existing Loran-A users and the general public (as taxpayers) depend on the following factors:

(a) the relative superiority of Loran-C over Loran-A for basic navigation, marine operations, and safety;

(b) the prices and supplies of Loran-C receivers;

(c) the length of the overlap period, and

(d) other Coast Guard policies and actions, including those education, information, and other programs that the Coast Guard or some other public agency may undertake.

The model estimated the benefits and costs of alternative Coast Guard actions for nine scenarios, each of which contains a different prediction. Net private and social benefits are estimated for each alternative action in each scenario, by region and for the nation.[1] These estimates are expressed in 1977 prices and are discounted to the present at an annual rate of 10%.

In evaluating alternative Coast Guard actions, incremental net private and social benefits were found by subtracting the net benefits estimated for currently scheduled Coast Guard actions from the net benefits estimated for each alternative action. The probability that each scenario will occur is specified, and a probability-weighted average of incremental net private and social benefits is calculated for each alternative action. The incremental net benefit estimates allow identification of actions that would maximize (1) the net private benefits and (2) the net social benefits of the conversion from Loran-A to Loran-C. In addition, the estimates permit measurement and comparison of the costs associated with Coast Guard actions other than those that maximize net private and social benefits.

The final step in the evaluation was a policy analysis that seeks to overcome the limitations of the benefit-cost analysis. Although the benefit-cost analysis can indicate the relative merits of alternative actions, the selection of a particular Coast Guard action or set of actions on the basis of such an analysis alone would not necessarily lead to optimum results from a social viewpoint. Such a situation occurs because models, though helpful, are simplistic, and actions have intangible as well as tangible benefits and costs. In addition, geographical, equity, and political consequences exist that cannot be incorporated into formal benefit-cost calculations. Thus, as stated in the introduction to this section, the choice among alternative Coast Guard actions ultimately must be a matter of judgment that carefully considers the objective results of benefit-cost analysis together with a

[1]Net private benefits equal total private benefits minus total private costs; net social benefits equal total private and public benefits minus total private and public costs.

subjective evaluation of the other important effects of each action.

The evaluation of Coast Guard actions offered in this report does not rely solely on estimated net private and social benefits. Instead, the evaluation and the recommendations that follow from it are based on an integration of the objectively determined (but nonetheless limited) benefit-cost results with an explicit subjective evaluation of the other important effects that fall outside the scope of the benefit-cost analysis.

STRUCTURE AND USE OF THE MODEL

The structure of the benefit-cost model is displayed in Figure 1. The model portrays the impact on private U.S. Loran-A users of the termination of Loran-A service through a set of causally-ordered submodels (hereafter referred to as modules). The first module depicts the pricing behavior of the Loran-C manufacturing industry. The second module describes the demand for and purchases of Loran-C receivers by current Loran-A users. In this module, annual purchases of Loran-C receivers depend on (1) the length of the overlap period of Loran-A and Loran-C service and (2) the level of knowledge among Loran-A users concerning the capabilities of Loran-C sets and Loran-C's scheduled implementation during the next few years. Results from the second module feed back to the first, because the model postulates that the retail price of Loran-C receivers will decline as more units are manufactured.

The third module assesses the benefits of Loran-C service to existing Loran-A users who purchase and use Loran-C sets; it also assesses the costs to Loran-A users who do not purchase Loran-C sets and who, after termination of Loran-A service, must then navigate by means other than Loran. Estimates of net private benefits are obtained by subtracting the costs incurred by those who do not convert to Loran-C from the net benefits received by those who do. The fourth module assesses the net social benefits of the termination of Loran-A by subtracting the costs of Coast Guard activities during the termination period from the net private benefits calculated with the third module.

The complete model is designed specifically to evaluate the impact on private U.S. Loran-A users of alternative Coast Guard actions with respect to the termination of Loran-A service and the conversion to Loran-C. Since this study deals only with the impact of Loran-A termination, the model includes only the benefits of the Loran-C system to Loran-A users, and it excludes the costs of operating the Loran-C system, which are independent of the termination of Loran-A service. As a consequence, the model has been constructed only to estimate the benefits and costs associated with alternative Coast Guard actions to reduce the burdens of Loran-A service termination, and cannot be used, for instance, to evaluate the original decision to terminate Loran-A and implement Loran-C.

The model consists of seven equations to predict the behavior of Loran-A users and 11 identities to calculate the benefits and costs of their actions. Each equation is presented and discussed in detail in Appendix VII. The data and parameter values required by the model have been estimated from the surveys of Loran-A users and Loran receiver manufacturers reported respectively in Appendices I and II, and from relevant professional, technical, and trade publications. The criteria that guided the selection of data and parameter values, as well as the sensitivity tests conducted with the model, are discussed below and in Appendix VII.

The major steps involved in using the model to evaluate alternative Coast Guard actions are summarized in Figure 2. Step I specifies the parameter values and data required for each module to generate its outputs. Step II predicts the magnitudes of policy-relevant variables under different Coast Guard actions. This step involved running the full model in order to calculate predicted values for the retail prices of Loran-C receivers, annual rates of purchase, benefits, and other factors. Step III estimates the incremental net private and social benefits of alternative Coast Guard policies and actions by subtracting predicted net benefits under currently scheduled action from the values of these benefits predicted under each alternative policy and action. These incremental net benefits provide an appropriate basis on which to evaluate alternative Coast Guard policies and actions.

CREDIBILITY OF THE RESULTS

The termination of Loran-A service is an unusual, if not unprecedented, action by a government agency. A systematic library

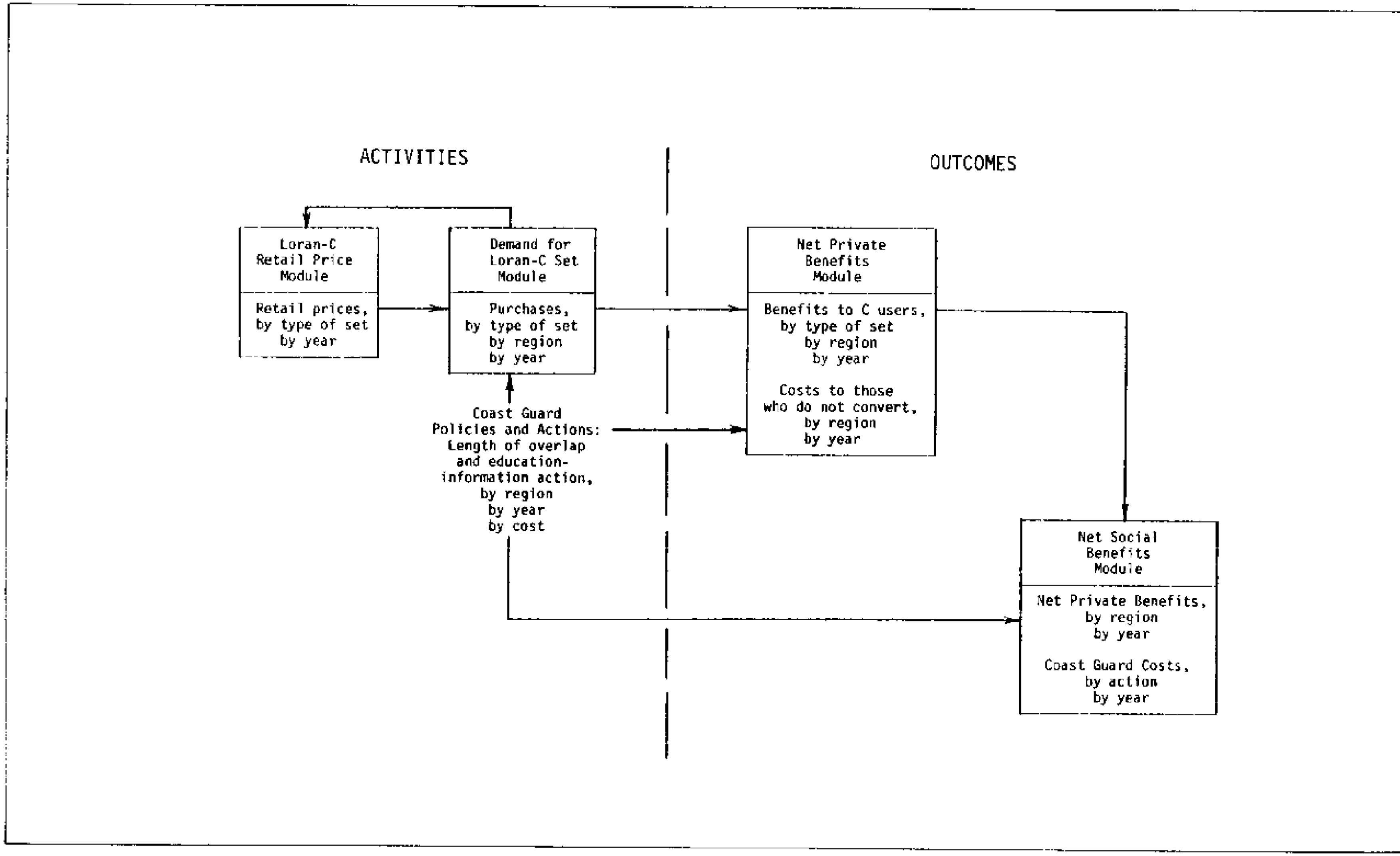

Fig. 1. Causal structure of the model

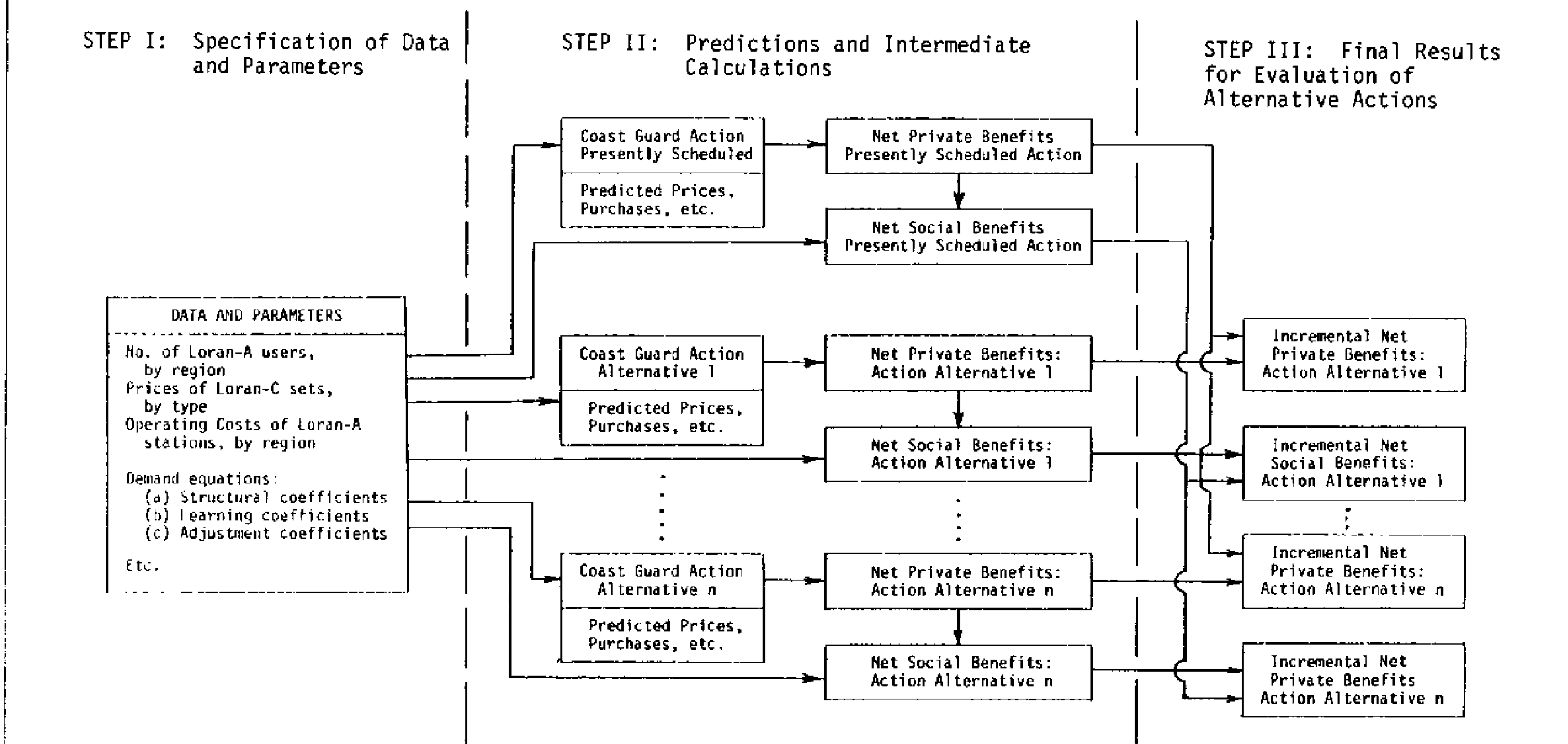

Fig. 2. Implementation and use of the model

search of relevant professional literature uncovered no benefit-cost or policy analysis of a comparable action by a public agency. As a consequence, the model developed for this study is unique, though the evaluation conducted with the model is quite conventional and relatively comprehensive.

The model as specified in Appendix VII is more aggregated, less sophisticated, and less complete than the one envisioned when the study began. It is more aggregated and less sophisticated because the amount and quality of data obtained from Loran-A users and the Loran receiver manufacturing industry proved to be more limited than anticipated. In retrospect, it is not surprising that users and manufacturers found it difficult, undesirable, or impossible to respond quantitatively to questions concerning their plans. The situation in which they find themselves is new and unusual, and it will affect them primarily in the future. Hence, they often had not thought through the full implications of termination, and they simply could not answer questions intended to provide the foundation for building a disaggregated model with the complexity and interrelatedness that was originally contemplated.

Problems of aggregation and sophistication are often encountered in model construction and use. The model builder typically prefers larger, more complex models to small, simple ones, and he or she seeks to compare the performance of a model against its rivals. In the present instance, there was no rival model. However, verification, validation, and sensitivity tests were performed to determine the reasonableness of the model's predictions, the sensitivity of results to different specifications of parameter values, and the variation in the rankings of alternative actions in the nine scenarios. Predictions generally conformed to our intuition. Substantial but reasonable changes in parameter values did not change the ranking of alternative actions appreciably or unexpectedly, and there was no unsystematic or unanticipated reordering of the ranking among different actions from one scenario to another. Overall, the test results revealed that the model is rather insensitive to the parameter changes considered.

The incompleteness of the model is documented in Appendices VI and VII, where we establish that (1) the net private benefits module omits the benefits of a Coast Guard education and information program for existing Loran-C users and (2) the net social benefits module omits the benefits and costs to Coast Guard search and rescue activity of its termination-related actions. The justification for each omission is different, but the bias resulting from each is described and taken into account in the evaluation of the model's predictions. This analysis permits the evaluation of alternative Coast Guard actions below to acknowledge the model's incompleteness by explicitly taking the biases into account. In a piece of good luck, these biases in fact strengthen rather than weaken the case for the actions ranked highest by the model. Thus, although the incompleteness of the model is dissatisfying, it does not seriously impair the model's usefulness for its intended purpose.

results

The burdens created by the currently scheduled termination of Loran-A service have led to proposals for Coast Guard actions that would lessen the adverse impact on U.S. civilian mariners of Loran-A termination and Loran-C implementation. Some proposals are feasible, others are not. Some proposals involve significant budget increases for the Coast Guard over several years, others would have hardly any effect on the budget. Some proposals are easily undertaken, others are impracticable.

Of course, the real question is not simply feasibility or cost, but whether the benefits of the proposed actions will be large enough to justify the costs they will entail.

In this part of the study, we present and discuss the results of a benefit-cost analysis of alternative Coast Guard actions. The first section indicates the sets of alternative actions considered, while the second presents the major results of the benefit-cost analysis. The third section discusses various features of the analysis.

ALTERNATIVE ACTIONS CONSIDERED

The benefit-cost model developed for this study can evaluate some, but not all, Coast Guard actions to less the burdens of Loran-A termination. The merit of the model lies in its ability to provide a systematic evaluation of the major benefits and costs associated with longer overlaps of Loran-A and Loran-C service and an education and information program consisting of elements specified in Appendix V. However, this benefit-cost analysis, like others, is necessarily narrow and limited because certain dimensions of the complex termination-conversion problem could not be quantified and included in the model.

The specific benefits of a longer overlap to the present Loran-A user community are as follows:

(1) Postponement of the date on which the user purchases a Loran-C receiver or incurs the costs of converting his existing Loran-A receiver, which means that the user reduces the present value of his or her conversion costs and the increased benefits, if any, to his or her marine operations from navigating with Loran-C instead of Loran-A.

(2) Postponement of the date on which Loran-A users who do not intend to convert must adopt a new method of navigation, which means that these users can reduce the present value of the costs they will incur by not converting to Loran-C.

(3) If the prices of Loran-C receivers decline over time, as expected, the present Loran-A user who delays purchase of a Loran-C receiver will benefit from the lower price as well as from the "pure postponement benefit" identified in (1).

(4) Independent of a Coast Guard education and information program, general knowledge of the Loran-C system, its operational characteristics, and receiver capabilities will increase through time. Users who convert in the future will therefore typically purchase types of Loran-C receivers better suited to their needs than the typical user who converts today.

Each of the above benefits is included in the model, and their total value is estimated by region and for the nation. Because there was no reason to favor or exclude arbitrarily particular overlap schedules, none was initially excluded from consideration in this study. Table 2 displays the 28 alternate Coast Guard actions considered and indicates whether their respective estimated incremental net social benefits are positive or negative. Preliminary computer runs of the model did establish, however, that overlap extensions for the Aleutian and Gulf of Alaska chains, as well as overlap extensions that differ greatly from those circled in Table 2, had large negative incremental net social benefits.[2] Benefit-cost estimates were not calculated in the final computer run for these alternatives.

The benefits of an education and information program for the existing Loran-A user community are as follows:

(1) If acquainted with the potential benefits and applications of Loran-C, users will convert by purchasing Loran-C receivers closer to the present. Earlier conversion means that users can reap the benefits of Loran-C navigation, if any, to their operations or activities sooner.

(2) By informing Loran-A users, dealers, and others of the characteristics and capabilities of the Loran-C system and of the different types of receivers, users will purchase and operate receivers more appropriately suited to their particular operations. Benefits received will be more consistent with user expectations.

Each of these benefits is measured in the model, and their total value is estimated by region and for the nation. These benefits, of course, do not encompass the full range of positive effects that could conceivably come from a comprehensive and well-executed education and information program. Most other benefits, however, appear to be directly related to the benefits that have been explicitly measured. Therefore, the benefits of the education/information program are slightly underestimated in the present benefit-cost analysis.

The set of alternative Coast Guard actions considered in this study is presented in Table 2. As previously indicated, analysis of these alternatives indicated at an early stage that actions differing greatly from those circled in Table 2, as well as overlap extensions for the Alaskan chains, had large negative incremental net social benefits, and these actions were not included in the final computer run.

MAJOR BENEFIT-COST RESULTS

Table 2 displays the 28 action alternatives that were considered and indicates whether their respective incremental net social benefits are positive or negative. Two actions have positive incremental net social benefits, while the other 26 generate negative returns to the nation as a whole.

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[2]The Alaskan chains are costly to operate and serve a small number of Loran-A users, partly because a relatively high percentage have already converted to Loran-C. Overlap extensions for the East and Gulf Coasts have negative incremental net social benefits because Loran-A users on these coasts have three years from the present to convert under the current termination schedule, and additional time to convert generates very much smaller benefits than on the West Coast, which is scheduled to have only two years to convert.

Overlap Extension (by years): West Coast less AK	East Coast Only: Education-Information Program	0 0	0 ✓	1 0	1 ✓	2 0	2 ✓	3 0	3 ✓
0	✓		(+)		-		-		-
1	0	(-)		-		-		-	
1	✓		(+)		-		-		-
2	0	-		(-)		-		-	
2	✓		-		(-)		-		-
3	0	-		-		(-)		-	
3	✓		-		-		(-)		-

Note: ( ) indicates the Coast Guard action with greatest incremental net social benefits among all actions for that particular row.

Table 2. Alternative Coast Guard actions considered, by length of overlap extension for West Coast less Alaska and East and Gulf Coasts with (✓) and without (0) the scheduled education-information program (+ indicates positive incremental net social benefits for the action, - indicates negative incremental net social benefits for the action)

The circles indicate the action with the largest positive incremental net social benefit, or the least negative as the case may be, for each row. An education and information program alone, or in combination with a one-year overlap extension on the West Coast (without Alaska), are the best actions from a social viewpoint for the Coast Guard to undertake.

Table 3 reports the estimated benefits and costs for the six Coast Guard actions that produce the largest incremental net social benefits among those actions considered in this study. Columns (1) through (3) in Table 3 characterize the features of the six actions, columns (4) through (6) present the probability-weighted average benefits and costs for each set of actions, and column (7) gives the benefit-cost ratio for each action.

ratio of at least 1.5, and generates net private benefits of about $650,000 and net social benefits exceeding $200,000. However, if the education/information program is combined with a one-year extension of Loran-A service on the West Coast, the net private benefits to present U.S. Loran-A users are estimated to increase to $1.5 million, and net social benefits are estimated to increase to $285,000. The benefit-cost ratio for this latter action is 1.24 in contrast to the ratio of 1.5 for the former action. If one values a dollar gained or lost by Loran-A users and by taxpayers equally, then the action that generates the larger net social benefits is the better action for the Coast Guard to undertake.

2. Extensions in the currently scheduled overlap of Loran-A and Loran-C service are predicted to reduce the burdens

Coast Guard Action Alternatives: Overlap Extention			Incremental Benefits and Costs (present values in thousands of 1977 dollars)			
West Coast less AK (1)	East & Gulf Coasts (2)	Education-Information Program (p, ✓) (3)	Net Private Benefits (4)	Coast Guard Costs (5)	Net Social Benefits (4) - (5) (6)	Benefit-Cost Ratio (4) ÷ (5) (7)
1	0	0	234	811	- 537	0.29
0	0	✓	649	434	215	1.50
1	0	✓	1,530	1,245	285	1.24
2	1	0	1,745	3,675	-1,930	0.47
2	1	✓	1,882	4,109	-2,227	0.46
3	2	✓	2,101	6,713	-4,612	0.31

Table 3. Estimated Incremental Benefits and Costs for Six (6) Coast Guard Action Alternatives (benefits and costs discounted at 10% and expressed in thousands of 1977 dollars)

The benefit and cost information in Table 3 establishes the basis for the following two findings:

1. Most importantly, there are two actions that would reduce the burdens of termination and conversion on existing Loran-A users by amounts greater than the cost of the actions to the Coast Guard, and hence ultimately to taxpayers. A four-year education/information program of the type outlined in Appendix V has a benefit-cost

of conversion on existing Loran-A users. Table 3 shows that successively longer overlap extensions (with or without an education/information program) generate increases in net private benefits, but at a diminishing rate. Although this is not surprising, one must recognize that the increase in costs of longer overlaps to the Coast Guard exceeds the increase in private benefits for every overlap extension except the one-year West Coast extension in combination with the education/information program. As a consequence, only if additional benefits to Loran-A users are valued much more highly than the additional costs to taxpayers should the Coast Guard extend Loran-A service, except for one year on the West Coast.

DISCUSSION OF BENEFIT-COST RESULTS

Because the future is uncertain, the figures in Table 3 are weighted averages of the benefits and costs estimated for each Coast Guard action in nine different scenarios, where the weights are subjective estimates of the probabilities that each scenario will occur. By evaluating an action on the basis of a weighted average of conceivable events, rather than on the basis of the single most likely event, the evaluation will include, in a systematic and conventional way, the impact of possible but less likely events on the net benefits of the action. To illustrate this procedure, as well as to reveal the ranges of conceivable outcomes for the two sets of actions in Table 3 with the highest net social benefits, the incremental net social benefits for those actions under the nine scenarios are presented in Table 4 with the probabilities assigned to each scenario. (The probabilities are given in the parentheses below the estimates of incremental net social benefits.)

A relatively high probability is assigned to the high estimate for the decline in Loran-C receiver prices, and a relatively low probability is given to the high estimate of the number of Loran-A users. The particular probabilities assigned to each scenario dimension are as follows:

	Decline in Loran-C Prices	Number of Loran-A Users
Low	0.1	0.4
Median	0.3	0.5
High	0.6	0.1

Taken together, these probabilities weight the lowest estimates in Table 4 most highly, and thereby generate what we regard to be conservative estimates of the expected net benefits of Coast Guard actions.[3]

When the estimates in Table 4 are interpreted broadly, they provide support for the following generalizations. The smaller the actual decline in Loran-C receiver prices and the larger the number of Loran-A users burdened by termination and conversion, the greater are the incremental net social benefits to be realized from the actions evaluated in Table 4. Conversely, the greater the decline in Loran-C receiver prices and the smaller the number of Loran-A users, the smaller are the incremental net social benefits. What happens in fact is that a larger decline in Loran-C receiver prices produces much the same result as the education/information program. Furthermore, because the social benefits of the one-year West Coast overlap extension combined with the education/information program are positive under every scenario, this action can be realistically termed "fail-safe" for the Coast Guard to undertake.

The benefits of Coast Guard actions, of course, derive from their impact on the decisions of present Loran-A users to convert to Loran-C. To show the probable impact of Coast Guard actions, Table 5 reports this study's predictions of the year of conversion, by region and by type of Loran-C receiver purchased, for the currently scheduled Coast Guard actions and the two alternative actions with the highest incremental net social benefits. The predictions are for the scenario that is assigned the highest probability of occurrence and, therefore, is weighted most heavily in the benefit-cost estimates. This scenario predicts that the price of the typical fully automatic Loran-C receiver will decline from $3,700 in 1977-78 to $2,250 in 1978-79 and $1,500 in 1979-80. The price of the typical manual receiver, by contrast, is predicted to decline from $1,100 in 1977-78 just to $875 in 1978-79 and $700 in 1979-80. Although these price declines are greater than those predicted in other scenarios, differences in the predictions in Table 5 of the number of Loran-A users converting to Loran-C are qualitatively representative of the differences found in other scenarios for the same actions.

Under currently scheduled Coast Guard actions, the model predicts that 2,467 Loran-A users on the West Coast including

[3]Although the probabilities are subjective, they do reflect the information obtained from a survey of the Loran manufacturing industry. In addition, a sensitivity analysis has been conducted for the scenario dimension with greatest uncertainty - the decline in Loran-C receiver prices. The analysis showed that alternative actions in Table 3 would change their ranking only if a probability of less than 0.50 was assigned to the high estimate for the decline in Loran-C receiver prices. A probability set this low, however, would be inconsistent with predictions made by Loran-C receiver manufacturers.

Coast Guard Action Alternatives	Estimated Decline in Loran-C Prices	Estimated Number of Loran-A Users			Probability Weighted Incremental Net Social Benefits
		Low	Median	High	
(1)	(2)	(3)	(4)	(5)	(6)
Education/Information Program Only	Low	1,205 (0.04)	1,386 (0.05)	1,569 (0.01)	
	Median	400 (0.12)	446 (0.15)	478 (0.03)	215
	High	-83 (0.24)	-77 (0.30)	-74 (0.06)	
One Year Extension on West Coast and Education/Information Program	Low	616 (0.04)	881 (0.05)	1,193 (0.01)	
	Median	298 (0.12)	471 (0.15)	661 (0.03)	285
	High	27 (0.24)	178 (0.30)	306 (0.06)	

Note: Probability weighted incremental net social benefits $= \sum_{i=1}^{9} P_i INSB_i$

Table 4. Estimated Incremental Net Social Benefits in Nine Scenarios for Education/Information Program Only and Combined with One-Year Extension on West Coast less Alaska, and Probabilities Assigned to Each Scenario (incremental net social benefits discounted to present at 10 % and expressed in thousands of 1977 dollars; probabilities given in parentheses)

Alaska, or 26% of the western user community that must purchase a new Loran-C receiver to convert, will not have done so by the termination of Loran-A service on 1 July 1979. If the Coast Guard undertook an education and information program, the number of Loran-A users who have not converted at termination is predicted to decline to 1,487, or 15% of the western users who need new receivers to navigate with Loran-C. The model predicts that the education/information program will induce Loran-A users throughout the nation to convert to Loran-C sooner and to purchase a somewhat greater number of fully automatic receivers than they would under currently scheduled actions. However, because an education/information program takes time to initiate and become truly effective, it will probably not have a particularly large impact on the type of receiver purchased if the overlap period remains as scheduled. Instead, the program's major effect will be to advance the time of conversion.

The predictions, however, change considerably for the West though not as much for the East if the education/information program is combined with a one-year overlap extension on the West Coast alone, without Alaska. The rate of conversion should be somewhat slower but conversion will be entirely completed by termination (Table 5). In addition, the model predicts that the overlap extension will allow western Loran-A users to benefit from the decline in fully automatic receiver prices in the same way that eastern users will. The number of conversions to fully automatic receivers is predicted to increase in the west by 576, or almost 9%.

Coast Guard Action Alternatives	Type of Receiver Purchased	Region	Estimated Number of Present Loran-A Users Converting, by year			Total	Change From Prediction for Currently Scheduled Action
			1977-78	1978-79	1979-80		
Currently Scheduled Actions	Automatic	West	1,227	3,246	[1,649]	6,122	
	Not Auto.	West	962	1,948	[918]	3,828	
	Automatic	East	2,350	6,098	7,067	15,515	
	Not Auto.	East	1,580	3,675	4,480	9,735	
Education Information Program Only	Automatic	West	1,387	3,806	[968]	6,162	+ 40
	Not Auto.	West	1,042	2,227	[519]	3,788	- 40
	Automatic	East	2,756	7,308	5,614	15,678	+163
	Not Auto.	East	1,794	4,140	3,538	9,472	-163
One-year Extension West Coast and Education Information Program	Automatic	West	1,387	2,581	2,730	6,698	+576
	Not Auto.	West	1,042	1,142	1,068	3,252	-576
	Automatic	East	2,756	7,308	5,630	15,694	+179
	Not Auto.	East	1,794	4,140	3,522	9,456	-179

Note: [ ] indicates the number of present Loran-A users predicted to convert after termination of Loran-A. With a one-year extension on the West Coast the model predicted 100% conversion before termination in this scenario. (Here year is 1 July - 30 June.)

Table 5. Predicted Number of Loran-A User Conversions to Loran-C Under Currently Scheduled Actions, the Scheduled Education/Information Program Only or Combined with One-Year Extension on West Coast less Alaska, by Region, Year, and Type of Receiver Purchased.

Finally, let us answer the traditional questions asked about the results of any benefit-cost analysis:

(1) How sensitive are the results to changes in the discount rate? Answer: The results are not sensitive to discount rate changes, because the benefits and costs associated with every action accrue within five years of the present. Therefore, sensitivity studies with rates of 5, 7.5, and 10 percent revealed that discounting with higher or lower rates of interest over such a short period of time had no effect on the ranking of alternative actions. As expected, of course, the level of incremental net social benefits did vary inversely with the rate of discount for actions with positive net social benefits, but varied directly with the rate of discount for actions with negative net social benefits.

(2) How sensitive are the results to changes in parameter values? Answer: The estimated levels of incremental net social benefits for each action, although not the ranking among the alternative actions, are sensitive to changes in the parameter values selected. Appendix VII presents arguments supporting the view that the parameter values chosen for the demand functions and representing the effectiveness of an education/information program are conservative and bias the estimated levels of net social benefits downward--more so for overlap extension than for the education information program. As a consequence, the "true" levels of private, and hence social, benefits for overlap extensions are probably higher than shown in Table 3, but not sufficiently high to make the incremental net social benefits of two- and three-year overlap extensions positive. (The sensitivity of the results to changes in the other parameter values have been discussed above, or were found to introduce a small downward bias without changing the rankings of alternative actions.)

(3) How do benefits and costs omitted from the analysis bias the rankings among the alternatives evaluated? Answer: (a) The omission of the benefits of the education/information program to existing owners of convertible Loran-A, Loran-A/C combination, and Loran-C receivers introduces a downward bias in the predicted level of incremental net social benefits for every action involving education and information activities; (b) the omission of termination-related benefits to the Coast Guard search-and-rescue mission biases the incremental net social benefits downward for short overlap extensions. (Appendices VI and VII provide the analysis to support these judgments.) As a consequence, when one takes account of the biases of omission, the superiority of the actions in Table 3 with highest incremental net social benefits is increased rather than diminished.

recommendations

The recommendations of this study derive both from the results of the benefit-cost analysis as well as from analysis of issues outside the scope of the model. Eight recommendations are offered; all carry our strong endorsement. The first two emerge directly from the benefit-cost analysis, the next two are closely related, and the last four are subjective. The order of their presentation does not imply ranking.

Recommendation 1. *Conduct the Loran-C Education Program specified in Appendix V.*

Discussion: The desirable results and cost effectiveness of an education and information program are amply demonstrated by the benefit-cost analysis. A few comments on some elements of the program are warranted:

a. Receivers: The project investigators recognize that minimum performance standards for Loran-C receivers are being developed at present. We applaud this effort and urge earliest possible publication of the standards. In addition, a receiver testing program should be considered, with results made public.

b. Tax treatment: The investigators carefully considered whether special tax treatment was appropriate, and concluded that it was not. Nonetheless, we strongly recommend that the provisions of available tax and loan treatments be examined, that their Loran-C applications be determined, and that this information receive wide publication.

c. Coordinate conversion: Conversion of coordinates is ultimately the responsibility of the individual user, but calculator conversion software and Loran-A/C overlap charts would be most helpful.

d. Notification of prospective Loran receiver purchasers: Every purchaser of a Loran-A or Loran-C receiver should be aware of the schedule for implementation of Loran-C and for termination of Loran-A.

A system of notification is feasible and could be worked out with manufacturers, distributors, and dealers. Stickers, brochures, and posters could assist in this effort.

Recommendation 2. *Extend Loran-A service for Washington, Oregon, and California to 1980, one year beyond the presently scheduled termination date.*

Discussion: This limited extension in conjunction with the education program, is also supported by the benefit-cost analysis. Although the resultant benefit-cost ratio is not as high as for the education program alone, net private benefits are much higher, net social benefits are higher, and net social benefits are positive under all nine scenarios. Extensions elsewhere and for longer periods would generate even larger net private benefits, but the increase in taxpayer costs would greatly exceed the increase in private benefits. (The investigators acknowledge that an acceptable, although less preferable, course of action would be to implement the education program but not to extend Loran-A service on the West Coast.)

Recommendation 3. *Develop a coordinated Loran plan with Canada.*

Discussion: Failure to develop a coordinated plan will probably result in a longer overlap period for some U.S. Loran-A users (see Appendix IV for a discussion). The consequences will be some users' slower rate of conversion to Loran-C, reduction of private and social benefits, and inequitable treatment of users.

Recommendation 4. *Do not reconfigure the East Coast as currently planned.*

Discussion: If the planned reconfiguration is carried out, it will penalize those Loran users who have switched to Loran-C early and voluntarily. Successful Loran-C experience for these users can contribute significantly to a smooth transition, but negative experience, as would be caused by the currently planned reconfiguration, will be unusually damaging.

The existing reconfiguration plan requires a second coordinate conversion of great operational difficulty. Not a single station-pair existing today would be retained under the new coverage. The change from Loran-A to Loran-C is complicated enough; to superimpose a second change of the magnitude planned complicates the situation even further, and is unnecessary.

Though reconfiguration of some kind is required, fundamental to a smooth reconfiguration is that the two most widely used station-pairs--Carolina Beach-Jupiter and Carolina Beach-Nantucket--be retained. We therefore urge consideration of an alternate reconfiguration plan, such as the following:

U.S. East Coast Chain: Master--Carolina Beach
Secondaries--Malone, Jupiter, Seneca, Nantucket

U.S. Southeast Chain: Master--Malone
Secondaries: Raymondville, Grangeville, Jupiter, Carolina Beach

U.S. Northeast Chain: Master--Caribou
Secondaries--Nantucket, Cape Race

U.S. Great Lakes Chain: Master--Dana
Secondaries--Minnesota, Seneca, Grangeville

The reconfiguration plan outlined above would be less disruptive operationally, would provide nearly the same coverage, and would tie in effectively with Loran-C transmitting stations that Canada may construct on the East Coast. By contrast, if the currently proposed reconfiguration is implemented, an additional year of Loran-A service will probably be required for the full East Coast. In any event, an additional year of service is mandatory for the coastal area off North Carolina, South Carolina, Georgia, and Florida, where only one year of overlapping service is planned at present, in direct contradiction to the minimum two-year overlap guaranteed by the *Annex to the National Plan for Navigation.*

Recommendation 5. *Terminate Loran-A service at a time of year when marine operations are at a minimum.*

Discussion: Loran-A service should be terminated when marine activity is at a low level, rather than in the middle of an operating season. In most areas, 1 July, the presently planned termination date, falls in mid-season. Since much marine activity is seasonal, the practical effect of revised termination dates is to grant the remainder of an extra year of service to Loran-A users. Preferable termination dates are:

Aleutians	1 August

Gulf of Alaska	1 November
West Coast	1 November
Gulf of Mexico	1 March
East Coast	1 February

RECOMMENDATION 6. *Ensure that nautical charts fully support Loran-C service.*

Discussion: Chart production does not at present support provision of full Loran-C service. Three cabinet-level departments--Transportation, Defense, and Commerce--are involved, and special attention to coordination is required. Current problems include an inadequate number of large-scale charts; failure to include bays, sounds, and harbors; security classification of the Additional Secondary Phase Factor routine; and some lack of coverage on Loran-A/C overlap charts.

RECOMMENDATION 7. *Publish Loran-C system specifications.*

Discussion: Even though the technical aspects of system specifications fall outside the scope of the present study, the topic still deserves attention. Specification of the signal will ensure that receiver designs can stabilize and guarantee a full lifetime without the uncertainty of changes. Related topics include clearing the 90-110 kHz and closely adjacent frequency spectrum of radio interference and establishing a common format for communication using the Loran-C signal.

RECOMMENDATION 8. *Ensure two years of overlapping and fully operational Loran service in all locations.*

Discussion: Implementation of Loran-C service can serve the U.S. marine navigator well. The Coast Guard, however, should not rush Loran-C chains into service. That Loran-C is a technically superior system to Loran-A has been widely advertised, and should be fact. However, early experience with Loran-C service on the West Coast is not auspicious. If the Loran-C signal is weak, if interfering signals are disabling, if charts are inaccurate, then the system should not be declared operational. A new ship undergoes sea trials and shakedown cruises before being placed in full service; perhaps implementation of Loran-C service should be handled in the same way. In any event, this study has been predicated on two years of overlapping Loran service as the *Annex to the National Plan for Navigation* guarantees. (At a minimum, two full operating seasons of overlapping service are needed to allow a smooth transition.) During these two years, Loran-C must be fully operational and the full quality of Loran-A service must be maintained.

In examining government-provided services, we see a delicate line between government assistance and government intervention. To date, the Coast Guard has not been active enough in ensuring a smooth transition. We advocate, however, not more government regulation and intervention, but instead more government assistance and encouragement of voluntary efforts. For example, receiver standards, and possibly receiver testing are needed, but government certification of receivers is not necessary. As another example, it would be desirable for a large number of mariners to use Loran-C: making Loran-C mandatory for various classes of vessels could bring this about. Another, and perhaps preferable, way is to work with marine insurance companies to develop lower rates for mariners with Loran-C, since it can measurably improve the safety of their operations.

Finally, the Coast Guard has been conscientious and competent in providing radionavigation aids of various kinds to U.S. marine users. Certainly this professional approach extends to Loran-C. Any fault has been the inordinate amount of attention given to putting the signal on the air and the inadequate attention paid to the total system, especially to the user and his or her problems. The mariner needs to know what Loran-C is, what it can do for him, and how to use it. He or she needs charts, and must convert Loran-A readings to Loran-C. Without such assistance, the transition will be more difficult, costly, and unpopular than it should be. With Coast Guard assistance, however, the transition to Loran-C can be relatively smooth and constructive, and the Loran-C system will come to serve the U.S. mariner well.

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technical appendices

appendix I summary of major Loran user group surveys

Section	Title
I-A	Commercial Fishing
I-B	Marine Commercial Sport-fishing Industry
I-C	Merchant Marine
I-D	Tug and Towboat Industry
I-E	Offshore Petroleum Service Industry
I-F	Marine Recreation
I-G	Other Loran-A Users
I-H	Loran-C Users

GENERAL DISCUSSION

From the outset of this project, we realized that information on U.S. civilian users of Loran-A was essential to perform the benefit-cost analysis and to evaluate the public policy aspects of the Loran transition. However, this kind of information does not exist.

Therefore, a major task of the project was collecting data on users, their characteristics, their location, Loran-A's economic and safety value for their marine operations, their plans with respect to Loran-C, and the problems and needs they confront with the navigational change. Information on Loran-A users was difficult to compile. Three factors in particular contributed to this: (1) Loran sets are not licensed, (2) a wide assortment of U.S., foreign, and World War II surplus sets are in use, and (3) the life expectancy of Loran receivers varies greatly.

This appendix presents the results of the various user surveys that were conducted as part of the project. The first six sections summarize survey results for the major Loran-A user groups. Section G acknowledges other users of Loran-A, and

Section H presents a brief summary of users of fully automatic Loran-C receivers.

Table I-1 shows the major Loran-A user groups and our best estimate of the number of users in each group. The community of Loran-A users is large, diversified in marine activities, generally satisfied with quality of service, and has been growing steadily in recent years.

receivers. Exhibit I-2 presents the recreational boating questionnaire.

The investigators recognized the hazard of double-counting and did their best to avoid it. That is, an oceangoing tug may also operate in the offshore petroleum service industry, a recreational vessel may charter or fish commercially on occasion, and a commercial fishing boat may participate in several different fisheries in different geographic regions in the course of a year. To the best of our abilities, we assigned a Loran-A user to that group which represented his or her major marine activity, for a single counting.

User group	Estimated number of Loran-A users (rounded to nearest hundred)
Commercial Fishing	15,000
Marine commercial sportfishing	1,800
Merchant marine	500
Tug and towboat industry	300
Offshore petroleum service vessel industry	600
Marine recreation	32,000
Other Loran-A users	500
Total	50,700

Table I-1. Estimated Number of U.S. Civilian Marine Loran Users.

Different sampling techniques were selected to collect data from the major groups according to composition, size, and accessibility of the group. For commercial fishing, field interviews with knowledgeable industry members and observers provided the basic data. For marine commercial sportfishing, a telephone questionnaire was used (for a sample of the questionnaire, see the Appendix of Oregon State University Sea Grant College Program Report, *Survey of Commercial Sportfishing in the Coastal United States* (5)). The merchant marine, tug and towboat, and offshore petroleum service vessel industries were sampled with a mailed questionnaire followed by telephone interviews with a random sample of nonrespondents. Exhibit I-1 presents the merchant shipping questionnaire to show the sampling instrument used with these three user groups. Indirect sources provided some data on marine recreation, but most data were collected by a mailed questionnaire sent to a sample of recreational boaters who were known to have purchased Loran-A

APPENDIX 1-A

COMMERCIAL FISHING

About one-fifth of the world's marine fisheries resources are found in waters within 200 nm of the U.S. coast. The U.S. commercial fishing industry consists largely of small businesses spread among the coastal states. An estimated 80% of the fishing craft in the United States are individually-or family-owned; 83% displace under five net tons (25).

The U.S. commercial fishing industry pursues many different species in many different geographic regions. Great variety

Merchant Shipping Questionnaire

(Please ignore small boxes on right side of paper. They are for our coding purposes.)

No

Wght

Exp

1. About how many people are employed by your company? ______________

2. Does your company receive an operating differential subsidy for merchant ship operations?

   yes   no   don't know

3. How many U.S. flag, privately owned merchant ships over 1000 gross tons does your company operate? (Include temporarily inactive ships but not laid up or mothballed ships?)

   ____

4. How many of these ships are equipped with Loran A but not Loran C?

   ____

5. How many of these ships are equipped with both Loran A and C?

   ____

How many of these ships are equipped with Loran C but not Loran A?

   ____

If you have Loran C on any ships, what kind of Loran-C receivers do you have?

- ____ Loran A converted to Loran C
- ____ Manual Loran C
- ____ A/C combination or partially automatic C
- ____ Fully automatic C
- ____ don't know

If you have ships equipped with Loran A but not Loran C, continue.

If not, go to page 6.

6. How would you rate the usefulness of Loran A to your ships in areas where Loran A is available? Circle the appropriate description.

26 [| | |]

for the purpose of:	Loran A is:				
a) safe navigation approaches to harbors	excellent	satisfactory	poor	don't use this function	don't know
b) preparedness for search and rescue operations	excellent	satisfactory	poor	don't use this function	don't know
c) general navigation while at sea	excellent	satisfactory	poor	don't use this function	don't know
d) saving voyage time through accurate navigation	excellent	satisfactory	poor	don't use this function	don't know

7. How would you compare the expected usefulness to your ships of Loran C compared to Loran A? Circle the appropriate description.

30 [| | |]

for the purpose of:	Loran C is:				
a) safe navigation in approaches to harbors	more useful	same	less useful	do not need this function	don't know
b) preparedness for search and rescue operations	more useful	same	less useful	do not need this function	don't know
c) general navigation while at sea	more useful	same	less useful	do not need this function	don't know
d) saving voyage time through accurate navigation	more useful	same	less useful	do not need this function	don't know

Exhibit I-1. Merchant shipping questionnaire

3

8. It is the Coast Guard plan to discontinue all Loran A transmissions by July 1980. Loran C installations will be complete by 1978. How many of your ships will you switch to Loran C in the next 4 years?

______ 34 [|]

9. Do you consider the necessity of replacing Loran A sets by Loran C sets to be a <u>major</u> economic burden?

yes no don't know 36 [ ]

10. What are the major problems you expect because of the change-over from Loran A to Loran C? (Check all that apply)

- ____ Receiver cost
- ____ availability of charts
- ____ limited supply of receivers
- ____ other ______ (please specify)
- ____ don't expect any problems
- ____ don't know

37 [| | | | |]

11. What kind of assistance would you like in switching to Loran C? (Check all that apply)

- ____ longer period than 2 years during which both A and C are operational
- ____ education programs
- ____ other ______ (please specify) ______
- ____ don't need any assistance
- ____ don't know

43 [| | | | |]

4

12. Would you be interested in any of the following educational programs? (Check all that apply)

- ____ Loran-C demonstrations
- ____ Workshops
- ____ Publications
- ____ other ______ (please specify)
- ____ don't need any
- ____ don't know

48 [| | | | |]

We need the answers to the following hypothetical questions to measure the potential benefits of Loran-C to the user community. We realize you probably cannot answer with a great deal of certainty but would appreciate your best approximations.

13. What is the most you would be willing to pay for a Loran A set that is convertible to Loran C? (Such a set would not give the full accuracy and range advertised for Loran C. Accuracy and range would be no better than that of Loran A.)

$ ______ don't know wouldn't buy at any price

54 [| | | |]

14. What is the most you would be willing to pay for a manual Loran C set? (Such a set would not give the full accuracy and range advertised for Loran C. Accuracy and range would be no better than that of Loran A.)

$ ______ don't know wouldn't buy at any price

59 [| | | |]

15. What is the most you would be willing to pay for an A/C combination set or partially automatic Loran C set. (Such sets usually have manual acquisition and automatic tracking. These sets would not give the full accuracy and range advertised for Loran C. Accuracy and range would be no better than that of Loran A.)

$ ______ don't know wouldn't buy at any price

64 [| | | |]

Exhibit I-1. continued

5

16. What is the most you would be willing to pay for a fully automatic Loran-C set. (Such sets will meet the advertised accuracy and range for Loran-C. They have readouts for 2 lines of position, have automatic acquistion and tracking, and are cycle matching.

69 [ ][ ][ ][ ][ ]

$ ________ don't know wouldn't buy at any price

If none of your ships will switch to Loran C go to Question 19. Otherwise, continue.

17. What kind of Loran-C set will you install in your ships? 74 [ ]

- ____ Convert present Loran A set to Loran-C.
- ____ Purchase an A set which is convertible to C.
- ____ Purchase A/C combination or partially automatic C set.
- ____ Purchase fully automatic Loran C set.
- ____ don't know

18. How much do you expect to spend per set?

$ ________ don't know

75 [ ][ ][ ][ ]

19. Could you give us the name of a person we could contact for more information on the subject of the effect of Loran A termination on your operations?

Name ________

Title ________

Address ________

____

Telephone Number ________
area code

6

Please answer the following questions for the ship named below. Check the accuracy of the recorded statistics on this ship and make any corrections that may be needed.

Name ________

1 (NEW CARD)

Gross tonnage [ ][ ][ ][ ][ ]

6

Dead weight [ ][ ][ ][ ][ ][ ]

12

Year built [ ][ ]

14

Type of ship ________ [ ][ ]

16

Interview number [ ]

20. What is the status of this ship in your company? 17 [ ]

continue to Question 21.
- ____ actively engaged in maritime commerce
- ____ temporarily inactive

terminate questionnaire.
- ____ laid up or mothballed
- ____ ship is not currently operated by our company

Exhibit I-1. continued

7

21. What is the usual area of operation of this ship? 18 ☐

____ foreign waters only

foreign and domestic waters

____ West Coast, Alaska/foreign

____ East and/or Gulf Coast/foreign

____ both U.S. coasts/foreign

domestic waters only

____ West Coast, Alaska

____ East and/or Gulf Coast

____ both U.S. coasts

____ don't know

22. What navigational devices does this ship have?
(Check all that apply)

____ Celestial

____ Radio Direction Finder

____ Fathometer

____ Radar

____ Omega

____ Satellite

____ Decca

____ Loran A

____ Loran C

____ other ____________

____ none

____ don't know

19 ☐☐☐☐☐☐☐☐☐☐☐☐ 24 … 30

8

23. Do you plan to install Loran-C in this ship in the next 4 years? 31 ☐

yes — go to Question 24

no — go to Question 25

don't know — terminate questionnaire

24. When do you expect to buy the Loran-C set for this ship? 32 ☐

____ soon, more than 6 months before the termination of Loran-A

____ within 6 months of the termination of Loran-A

____ late, more than 6 months after the termination of Loran A.

____ don't know.

(terminate questionnaire after answering)

Note: Loran A termination is scheduled for July 1979 on the West Coast, Hawaii, and Alaska and for July 1980 on the East and Gulf Coasts.

Exhibit I-1. continued

25. Why do you not plan to install Loran C on this ship? 33 ☐

____ Will install other navigational devices to make up for loss of Loran-A. Go to Question 26.

terminate questionnaire after answering:

____ Loran-C will not be available in this ship's area of operations

____ Currently have sufficient navigation capacity from other systems

____ Loran-C is not worth the cost

____ This ship will be scrapped or otherwise disposed of

____ other ____________ (please specify)

____ don't know

26. What navigation equipment do you expect to install to make up for the loss of Loran-A? 34 ☐☐

____ radio direction finder

____ radar

____ Omega

____ Decca

____ satellite

____ other ____________ (please specify)

____ don't know

THANK YOU VERY MUCH

Exhibit I-1. continued

Recreational Boating Questionnaire

1) Length of boat________ Primary propulsion: ____ sail ____ inboard motor ____ outboard motor

Homeport________ Primary boating activity ____ fishing ____ racing ____ cruising ____ other

2) What is the average number of days a month you spend boating? ________ days

3) What is the furthest from shore you normally go? ________ nautical miles

4) About what percent of the time is this boat operated in darkness or low visibility? ________ %

5) Is this boat documented with the Coast Guard?

____ yes ____ no

6) What navigation equipment does your boat have (circle those which you have)?

fathometer radar RDF Loran-A Loran-C Omega ________ other

If you have a Loran-A set or an A/C combination set, continue to question 7. If you do not have Loran-A the questionnaire is finished.

7) How many years experience do you have with Loran-A? ________ yrs

How old is your present Loran-A set? ________ yrs

Under normal usage how much longer would you expect your Loran-A set to last? ________ yrs

What are your annual repair and maintenance costs? $________

What type of Loran-A set do you have?

manual semi-automatic fully automatic A/C combination

Is your Loran-A set convertable to Loran C? yes no don't know

8) How would you rate the usefulness of Loran-A in the following areas? Circle the appropriate response.

For:	Loran-A is				
general navigation (getting from one place to another)	excellent	satisfactory	poor	don't use this function	don't know
Fishing (finding fish, finding pots, etc.)	excellent	satisfactory	poor	don't use this function	don't know
Safety (search and rescue, low visibility)	excellent	satisfactory	poor	don't use this function	don't know

9) How would you compare the expected usefulness of Loran-C to Loran-A? Circle the appropriate response.

For:	Loran-C will be				
general navigation (getting from one place to another)	more useful	same	less useful	don't use this function	don't know
fishing (finding fish, pots, etc.)	more useful	same	less useful	don't use this function	don't know
safety (search and rescue, low visibility)	more useful	same	less useful	don't use this function	don't know

10) Do you expect to switch to Loran C by 1980 when Loran A is terminated?
Yes No Don't Know

11) What do you see as the major problems facing you during the transition from Loran-A to Loran-C? ________

12) If you do not plan to switch to Loran-C, why not? ________

(Terminate questionnaire if you do not plan to switch)

13) If you do plan to switch, what kind of set do you intend to buy?

____ convert present A set to C

____ buy A set convertible to C

____ buy manual C set

____ buy A/C combination set

____ buy fully automatic C set

14) How much do you expect to pay for this set or for the conversion? $ ________

15) When do you expect to buy this set?

____ soon, more than 6 months before A termination

____ near A termination

____ later, more than 6 months after A termination.

NOTE: Loran-A is scheduled to terminate in July 1979 for the West Coast and Alaska and in July 1980 for the East and Gulf Coasts.

THANK YOU VERY MUCH

Exhibit I-2. Recreational boating questionnaire exists among fishing vessels, fishing gear, fishing techniques, and navigational needs and equipment.

This portion of Appendix I presents the results of a survey of the U.S. commercial fishing industry made to determine vessel characteristics, use of Loran, and plans for the Loran-A to Loran-C transition. The first section discusses the survey's methodology; the second describes the characteristics of the commercial fishing industry and its vessels; the third discusses the use of Loran by commercial fishing craft; and the fourth describes Loran-C transition plans and expectations of Loran-A users. The final section presents the problems Loran-A users expect during the transition and the forms of assistance they prefer.

METHODOLOGY

The U.S. commercial fishing industry is notoriously difficult to survey. No comprehensive list of fishing craft exists from which a random sample can be drawn. In the past, mailed questionnaires and telephone surveys have received a discouragingly low response rate. A statistically rigorous, personal interview, sampling technique would have been extremely difficult and expensive, would have required too much time, and, as well, might have been less than fully successful.

Therefore, the following approach was used. Indirect sources, including government publications, Sea Grant technical reports, and unpublished manuscripts, provided some background data. Most of the data, however, were collected through a system of carefully selected interviews. The network of Sea Grant institutions and its strong ties with industry were used to identify both key fishermen and industry representatives and observers. Almost all of the data on the commercial fishing industry were collected through resultant personal interviews that were conducted in fishing ports around the United States.

Project investigators visited each of the 22 coastal states at least once, spending 75 days in the field conducting interviews. In addition to interviewing over 500 fishermen, we conducted supplementary interviews with well over 100 Sea Grant marine advisory agents, marine electronics dealers, seafood processors, boat builders, boat repair firms, and port officials in order to collect supporting data.

The methodology was subjective, was definitely not random, and also resulted in collected data of a quantity and quality not previously assembled. Essential to the process were Sea Grant professional personnel, who individually possessed great knowledge of the fishing industry in their respective areas, and who identified representative and reliable spokesmen. In addition, the Sea Grant personnel enjoyed the confidence of the industry, to the extent that arrangements and introductions by them were sufficient to allow productive interviews to take place.

CHARACTERISTICS OF COMMERCIAL FISHING CRAFT AND OF THE COMMERCIAL FISHING INDUSTRY

The U.S. commercial fishing industry consists of 149,000 fishermen and 90,000 fishing craft. Of the fishing craft 15,400 are vessels displacing five net tons or more and 74,600 are boats of less than five net tons (25). Many fishing craft in both categories operate in bays, sounds, restricted waters, or close to shore.

Fishing vessels (of five net tons or more) tend to be small by oceangoing standards. In 1973, over three-quarters were less than 60 feet in length, although a high percentage of vessels constructed since then are larger. Table I-A-1 presents the distribution in length of U.S. fishing vessels of five net tons or more. The sizes of boats displacing less than five net tons run even smaller. In spite of their size, many of these smaller boats are full-time commercial oceangoing operating units.

Vessels of the U.S. commercial fishing fleet also tend to be old (table I-A-2 presents the age distribution of U.S. fishing vessels of five net tons or more). Three-fifths of the fleet was built before 1960; the oldest vessel was built in 1849. The statistics from which this table were compiled are for the year 1973, the most recent year for which a detailed breakdown is available. Since 1973, a relatively large number of new vessels have been built, and some of the older vessels have been retired. The 1977 age distribution of fishing vessels will thus be somewhat different from that presented in Table I-A-2. The general age situation for the U.S. commercial fishing fleet, however, is accurately depicted: the fleet is old.

Government statistics both at the federal and state levels were examined for possible

Length (feet)	Number of Vessels	Percent of Vessels (%)
20-39	6929	45.1
40-59	5163	33.6
60-79	2755	17.9
80-99	228	1.5
100-149	178	1.2
150-199	107	.7
200 and over	7	.05
TOTAL	15367	100.35

Source: National Marine Fisheries Service, Fishery Statistics of the United States 1973 (25).

Table I-A-1. Length Distribution of U.S. Fishing Vessels (5 net tons or more)

further use in the present study, but they were incomplete, duplicative, and inconsistent. Some fishing vessels over five net tons are undocumented and therefore do not appear in *Fishery Statistics of the United States* or *Merchant Vessels of the United States* (25,27). The criteria and systems for state registration of boats vary. In most cases, it is impossible to determine the primary marine use of a given boat. Different states collect and summarize fisheries statistics by very different methods: some states license fishermen, some states license boats, some fisheries require licenses for fisherman and/or boats, and some do not. As a final complication, many fishermen and boats are licensed in more than one state.

Fishing gear and techniques also vary widely. The most common methods used by U.S. marine commercial fishing craft are trawling, trolling, drift gillnetting, purse seining, pots, dredging, longlining, and hand lines. The species of fish or shellfish being harvested determines the gear, fishing techniques, and navigational needs.

Because of this variation among fisheries and methods, generalizations on

Year built	Number of Vessels	Percent of Vessels (%)
Before 1900	28	.2
1900-1919	558	3.6
1920-1939	2054	13.4
1940-1959	6433	41.9
1960-1973	6080	39.6
Unknown	213	1.4
TOTAL	15367	100.1

Source: National Marine Fisheries Service. Fishery Statistics of the United States 1973 (25).

Table I-A-2. Age Distribution of U.S. Fishing Vessels (5 net tons or more) navigational equipment are difficult to make. Therefore, Table I-A-3 presents average ranges of occurrence for navigational equipment within the total U.S. marine commercial fishing industry. More specific navigational usage rates can only be given in reference to a given fishery in a given area, and may differ widely from the average ranges presented. Nonetheless, the most common types of electronic navigational equipment for U.S. marine commercial fishing craft in all fisheries are fathometers, radars, and Loran-A receivers. Radio direction finders and Loran-C receivers are relatively less common. Very few fishing craft carry Omega, Decca, or satellite navigation systems.

Type of Navigation Equipment	Percent of Fishing Craft (Estimated Range) (%)
Radio direction finder	20-35
Fathometer	80-95
Radar	30-45
Omega	< 1
Decca	< 1
Satellite navigation system	< 1
Loran-A	25-40
Loran-C	5-15

Table I-A-3. Navigation Equipment Carried by U.S. Marine Commercial Fishing Craft

The vast majority of U.S. fishing craft are owned and operated by individuals or families. Relatively few large companies own and operate fishing craft. Perhaps 20% of the fleet is owned by small enterprises, which typically comprise an individual or family active in commercial fishing, a seafood processor, or another small company, and rarely own and operate more than ten fishing craft.

Most U.S. commercial fishermen are full-time, in the sense that their primary source of income derives from commercial fishing, but many of the operations are also marginal economically. Many boats operate in one fishery only; others are combination boats that pursue more than one fishery in the course of a year. Many boats fish regionally, without going far from their home ports; many boats are also highly mobile, making long trips and moving from region to region as a normal part of their operations. A small but significant number of boats that sometimes fish commercially are basically recreational or commercial sportfishing boats.

USE OF LORAN BY COMMERCIAL FISHING CRAFT

About 15,000 U.S. marine commercial fishing craft have Loran capability. Table I-A-4 shows the regional distribution of these users. One-fifth have both Loran-A and Loran-C capability (Table I-A-5). Virtually all users of Loran-C also have Loran-A.

	Number of Craft (Estimate)	Percent of Vessels(%)
Alaska	1200	7.8
West Coast	6000	39.0
Gulf Coast	3500	22.7
East Coast	4700	30.5
TOTAL	15,400	100.0

Table I-A-4. Regional Breakdown of Loran Users Among Loran-Equipped Commercial Fishing Craft

The manual set is the most common type of Loran-A receiver (Table I-A-6). The next most common type is the manual-acquisition, automatic-tracking, Loran-A receiver. About one-third of these two types of sets are convertible to Loran-C.

The majority of Loran-C sets in use are A/C combination sets (Table I-A-7). Of the manual Loran-C sets and visual-acquisition, automatic-tracking, Loran-C sets, about half were purchased as Loran-C sets and half were converted from Loran-A.

	Number of Craft (Estimate)	Percent of Vessels (%)
Loran-A Only	11,800	76.6
Both Loran-A and Loran-C	3,200	20.8
Loran-C Only	400	2.6
TOTAL	15,400	100.0

Table I-A-5. Breakdown of Loran-A and Loran-C Use Among Loran-Equipped Commercial Fishing Craft

The rate of Loran usage and types of sets used vary widely by fishery. Some fisheries have used Loran since its first commercial availability, and essentially every boat in the fishery has Loran. For instance, every boat in the Alaska king crab fishery operating out of Kodiak and Dutch Harbor uses Loran, and at least two-thirds of them use fully automatic Loran-C receivers. Almost all vessels in the surf clam industry on the East Coast use fully automatic Loran-C receivers. Similarly, almost all Gulf of Mexico shrimp boats ("Gulf shrimpers" as contrasted with "bay shrimpers") are equipped with Loran-A.

Other fisheries have only recently begun to use Loran, and at the present time an intermediate, but steadily growing, number of boats use Loran. For instance, about half of the salmon trollers on the West Coast use Loran-A, and the annual rate of adoption in recent years has been at the level of 5-10%. Similarly, Loran-A usage in the New England lobster fleet is a relatively recent event. One-quarter to one-third of the inshore lobster vessels (in contrast to skiffs) have Loran-A, and again rate of growth has been steady. In other fisheries, Loran usage is non-existent or incidental.

Most Loran-A-equipped fishing craft have one receiver, but in some fisheries, such as trawling for bottomfish and Gulf shrimping, half or more of the boats have two Loran receivers and a few even have three. The age of Loran-A sets in use ranges up to thirty years or more, since World War II surplus sets are still in use. The life expectancy of a Loran-A receiver depends on the set itself, the environment in which it operates (especially temperature and moisture levels), maintenance, and the way in which it is operated. Some sets last only one or two years, but typical useful life of a Loran-A receiver falls between five and eight years. Of course, another factor for determining when to retire a Loran-A set is technical obsolescence. Half of the sets in use are only three to four years old or younger.

Commercial fishermen commonly use Loran-A for general navigation, for navigation in piloted waters, for reducing voyage time, and for safety preparedness. However, by far the dominant use is to support directly the catching of fish or shellfish. Commercial fishing, more than any other Loran user group, uses Loran in the repeatable mode, that is, fishing vessels record at sea a Loran position to which they especially want to return (to retrieve a pot or relocate a productive fishing area) or to avoid (like bottom obstructions). These positions, recorded in logbooks over the years, have great economic and safety value to fishermen, who face the major task of converting A coordinates to C.

LORAN-C PLANS AND EXPECTATIONS

Most commercial fishermen have not yet planned for the Loran-A to Loran-C transition. They lack information on the implementation of Loran-C, the termination schedule for Loran-A, and other aspects of the transition, and as a result many have not yet decided on their specific actions. Nonetheless, almost all commercial fishermen who use Loran-A plan to switch to Loran-C.

Since most commercial fishermen who use Loran consider it essential for their fishing operations, the vast majority will switch to Loran-C before termination of Loran-A (Table I-A-8). Close to 10% will switch within the year after termination and only a few will not switch.

At current prices, and by their current plans, the largest number of commercial fishermen plan to purchase fully automatic Loran-C receivers (Table I-A-9). Substantial numbers also plan to convert existing Loran-A sets, to use or purchase Loran A/C combination sets, or to purchase Loran-C manual or semiautomatic sets that employ

	No. of craft (estimate)	% of vessels
Manual	7000	46.7
Manual-acquisition, automatic-tracking	5000	33.3
Fully automatic	1000	6.7
A/C combination	2000	13.3
TOTAL	15000	100.0

Table I-A-6. Types of Loran-A in use by Loran-A equipped fishing craft

	No. of craft (estimate)	% of craft
Manual	100	2.8
Visual-acquisition, automatic-tracking	500	13.9
A/C combination	2000	55.6
Fully automatic	1000	27.8
TOTAL	3600	100.1

Table I-A-7. Types of Loran-C in use by Loran-C equipped fishing craft

When Expect to Switch	Percent of Craft (Estimated Range) (%)
More than 6 mo before Loran-A termination	45-55
Within 6 mo before Loran-A termination	30-40
Within 12 mo after Loran-A termination	5-15
Never	0-10
TOTAL	100

Table I-A-8. When U.S. Commercial Fishermen Using Loran-A Expect to Switch to Loran-C

Kind of Loran-C set	Percent of Craft (Estimated Range) (%)
Convert present Loran-A set	20-30
A/C combination set	20-30
Manual or semiautomatic set employing visual acquisition	10-20
Fully automatic set	30-40
TOTAL	100

Table I-A-9. Kind of Loran-C Set Loran-A Users Intend to Buy/Use

visual acquisition. Those who plan to purchase fully automatic Loran-C receivers expect to pay $3000-5000 for the set. If Loran-C receiver prices drop, a widely cited figure representing a price breakthrough is $2000. That is, if fully automatic Loran-C receiver prices drop to $2000 before Loran-A is terminated, a much higher number than Table I-A-9 indicates will purchase such sets.

Commercial fishermen generally expect Loran-C to provide better navigational service than Loran-A. Many also point out that they do not need better navigational service for their particular fishing operations. In Alaska and New England, where there has been considerable experience with Loran-C, the expectations and enthusiasm for Loran-C run much higher.

PROBLEMS AND POTENTIAL REMEDIES

The major problems facing commercial fishermen are (1) the cost of switching from lower-priced Loran-A receivers to higher-priced Loran-C receivers, (2) the need to switch before the end of the useful life of an installed Loran-A set, and (3) the necessity of converting Loran-A coordinates to Loran-C. Most fishermen regard the forced transition as a major economic burden, although some who have switched point out that the superior navigational capability of Loran-C makes money for their fishing operations. For instance, an Alaskan king crab fisherman in Kodiak commented, "My Loran-C set paid for itself, perhaps in a day and a half, but certainly in the first three weeks I had it." Most fishermen who use Loran-A in the repeatable mode also consider conversion of data a major problem, do not know at the present time what method they will use to convert data, and regard conversion as expensive to their operations both in terms of time and money (lost fishing time, possible reduced catches, inability to retrieve pots, increased damage to nets). Other frequently mentioned problems include availability, quality, and coverage of charts; availability of receivers; and dependability and technical adequacy of Loran-C signals.

Commercial fishermen have identified a number of forms of assistance that would help them. Many desire financial assistance, especially clarification of tax and investment-credit treatment and information on the availability of commercial and government loans. Many fishermen seek assistance with data conversion through such means as Loran A/C overlap charts, calculator conversion software, and information on technical aspects and methods of conversion. Also popular are a longer transition period more extensive information on the transition, and education programs, which run the gamut from demonstrations and workshops to publications.

APPENDIX I-B

SURVEY OF U.S. COMMERCIAL SPORTFISHING INDUSTRY

Approximately 4000 U.S. flag vessels carry sportfishermen for hire. Vessels and vessel operations in this group have some of the characteristics of both commercial fishing and recreational boating, but are sufficiently different from either of these larger groups to warrant a separate category.

Many different names apply to vessels in this group, such as charterboat, party boat, and head boat. Some name differences reflect regional variation, whereas others reflect differences in how passengers are acquired. In general, sportfishing vessels for hire can be divided into two basic classes: vessels that sail on a regular schedule with as many passengers as have bought tickets, and vessels that operate only when chartered by a group.

Appendix I-B presents the results of a survey designed to determine the characteristics of commercial sportfishing Loran-A users and their plans for the transition to Loran-C.[4] The first section presents the survey's methodology; the second describes the characteristics of the Loran-A user and compares these with nonusers'. A discussion follows of users' experience with Loran-A and their plans and expectations for Loran-C. The last section presents problems and potential remedies identified by users.

METHODOLOGY

Choice of Survey Medium

Each of the three standard survey media--personal interview, telephone interview, and mailed questionnaire--has different advantages. Three criteria were important in selecting a medium: expense, response rate, and availability of a sampling frame. The personal interview was too expensive. The estimated response rate to a mailed questionnaire of commercial sportfishing skippers was too low to make this feasible. The telephone interview, with moderate expense and high response rate, was therefore chosen as the survey medium. In addition, the only sampling frame available, consisting of the telephone numbers of all commercial sportfishing operators advertising in yellow pages, lent itself best to the telephone interview.

[4] For further information on the commercial sportfishing industry see (5).

Sampling Plan

Before a sample could be drawn, one necessary task was to determine the size and distribution of the commercial sportfishing population. Since no reliable estimates on a national scale appear in the literature, we estimated the number of commercial sportfishing vessels in each port of the coastal United States, using all available sources of information, including marine advisory personnel, other Sea Grant specialists, state tourist boards, state development agencies, state park and recreation departments, local chambers of commerce, harbor masters, and other knowledgeable people identified in this search.

A self-weighting stratified random sample was then drawn. Each of the ports constituted a stratum of sportfishing vessels from which a number of vessels was chosen randomly, at a ratio of 1:24. As many random numbers between one and 100 were drawn as the number of vessels for sampling in each port, and each random number was then converted to a telephone number. However, two major problems made this process difficult. First, it would have been impractical to compile all telephone numbers listed in the yellow pages. This would have required ordering well over 100 telephone books, and the compiled list would have been much shorter than an actual list of vessels, since a number of vessels frequently operate out of one office with only one telephone book listing and not all vessels have a yellow pages listing.

Since no better sampling frame existed, we lived with the second problem, the inadquacies of the yellow pages list. We therefore made the assumption that no difference exists between the population of charterboats that advertize in the yellow pages and those that do not. To work around our inability to compile the yellow pages list, we used the following procedure:

1. The frequency of each initial letter

in the white pages of the Portland, Oregon, telephone book was computed and expressed as a cumulative percentage.

2. Each of the random numbers between one and 100 drawn in the sample could then be converted to an initial letter.

3. The telephone numbers of all commercial sportfishing listings that began with each of the letters selected for each port were requested from information operators or some other source.

4. If no listing existed with the required first letter, the next listing was requested.

5. When an office representing more than one vessel was reached, the respondent was asked to list the vessels. The interviewer then chose randomly a particular vessel.

6. When we needed to replace a number, we used the next number on the list.

7. In a few cases, the problem of obtaining telephone numbers according to these rules was so great that a number was obtained by any means available.

Disposition of Calls

Interviewers made 537 calls to complete 156 interviews (Table I-B-1). Of the 298 calls that resulted in no answer, a busy signal, or an invitation to call back, most were repeated at least six times or until some other response was obtained. These 298 calls therefore introduce little bias. However, 39 calls did not eventually result in a successful interview, primarily because the skipper could not be reached; these calls included disconnected numbers and recordings giving sailing information. Of necessity telephoning occurred during the off-season for many parts of the country: many skippers had closed down their operations or moved south for the winter season. We trust that skippers we could not reach are not unusual in their Loran characteristics so that little bias is created in the survey. The number of refusals to answer was encouragingly low.

Computational Procedures

Since the sample is self-weighting, $\bar{x}$ is simply the mean of all observations:

$$\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N}$$

where:
x_i is the value of the variable in case i, and
N is the total number of valid cases.

The formula used to calculate the standard error is:

$$S.E. = \left(\frac{\sum_{i=1}^{N} (x_i - x)^2}{N(N-1)} \right)^{1/2}$$

INCORRECT NUMBERS	15
OUT OF BUSINESS	26
CALL-BACKS	71
NO ANSWER	195
BUSY SIGNAL	32
NUMBER DISCONNECTED ("... per customer's request")	20
SKIPPER OUT FOR SEASON	15
RECORDING ONLY (fishing information, departure times, etc.)	4
REFUSALS TO ANSWER QUESTIONNAIRE	3
SUCCESSFUL INTERVIEWS	156
TOTAL CALLS MADE	537

Table I-B-1. Telephone Calls Made in Surveying the Commercial Sportfishing Industry.

This formula assumes that the sample is a simple random one rather than a stratified random sample. Since stratifying reduces the variance in a heterogenous but regionally homogeneous population, the formula when used for a simple random sample results in an estimated standard error that is larger than its true value. The 95% confidence limits on the mean were calculated using the following formulas:

$$\text{upper limit} = \bar{x} + 1.96\ (\text{S.E.})$$

$$\text{lower limit} = \bar{x} - 1.96\ (\text{S.E.})$$

If the sample were drawn many times, the mean would fall within these confidence limits 95% of the time.

The significance of a relationship between two variables is determined using the Chi-square test. First, a two dimensional contingency table is constructed. A hypothetical table is given below as an example for two variables, each of which takes on two values, yes or no (Table I-B-2).

Variable 1	Variable 2: Yes	Variable 2: No	Marginal Totals
Yes	10 (20)	40 (30)	50
No	30 (20)	20 (30)	50
Marginal Totals	40	60	100

Table I-B-2. A Hypothetical Contingency Table.

The numbers in each cell, or fo^i, are the actual frequency of occurence of that response, expressed as a percentage. The marginal totals are the sum of row and column frequencies. The number in parentheses within each cell, or fe^i, represents the expected frequency in that cell calculated by multiplying the appropriate row and column marginals. The value of Chi-square is then calculated according to:

$$\chi^2 = \frac{(fo^i - fe^i)^2}{fe^i}$$

The probability of obtaining the given value of χ^2 with the appropriate degrees of freedom is obtained from a table. When the probability is .05 or less, the null hypothesis, that there is no relationship between the variables, was rejected.

CHARACTERISTICS OF THE COMMERCIAL SPORTFISHING COMMUNITY

There are 3963 commercial sportfishing vessels in the United States; two-thirds of them are located on the East Coast (Table I-B-3). Although all these vessels differ, certain characteristics are typical. Most commercial sportfishing vessels (87%) are operated by skippers who also own them. These skipper-owners almost always have only one vessel. Owners who are not skippers frequently operate up to five vessels. For the majority of operators (72%), commercial sportfishing is the primary source of income; for most of the others (22%), however, commercial sportfishing represents a small percentage of their income. The typical operator runs his business from a small office that represents up to four vessels, although some offices handle up to 40 vessels. Almost three-quarters of all commercial sportfishing vessels range from 22 feet to 60 feet in length (Table I-B-4). The capacity of charterboats varies from three to more than 90 passengers, with the average vessel carrying 32 (Table I-B-5). The average number of passengers carried per trip is 19 people, much smaller than the average vessel capacity. Most vessels go far enough offshore (more than 15 miles) so that visual or radar navigation is impossible (Table I-B-6). The vast majority of trips take between five and 12 hours, so that most commercial sportfishing vessels make one trip per day (Table I-B-7). The average charge per passenger per trip is just under $24.00 (Table I-B-8).

EXPERIENCE WITH LORAN-A

Number of Loran Users

The majority of commercial sportfishing vessels in the United States are equipped with some form of Loran set (Table I-B-9). Nearly half are equipped with Loran-A, and 13% with Loran-C. Although the percentage of each type of Loran varies considerably for different coasts, the percentage of vessels that have either Loran-A or Loran-C is remarkably constant, varying only from 59% on the Atlantic Coast to 67% on the Gulf Coast.

STATE	NO. OF VESSELS	
Washington	354	
Oregon	239	
California	308	
SUB-TOTAL, PACIFIC COAST		901
Texas	99	
Louisiana	35	
Mississippi	36	
Alabama	34	
Florida (Gulf Coast)	375	
SUB-TOTAL, GULF COAST		579
Florida (Atlantic Coast)	297	
Georgia	24	
South Carolina	50	
North Carolina	196	
Virginia	226	
Maryland	190	
Delaware	72	
New Jersey	406	
New York	507	
Connecticut	146	
Rhode Island	42	
Massachusetts	233	
New Hampshire	26	
Maine	68	
SUB-TOTAL, ATLANTIC COAST		2483
TOTAL UNITED STATES		3963

Table I-B-3. Distribution of vessels carrying sportsfishermen for hire.

Vessel Length (feet)	Percent of Vessels (%)
less than 41	34
41-60	38
61-80	20
81-100	6
101-120	2

Average = 51 ft.

Table I-B-4. Length of Commercial Sportfishing Vessels

Capacity (passengers)	Percent of Vessels (%)
3-6	38
7-30	22
31-60	22
61-90	8
More than 90	10

Average = 32 people

Table I-B-5. Passenger Capacity of Commercial Sportfishing Vessels

Miles offshore	Percent of Vessels (%)
2-15	30
16-50	49
51-110	21

Average = 33 miles

Table I-B-6. Distance Travelled Offshore

Trip time (hours)	Percent of Vessels (%)
Less than 5	10
5-8	45
9-12	39
More than 12	6

Average = 9 hours

Table I-B-7. Trip Time in Hours

Charge ($)	Percent of Vessels (%)
Less than 20	45
21-40	49
41-60	4
More than 61	2

Average = $23.73

Table I-B-8. Charge per Passenger

	Atlantic		Gulf		Pacific		U.S.		95% Confidence Limits for Number in U.S.
	Percent (%)	Number	Percent (%)	Number	Percent (%)	Number	Percent (%)	Number	
Nonuser	41	1018	33	191	37	333	39	1546	1474-1632
Loran-A user	39	968	53	307	63	568	47	1863	1787-1930
Loran-C user	20	497	14	81	0	0	14	555	518-592
Total	100%	2483	100%	579	100%	901	100%	3963	

Table I-B-9. Number of Charterboats Equipped with Loran

Commercial sportfishing vessels using Loran have significantly different characteristics from vessels not so equipped. Loran-equipped vessels are likely to be longer and able to carry more passengers (Table I-B-10). Loran users go farther offshore than nonusers and stay out longer (Table I-B-11).

Characteristics of the Loran-A user

Commercial sportfishing skippers who use Loran-A comprise a rapidly growing group of very satisfied Loran users. Forty percent of all Loran-A users have five or fewer years of experience with Loran-A (Table I-B-12). Of Atlantic Coast users, 80% have more than five years of experience. But the Pacific Coast user is very new to Loran-A; 60% have less than five years of experience.

Almost all commercial sportfishing skippers reported using Loran for general navigation, as a safety feature in conditions of low visibility, and for fishing operations. Skippers most commonly use Loran to repeatedly find a rich fishing ground or to stay with or find a school of pelagic fish.

Almost all of these Loran-A users are very satisfied with the service they receive (Table I-B-13). On every coast at least 59% of the respondents rate Loran-A as

Length (feet)	Percent of Nonusers (%)	Percent of A users (%)	Percent of C users (%)
21-40	45	31	9
41-60	41	42	19
61-80	9	22	48
81-100	5	4	14
101-120	0	1	10
Total	100%	100%	100%

χ^2 probability = .0001

Table I-B-10. Length of Vessel for Loran Users and Nonusers

Distance travelled offshore (miles)	Percent of Nonusers (%)	Percent of A users (%)	Percent of C users (%)
2-15	55	11	25
16-50	38	59	40
51-110	7	30	35

χ^2 probability less than .0001

Table I-B-11. Distance Travelled Offshore for Loran Users and Nonusers

Years of Experience with Loran-A	Percent of users (%)			
	Atlantic Coast	Gulf Coast	Pacific Coast	Total U.S.
1-5	21	46	59	40
6-10	30	36	21	27
11-15	15	0	10	11
More than 15	34	18	10	22
Total	100%	100%	100%	100%
Average	13 yrs.	10 yrs.	8 yrs.	11 yrs.

Table I-B-12. Years of Experience with Loran-A

For the purpose of:	Percent rating Loran-A as excellent (%)		
	Atlantic Coast	Gulf Coast	Pacific Coast
Navigation	59	64	76
Safety	59	60	79
Operations	59	64	86

Table I-B-13. Commercial Sportfishing Skippers Rating of Loran-A Service

Quality of Loran-A coverage	Percent of nonusers intending to buy Loran (%)
Good	25
None or poor	10
χ^2 probability = .11	

Table I-B-14. Percentage of Nonusers Intending to Buy Loran By Quality of Loran-A Coverage

excellent. Loran-A's excellent reputation is one of the main reasons that its population of users has grown so rapidly. As a result, a much higher percentage of nonusers in areas of good Loran-A coverage intend to buy Loran in the future than do nonusers in areas of poor or no Loran-A coverage (Table I-B-14).

The characteristics of the Loran-A sets in use on commercial sportfishing vessels vary considerably: half are partially automatic, with manual acquisition and automatic tracking (Table I-B-15). Most of the other sets in use are manual, and only 4% are fully automatic, dual-track sets. The age of sets in use varies greatly between coasts (Table I-B-16): sets on the Pacific and Gulf Coasts average six years old. Newer sets are more often partially or fully automatic than older sets.

Kind of set	Percent of sets (%)
Manual	46
Partially automatic	50
Fully automatic Dual track	4
Total	100

Table I-B-15. Kinds of Sets in Use

Purchase Price ($)	Percent of sets (%)
1-500	14
501-1500	61
1501-2500	25
Total	100%
Average	$1274

Table I-B-17. Purchase Price of Loran Sets in Use

Age of set (years)	Percent of sets (%)			
	Atlantic Coast	Gulf Coast	Pacific Coast	Total U.S.
1-3	23	64	65	46
4-6	47	27	28	37
7-9	15	0	7	9
More than 9	15	9	0	8
Total	100%	100%	100%	100%
Average	6 yrs.	3 yrs.	3 yrs.	4 yrs.

Table I-B-16. Age of Loran-A Sets by Coast

The average purchase price of sets is $1274, although actual purchase prices may vary up to $2500 (Table I-B-17).

LORAN-C PLANS AND EXPECTATIONS

Most commercial sportfishing skippers who use Loran-A have made some tentative plans for the changeover, and have some expectations for Loran-C. Most intend to switch to Loran-C (Table I-B-18). The kind of Loran-C set operators intend to buy varies considerably throughout the country (Table I-B-19). The percentage of operators who want fully automatic Loran-C sets drops from 50% on the Atlantic Coast to 30% on the Gulf Coast to only 14% on the Pacific Coast. One hypothesis to explain this variation is that the kind of set purchased depends on the fleet's experience with Loran-C and word-of-mouth evaluation of the different kinds of sets. For example, until very recently the Pacific Coast fleet has had very little exposure to Loran-C and therefore has no experience with the problems of operating manual Loran-C sets or the advantages of a fully automatic set. But regardless of the kind of Loran-C set an operator intends to

Coast	Percent of Loran-A users intending to switch (%)
Atlantic	79
Gulf	92
Pacific	97
Total U.S.	88%

Table I-B-18. Percentage of Loran-A Users Intending to Switch to Loran-C

purchase, he or she expects it to perform better than Loran-A (Table I-B-20). Thus, the Coast Guard and the commercial sport-fishing Loran user face potential problems if these expectations are not met or replaced by more realistic ones.

Many users' plans are not yet firm enough for them to say when they intend to buy their Loran-C set. Those with definite plans generally intend to buy a set within six months of Loran-A termination (Table I-B-21). If the termination of Loran-A were delayed for one year, almost all of these purchasers would delay their purchase as long as possible. However, a substantial minority intends to purchase a set six months or more before Loran-A termination. Approximately 70% of these early purchasers

Kind of Loran-C	Percent (%) of Loran-C buyers			
	Atlantic	Gulf	Pacific	Total U.S.
A convertible to C	7	10	0	5
Convert present A to C	11	20	29	20
Manual C	4	10	21	12
Partially automatic C or A/C combination	11	0	18	12
Fully automatic C	52	30	14	32
Don't know	15	30	18	19
	100%	100%	100%	100%

Table I-B-19. Kind of Loran-C Loran-A Users Intend to Buy

Kind of C set intending to buy	Percent expecting Loran-C to be better than Loran-A (%)			
	Atlantic	Gulf	Pacific	Total U.S.
Fully automatic C	100	100	67	94
All other types of C	100	100	61	75

Table I-B-20. Expectations for Loran-C

Purchase time	Percent of those switching to Loran-C (%)
6 months or more before termination	26
Near termination	42
Don't know	32
	100%

Table I-B-21. When Loran-A Users Intend to Purchase Loran-C

Problem	Percent who mentioned the problem (%)
Cost of buying Loran-C set	30
Availability of charts	9
Conversion of hang data	27
Cost of conversion of electronics	9
Expect no problems	15

Table I-B-22. Expected Problems During the Transition from Loran-A to Loran-C

intend to buy fully automatic sets. The timing of most of these purchases would not be affected by changes in the Loran-A termination schedule.

PROBLEMS AND POTENTIAL REMEDIES AS SEEN BY THE COMMERCIAL SPORTFISHING SKIPPER

Commercial sportfishing vessel operators identified the major problems that they expected during the transition from Loran-A to Loran-C, and the potential assistance that would help them live with these problems (Tables I-B-22 and I-B-23). They most often cited the problems of the cost of buying a Loran-C set and the difficulties involved in converting hang data or favorable fishing ground locations from Loran-A to Loran-C coordinates. Government financial assistance, in the form of grants, loans, or a buy-back program, and educational and informational programs were the most frequently requested forms of assistance. Almost a quarter of the respondents, however, felt that they did not need any assistance. When questioned about the desirability of specific kinds of educational and informational programs, such as demonstrations, workshops, or publications, slightly less than a third of the operators felt that each of the three types of programs would be valuable to them, whereas the same number said that no educational programs were needed (Table I-B-24).

Form of Assistance	Percent who mentioned (%)
Longer overlap	12
Educational programs	14
Favorable tax treatment	9
Government grants or loans	17
Discount on insurance rates	2
No assistance desired	24

Table I-B-23. Assistance Desired During the Transition from Loran-A to Loran-C

Program	Percent desiring program (%)
Demonstrations	32
Workshops	27
Publications	29
No programs needed	30

Table I-B-24. Educational Programs Desired

APPENDIX I-C

SURVEY OF THE MERCHANT MARINE

The United States merchant marine is one of the most visible segments of the U.S. marine community, but is also one of the smallest groups in terms of number of vessels. In contrast to most other vessel operators, such as fishermen or tugboat firms, merchant vessel operators are usually large companies with substantial capital assets and many employees. Merchant vessels also typically operate worldwide, whereas vessels in most other user groups operate locally, regionally, or coastwise.

Because merchant ships operate in many different types of waters in many parts of the world, their navigational needs are demanding. The complement of electronic navigational aids most merchant ships carry is therefore larger than that carried by other types of vessels. To prevent vessel collisions and groundings, and to protect the marine environment from harm, the Coast Guard proposes to require all merchant vessels of 1600 gross tons or more that operate in U.S. waters to carry a Loran-C receiver. If this requirement is adopted, some merchant vessel operators will alter their Loran plans from those stated in this report.

This section of Appendix I presents the results of a survey of merchant vessel operators taken to determine their vessel characteristics, use of Loran, and plans for Loran-A to Loran-C transition. The first section discusses the survey's methodology used in the survey; the second gives the characteristics of merchant vessels and the companies that operate them; and the third describes merchant vessels' use of Loran. The Loran-C transition plans and expectations of Loran-A users then follow. The final section presents the problems merchant mariners who use Loran-A expect during the transition and the forms of assistance they prefer.

METHODOLOGY

Choice of Survey Medium and Questionnaire Development

The medium chosen was a mailed questionnaire followed by telephone calls to nonrespondents. Personal interviews were too expensive and time-consuming. Less costly in time and money, a telephone survey of a sample of firms would have been feasible. Because the estimated response rate of merchant vessel operators to a mailed questionnaire was higher than for many other user groups, the mailed questionnaire was also feasible, and least time-consuming and expensive. However, we could reach a larger sample of firms than possible with the telephone survey, with more statistical assurance than with the mailed survey by combining telephone and mail. We therefore decided to start with a questionnaire mailed to all merchant vessel operators, followed up by telephone calls to a sample of nonrespondents. This procedure ensured that a large proportion of the population could be surveyed quickly, cheaply, and accurately with a minimum of telephoning.

We then developed a questionnaire for mailing. With branching kept to a minimum and the overall length short, the questionnaire was divided into two parts. The first part dealt with the company, the number of vessels it operated, and management's attitudes and plans for the Loran transition. The second part questioned respondents about a randomly drawn sample of individual ships--where they operate, what navigational devices they use, and their Loran-C plans. A copy of this questionnaire is reproduced at the beginning of this Appendix.

Sampling Plan

Before proceeding with mailing or telephoning, we needed to draw up a list of U.S.-registered merchant ships and the names of their operators. In its *Vessel Inventory Report*, the Maritime Administration lists all U.S.-flag vessels and their owners, with updates given in the monthly *Status of American Merchant Marine* (23,24). Although it does not name operators, the list of vessels thus compiled is very complete. Operators for most of these vessels can be obtained from the list prepared by the trade magazine *Marine Engineering/Log* (32). A combination of the two lists plus supplementary information from the Maritime Administration allowed us to compile an accurate and complete list of vessels and operators. The *Marine Directory* published by *Marine Engineering/Log* lists the address, telephone number, and name of the operations manager for each firm (11).

Once the list was prepared, we could implement the sampling plan. First, a questionnaire was mailed to all firms. When the number of returned questionnaires received per day began to drop off, a second mailing was sent to all nonrespondents.

After the response rate per day had again declined to zero, the largest nonresponding firms were telephoned. The list of firms was then divided into two strata: (1) those firms that had already answered and (2) those firms that had not yet responded. We then telephoned a 25% random sample of the firms in Stratum 2. When we had to replace a firm, the next firm on the list was selected. The overall plan therefore consisted of a stratified sample with different sampling fractions in each of the two strata.

Disposition of Responses

Knowing the disposition of responses allows an evaluation of the validity of survey results. Table I-C-1 shows the number of firms and vessels, and the number sampled, in each stratum for both Parts 1 and 2 of the questionnaire. About half of the companies and three-fourths of the vessels are contained in Stratum 1, indicating that a very high proportion of the population is known completely without error. Table I-C-2 gives the disposition of phone calls for the random sample of Stratum 2. "Busy," "no answer," and "call back" responses are not included, since repeated attempts were made until one of the responses in Table I-C-2 was obtained. The relatively large number of refusals, compared to the number

	Total Number of		Number Sampled in Part 1 questions		Number Sampled in Part 2 questions	
	Firms	Vessels	Firms	Vessel	Firms	Vessels
Stratum 1	32	428	32	428	32	53
Stratum 2	35	151	7	37	7	10
Total	67	579	39	465	39	63

Table I-C-1. Number of Firms and Vessels Present and Sampled in Each Stratum

	Number of calls
Refuse to answer questionnaire	3
Telephone number of firm not available	1
Knowledgeable person not available	1
Successful interviews	10
Total	15

Table I-C-2. Disposition of Phone Calls in the Sampling of Stratum 2 of completed interviews, may introduce a small amount of bias into Stratum 2, although since Stratum 2 is such a small proportion of the population the biasing effect on estimates of the entire population will be slight.

Computational Procedures

The formula used for the mean calculation is:

$$\bar{x} = \left(\frac{1}{\sum_{j=1}^{N_1} S_{1j} + \sum_{j=1}^{N_2} S_{2j}} \right) \sum_{j=1}^{N_1} \frac{S_{1j}}{s_{1j}} \sum_{k=1}^{S_{1j}} x_{1jk} +$$

$$\left(\frac{1}{\sum_{j=1}^{N_1} S_{1j} + \sum_{j=1}^{N_2} S_{2j}} \right) \left(\frac{\sum_{j=1}^{N_2} S_{2j}}{\sum_{j=1}^{n_2} S_{2j}} \right) \sum_{j=1}^{n_2} \frac{S_{2j}}{s_{2j}} \sum_{k=1}^{s_{2j}} x_{2jk}$$

where

x_{ijk} = measured attribute of the k^{th} ship of the j^{th} firm of the i^{th} stratum

S_{ij} = the number of ships operated by the j^{th} firm of the i^{th} stratum

s_{ij} = sample size drawn from the j^{th} firm of the i^{th} stratum

N_i = the number of firms in the i^{th} stratum

n_i = the number of firms sampled in the i^{th} stratum (In this survey $n_1 = N_1$).

This formula applies to variables in both Part 1 and Part 2 of the questionnaire.

Standard error calculations were made only for a small number of Part 1 variables, each of which measures the possession of an attribute. Because all vessels in Stratum 1 were inventoried, Stratum 1 does not contribute to the standard error. We made the assumption that Stratum 2 was a random sample of ships, rather than a random sample of firms in which the characteristics of all ships in each firm sampled were determined. Calculations made with the true formula indicate that this is a valid assumption. The formula used for standard error is:

$$S.E. = \left[\left(\frac{\sum_{j=1}^{N_2} S_{2j}}{\sum_{j=1}^{N_1} S_{1j} + \sum_{j=1}^{N_2} S_{2j}} \right)^2 \frac{P(1-P)}{\sum_{j=1}^{n_2} S_{2j}} \left(1 - \frac{\sum_{j=1}^{n_2} S_{2j}}{\sum_{j=1}^{N_2} S_{2j}} \right) \right]^{1/2}$$

where p = proportion of the sample possessing the attribute. This proportion equals the mean if the value of the variable is 1 when the attribute is present and 0 when it is not.

We used standard error values to determine 95% confidence limits as a measure of the precision of the estimate of the mean. These limits were calculated using the formulas:

$$\text{upper limit} = \bar{x} + 1.96\ (S.E.)$$

$$\text{lower limit} = \bar{x} - 1.96\ (S.E.)$$

If the sample were drawn many times, the mean would fall within these confidence limits 95% of the time.

The significance of hypothesized relationships between variables was determined using the Chi-square test, an explanation of which is given in the commercial sportfishing portion of this appendix. Since this survey was not self-weighting, each value of x_{ijk} was multiplied by weighting factor, ρ.

$$\rho = \left(\frac{\sum_{j=1}^{n_1} s_{1j} + \sum_{j=1}^{n_2} s_{2j}}{\sum_{j=1}^{N_1} S_{1j} + \sum_{j=1}^{N_2} S_{2j}} \right) \left(\frac{\sum_{j=1}^{N_i} S_{ij}}{\sum_{j=1}^{n_i} S_{ij}} \right) \left(\frac{S_{ij}}{s_{ij}} \right)$$

This factor weights each observation according to the number of cases the observation really represents, and also maintains the total number of cases at the number of cases actually sampled so that the probability obtained from the Chi-square test is not influenced by an artificially high number of cases. Because of the small number of weighted cases, a probability of .25 was accepted as significant. Only significant relationships are discussed.

CHARACTERISTICS OF MERCHANT VESSELS AND THE FIRMS THAT OPERATE THEM

As of September 1976, there were 579 privately owned U.S.-flag merchant vessels over 1000 gross tons (24). Tankers are the most common type, followed by cargo vessels and containerships (Table I-C-3). Most of the vessels engage in domestic-to-foreign or domestic-to-domestic commerce; only a few are employed in foreign-to-foreign commerce (Table I-C-4). Tables I-C-5 and I-C-6 give the distributions, as predicted by the sample, of U.S. ships by gross tonnage and deadweight tonnage. Although most ships appear in the smallest categories, the average gross tonnage and deadweight tonnage of ships have increased since 1968 because of the addition of large tankers of more than 40,000 DWT. Most vessels have been built since 1960, although a substantial number of older vessels were built during the 1940s (Table I-C-7).

Merchant vessels carry a number of electronic navigation devices in addition to celestial navigation equipment (Table I-C-8). All vessels carry radio direction finders, as required by Coast Guard regulation. All vessels also carry one or more fathometers and radars. Most ships have Loran capability; some can receive Loran-A only, a few receive Loran-C only, and many receive both. Relatively few vessels carry Decca, Omega, or satellite systems, although some firms are experimenting with satellite systems on a few of their vessels.

Companies that operate merchant vessels also vary greatly. Seventeen companies, representing 196 vessels, are assisted through operating differential subsidies (21), and most of the rest are indirectly subsidized. Most companies are small, with 50 to 400 employees (Table I-C-9) (21). But a few very large companies, notably the oil companies, have numbers of employees ranging into the tens of thousands.

Ship Type	Number of Vessels	
Total Freighters		310
General Cargo	131	
Containerships	134	
LASH	27	
Roll-on/Roll-off	12	
Combination Passenger & Cargo	6	
Bulk Carriers		18
Total Tankers		251
Oil Tankers	233	
Other Tankers	18	
Total Vessels		579

Source: Maritime Administration, Vessel Inventory Report, (23, pp 18-39).

Table I-C-3. Numbers of U.S. Vessels by Ship Type

Area Employed	Number of Vessels
U.S.-to-foreign	281
Foreign-to-foreign	12
U.S. domestic trade	177
Inactive vessels	62
Total	579

Source: Maritime Administration, *Employment of United States Flag Oceangoing Merchant Fleet as of September 1, 1976* (22).

Table I-C-4. Area of Employment of Privately Owned U.S.-Flag Vessels

Gross Tonnage	Number of Vessels
1000-10,000	61
10,000-20,000	343
20,000-30,000	116
30,000-40,000	34
40,000-50,000	23
Did not respond to question	3
Total	579

Average = 17,611 gross tons

Table I-C-5. Gross Tonnage Distribution of Privately Owned U.S.-Flag Vessels

Deadweight Tonnage	Number of Vessels
0-20,000	278
20,000-40,000	240
40,000-60,000	18
60,000-80,000	12
80,000-100,000	27
More than 100,000	3
Total	579

Average = 27,493 deadweight tons

Table I-C-6. Deadweight Tonnage Distribution of Privately Owned U.S.-Flag Vessels

Year Built	Number of Vessels
1930-1939	1
1940-1949	160
1950-1959	98
1960-1969	193
1970-1976	115
Unknown	12
Total	579

Source: "The U.S.-Flag Oceangoing Fleet," (32, pp 99-116); and U.S. Department of Transportation, United States Coast Guard, *Merchant Vessels of the United States: 1974.*

Table I-C-7. Age Distribution of Privately Owned U.S.-Flag Merchant Vessels

Type of Electronic Navigation Equipment	Percent of Fleet (%)
Radio direction finder	99*
Fathometer	99*
Radar	99*
Omega	9
Decca	24
Satellite navigation system	8
Loran-A	86
Loran-C	59
Other systems	6

*The remaining 1% is comprised of vessels for which no information on navigation systems is available.

Table I-C-8. Electronic Navigation Equipment Carried by Merchant Vessels

Companies also differ in the number of ships they operate, which does not always correlate with company size (Table I-C-10). Again, the largest percentage of firms are the smaller companies that operate less than 10 vessels.

USE OF LORAN BY MERCHANT VESSELS

Almost all U.S. flag merchant vessels have at least one Loran receiver (Table I-C-11). Thirty-seven percent of the ships can receive Loran-A only; nearly 50% have both Loran-A and Loran-C capability; and only 10% have just Loran-C. The majority of Loran-C sets in use are A/C combination sets (Table I-C-12); these account for 81% of the vessels with both Loran-A and Loran-C. The remaining Loran-C sets are equally divided between fully automatic and manual sets. A Loran-C equipped vessel is more likely to have a greater tonnage and to be a tanker than a vessel equipped only with Loran-A (Table I-C-13 and Table I-C-14). Interestingly enough, Loran-C usage does not correlate with age of vessel.

Merchant vessel operators use Loran-A in various ways, most commonly for general navigation and to cut voyage time and expenses through accurate navigation. Loran-A is also used slightly less frequently for navigation in crowded piloted waters and as insurance for emergency situations. Merchant vessel operators are not as happy with Loran-A as mariners in some other groups. Only one-third rate Loran-A as excellent, whereas slightly more than half rate Loran-A as satisfactory (Table I-C-15).

Number of Employees	Number of Companies
1-200	18
201-400	17
401-600	6
601-800	2
801-1000	0
1001-5000	10
5001-55,000	6
Unknown	8
Total	67

Table I-C-9. Size Distribution of Companies Operating Merchant Vessels Measured by Number of Employees

Number of Ships	Number of Companies
1-10	39
11-20	21
21-30	4
31-50	3
Total	67

Average Number of Vessels Operated = 11

Table I-C-10. Number of Ships Operated by Firms

LORAN-C PLANS AND EXPECTATIONS

Most merchant vessel operators have already made plans for the Loran-A to Loran-C transition. About three-quarters

	Percent of vessels (%)	Number of vessels	95% Confidence Limits on number of vessels
Loran-A only	37	216	198-234
Both Loran-A and Loran-C	49	282	264-300
Loran-C only	10	56	52-60
No Loran	4	25	21-29
Total	100	579	

Table I-C-11. Use of Loran-A and Loran-C by Merchant Vessels

Type of Set	Percent of vessels (%)	Number of vessels	95% Confidence Limits on number of vessels
Automatic	14	46	38-54
Manual	16	54	41-67
A/C combination	68	229	216-242
Don't know	2	9	*
Total	100	338	

* Confidence limits not calculated

Table I-C-12. Types of Loran-C Sets in Use Out of 338 Loran-C Equipped Ships

Gross tonnage	Loran Usage		
	Loran-A only (Percent of Vessels) (%)	Both Loran-A and C (Percent of Vessels) (%)	Loran-C only (Percent of Vessels) (%)
1000-10,000	14.4	5.6	25.3
10,001-20,000	75.2	58.9	19.1
20,001-30,000	10.4	21.6	40.0
30,001-40,000	0	10.3	0
40,001-50,000	0	3.5	15.6
Total	100%	100%	100%

χ^2 probability = .11

Table I-C-13. Correlation of Loran Use with Size of Vessel

Type of Vessel	Loran Usage		
	Loran-A only (Percent of Vessels) (%)	Both Loran-A and C (Percent of Vessels) (%)	Loran-C only (Percent of Vessels) (%)
Tanker	25.0	57.9	59.7
Containership	13.5	24.7	32.5
Cargo	44.2	15.7	7.8
Other types	17.3	1.7	0
Total	100%	100%	100%

χ^2 probability = .20

Table I-C-14. Correlation of Vessel Type with Loran Usage

For the purpose of	Excellent	Satisfactory	Poor	Not Used for This Purpose	Total
Navigation in piloted waters	37	55	5	3	100%
General navigation at sea	41	57	2	0	100%
Safety preparedness	31	58	1	10	100%
Cutting voyage time	26	63	11	0	100%

Table I-C-15. Rating of Loran-A by Operators of Vessels with Loran-A Only

	Percent of Loran-A only vessels (%)	Number of vessels	95% Confidence Limits on Number of Vessels
Will switch to Loran-C	74	160	148-172
Will not switch	18	38	*
Don't know	8	18	7-29
Total	100%	216	

* Confidence limits not calculable

Table I-C-16. Loran-A-Only Users Who Intend to Switch to Loran-C by the Termination Date of Loran-A

of the vessels having Loran-A only will have switched to Loran-C by the Loran-A termination date (Table I-C-16). Most of the small percentage of operators who have not yet decided are considering alternative systems such as Omega or satellite navigation. Many of the vessels that will not be equipped with Loran-C were built before 1950 and will probably be scrapped in the near future. Most vessels that will switch to Loran-C will be equipped with fully automatic sets (Table I-C-17); 15% will be fitted with A/C combination sets. Existing Loran-A sets will be converted to Loran-C in only a few cases. Merchant marine operators are better informed and more realistic about the prices they expect to pay for Loran-C sets than any other user group (Table I-C-18). The average estimated price is $4200, with more than 70% of the operators expecting to pay more than $3000.

Merchant marine operators are less optimistic than other user groups about the value of Loran-C compared to Loran-A. Only 50% believe that Loran-C will provide better service than Loran-A, and more than one-third believe Loran-C will provide either the same service as Loran-A or worse (Table I-C-19). Operators who have had experience with Loran-C regard it more favorably than those who have not (Table I-C-20).

Kind of Loran-C	Number of Sets	Percent (%)
Fully automatic	123	77
A/C combination	24	15
Convert existing Loran-A	5	3
Don't know	8	5
Total	160	100%

Table I-C-17. Kind of Loran-C Set Loran-A Users Intend to Buy

Price ($)	Number of Sets	Percent (%)
2000-3000	22	14
3001-4000	43	27
4001-5000	51	32
5001-6000	21	13
Don't know	23	14
Total	160	100%

Average price = $4200

Table I-C-18. Price Loran-A Users Expect to Pay for Loran-C

For the purpose of	Rating of Loran-C Compared to Loran-A (Percent of vessels) (%)					
	C Better	C the Same	C Worse	Don't Use This Function	Don't Know	Total
Navigation in piloted Waters	54	29	6	3	8	100%
General navigation at sea	54	26	12	0	8	100%
Safety preparedness	43	26	6	9	16	100%
Reducing voyage time	50	30	11	0	9	100%

Table I-C-19. Expected Usefulness of Loran-C Compared to Loran-A

For the Purpose of:	Percent expecting Loran-C to be better than Loran-A (%)	
	Companies Also Having Vessels with Loran-C	Companies Having No Vessels with Loran-C
Navigation in Piloted Waters	74	55
General navigation	74	46
Safety preparedness	68	31
Reducing voyage time	74	41

Table I-C-20. Expectations of Loran-A Users by Experience with Loran-C

When Expect to Purchase	Percent of vessels (%)	Number of vessels
More than 6 months before termination	21	34
Within 6 months of termination	46	73
Don't know	33	53
Total	100%	160

Table I-C-21. When Loran-A Users Intend to Buy Loran-C

Although half of the vessels that will be switched will be equipped with Loran-C sets close to the termination of Loran-A, 20% will be equipped with Loran-C sooner, at least six months prior to termination (Table I-C-21). Larger companies and companies that operate several vessels are more likely to purchase Loran-C early than smaller companies (Table I-C-22). Those who perceive the forced transition from Loran-A to Loran-C as an economic burden will more likely delay their switch until the last minute (Table I-C-23).

PROBLEMS AND POTENTIAL REMEDIES

The cost of switching from a lower-priced Loran-A receiver to a higher-priced Loran-C receiver is the major problem merchant marine operators perceive. One-third of the companies, representing about half of the vessels having only Loran-A, perceive the forced transition to be a major economic burden (Table I-C-24). The size of company relates to this perception: the smaller company is more likely to find the changeover burdensome (Table I-C-25). Other frequently mentioned problems include limited availability of charts and receivers. (Table I-C-26).

Merchant marine operators identified several forms of assistance that would help them (Table I-C-27). Even though financial impact was the problem they most frequently cited, very few proposed any form of direct financial assistance. They preferred forms of assistance such as a longer

Number of Employees	When Purchase Expected	
	Soon (Percent of Vessels) (%)	Near Termination (Percent of Vessels) (%)
Less than 200	0	11
201-400	0	40
401-600	0	50
601-800	22	0
801-1000	0	0
1001-5000	78	0
Total	100%	100%

χ^2 probability = .07

Table I-C-22. When Loran-C Purchase is Expected by Size of Company

Perceive Forced Transition to be Burdensome	When Purchase is Expected	
	Soon (Percent of of Vessels) (%)	Near Termination (Percent of Vessels) (%)
Yes	0	82
No	100	18
Total	100%	100%

χ^2 probability = .05

Table I-C-23. When Loran-C Purchase is Expected by Perception of Burden

Perception of Forced Transition	Number of Companies	Number of Loran-A Only Vessels
Burdensome	12	102
Not burdensome	23	113
Total	35	215

Table I-C-24. Perception of Economic Burden of Forced Transition to Loran-C

	Size of Company (Number of Employees)		
Perception of Burden	0-400 (%)	400-800 (%)	More Than 800 (%)
Burdensome	72	20	0
Not burdensome	28	80	100
Total	100%	100%	100%

χ^2 probability of .04

Table I-C-25. Perception of Economic Burden by Size of Company

Problem	Percent of Operators Who Mentioned Problem (%)	Percent of Loran-A-only Vessels Represented (%)
Receiver costs	43	53
Availability of charts	29	31
Limited supply of receivers	17	18
Training of personnel	6	8
Inadequate coverage	6	8
Inadequate sets	9	7
Don't expect any problems	17	13
Other	9	9
Don't know	3	2

Table I-C-26. Problems Expected by Vessel Operators During the Transition from Loran-A to Loran-C

Form of Assistance	Percent of Operators Who Mentioned (%)	Percent of Loran-A-only Vessels Represented (%)
Longer transition	20	22
Education programs	26	32
Standards for sets	11	13
Financial assistance	3	4
Don't need assistance	34	37
Other	2	1
Don't know	3	2

Table I-C-27. Assistance Desired During the Transition from Loran-A to Loran-C

Program	Percent of Operators Desiring (%)	Percent of Loran-A-only Vessels Represented (%)
Loran-C demonstrations	31	40
Workshops	11	17
Publications	60	58
Other	6	12
Don't need any	20	23
Don't know	3	2

Table I-C-28. Education/Information Programs Desired

transition period and education programs to help retrain personnel. About 10% of the operators, mostly those contacted after the announcement of the Coast Guard's proposed requirement for Loran-C, wanted the government to set minimum standards for Loran-C receivers as soon as possible. Thirty-four percent, a relatively large number, felt that they needed no assistance. Many operators favored education programs when questioned specifically about these (Table I-C-28). Sixty percent indicated that they would like explanatory publications; some operators favored these because they could avoid paying employees to attend demonstrations and workshops. Demonstrations were preferred three to one over workshops. Only 20% of the operators felt that they did not need any educational programs.

APPENDIX I-D

TUG AND TOWBOAT TRANSPORTATION INDUSTRY

The tug and towboat fleet is a flexible and innovative segment of the ocean transportation industry. Company and vessel characteristics are intermediate between those of the merchant marine and the independent commercial fisherman or sportfisherman. Much smaller than a typical merchant ship, tugs are larger than an average fishing vessel. Some firms, large and diversified, are similar to merchant marine companies. Others are small, family operations more similar to those of commercial fishermen. Typically confined to the domestic coastwise trade, the tugboat operation is more localized than that of the merchant shipping firm.

This portion of the appendix presents the results of a survey of the oceangoing tugboat industry. The first section presents the survey's methodology; the second describes the characteristics of tugboats and the companies that operate them; the third section describes tugboat operators' experience with Loran. The plans and expectations of the Loran-A users for the transition to Loran-C then follow. Finally, the problems tugboat operators face during the transition are discussed.

METHODOLOGY

The methodology used for the tugboat survey is very similar to that used for the merchant marine survey. With minor modifications, the questionnaire developed for the merchant marine was applied to the tugboat industry. The questionnaire had two parts, one of which asked about the firm and all that firm's vessels, and the second part concentrated on a few specific vessels. As with the merchant marine, the survey medium was a mailed questionnaire followed by a telephone survey of nonrespondents. After the mailing had been completed, the tugboat population was divided into two strata. Those responding to the mailed questionnaire constituted Stratum 1, and those not responding constituted Stratum 2. The sampling fraction in Stratum 1 was therefore 1.00, and the Stratum 2 fraction was chosen to be .25. As a result, only variation in Stratum 2 contributed to the standard error of the population estimates. The equations used to calculate the mean, the standard error, and Chi-square probabilities were exactly those used for the merchant marine. As with the merchant marine, a probability level of .25 was accepted as statistically significant. In fact, methodology for the tugboat survey only differed from methodology for the merchant marine survey in the compilation of the list of vessels and operators and the analysis of the disposition of responses.

Compilation of List

The basic source for the list of tugboats and their operators was a U.S. Army Corps of Engineers publication, *Transportation Lines on the Atlantic, Gulf, and Pacific Coast, 1976* (20). Compiled yearly from a Corps survey, this publication lists addresses, area of operations, vessel names, and vessel statistics for all firms operating U.S.-flag vessels in waterborne commerce on the U.S. coasts or navigable rivers. A large fraction of the firms (those not operating tugboats in the coastal confluence zone) on the list were eliminated. After consulting with industry spokesmen and major tugboat firms a few firms were added to the list. The result was a list of tugboats that are very likely to operate in the coastal confluence zone. Because of ambiguities in the Corps list, and because many firms run harbor or river tugs in addition to ocean tugs, we could not reduce the list to ocean-going tugs without further information from the firms. Telephone numbers and the names of operations managers were obtained from the *Marine Directory* issued by the magazine *Marine Engineering/Log* (11).

Disposition of Responses

The rate of response to the mailed questionnaire and the rate of substitution for firms drawn in the sample demonstrate the validity of the survey results. Table I-D-1 gives the total number of firms and vessels, the number sampled in Part One questions, and the number sampled in Part Two questions. Fifty-seven out of 113 firms responded to the mailed questionnaire, giving a Stratum 1 of 57 firms and 406 vessels. Thus, we know without any error or bias a substantial percentage of the entire population for Part One questions. Since Stratum 1 firms answered questions concerning all vessels requested, we did not need to replace vessels in Part Two sampling of Stratum 1. Therefore, no bias is introduced into the Part Two sample for Stratum 1.

	Total number of		Number sampled in Part 1 questions		Number sampled in Part 2 questions	
	Firms	Vessels	Firms	Vessels	Firms	Vessels
Stratum 1	57	406	57	406	57	74
Stratum 2	56	267	15	91	15	19
Total	113	673	72	497	72	93

Table I-D-1. Number of Firms and Vessels Present and Sampled in Each Stratum

Fifteen firms and 91 vessels were sampled in Stratum 2, out of totals of 56 firms and 267 vessels. Twenty-three firms had to be selected to obtain the desired 15 successful interviews (Table I-D-2). Many more calls than 23 were actually made, but "busy," "no answer," and "call back" results were not included, since repeated attempts were made until one of the responses in the table was obtained. Seven of the eight replacements were made because a valid telephone number could not be located for the selected firm. This relatively high rate of substitution may introduce some small bias into Stratum 2 estimates, since small, hard-to-contact firms are underrepresented.

CHARACTERISTICS OF OCEANGOING TUGBOATS AND THE FIRMS THAT OPERATE THEM

About 408 oceangoing tugboats operate in the United States (Table I-D-3). More than half of these vessels usually operate on the open ocean out of sight of land. Most of the rest operate coastally, usually within sight of land. A few vessels operate primarily in rivers or harbors, but occasionally venture out of sheltered waters. The survey also reached 223 vessels that operate exclusively in rivers, harbors, sounds, and intracoastal waterways. We excluded these vessels, and firms that operate only such vessels, from all further consideration and tabulation in this appendix.

Although tugboats vary greatly, the characteristics of most cluster around typical values. The average net tonnage of tugboats is 111 tons, with more than half of all tugboats falling in the range from 50 to 150 net tons (Table I-D-4).

Response	Number
Telephone number of firm not available	7
Knowledgeable person not available	1
Successful interviews	15
Total	23

Table I-D-2. Disposition of Phone Calls in the Sampling of Stratum 2

Type of waters	Number of vessels
Open ocean	236
Coastal	161
Sheltered waters usually, but sometimes on the ocean	11
Total oceangoing	408
Harbor, river, other sheltered	223
Not currently operated	42
Total sampled	673

Table I-D-3. Type of Waters in Which Tugboats Operate

Net tonnage	Number of vessels
1-50	82
51-100	91
101-150	146
151-200	74
201-250	14
251-300	1
Total	408

Average net tonnage = 111

Table I-D-4. Net Tonnage Distribution of Tugboats

Although a few vessels have up to 9000 HP, the horsepower of most tugboats varies between 1000 and 3000 HP (Table I-D-5). The tugboat fleet is relatively new: two-thirds of all vessels have been built since 1960 (Table I-D-6). More tugboats operate along the East and Gulf Coasts than along the West Coast (Table I-D-7). Since most operate locally, along a single coast, only a few run between coasts through the Panama Canal.

Tugboats generally do not carry as much electronic navigation equipment as do merchant vessels (Table I-D-8). Radar, followed by Loran-A, is the most common piece of equipment. Tugboats also use radio direction finders and fathometers. The sampled tugboats have experimented very little with either Omega or satellite systems; because most tugboats operate so close to the United States, they have had almost no opportunity to use Decca.

Tugboat firms vary more than the tugboats themselves. Some firms are small, family-run businesses operating fewer than five vessels. The giant, diversified, and integrated oil companies frequently operate

Year	Number of vessels
1930 - 1940	10
1941 - 1950	72
1951 - 1960	60
1961-1970	193
1971-1980	73
Total	408

Average year of construction = 1962

Table I-D-6. Year of Construction for Tugboats

Horsepower	Number of vessels
1000 or less	94
1001 - 2000	112
2001 - 3000	54
3001 - 4000	93
4001 - 5000	35
5001 - 6000	13
More than 6000	7
Total	408

Average horsepower = 2340 HP

Table I-D-5. Horsepower Distribution of Tugboats

Area of Employment	Number of Vessels
West Coast-to-foreign	23
West Coast domestic	51
East or Gulf Coast-to-foreign	72
East or Gulf Coast domestic	193
Intercoastal-to-foreign	62
Unknown	7
Total	408

Table I-D-7. Area of Employment for Tugboats

Type of Equipment	Percent of fleet (%)
Radio direction finder	60
Fathometer	71
Radar	94
Omega	0
Decca	4
Satellite navigation system	0
Loran-A	81
Loran-C	24
Other systems	13

Table I-D-8. Electronic Navigation Equipment.

small numbers of vessels. Finally, the large tugboat firms operate many vessels; these firms are small compared to the oil companies but large compared to the smallest tugboat firms. To summarize, although some firms employ thousands, most tugboat firms are small, with under 100 employees (Table I-D-9). Most firms operate fewer than five vessels, but some operate as many as 75 (Table I-D-10).

EXPERIENCE WITH LORAN

Eighty-four percent of the oceangoing tugboats carry some kind of Loran set (Table I-D-11). About three-fifths of these vessels have Loran-A, one-fifth carry Loran-A and Loran-C, and a few have only Loran-C. Almost all of the vessels with both Loran-A and Loran-C have A/C combination sets and are typically operated by one of the largest tugboat firms (Table I-D-12). The few vessels that have only Loran-C usually have automatic sets.

Use of Loran correlates with characteristics of the vessel and the firm. The

Number of Employees	Number of firms
1-10	17
11-100	19
101-200	9
201-300	4
301-400	1
401-500	8
More than 500	3
Unknown	12
Total	72
Average Number of employees = 194	

Table I-D-9. Size of Tugboat Firms as Measured by Number of Employees

Number of Vessels	Number of firms
1 - 5	53
6 - 10	10
11 - 15	3
16 - 20	1
21 - 75	2
Total	72
Average Number of Vessels	6

Table I-D-10. Number of Vessels Operated by Tugboat Firms

	Percent of vessels (%)	Number of vessels	95% Confidence Limits on Number of vessels
Loran-A only	59	240	231-249
Both Loran-A and Loran-C	22	92	*
Loran-C only	2	10	*
No Loran	16	66	7-25
Total	100 %	408	-

* Confidence limits were not calcuable

Table I-D-11. Use of Loran by Tugboats

Type of Set	Percent of vessels (%)	Number of vessels
Automatic	10	10
Manual	1	1
A/C Combination	82	84
Don't know	7	7
Total	100 %	102

Table I-D-12. Types of Loran-C Sets in Use

vessel with Loran, and particularly Loran-C, is usually larger and has greater horsepower (Table I-D-13). Also, the farther from shore a vessel usually travels, the more likely it is to have Loran-A or Loran-C (Table I-D-14). Tugboats with Loran are generally operated by firms with larger numbers of vessels (Table I-D-15).

Tugboats use Loran-A very much as merchant ships do. General navigation while at sea is the most common and also the most valued use of Loran-A (Table I-D-16). Operators also use Loran to reduce voyage time through accurate navigation. Users feel that Loran does not perform as well for navigation in piloted waters and for safety preparedness as for other purposes.

Horsepower	Loran Usage: Nonuser (Percent of Vessels) (%)	Loran-A Only (Percent of Vessels) (%)	Loran A & C (Percent of Vessels) (%)	Loran-C only (Percent of Vessels) (%)
Less than 2000	93	48	52	0
2001 - 4000	7	42	33	32
More than 4000	0	10	15	68
Total	100 %	100 %	100 %	100 %

χ^2 probability = .06

Table I-D-13. Correlation of Loran Usage with Vessel Horsepower

Type of Waters	Loran Usage: Nonuser (Percent of Vessels) (%)	Loran-A Only (Percent of Vessels) (%)	Loran A & C (Percent of Vessels) (%)	Loran-C only (Percent of Vessels) (%)
Harbors, Rivers, Other Sheltered Waters	13	1	0	0
Coastal	87	39	14	0
Open Ocean	0	60	86	100
Total	100 %	100 %	100 %	100 %

χ^2 probability = .07

Table I-D-14. Correlation of Loran Use with type of Waters Operated

Number of Vessels	Loran Usage (Percent of Vessels) (%)			
	Nonuser	Loran-A Only	Loran A & C	Loran-C Only
1-5	70	30	28	66
6-10	30	14	14	0
11-20	0	54	14	34
More than 20	0	0	45	0
Total	100 %	100 %	100 %	100 %

χ^2 probability less than .01

Table I-D-15. Correlation of Loran Use with Number of Vessels Operated by the Firm

For the Purpose of	Rating of Loran-A (Percent of A-only vessels) (%)				
	Excellent	Satisfactory	Poor	Do Not Use A for This Purpose	Total
Navigation in piloted waters	23	53	9	15	100 %
General navigation at sea	47	50	3	0	100 %
Safety preparedness	6	70	0	24	100 %
Reducing voyage time	33	49	18	0	100 %

Table I-D-16. Rating of Loran-A by Operators of Vessels with Loran-A Only

LORAN-C PLANS AND EXPECTATIONS

Most tugboats operators have already made plans for the transition to Loran-C. More than three-quarters of the tugboats with just Loran-A will be converted to Loran-C (Table I-D-17). Seventy-nine percent of the vessels converting will be equipped with a fully automatic Loran-C set (Table I-D-18). Operators for most of the other vessels have not yet decided on a type of set, nor do they yet know the price they will have to pay for a Loran-C set (Table I-D-19). Those who do know generally expect to pay between $3000 and $5000.

Tugboats expect to switch to Loran-C faster than other user groups. Almost half of those who have decided expect to purchase Loran-C more than six months before the termination of Loran-A (Table I-D-20). Larger firms expect to switch sooner than smaller firms (Table I-D-21).

Tugboat operators, as merchant ship operators, do not have the same high expectations for Loran-C expressed by commercial fishermen and sportfishermen. Just under half of the operators expect Loran-C to be better than Loran-A, and approximately an additional quarter expect Loran-C to

	Percent of vessels (%)	Number of vessels	95% Confidence Limits on Number of Vessels
Will switch to Loran-C	77	185	172-198
Will not switch	33	55	*
Don't know	0	0	*
Total	100%	240	

* Confidence limits not calculated

Table I-D-17. Loran-A Only Users That Intend to Switch to Loran-C by the Termination Date of Loran-A

Kind of set	Number of sets	Percent of sets (%)
Fully automatic	190	79
A/C Combination	5	2
Manual	0	0
Convert existing A	3	1
Don't know	43	18
Total	240	100%

Table I-D-18. Kind of Loran-C Set Loran-A Users Intend to Buy

Price ($)	Number of sets	Percent (%)
1000-2000	13	5
2001-3000	17	7
3001-4000	48	20
4001-5000	19	8
More than 5000	3	1
Don't know	141	59
Total	240	100%

Table I-D-19. Price Loran-A Users Expect to Pay for Loran-C

	Percent of vessels (%)	Number of vessels
More than 6 months before A termination	41	76
Within 6 months of A termination	47	87
More than 6 months after A termination	0	0
Don't know	12	22
Total	100%	185

Table I-D-20. When Loran-A Users Expect to Purchase Loran-C

	When Purchase Expected (Percent of Vessels) (%)		
Number of Employees	Soon	Near Termination	Late
1-100	17	50	100
101-300	17	17	0
301-500	50	33	0
More than 500	16	0	0

χ^2 probability = .21

Table I-D-21. When Loran-C Purchase is Expected by Size of Company provide service equivalent to Loran-A (Table I-D-22). If, in addition to Loran-A equipped vessels, tugboat operators have any boats equipped with Loran-C, they tend to regard Loran-C less favorably than if they had no such experience with Loran-C (Table I-D-23). In elaborating on this response, some of these tugboat operators said that they had not found Loran-C sets that worked as well as Loran-A for general navigation.

PROBLEMS AND REMEDIES

Tugboat operators' major problem created by the transition to Loran-C is the cost of

For the purpose of:	Rating of Loran-C Compared to Loran-A (% of vessels)					
	C Better	C the Same	C Worse	Don't Use This Function	Don't Know	Total
Navigation in piloted waters	45	25	4	6	20	100 %
General navigation at sea	49	27	4	0	20	100 %
Safety preparedness	41	23	4	11	21	100 %
Reducing voyage time	46	30	4	0	20	100 %

Table I-D-22. Expected Usefulness of Loran-C Compared to Loran-A

For the Purpose of:	Percent of Companies Expecting Loran-C to Be Better Than Loran-A (%)	
	Companies also Having Vessels with Loran-C	Companies Having No Vessels with Loran-C
Navigation in piloted waters	40	52
General navigation at sea	36	68
Safety preparedness	20	55
Reducing voyage time	40	57

Table I-D-23. Expectations of Loran-A Users by Experience with Loran-C the changeover. Operators for 116 out of 240 A-only vessels perceived the forced transition to Loran-C as a major economic burden (Table I-D-24). Any expense burdens a small firm, and replacing a large number of sets at once represents a significant expense. Other problems mentioned included availability of charts and the need to retrain personnel (Table I-D-25).

Tugboat operators identified the forms of assistance they most favored (Table I-D-26). About half of the vessel operators desired a longer transition period and education programs to retrain personnel. Direct governmental financial assistance was favored by only about 10%. Around 15% felt that they needed no assistance; this percentage was much smaller among tugboat

Perception of Forced Transition	Number of Firms	Number of Loran-A Only Vessels
Burdensome	10	116
Not burdensome	21	87
Don't know	7	38
Total	38	240

Table I-D-24. Perception of Economic Burden of Forced Transition to Loran-C

Problem	Percent of Operators Who Mentioned Problem (%)	Percent of A-only Vessels Represented (%)
Cost of receiver	55	68
Availability of charts	29	29
Training of personnel	16	23
Supply of receivers	11	12
Maintenance of Loran-C receivers	8	16
Inaccuracy of Loran-C system	5	3
Other problems	14	18
No problems expected	18	5

Table I-D-25. Problems Expected by Vessel Operators During the Transition

Form of Assistance	Percent of Operators Who Mentioned (%)	Percent of A-only Vessels Represented (%)
Longer transition	29	53
Education programs	42	40
Governmental financial assistance	11	13
Other	5	18
No assistance needed	18	10

Table I-D-26. Assistance Desired During the Transition

Program	Percent of Operators Desiring (%)	Percent of A-only Vessels Represented (%)
Demonstrations	55	40
Workshops	34	32
Publications	60	48
Other	11	13
None desired	24	32

Table I-D-27. Education/Information Programs Desired

operators than for the merchant ship operators. When questioned specifically about education programs, only one-quarter thought that they did not need them. Publications were most favored, followed closely by demonstrations; workshops were less popular (Table I-D-27).

APPENDIX I-E

SURVEY OF THE OFFSHORE PETROLEUM SERVICE INDUSTRY

Offshore petroleum exploitation, and the attendant service vessel industry, have grown very rapidly in this century. The first offshore wells, drilled off the Southern California coast in the 1890s, were often so close to shore that rock causeways were built out to them for easy transportation of men, equipment, and materials. But as wells were drilled farther and farther from shore (the first producing wells out of sight of land were drilled in the Gulf of Mexico in the late 1940s), an offshore petroleum service fleet became a necessity.

This portion of Appendix I presents the results of a survey of the marine service fleet. The first section gives the methodology used. Section two describes the characteristics of vessels and service vessel companies. Section three discusses how service vessels use Loran, and four the plans and expectations of Loran-A users for the transition to Loran-C. Finally, the last section identifies the problems service vessel operators expect to face during the transition and the type of assistance they would like to receive.

METHODOLOGY

Choice of Survey Medium

We wished to choose a survey medium that minimized variance, bias, cost, and effort. We eliminated the personal interview as too expensive. The easiest medium, the mailed questionnaire, was not expected to give a high enough response rate to yield unbiased results, and the more expensive and time-consuming telephone interviews would give a higher response rate. We therefore decided to combine the best features of mail and telephone media. To do this, we mailed the questionnaire to sample firms, and telephoned nonrespondents after most questionnaires had been returned. This procedure ensured that a large percentage of the selected firms could be interviewed easily and cheaply by mail. The time-consuming telephoning was reserved for a minority of the sample.

Questionnaire Development

We developed a short questionnaire for mailing; branching was kept to a minimum. Our result resembled the first part of the merchant marine questionnaire included at the beginning of Appendix I. Because we could not prepare a list of vessels for the entire industry, we included no questions about individual vessels.

Sampling Plan

A list of all firms operating offshore petroleum service vessels was compiled from three sources:

1) a yearly inventory made by *Offshore* magazine (10);

2) a yearly inventory made by *Ocean Industry* magazine (1); and

3) a list of firms active in transportation from *Offshore Contractors Directory* (15).

Firms that did not operate U.S.-flag vessels were eliminated wherever possible. Addresses and telephone numbers were obtained from the *Offshore Contractors Directory* or from telephone information operators.

The list was then organized into four strata based on the estimated number of vessels operated by each company (Table I-E-1). This stratification reduced estimated variance in a population that is heterogeneous overall but more homogeneous within each of its strata. We hypothesized that this situation was true for offshore service vessels if they were grouped by size. Second, stratification allowed us to use different sampling fractions in each stratum so that we could concentrate effort on the strata representing the greatest number of vessels.

We then implemented the sampling plan. When we had drawn a random sample at the desired rate for each stratum, we mailed the

Stratum	Number of Vessels Per Firm	Sampling Fraction	Number of Firms	Estimated Number of Vessels
1	1-9	.25	47	129
2	10-25	.50	26	348
3	More than 25	1.00	8	480
4	Unknown	.25	33	107
Totals			114	1063

Table I-E-1. Stratification Scheme and Sampling Fraction Used in Sampling Plan questionnaire to all selected firms. After response to the first mailing had diminished, a second mailing was made to all nonrespondents. Finally, when response diminished again, each nonrespondent firm was telephoned. When we had to replace a firm, the next on the list was chosen.

Disposition of Responses

The combination of mail and telephone sampling produced a very high response rate in three of the four strata (Table I-E-2). Only in Stratum 1 was the substitution rate high; seven out of the original 15 selected had to be replaced, usually either because the telephone number or address of the firm could not be located, or because a knowledgeable party would not be available within the time constraints of the survey (Table I-E-3). Inability to locate a firm could produce some bias in Stratum 1 since hard-to-locate firms are underrepresented. Because Stratum 1 is a small percentage of the total population of vessels, however, the magnitude of bias should be small. The second major group of replacements was made because the person in the firm knowledgeable about Loran use and Loran-C plans was away on business or on vacation. Since we believe failure to respond for this reason is not related to use of Loran,

Stratum	Number of firms	Number of firms contacted	Number of successful interviews
1	47	22	15
2	26	15	13
3	8	8	7
4	33	10	8
Totals	115	55	43

Table I-E-2. Number of Companies Contacted and Interviewed in Each Stratum

Response	Number of Calls
No answer after repeated attempts	2
Could not find telephone number	3
Refused to answer questionnaire	2
Knowledgeable person not available	4
Company no longer exists	1
Successful interviews	43
Total	55

Table I-E-3. Disposition of Contacts in Sample no bias is produced. Only two of the 55 contacts refused to answer questions, an encouragingly small number. The total bias of estimates is therefore judged to be small.

Computational Procedures

The formula used for calculating the mean is:

$$\bar{x} = \sum_{i=1}^{4} w_i \frac{\sum_{j=1}^{n_i} \sum_{k=1}^{S_{ij}} x_{ijk}}{\sum_{j=1}^{n_i} S_{ij}}$$

where

X_{ijk} = measured attribute of the k^{th} vessel of the j^{th} firm of the i^{th} stratum

S_{ij} = the number of vessels operated by the j^{th} firm of the i^{th} stratum

N_i = the number of firms in the i^{th} stratum

n_i = the number of firms in the i^{th} stratum

w_i = the stratum weight, or the ratio of the number of vessels in the stratum to the number of vessels in the population.

It is given by:

$$w_i = \frac{\frac{N_i}{n_i} \sum_{j=1}^{n_i} S_{ij}}{\sum_{i=1}^{4} \frac{N_i}{n_i} \sum_{j=1}^{n_i} S_{ij}}$$

The standard error was calculated for a few variables that measure possession of an attribute. In such cases, if possession of the attribute was given the value 1 and lack of the attribute the value 0, the sample mean, $\bar{x}$, is the same as the proportion, p, of the population that has the attribute. The standard error can be calculated using the value p. The following formula assumes that the sample of each stratum was a random sample of vessels rather than a random sample of firms. The formula used is:

$$S.E. = \left[\sum_{i=1}^{4} w_i \frac{p_i(1-p_i)}{n_i \sum_{j=1}^{} S_{ij}} \left(1 - \frac{n_i}{N_i}\right) \right]^{1/2}$$

To measure the precision of the mean, standard error values were calculated to determine 95% confidence limits, using the formulas:

upper limit = $\bar{x}$ + 1.96 (S.E.)

lower limit = $\bar{x}$ - 1.96 (S.E.)

If the sample were drawn many times, the mean would be expected to fall within these confidence limits 95% of the time.

CHARACTERISTICS OF OFFSHORE SERVICE VESSELS AND THE FIRMS THAT OPERATE THEM

According to the survey, there are 1063 offshore petroleum service vessels. An additional 143 vessels that sometimes operate as service boats were included in the tugboat survey and are not considered here. Thirty-eight of the 114 firms on the initial list did not operate offshore self-propelled vessels and were eliminated.

A number of different vessels make up the offshore petroleum service fleet (Table I-E-4). The most common types are the supply vessel, the tugboat, the crewboat, and the tug/supply vessel. Excluding combination vessels, basic types are the crewboat, the supply boat, the utility vessel, the tugboat, and the oceanographic/geophysical vessel. Table I-E-5 gives the average length, net tonnage, and horsepower for each of these types. A small, relatively high-speed vessel, the crewboat is used for transferring personnel. The larger and higher-horsepower supply vessel has deck space for cargo and inside tanks for bulk goods. The utility vessel is a small, low-powered vessel used for maintenance and general work. Tugs are high-horsepower vessels used for towing. The largest boats,

Vessel type	Percent of fleet (%)
Crew	16
Crew/Supply	3
Crew/Utility	1
Supply	31
Utility	1
Utility/Supply	5
Tug/Towboat	29
Tug/Utility	0
Tug/Supply	13
Oceanographic/ Geophysical	1
Total	100 %

Table I-E-4. Types of Service Vessels Operating in U.S. Waters

Area	Percent of fleet (%)
Atlantic	1
Gulf	59
California	4
Alaska	3
Foreign	33

Source: E Alan Lohse, *Inventory of U.S. Companies' Offshore Petroleum and RElated Activity*, (9, p. 25).

Table I-E-6. Area of Employment of U.S.-Flag Service Vessels, 1974.

Vessel Type	Mean Length (feet)	Mean Net Tonnage	Mean Horsepower
Crew	89	46	1575
Supply	142	130	2014
Utility	91	74	994
Tug	97	114	3329
Oceanographic/ Geophysical	147	-	1520

Source: E. Alan Lohse, *Inventory of U.S. Companies' Offshore Petroleum and Related Activity*, (9, pp 27-28).

Table I-E-5. Characteristics of Major Vessel Types oceanographic/geophysical vessels engage in geophysical and seismic research and survey.

The location of U.S.-flag vessels in 1974 is given in Table I-E-6. Because vessels move throughout the world from year to year in response to contracts, it would not be accurate to eliminate vessels operating in foreign waters in any one year as outside the coastal confluence zone of the United States. They could very well operate inside this zone in the near future. This survey therefore considers all U.S.-flag vessels no matter where they currently operate.

The companies operating offshore vessels have evolved since the industry began to develop rapidly in the late 1940s. Many of them began as very small proprietorships with a few employees and a single vessel. Since then, they have evolved into larger companies with more vessels and a more sophisticated approach to business.

Today, most companies have less than 500 employees, with the average being 340 employees (Table I-E-7). Because the major oil companies have not entered the marine service industry as they have the merchant shipping and tugboat industries, the largest service vessel company has only 3300 employees. Most companies operate 10 or fewer U.S.-flag vessels; the average is nine (Table I-E-8). A few operate over 40 vessels, however, and the largest company operates 135. Many of these companies also operate foreign-flag vessels.

USE OF LORAN

The offshore petroleum service fleet's use of Loran is not as extensive as that of the merchant shipping and tugboat industries. Only 37% of the fleet has just Loran-A and only 56% has any form of Loran at all (Table I-E-9). A number of reasons explain this limited use of Loran. Navigation is easy in the Gulf of Mexico, where most of the vessels are located: the weather is usually benign, and because the Gulf is studded with landmarks such as offshore petroleum platforms, dead reckoning is easy, common, and traditional. Finally, most of the trips made by service vessels cover short distances. Where distances have increased, use of Loran has as well.

Loran-C represents 19% of all Loran sets in the fleet. About half of these Loran-C sets are A/C combination and the rest are approximately equally divided between manual and fully automatic sets (Table I-E-10).

Service vessel operators use Loran-A most commonly for general navigation and to reduce voyage time and expenses through accurate navigation. Loran-A is especially

Number of Employees	Number of Companies
1-100	44
101-500	22
501-1000	4
More Than 1000	5
Unknown	2
Total	77

Average number of employees = 340

Table I-E-7. Size of Companies as Measured by Number of Employees

Number of Vessels	Number of Companies
1-10	48
11-20	18
21-30	5
31-40	1
More than 40	4
Total	76

Average number of vessels = 9

Table I-E-8. Number of U.S.-Flag Vessels Operated per Company

	Percent of Vessels (%)	Number of Vessels	95% Confidence Limits on Number of Vessels
Loran-A only	37	390	360-420
Both Loran-A and Loran-C	16	173	148-198
Loran-C only	3	27	14-40
No Loran	44	474	*
Total	100 %	1064	

*Confidence limits not calculated

Table I-E-9. Use of Loran by the Offshore Petroleum Service Fleet

Type of Set	Percent of Vessels (%)	Number of Vessels
Automatic	22	46
Manual	19	37
A/C combination	57	114
Don't know	2	3
Total	102	200

Table I-E-10. Types of Loran-C Sets in Use

valuable for deploying vessels throughout the world. All operators reported using Loran-A for these purposes and about 70% rated Loran-A excellent (Table I-E-11). Almost all operators also reported using Loran-A for navigation in piloted waters, but they were much less happy with its performance for this purpose. About a third of all operators reported that they did not use Loran-A for safety preparedness or to position precisely offshore equipment. Those who use Loran-A for safety and positioning are less satisfied with its performance in these functions than they are with its other uses.

LORAN-C PLANS AND EXPECTATIONS

Loran-A users reported their plans for the Loran-A to Loran-C transition. Eighty-four percent intend to switch whereas only 2% do not intend to switch (Table I-E-12). Most of them will make the switch at the time of termination (Table I-E-13). Although small numbers will purchase A/C combination sets or manual sets, most of the vessels converted will be fitted with fully automatic sets (Table I-E-14).

Offshore petroleum service vessel operators are more optimistic about Loran-C than either merchant shipping or tugboat operators (Table I-E-15). Approximately two-thirds believe Loran-C will be more useful than Loran-A for navigation at sea and reduction of voyage time. They are less optimistic about the usefulness of Loran-C for safety preparedness and precise positioning of equipment.

PROBLEMS AND POTENTIAL REMEDIES

Offshore service vessel operators find the transition from Loran-A to Loran-C to be less of an economic imposition than any other user group. Only four out of 52 companies, representing 55 out of 390 vessels, think the transition will be a major economic burden (Table I-E-16). Because they can pass the expense directly to their customers, the oil companies, most firms will not feel a burden.

For the purpose of	Rating of Loran-A (Percent of Vessels) (%)				
	Excellent	Satisfactory	Poor	Do not Use	Total
Navigation in piloted waters	33	58	5	4	100 %
General navigation at sea	73	27	0	0	100 %
Safety preparedness	31	37	0	32	100 %
Reducing voyage time	71	28	0	1	100 %
Precise positioning of equipment	27	26	9	38	100 %

Table I-E-11. Rating of Loran-A by Users

	Percent of Loran-A Only Vessels (%)	Number of Vessels	95% Confidence Limit on Number of Vessels (%)
Will switch	84	328	296-360
Will not switch	2	8	*
Don't know	14	54	*

* Confidence limits not calculated

Table I-E-12. Loran-A Only Users Intending to Switch to Loran-C

When Expect to Purchase	Percent of Vessels (%)	Number of Vessels
More than 6 months before termination	17	57
Within 6 months of termination	68	224
Don't know	15	47
Total	100 %	328

Table I-E-13. When Loran-A Users Intend to Buy Loran-C

Kind of Loran-C Set	Number of Sets	Percent (%)
Fully Automatic	249	76
A/C Combination	56	17
Manual C	20	6
Convert Existing A	3	1
Total	328	100

Table I-E-14. Kind of Loran-C Set Loran-A Users Intend to Buy

For the Purpose of	Rating of Loran-C Compared to Loran-A (Percent of Vessels) (%)				
	C Better	C the Same	C Worse	Don't Use Function	Total
Navigation in piloted waters	68	31	0	1	100%
General navigation at sea	68	32	0	0	100%
Safety preparedness	36	36	0	28	100%
Reducing voyage time	68	31	0	1	100%
Precise positioning of equipment	37	23	0	40	100%

Table I-E-15. Expected Usefulness of Loran-C Compared to Loran-A

Perception	Number of Companies	Number of Loran-A Only Vessels
Burdensome	4	55
Not burdensome	41	300
Don't know	7	34
Total	52	390

Table I-E-16. Perception of Economic Burden of Forced Transition to Loran-C

Operators do not believe they will face many problems during the transition (Table I-E-17). Forty-six percent of the firms operating 38% of the Loran-A equipped vessels expect no problems. The problems most frequently mentioned by those who do expect them are the cost and supply of Loran-C receivers.

Large and small companies differ in their desire for assistance during the transition. Operating only 35% of the vessels, a majority of small operators say that they do not need any assistance (Table I-E-18). In contrast, a smaller number of larger companies would like to see a longer transition to enable them to amortize more of their investment in Loran-A receivers. Other kinds of assistance users believed would be valuable were educational programs such as publications, demonstrations, and workshops (Table I-E-19). The greatest percentage of operators, representing 86% of the vessels, favored publications.

APPENDIX I-F

MARINE RECREATION

Participation in recreational boating is growing rapidly. Increases in disposable income, leisure time, and population

Problem	Percent of Operators (%)	Percent of A-only Vessels (%)
Receiver cost	11	22
Availability of charts	9	6
Supply of receivers	11	8
Training of personnel	6	9
Other problems	15	35
No problems expected	46	38

Table I-E-17. Problems expected by Vessel Operators During the Transition

Form of Assistance	Percent of Operators (%)	Percent of Vessels (%)
Longer transition	23	62
Education programs	9	17
Governmental financial assistance	4	7
Other forms of assistance	4	12
None needed	62	35

Table I-E-18. Assistance Desired During the Transition

Program	Percent of Operators (%)	Percent of Vessels (%)
Loran-C demonstrations	25	47
Workshops	33	51
Publications	67	86
None needed	8	1

Table I-E-19. Education/Information Programs Desired

all contribute to this growth. Loran usage among recreational boaters has been increasingly even faster than boating itself. In fact, recreational boaters are by far the largest single group of Loran users.

Despite this, recreational Loran users are very hard to contact and difficult to characterize. They are spread very thinly throughout the population of all recreational boaters and so are hard to find. Further, almost no regular relationships exist between boater or vessel characteristics, that is, an individual recreational user of Loran is rarely similar to any other.

This portion of Appendix I addresses the recreational Loran-A user's characteristics and Loran-C plans. Section one presents the methodology used and its rationale. Section two describes the recreational Loran-A user and three the use of Loran in recreational boating. Finally, section four discusses users' Loran-A plans and expectations, as well as the problems users expect during the transition.

METHODOLOGY

In preparing a sampling plan, the most difficult element was the compilation of a list of recreational boaters that would allow contact of individual boaters. In addition, the sampling procedure had to include enough recreational Loran-A users to permit accurate predictions of the characteristics and Loran-C plans of all Loran-A users.

A number of possible methods were available for developing a list. A list compiled from boat registration or documentation lists for each of the coastal states would have been expensive and time-consuming and would have reached, on the average, only five Loran-A users for each 1000 contacted (29, pp. 27, 28, 56). Another possibility would have been to use mailing lists of subscribers to boating magazines. Although this would have led to problems of double-counting, since many boaters subscribe to more than one magazine, the contacts with Loran-A sets could have been increased to several percent (19). However, this still was not high enough for an efficient survey. Since so many companies insure recreational boats, using lists of insured boats would have been impractical. Asking marine electronics dealers for customer lists was an approach we tried and abandoned because it was too time-consuming and because many dealers felt they could not fully cooperate.

We finally used the method of compiling the list from warranty card files of Loran-A manufacturers. A number of advantages favored this method. Because almost 100% of those contacted had Loran-A sets, we could reach a large number of users with relatively few contacts. Double-counting was reduced to essentially zero. Compared to other methods, compilation of this list was relatively inexpensive and was not time-consuming.

However, a number of disadvantages with this method of compiling the list should be kept in mind when evaluating results. Using warranty card files selects from the total population of Loran-A users only those who return the cards. Industry sources indicate the return rate for warranty cards varies by manufacturer from less than 10% to 70%. In addition, a number of importers of foreign sets do not have warranty card systems. A few manufacturers do not have sufficient information on their warranty cards to make cards useful for compiling a list. Finally, some manufacturers declined to release the information on their cards.

In spite of these problems, we attempted to obtain a representative sample in terms of regional distribution and type of set (Table I-F-1 and I-F-2). The Atlantic Coast is underrepresented in the sample, and the Pacific Coast is probably overrepresented. The sample is very deficient in respondents with A/C combination sets and imported sets.

The rest of the sampling plan was largely determined by the characteristics of the list. Since mailing addresses, but not telephone numbers, were available on the

Coast	Percent of Respondents
Atlantic	34
Gulf	37
Pacific	29

Table I-F-1. Distribution of Sample Respondents

Type of Set	Percent of Respondents
Manual	20
Semiautomatic	33
A/C Combination	3
Automatic	44

Table I-F-2. Distribution of Sample Respondents by Type of Loran-A Set

warranty cards, a mailed survey was chosen. Telephoning a large number of boaters would have been impractical. Because time was running short, and because previous investigators' experience indicated that recreational boaters responded enthusiastically in high volume, we decided to make only one mailing with no subsequent sample of nonrespondents. The questionnaire was developed with this decision in mind. A copy of the questionnaire can be found at the beginning of Appendix I. To encourage a quick and sure response, we kept the questionnaire extremely short, and the questions unambiguous. The disposition of responses shows that 53% of those receiving a questionnaire completed and returned it, a very high response for a mailed survey (Table I-F-3). Because we know nothing about nonrespondents, they may differ substantially from respondents. If so, bias is introduced into estimates of population characteristics.

THE RECREATIONAL LORAN-A USER

Number of Loran-A Sets in Recreational Use

Determining the number of recreational Loran-A users was a difficult task. The only estimate of this number available in the literature was that of 45,593, given

Questionnaires mailed	419
Returned by Post Office as undeliverable	- 45
Questionnaires presumed to have reached boater	374
Responses	199
Percent responding	53

Table I-F-3. Disposition of Responses

in the Coast Guard's 1973 nationwide boating survey (29, p.56). The Coast Guard indicated that 95% confidence limits on this estimate range from 15,574 to 74,815 (28). Because of this wide range, the boating survey estimates were inadequate for the purposes of this study. Further, all other evidence indicated that the number of recreational users is smaller than 46,000.

We therfore decided to approach the number of recreational users indirectly. The first step was to estimate how many Loran-A sets had been sold in the United States since 1970. Because of uncertainties, we decided to prepare three estimates of this value--low, high, and an intermediate best value. To do this, all known manufacturers or importers of Loran-A or A/C combination sets were asked for their estimate of the number of sets they had sold since 1970. The sum of these figures, 42,500, became the low estimate of the number of Loran-A sets sold in the United States. Calculated by adding to the low estimate reasonable values for the number of sets missed through the above procedure, the intermediate best estimate was 50,000 sets sold in the United States. The high estimate, 60,500, was set as the highest figure that could be reasonably supported by all available evidence.

Our second step was to calculate the number of known Loran-A sets used by all other groups. Shown in Table I-F-4, this calculation estimates 18,700 Loran-A sets in other than recreational use. This figure was then subtracted from each of the estimates of the number of sets sold and rounded to to the nearest thousand to obtain three estimates of the number of recreational users (Table I-F-5). The best estimate of the number of recreational users is 32,000.

User Group	Number
Commercial fishing	15,000
Merchant marine	500
Tug and towboat	300
Offshore petroleum	600
Commercial sportfishing	1,800
Other	500
Total	18,700

Table I-F-4. Number of Loran-A Sets in Uses Other than Recreation

Low estimate	24,000
Best estimate	32,000
High estimate	42,000

Table I-F-5. Estimate of the Number of Recreational Loran-A Users

Characteristics of Loran-A Users

Loran-A-equipped vessels vary in length, type of propulsion, and kind of electronic navigational aids carried. Medium to large in size, most recreational boats using Loran vary from 26 to 46 feet in length (Table I-F-6). A quarter of the vessels, however, measure less than 26 feet in length, and the smallest encountered in this survey was 19 feet. Approximately three-quarters of the vessels are propelled by inboard motors (Table I-F-7). Although often supplemented by an auxiliary inboard motor, a substantial minority of 18% list sail as the primary power source. Only a few of the smaller boats are powered by outboard motors. In electronic navigational aids, almost all boats that carry Loran-A also carry a fathometer (Table I-F-8) less common than fathometers, radio direction

Length (feet)	Percent of Vessels (%)
Less than 26	25
26 - 40	44
41 - 64	30
65 and over	1
Total	100%

Average = 37 feet

Table I-F-6. Length of Recreational Loran-A Vessels

Primary Type of Propulsion	Percent of Vessels (%)
Sail	18
Inboard motor	77
Outboard motor	5

Table I-F-7. Propulsion Type of Loran-A Vessels

Electronic Navigational Aid	Percent of Vessels (%)
Fathometer	93
Radar	20
Radio Direction Finder	48
Omega	0

Table I-F-8. Other Electronic Navigational Aids on Loran-A Equipped Vessels finders and radars are installed on 48% and 20% of the boats, respectively. Although a few skippers indicated that they were considering Omega, none had as yet installed it.

The type of recreational activity also varies. Fishing is by far the predominant pursuit in Loran-A equipped boats (Table I-F-9). Cruising is also popular. A few skippers mentioned racing or other activities, such as scuba diving, as their primary boating activity.

Activity	Percent of Operators (%)
Fishing	76
Cruising	37
Racing	2
Other	3

Table I-F-9. Recreational Activities Using Loran-A Equipped Vessels

The average number of days a month spent boating varies from one to 30 days (Table I-F-10). Most boaters spend fewer than 10 days a month boating. At the other extreme, a very few boaters live on their vessels and spend most of their time cruising.

A large percentage of the Loran-A-equipped boats operate in conditions and locations in which Loran would assist in navigation. Most boating trips in Loran-A equipped vessels reach a distance from shore of between 16 and 100 miles (Table I-F-11). Only a few skippers regularly stay closer than 16 miles, or usually in sight of land. At least part of the time, a large percentage of boats operate under conditions of low visibility, such as fog or darkness (Table I-F-12). Some skippers, especially those who go on long voyages, operate for substantial percentages of their total boating time in conditions of low visibility.

Number of Days	Percent of Vessels (%)
1-5	28
6-10	42
11-15	15
16-20	8
21-25	4
26-30	3
Total	100%
Average = 10 days	

Table I-F-10. Number of Days per Month Spent Boating

Distance (miles)	Percent of Vessels (%)
0-15	9
16-50	47
51-100	32
101-500	10
More than 500	2
Total	100%
Average = 91 miles	

Table I-F-11. Distance from Shore Reached by Loran-A Equipped Vessels

Percent of Time (%)	Percent of Vessels (%)
0-10	55
11-20	23
21-30	12
31-40	4
41-50	6
Total	100 %
Average = 16%	

Table I-F-12. Percentage of Time Loran-A Equipped Vessels are Operated In Conditions of Low Visibility

EXPERIENCE OF LORAN-A USERS WITH LORAN

Loran-A usage among recreational boaters has increased very rapidly in recent years. A very high 84% of skippers have five or fewer years of experience with Loran-A; the average number of years of experience is four (Table I-F-13). The typical Loran-A set is even more youthful, and averages two years old (Table I-F-14).

Because most Loran-A sets are so new, many users resent the necessity of retiring a Loran-A set and buying a Loran-C set. Although their expectations may be unrealistic, Loran-A users believe they can obtain an average of eight years of further service from their present sets (Table I-F-15). Recorded in the table as expecting 10 additional years of service, a large number of users believe that a solid-state receiver should last indefinitely.

Recreational Loran-A users are very happy with Loran-A as an aid to navigation but are less satisfied with it for fishing or for safety preparedness (Table I-F-16). Seventy-five percent believe that Loran-A is excellent for navigation, whereas only 55% and 57%, respectively, believe its performance excellent for fishing and safety. The rating of Loran-A for fishing would be higher, around 63%, if those skippers who do not fish had been eliminated from the calculations.

Years of Experience	Percent of Skippers (%)
0-5	84
6-10	10
11-20	3
21-30	3
Total	100 %
Average = 4 years	

Table I-F-13. Experience of Skippers with Loran-A

Age of Set (years)	Percent of Vessels (%)
0-3	83
4-6	16
7-9	0
More than 9	1
Total	100 %
Average = 2 years	

Table I-F-14. Age of Recreational Loran-A Sets

Years of Additional Life	Percent of Vessels
1-5	33
6-10	56
11-15	9
16-20	2
Total	100 %
Average = 8 years	

Table I-F-15. Expected Additional Life of Loran-A Sets in Use Today

	Percent of Vessels (%)	Number of Vessels
Will switch	53	17,000
Won't switch	15	4,800
Don't know	32	10,200
Total	100	32,000

Table I-F-17. Loran-A Users Who Intend to Switch to Loran-C

For the Purpose of:	Percent of Skippers Rating Loran-A (%)				
	Excellent	Satisfactory	Poor	Don't Use This Function	Total
Navigation	75	23	1	1	100%
Fishing	55	28	5	12	100%
Safety	57	30	1	12	100%

Table I-F-16. Rating of Loran-A Service

LORAN-C PLANS AND EXPECTATIONS

Recreational users are less sure about their plans for Loran-C than some of the other user groups. Although a slim majority (53%) have already decided to switch to Loran-C, a relatively large 32% do not yet know what they will do (Table I-F-17). Marginal comments and answers to other questions indicated that some of these users did not even know Loran-A was being terminated; others were poorly informed about overlap, termination, and reconfiguration schedules.

Cost is the primary reason why most skippers either will not switch or are uncertain about switching. Seventy percent of those who do not plan to switch give as the reason the cost of buying a more expensive Loran-C set (Table I-F-18). Because many of the boaters who have no plans indicate the reason for their uncertainty, we can assert that cost is also the main reason why they are uncertain. If the cost of fully automatic Loran-C sets were to decline substantially, many of those who do not plan to switch or who have no plans would change to Loran-C.

Those who will switch intend to buy a variety of different kinds of sets. The greatest segment of users, but still less than half, will buy fully automatic sets (Table I-F-19). Thirty-two percent will convert their present sets. Although our

Reason	Percent of Those Not Switching (%)
Cost of Loran-C receiver	70
Don't need Loran	5
Resistance to Coast Guard plans	3
Switch to some other navigational aid, such as Omega	11
Other	11
Total	100%

Table I-F-18. Reasons Some Loran-A Users Are Not Switching

this is still a very substantial percentage. These convertible sets divide approximately equally between manual sets and semiautomatic Loran-A sets. Few recreational users intend to buy manual Loran-C or A/C combination sets.

The type of set users intend to buy strongly influences the price users expect to pay. Those who intend to convert existing sets expect to pay $300 to $500 for the conversion. The majority of buyers of fully automatic sets expect to spend between $1000 and $3000 (Table I-F-20). Compared to buyers in other groups, recreational users expect to spend much less on a fully automatic set. These expectations are unrealistic at prices in effect during the first half of 1977. We could not tell from survey results whether recreational users are poorly informed on Loran-C prices or whether they expect prices to drop substantially in the future.

Recreational boaters will switch to Loran-C later than will other groups, perhaps because Loran is not essential to their occupation. Only a small percentage expect to switch to Loran-C early (more

Type of Set	Percent of Users (%)	Number of Sets *
Convert existing A	32	8,700
Manual C	5	1,400
A/C Combination	2	500
Automatic C	38	10,300
Don't know	23	6,300
Total	100%	27,200

* Using 32,000 as the number of recreational Loran-A users

Table I-F-19. Kind of Loran-C set Loran-A Users Intend to Buy.

result is probably influenced by the companies from which we obtained the sample,

than six months before A termination) (Table I-F-21). About half expect to switch near

Price ($)	Percent of Users (%)
0-1000	2
1001-2000	27
2001-3000	45
3001-4000	20
4001-5000	4
5001-6000	2
Total	100%

Table I-F-20. Price Users Intend to Pay for Fully Automatic Loran-C

Purchase time	Percent of those Switching to Loran-C (%)
6 months or more before termination	11
Near termination	56
6 months or more after termination	10
Don't know	23
Total	100

Table I-F-21. When Loran-A Users Expect to Switch to Loran-C

termination, 10% expect to convert more than six months after termination, and almost a quarter have not yet decided.

A slight majority of recreational boaters expect Loran-C to provide the same or worse navigational service than Loran-A (Table I-F-22). Only 40% to 50% expect Loran-C to give better service. This reflects the fact that Loran-A has served the needs of the recreational boater very well; many boaters feel bitter about the Coast Guard's decision to terminate Loran-A.

PROBLEMS DURING THE TRANSITION

By far the most universal problem faced by recreational boaters during the transition from Loran-A to Loran-C is the cost of buying a more expensive Loran-C set (Table I-F-23). Because this response was unprompted and had to be written in by the respondent, the importance of this problem to the recreational user is even further emphasized. Other problems mentioned by a minority of the users include conversion of Loran-A readings to Loran-C signals, unavailability of charts, and inadequate coverage of Loran-C. Some of those mentioning the last problem were upset that Loran-C was not to have wider coverage, and others were unaware of the Coast Guard's intention to reconfigure the East Coast chain and construct the Southeast chain.

APPENDIX I-G

OTHER LORAN-A USERS

The project investigators surveyed in detail six major Loran-A user groups as reported in sections A-F of this appendix. In addition, a number of other types of civilian marine vessels use Loran-A, such as:

- Cable layers
- Dredges
- Excursion vessels
- Ferries
- Oceanographic research vessels
- Oil drilling ships
- Oil exploration vessels
- Pile drivers
- Pilot boats
- Sail training ships
- Salvage vessels
- Scuba-diving charter vessels

For the Purpose of	Rating of Loran-C Compared to Loran-A (Percent of Skippers) (%) C Better	C the Same	C Worse	Don't Use This Function	Total
General navigation	39	54	6	1	100%
Fishing	48	36	5	11	100%
Safety	43	45	3	9	100%

Table I-F-22. Expected Usefulness of Loran-C Compared to Loran-A

Problem	Percent of Skippers Mentioning (%)
Cost of conversion	64
Quality of equipment	3
Conversion of readings	11
Availability of charts	3
Inadequate coverage	3

Table I-F-23. Problems Loran-A Users Expect to Face During the Transition

The vessels in these categories are relatively numerous, and a substantial percentage use Loran-A. However, our study did not survey them. We estimated that the total number of Loran-A sets in use by vessels in these unsurveyed groups is between 500 and 1000.

APPENDIX 1-H

LORAN-C USERS

Collecting data on Loran-C users was not a specified task of this project. However, in the process of amassing data on Loran-A users and interviewing manufacturers and dealers, we obtained considerable information on Loran-C users. Because this information may be of interest and value to some readers, we present a brief summary here.

Table I-H-1 presents the major Loran-C user groups and our best estimate of the number of users in each group. (See Table 1 for contrast with estimated numbers and distribution of Loran-A users). Many of the 3500 civilian users of Loran-C in the United States have had prior experience with Loran-A and still have Loran-A receivers on their vessels. We should also note that there are at least as many additional users who have other types of receivers capable of receiving Loran-C signals, including Loran-A/C combination receivers and Loran-C receivers employing visual acquisition.

Most U.S. Loran-C users are concentrated in Alaskan waters south of the Aleutian Islands, and in the Bering Sea, and in the Northwest Atlantic off New England. Alaskan users are almost exclusively commercial fishermen, whereas New England users split among commercial fishermen, commercial sportfishermen, recreational boaters, and other commercial users. U.S. Loran-C users are also found in lesser numbers in the Mid-Atlantic region, Southeast, Gulf of Mexico, and Great Lakes.

User Group	Estimated Number of Loran-C Users
Commercial fishing	1000
Marine commercial sport-fishing	390
Merchant marine	50
Tug and towboat industry	10
Offshore petroleum service vessel industry	50
Marine recreation	1800
Other	200
Total	3500

Table I-H-1. Estimated Number of U.S. Civilian Marine Loran-C Users of Fully Automatic Receivers

In addition to U.S. Loran-C users noted above, there are about 1000 other users of commercially available, fully automatic, Loran-C receivers. These are mainly Canadian and overseas vessels, plus publicly owned vessels of many different types, operated by governmental and quasi-governmental agencies in the United States. The international tanker fleet, including both U.S.-owned tankers of foreign registry as well as foreign-owned tankers, forms a significant category of Loran-C users.

appendix II
the Loran receiver manufacturing industry

This appendix presents the results of a survey of the Loran-C receiver manufacturing industry, involving personal and telephone interviews with actual and potential domestic manufacturers and importers of Loran-C receivers. We conducted interviews with 19 firms between December 1976 and May 1977; telephone interviews were conducted with four firms. Most information reported here comes from responses to questions asked during personal interviews at the firms' U.S. headquarters. Exhibit II-1 at the end of this appendix presents the questions asked during these interviews.

The first section of the appendix describes the structure of the Loran manufacturing industry, and characterizes the industry's size, capacity, and past and projected output. The second section describes the past and expected future pricing, product, and marketing policies of the industry. The final section reports manufacturers' suggestions concerning Coast Guard actions that would promote a successful transition from Loran-A to Loran-C.

SIZE, CAPACITY, AND OUTPUT

In 1977, 14 firms will manufacture Loran-C receivers for sale in the United States market (Table II-1). The typical manufacturing firm is small and has a product line limited to Loran receivers and closely-related marine and other electronics products. Some manufacturers, however, are small divisions in quite large firms with national or international reputations.

Firms vary considerably in their production capacity of Loran-C receivers (Table II-1). The median firm estimated its annual capacity at 2,000-3,000 receivers. The smallest firm estimated that it could produce about 600 receivers, while the largest estimated a capacity of 10,000-12,000 receivers. Almost every manufacturer has recently expanded capacity in anticipation of the termination of Loran-A service. As a consequence, the industry now has a total production capacity of at least 20,000, and most probably 33,000, Loran-C receivers per year.[5]

Industry Characteristics		Low	Median	High
Size of Industry				
Number of firms, by estimated 1977 capacity to produce receivers:	Under 2,000 recrs.	5	4	3
	2-5,000 recrs.	8	8	7
	5,000+ recrs.	1	2	4
	Total firms	14	14	14
Industry capacity in 1977 to produce Loran-C receivers		21,000	33,000	56,000
Number of firms currently considering entry to the industry			5	
Experience in Loran-C Production				
Number of firms, by years of production experience:	0-2 years		6	
	2-5 years		4	
	5+ years		4	
Median years of production experience			2.5	
Output				
Cumulative industry output to June 1977				
Loran-A:	Convertible and A/C Combination receivers	11,700	14,500	18,900
	Other receivers	30,800	36,000	41,600
	Total	42,500	50,500	60,500
Loran-C:	Receivers of all types	3,500	4,500	5,000
	Total	46,000	55,000	65,000
Average annual Loran-A plus Loran-C output, 1974-1976		5,000	6,000	7,000

Table II-1. Estimated Size, Experience, Capacity, and Output of the Loran-C Manufacturing Industry

The cumulative and annual output estimates in Table II-1 (46,000-65,500 and 5,000-7,000 receivers, respectively) are hardly impressive when compared with the present annual capacity of the industry (21,000-33,000 receivers). However, readers should not conclude from this comparison that the industry has excessive capacity at the present time. For, if Loran usage

[5] The high estimate of industry capacity in Table II-1 is based on survey results, but it is not particularly credible given the limited production experience of most firms to date. Of course, if one or more of the firms now considering entry did enter, then the low and median capacity estimates in the table would understate the "best" low and median estimates.

were to grow in the future as it has in the past, and if current Loran-A users convert to Loran-C as the user surveys and model in Appendix VII indicate, the demand for Loran-C receivers will grow as shown in Table II-2 and present excess capacity will be almost fully utilized within two to three years.

	Low	Median	High
Demand (thousands of receivers)			
1977 - 1978	10	12	16
1978 - 1979	16	20	31
1979 - 1980	18	25	34
Capacity Utilization (percent of 1977 industry total)			
1977 - 1978	33	49	67
1978 - 1979	76	82	93
1979 - 1980	86	92	103

Sources: Professional judgment and findings derived from the surveys of Loran-A user groups and the Loran manufacturing industry.

Table II-2. Predicted Demand for Loran-C Receivers and Capacity Utilization in the Loran-C Manufacturing Industry, 1977-1980.

The findings in Table II-2 are important for two reasons: first, they demonstrate that the Loran-C manufacturing industry currently has sufficient capacity to meet the demands for receivers by the existing Loran-A user community, and second, they provide information helpful to firms planning production, product development, investment, and entry to (or exit from) the industry.

PRICING, PRODUCT, AND MARKETING POLICIES

The pricing, product, and marketing policies of the Loran manufacturing industry are in most respects typical of those found in other imperfectly competitive industries. Each firm produces receivers comparable but not identical to those produced by other firms in the industry. Since the receivers are not identical, they are not perfect substitutes for one another, and different firms charge different prices for similar receivers. There are limits, of course, on how the prices of similar receivers can differ without initiating price changes or other competitive reactions by manufacturers of similar receivers. Loran manufacturers recognize the mutual interdependence that exists between their individual actions (price selection, development of new products, arrangements with dealers, warranties) and those of their rival competitors. As a result, the policies adopted by firms in the Loran industry have considerable similarity and stability.

Manufacturers have typically been small, regionally specialized in terms of sales, and have produced receivers that could be effectively differentiated from those sold by rivals. These conditions allowed Loran-A manufacturers to maintain relatively stable prices for their receivers and to engage in other forms of competition than price. Price differentials between similar receivers have varied in size through time, but they have been pervasive and persistent. Instead of price competition, firms have competed in the rapidly-growing Loran market by introducing receivers with features somewhat different from those of their rivals, by advertising, by using national or international distributors, and by expanding their dealer networks.

In this instance, however, it would be incorrect to project past forms of industry conduct into the future. Loran-C manufacturers now expect receiver prices to decline significantly (perhaps 25% to 50%) during the next two years. They expect the industry to compete more through price in the near future than it has in the past. Three reasons given in the survey support this prediction: (1) one or more new firms are expected to enter the industry on a relatively substantial scale, thereby providing new competition as they seek a share of the market; (2) many existing firms are developing lower-cost versions of their present top-of-the-line receiver (they now expect to introduce these receivers at retail prices significantly below present prices for comparable sets); and (3) the demand for Loran-C receivers has not grown as rapidly in the past year as manufacturers had expected, and the typical firm has more excess capacity than its owners and investors had anticipated. As a consequence, firms face pressures to reduce prices and recoup the substantial investments made to develop the Loran-C receivers now on the market. However, considerable uncertainty exists concerning precisely when entry will occur, new receivers will be introduced, and prices will decline. Nonetheless, manufacturers do expect that the prices of fully automatic receivers will decrease more than those of other types of receivers.

Very much less uncertainty surrounds marketing policy in the industry. Firms typically plan to expand their existing dealer networks, reduce their dependence on sales to particular regions, market their receivers overseas if they can identify opportunities, and provide improved receiver repair service. However, the aggressiveness with which these policies will be pursued varies greatly within the industry. In fact, less than one-third of the firms have truly aggressive marketing policies at the present time.

SUGGESTIONS FOR TRANSITION FROM LORAN-A TO LORAN-C

Loran-C manufacturers identified various Coust Guard actions that could promote a successful transition from Loran-A to Loran-C. They typically favored expanded education and information efforts by the Coast Guard, but they were sharply divided over possible extension in Loran-A service. Loran manufacturers almost unanimously believe that their communications with the Coast Guard are less regular and less reliable than they should be. Manufacturers suggest that a Coast Guard newsletter on the status of Loran-C implementation and related activities be published on a regular basis until the Loran transition has been completed. The newsletter would let them plan more confidently and respond to questions from users and dealers more positively.

Manufacturers also suggest that the Coast Guard undertake an education and information program directed toward those who already use Loran-A, as well as toward potential new users of Loran-C. They believe that the Coast Guard is the appropriate organization and has the responsibility to (a) publicize the benefits of Loran-C, (b) explain how it works, (c) identify its potential applications in different marine activities, and (d) help make the Loran-C system work for users in the best possible way. Manufacturers are convinced that the U.S. marine community seriously underestimates the range of applications and potential benefits of Loran-C. They further believe that the Coast Guard can provide more credible and consistent information to the potential Loran-C user community than they can.

However, manufacturers are far from unanimous concerning extensions in the currently scheduled overlap of Loran-A and Loran-C service. Firms that produce convertible Loran-A and/or Loran A/C combination receivers favor extension of Loran-A service, provided that the Coast Guard will maintain the quality of Loran-A signals. These manufacturers recognize that an extension would probably benefit their own firms, but they suggest that the Loran-A user community would also benefit substantially from an extension of Loran-A service.

In sharp contrast, firms that do not produce convertible or combination receivers argue strongly against any extension of Loran-A service. They argue that the user community will not be convinced of the merits of Loran-C if the termination of Loran-A is postponed. They assert that an extension, or indecisiveness concerning extension, will hurt both domestic manufacturers and the user community. Some predicted that an extension would allow

Japanese manufacturers to flood the market with inferior, low-priced receivers, thereby damaging a domestic industry well-prepared to satisfy the demands of the U.S. marine community.

EXHIBIT II-1

QUESTIONS ASKED LORAN MANUFACTURERS

Loran-A History

1. Can you briefly give me a history of your firm's experience producing and selling Loran-A sets? I am particularly interested in establishing the retail prices charged for sets, annual production rates, your estimates of market sizes, and firms and sets competitive with your own during the past few years.

2. Could you estimate the geographical distribution of your total sales, by type of receiver?

3. How many Loran-A sets do you believe are in use today in the coastal confluence zone by U.S. citizens? (Including sets originally produced for the government but purchased as surplus by private citizens.)

Loran-C Experience

1. When did your firm begin production of Loran-C or A/C receivers? What types of receivers have been produced and sold commercially to date? How have prices and annual production rates changed over time? What companies and which sets have been your major competitors? Do you have any published materials providing a brief history of your company and its involvement with Loran-C?

2. What is the geographical distribution of your firm's sales of Loran-C sets to date?

3. How many dealers does your firm have in each region today?

4. What instructional materials, manuals, brochures, and promotional campaigns has the firm undertaken to date? Could you provide these materials to OSU?

5. What are the expected lifetimes and annual repair costs of the receivers produced by your firm?

6. What percentage of total production cost can be assigned to each component in your sets? (Components are defined as follows: power supply; electronics package - receiver and signal processing unit; display unit; and case.)

7. Do you foresee development of the non-marine market for Loran-C receivers, product improvements, competition among suppliers of components, or new technical developments significantly affecting receiver costs during the next five to six years?

Loran-C Plans

1. What do you expect your prices, sales and capacity will be during the next few years? When, if at all, do you intend to introduce new receiver models? Who do you regard to be your major competitors? What do you expect will be the size of the total market for Loran receivers?

2. How do you plan to finance your planned expansion(s) in capacity and/or new product development?

3. What share of your sales do you expect to be to recreational boaters? What types of sets will recreational boaters purchase? What is the basis for these predictions? Do you have comparable predictions for other classes of customers?

4. What share of the U.S. market do you expect will be taken by foreign manufacturers? Which foreign companies do you regard as major competitors? Do they have special advantages over domestic companies? How might these advantages be overcome?

5. Do you intend to market your receivers overseas? If so, where and with what success?

6. Does your company plan to extend its network of dealers during the next five or six years? If so, where and at what rate?

7. Since Loran-C receivers differ considerably from Loran-A receivers, what type of training program do you plan to have for your dealers?

8. Do you plan any special marketing efforts, trade-in offers, etc. in the near future?

9. Would any of your dealers be especially worthwhile to talk with about the user community and its Loran experience, etc?

10. Are you presently developing, or are about to develop, new instructional materials, manual, brochures, etc. to assist actual and/or potential purchasers of your receivers? How will these materials differ from those you have prepared in the past?

11. What should be done to have a smooth transition from Loran-A to Loran-C? By whom?

12. Do you have any recommendations or suggestions of data sources, methods, or literature that may be relevant or helpful in predicting the prices and availability of Loran-C receivers?

appendix III Loran-A service operating cost estimates

This appendix presents estimates of the operating costs for Loran-A service, by region and for different possible overlap schedules for Loran-A and Loran-C service. The cost estimates are based on Coast Guard records and special studies conducted at Coast Guard Headquarters and Oregon State University to estimate the minimum incremental cost of extending Loran-A service beyond the announced termination dates.

The estimates are not based on the simple extrapolation of historical trends. Rather, they explicitly allow for the impact of projected reductions in station personnel because of the recent installation of new equipment, as well as the opportunities that exist to reduce maintenance, repair, and other costs in the year or two immediately prior to termination of Loran-A service. Costs are expressed in 1977 prices and on the July 1 to June 30 year basis appropriate for the benefit-cost analysis reported in this study.

COST ESTIMATES: BY TYPE, YEAR OF OPERATION, AND REGION

This section explains the methods and data that underlie the annual operating cost estimates reported in Table III-1.

Military Pay and Allowance Expenditures: Subhead 01

Cost Guard Headquarters provided estimates of the number of commissioned officers, warrant officers, and enlisted personnel required to operate selected Loran-A stations in 1980(14). The estimates for Loran-A/C stations were incremental and reflected only the number of additional personnel that would remain if Loran-A was not terminated as scheduled. Headquarters also provided the standard annual personnel and general detail costs currently used to prepare personnel cost estimates for the 1977-80 period.

The estimates for military pay and allowances in Table III-1 were obtained by aggregating the number of personnel required to operate Loran-A stations by region and

Subhead Number	Operating Costs, Type	Year of Operation in Overlap	Region: East and Gulf Coasts	West Coast and Alaska	West Coast and Gulf of Alaska	West Coast Only
01	Military Pay and Allowances	All	1,375	1,973	1,139	537
30	Operating and Maintenance	All but last	750	815	567	245
		Last	663	612	426	184
42	Electronics Program	All	32	26	19	12
43	Shore Unit Program	All but last two	628	476	323	170
		Next-to-last	471	358	243	128
		Last	419	317	215	113
	TOTAL OPERATING COST	All but last two	2,785	3,290	2,048	964
		Next-to-last	2,628	3,172	1,968	922
		Last	2,478	2,918	1,799	846

Sources: Professional judgment and various documents cited in text.

Table III-1. Annual Loran-A station operating cost estimates, by type, year of operation in overlap, and region (thousands of dollars in 1977 prices) then valuing them at their respective standard rates. Or, more precisely, estimates were calculated with the following formula:

$$MAP_j = \sum_i n_{ij} w_i (1 + gd_i)$$

where MAP_j = annual total military pay and allowance costs in region j,

n_{ij} = number of type i personnel required to operate Loran-A in region j,

w_i = standard annual personnel cost for type i personnel, and

gd_i = standard general detail (i.e. related personnel support) costs for type i personnel.

Operating and Maintenance Costs: Subhead 30

Coast Guard Headquarters provided Annual OE Cost Reports for Loran stations from fiscal 1960 to 1976 (12, 14). Following a review of these reports and discussions with Headquarters personnel, it was concluded that operating and maintenance costs (subhead 30) in fiscal 1976 could be regarded as representative of their probable level during the overlap. Therefore, the estimates for operating and maintenance costs in Table III-1 are based principally on cost experience at Loran stations in the most recent year for which cost data is available.

The operating and maintenance cost estimates for all but the last year of operation were calculated by using fiscal 1976 subhead 30 cost data and the following formula:

$$OMC_j = [ROMC_j + s_j \overline{omc} + s_j' (0.5) \overline{omc}](1.10)^2$$

where OMC_j = annual total operating and maintenance costs in region j for all but the last year of operation,

$ROMC_j$ = reported total operating and maintenance costs for Loran-A stations in region j for fiscal year 1976,

s_j = number of Loran-A stations in region j with full complement of enlisted personnel but no subhead costs reported for fiscal 1976 in the Annual OE Cost Report.

$\overline{omc}$ = average total operating and maintenance cost per Loran-A station in fiscal 1976 (=\$40K), and

s_j' = number of Loran-A/C and Loran-A stations with less than a full complement of enlisted personnel and no reported subhead 30 costs in fiscal 1976.

Two comments concerning this estimation procedure are in order. First, Headquarters personnel and analysis of recent trends in operating and maintenance costs suggested that 1976 costs are appropriately inflated at an annual rate of 10%. Second, the estimated subhead 30 costs for (a) Loran-A/C stations and (b) Loran-A stations with projected 1980 personnel allowances of only three enlisted men are set equal to one-half of the average costs for a Loran-A station with five to nine enlisted men because analysis reveals a direct and approximately proportional relationship between staffing level and subhead 30 costs.

In the last year of operation some (though not all) maintenance expenses would be unnecessary. Therefore, operation and maintenance expenditures in the final year of Loran-A service are postulated to be 75% of their level in earlier years.

Electronics Program Costs: Subhead 42

Electronics program costs for 25 Loran-A stations in fiscal 1976 were \$52,379, or approximately \$2,100 per station. These costs had been increasing at an annual rate of about 5% in recent years (12,14). Assuming that this trend will continue, electronic program costs are estimated to be \$2,300 per station in 1977 prices. (Successful completion of the Loran-A Replacement Equipment program, LARE, provides the basis for the assumption that real costs in subhead 42 will not increase as time passes.) The electronics program cost estimates in Table III-1 are the product of \$2,300 per station and the number of Loran-A and Loran-A/C stations in each region. Electronics program costs for Loran-A operations at A/C stations are postulated to be the same as those at Loran-A stations.

Shore Unit Program Costs: Subhead 42

Coast Guard Headquarters provided estimates of the shore unit program costs involved in one, two, and three year extensions of Loran-A service in specified regions (13). These estimates were based on historical cost experience adjusted to account for known major projects and expected inflation over the 1976-1984 period, but not adjusted for the highly probable reduction in these costs during the year or two immediately prior to termination of Loran-A service.

In Table III-1 the shore unit program cost estimates for all but the last two years of operation are the Coast Guard estimates expressed in 1977 prices and on a July 1 to June 30 year basis. Since Headquarters personnel indicated that a 10% inflation rate had been assumed in their preparation of estimates by fiscal years, these estimates were deflated by 10% per year and then converted to the annual basis appropriate for the benefit-cost analysis in this study.

Following discussions with Coast Guard personnel, the Oregon State University research team concluded that shore unit program costs would be substantially lower in the final years of Loran-A station service than an unqualified extrapolation of historical cost data would imply. Some, but not all, expenditures would be unnecessary in the years just before termination. Therefore, in Table III-1 shore unit program costs in the next-to-last and last year of operation are predicted to be 75% and 67%, respectively, of their predicted level in earlier years.

LORAN-A OPERATING COST ESTIMATES FOR ALTERNATIVE OVERLAP SCHEDULES

Table III-2 presents the annual Loran-A operating cost estimates by year and region under the alternative overlap schedules evaluated elsewhere in this report. The estimates are derived from the total operating cost figures present in Table III-1, and they provide the basis for calculation of the incremental operating costs of one, two, and three year extensions in Loran-A service.

One feature of the cost estimates in Table III-2 deserves special comment. An extension of Loran-A service increases costs during the last two years of the currently scheduled overlap period as well as during the additional year(s) of Loran-A service. For example, observe the increase in costs on the East and Gulf Coasts in 1978-1979 and 1979-80 when the planned schedule is extended by one year. As a consequence, the incremental cost of extending the overlap of Loran-A and C service exceeds the cost of additional year(s) of Loran-A service alone.

Possible Overlap Schedules	Year	Regions: East and Gulf Coasts	West Coast and All Alaska	West Coast and Gulf of Alaska	West Coast Only
Present Schedule	1977-78	2,785	3,172	1,968	922
	1978-79	2,628	2,918	1,799	846
	1979-80	2,489	-	-	-
One Year Extension of Present Schedules	1977-78	2,785	3,290	2,048	964
	1978-79	2,785	3,172	1,968	922
	1979-80	2,628	2,918	1,799	846
	1980-81	2,489	-	-	-
Two-Year Extension of Present Schedules	1977-78	2,785	3,290	2,048	964
	1978-79	2,785	3,290	2,048	964
	1979-80	2,785	3,172	1,968	922
	1980-81	2,628	2,918	1,799	846
	1981-82	2,489	-	-	-
Three-Year Extension of Present Schedule	1977-78	2,785	3,290	2,048	964
	1978-79	2,785	3,290	2,048	964
	1979-80	2,785	3,290	2,048	964
	1980-81	2,785	3,172	1,968	922
	1981-82	2,628	2,918	1,799	846
	1982-83	2,489	-	-	-

Source: Table III.1

Table III-2. Annual Loran-A station operating cost estimates, by region and possible overlap schedule, 1977-83 (thousands of dollars in 1977 prices)

appendix IV
Canada

Measuring the impact on the Canadian mariner of the transition from Loran-A to Loran-C is not officially part of the present study. Yet, because of its proximity to the United States and substantial interactions in navigational service and impact on users between the two countries, Canada cannot be ignored.

At the present time, Canada operates Loran-A, Loran-C, and Decca transmitting stations on the east coast and Loran-A and Loran-C stations on the west coast. The east coast Decca system is exclusively Canadian. In the case of Loran-A, there are station pairs on both coasts which are exclusively Canadian, but full Loran-A coverage of Canadian waters depends in addition on Danish and United States stations on the east coast of Canada and on United States stations on the west coast of Canada.

The situation with respect to Loran-C is similarly complex. East coast Loran-C coverage is incomplete, but service to portions of Canadian waters is provided by the North Atlantic and U.S. East Coast Loran-C chains. Canada operates the Loran-C transmitting station at Cape Race, Newfoundland, which functions as a secondary in both these chains. Plans call for implementation of operational Loran-C service on the west coast of Canada during 1977. Construction of the Canadian west coast Loran-C chain is complete, and consists of a master transmitting station at Williams Lake, British Columbia, and secondaries at Shoal Cove, Alaska, and George, Washington.

The Loran service of the two countries is interrelated and mutually dependent; that is, Loran-A and Loran-C service off Canada depend in part on signals from U.S. transmitting stations. Conversely, Loran-A and Loran-C service off portions of the United States depend on signals from Canadian transmitting stations.

Canada will soon decide what system will be the prime marine radionavigation system for Canadian waters in the coming years, and Loran-C must be considered a strong contender. Assuming that it is selected, additional Loran-C transmitting stations must be constructed: one or more on the east coast and perhaps one on the west coast as well. Once the Loran-C stations are built and the expanded service begins operating there will then need to be a period of overlapping service before Loran-A is terminated.

It is estimated that in Canada there are approximately 1400 civilian Loran-A users on the east coast and 2400 on the west coast. The problems these Canadian users will face in converting to Loran-C are of the same nature and degree of difficulty as those facing U.S. users. The Canadian situation is further complicated by timing; that is, Canadian decisions and actions on Loran-C will take place one to three or more years later than those in the United States.

The result is a complex, delicate situation of international import. Mariners of both the United States and Canada are affected. Effective Loran coordination between the two countries is essential. Otherwise, one or the other of two difficult situations will occur. On the one hand, if the United States terminates all U.S. Loran-A service on the present schedule, Canadian Loran-A users, depending on their area of operation, will lose Loran-A service, or the quality of their service will be detrimentally affected, and, in either case, the length of their overlapping service will be effectively shortened. On the other hand, the United States can selectively continue the operation beyond the scheduled termination date of those Loran-A transmitting stations that are necessary to full Loran-A coverage of Canadian waters. Such continuation would affect the Nantucket, Massachusetts, and possibly the Marshall Point, Maine, Loran-A stations on the East Coast and the Point Grenville, Washington, and Biorka, Alaska, stations on the West Coast. Canadian users would then continue to receive full Loran-A service. Adjacent U.S. users, however, would also continue to receive full or partial Loran-A service (that is, one or two Loran-A lines of position) beyond the time at which Loran-A is terminated elsewhere in the United States, and a consequent inequity of treatment on the basis of their proximity to Canada would result for some U.S. users.

Both of the above situations are undesirable, and would be costly to civilian users. In the first case, Canadian Loran-A users would suffer. In the second case, some U.S. Loran-A users would be treated inequitably. Neither situation would help a smooth transition to Loran-C.

appendix V Loran education program

A substantial percentage of Loran-A users converting to Loran-C in all groups hold incorrect expectations for Loran-C, given the type of receiver they presently plan to use. As an additional complication, many users also plan to delay switching to Loran-C until the last six months of the transition period. An education program is needed to ensure that users' expectations are consistent with the type of receiver they plan to use and to even out the rate at which users switch.

A preliminary plan for a Loran-C Education Program was developed at a workshop held in Chicago, Illinois, on 14 and 15 December 1976. Workshop participants were:

Daniel Panshin, Extension Oceanographer, Oregon State Univeristy, Workshop Convener

Douglas Coughenower, Marine Education Coordinator, University of Massachusetts

Commander Robert Dugan, Chief, Electronics Engineering Branch, 13th Coast Guard District

Gary Graham, Extension Marine Fisheries Specialist, Texas A & M University

Lieutenant Commander Roger Hassard, Chief, Electronics Branch, 8th Coast Guard District

Mark Hutton, Marine Advisory Agent, University of Alaska

Captain William Roland, Commanding Officer, Coast Guard Electronics Engineering Center

Robert Shephard, Program Manager, NOAA Marine Advisory Service

Charles Vars, Associate Professor of Economics, Oregon State University

Commander William Walker, Chief, Loran-C Implementation Branch, Coast Guard Headquarters

The third project progress report submitted on 17 January 1977 forwarded the preliminary education plan, and contained an interim recommendation that this be implemented as soon as possible. On 1 February 1977 the Coast Guard Chief of Staff approved the education program and directed that it be conducted.

The remainder of this appendix describes the recommended Loran-C Education Program, including minor revisions that have been incorporated since January 1977.

OBJECTIVES

The objectives of the Loran-C Education Program are:

1. To minimize the impact on the existing Loran-A user of the termination of Loran-A service and conversion to Loran-C.

2. To help the user understand Loran-C and the equipment needed to use it.

3. To help make Loran-C work for the user in the best possible way.

4. To help the Loran-A user look forward to the change to Loran-C (rather than to oppose it because of inadequate or erroneous information).

SPECIFICATIONS

1. Direct the education program primarily at those who already use Loran-A, but also at those who are not currently Loran users.

2. Address the benefits of Loran-C as well as describe what Loran-C is and how it works.

3. Emphasize educational efforts; only those information and public relations efforts that are needed to support and reinforce a coordinated education program should be conducted.

4. The education program for users should be conducted by the Coast Guard and Sea Grant but should not exclude other appropriate participants, such as the National Ocean Survey and the Wild Goose Association.

APPROACH

The Coast Guard has the responsibility of planning, managing, executing, monitoring, and evaluating the Loran-C Education Program. The overall program will consist both of projects that the Coast Guard will conduct as well as those that others may conduct with Coast Guard participation or sponsorship.

The primary audience for which the Loran-C Education Program is intended is the private marine Loran-A user, and in particular the small business operator who uses Loran-A. These users are most common in the commercial fishing and commercial sportfishing categories, although a significant number of small businessmen also operate in the tug/towboat and offshore petroleum service vessel categories. The products of this program will also be available to recreationists, operators of large businesses, and those who do not presently use Loran-A.

A successful program will be low key; operated at a regular and sustained level of activity, continuing at least through 1980; composed of multiple elements that are integrated so that redundant efforts may reach the intended audience; and coordinated nationally.

The Loran-C Education Program will be comprised of a number of specific elements:

- Commandant's policy statement
- Education Coordinator
- Public relations contract:
  - Loran-C education kit
  - Loran-C User Handbook (revision)
  - Loran-C brochure
  - Loran-C speaker's kit
  - Feature articles
  - Radio public service announcements
  - Slide-tapes
  - Videotapes
- Newsletter for manufacturers and dealers
- Poster announcing Loran conversion schedule
- Loran-C field demonstrations

Calculator conversion software

Receiver buyers' guide

Bulletin: "Ten easy steps to conversion of Loran readings"

Bulletin: "Reconfiguration made easy"

Loran-C application notes

Bulletin: "Economic aspects of Loran conversion"

All of the individual elements detailed above are needed and should be implemented. Some are more critical than others, however, in terms of their timing or their effect on determining the probable success of other items.

The most crucial elements in order of priority (highest first) are:

1. Commandant's Policy Statement. Comment: The statement endorsing the Loran-C Education Program is necessary in order to reinforce official Coast Guard policy and to make available Coast Guard personnel.

2. Education Coordinator. Comment: Without an Education Coordinator in Coast Guard Headquarters, educational efforts will remain fragmented and the educational program will not be fully effective. A single person must be designated to be the full-time point of focus and responsibility for national coordination.

3. Public Relations Contract. Comment: The public relations effort and education kit can provide proper support to those Coast Guard district and Sea Grant personnel who are conducting local educational programs. We strongly recommend a contract to a competent public relations firm. An acceptable alternative may be to assign this task to Public Affairs in Coast Guard Headquarters, but success depends on proper commitment of people, funds, and time.

4. Newsletter for Manufacturers and Dealers. Comment: Loran manufacturers and dealers comprise a key audience which has been neglected. They need regular and reliable information on the status of Loran-C implementation, because of its impact on their own plans, because of their important role in the adoption of Loran-C, and because of their regular contact with prospective Loran-C users. We recommend an informal newsletter published on a regular schedule until the implementation of Loran-C is complete. This recommendation deserves high priority because manufacturers and dealers are affected earlier in the transition than others, and because this mechanism can greatly aid wise receiver choices by users.

The estimated annual cost of the Loran-C Education Program is $100,000-$200,000 per year. Many of the recommended elements have little or no direct cost. However, these elements can only be fully effective as part of a total program. Individual pieces like newsletters, port meetings, talks, and exhibits at trade shows are already being conducted here and there but have been only partially successful: they are haphazard in timing and location and do not enjoy national coordination. Continuation of present efforts or implementation of only part of the education program would be false economy.

We should also note that many of the recommended elements have potential for multiple use. For instance, portions of the Loran-C Applications Notes and feature articles will be appropriate for reprinting in the many Sea Grant and industry association newsletters. Likewise, figures developed for publications will be suitable for reproduction as slides and transparencies for further use in workshops.

The elements recommended herein are for the Loran Education Program to take place during calendar year 1977. The program should be reviewed annually and modified accordingly for following years.

appendix VI search and rescue activities

One limitation of the benefit-cost model in Appendix VII is the omission of equations that predict the impact of implementation of Loran-C and termination of Loran-A on Coast Guard expenditures for search and rescue (SAR) activites. We made considerable effort to develop a methodology to estimate and measure the relevant net change in SAR expenditures.[6] This effort was unsuccessful. Fortunately, however, the direction of the bias introduced by this omission can be specified.

Implementation of Loran-C and termination of Loran-A will affect SAR activities in three ways: (1) search expenditures in the newly-expanded Loran coverage area will decline, because Loran-C-equipped vessels in distress can more accurately inform the Coast Guard of their location; (2) search expenditures in areas now served by Loran-A will increase after termination because location of vessels that have not converted will be more difficult and costly; and (3) search expenditures will decrease and the benefits of quick location will increase as SAR forces conduct their searches more efficiently and safely and use search patterns superior to those used at present. Expenditure changes (1) and (2) will vary with the rate of conversion to Loran-C by present Loran-A users, but the net benefits of change (3) depend strictly on the rate at which the Coast Guard equips its search craft with Loran-C receivers.[7]

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[6]Headquarters personnel prepared a summary of data on SAR incidents and activity in both existing Loran-A as well as expanded Loran-C coverage areas (13). The *National Search and Rescue Manual*, various documents prepared for the *Study of Alerting and Locating Techniques and Their Impact* (SALTTI) for the coastal area, and other published and unpublished studies for or by the Coast Guard were reviewed (30,31). Personal interviews were also conducted with Coast Guard SAR personnel in San Francisco, California, Astoria, Oregon; Cape Disappointment, Washington; and Kodiak, Alaska.

Effective Coast Guard education and information programs will tend to increase the rate of conversion by present Loran-A users, increase the use of Loran-C throughout the Loran coverage area, and thereby decrease search expenditures in both existing and expanded Loran coverage areas. As a consequence, the omission of equations to predict SAR expenditures from the benefit-cost model means that the net social benefits of education and information programs are further understated.

In contrast, extension of the currently scheduled overlap of Loran-A and Loran-C service will postpone existing Loran-A users' conversion and reduce the use of Loran-C throughout the entire coverage area during the early years of the extended overlap. Compared to what would occur under the present schedule, an overlap extension will tend to increase search expenditures during the overlap period and postpone the date on which search expenditures will decrease in the newly covered areas. An extension will, of course, also postpone the date when search expenditures increase for locating unconverted vessels in areas now covered by Loran-A.

Although the net effect of overlap extensions on search expenditures would appear indeterminant, we can specify the factors that affect their direction and magnitude and can draw useful conclusions. This results because the change in search expenditures must vary directly with (1) the expected number of SAR incidents in the new areas covered by Loran-C and (2) the expected number of Loran-A users who have not converted after termination. We would expect search costs to decrease if an overlap extension significantly reduced the predicted number of Loran-A users who would not have converted by termination, and if the increase in incidents within newly covered areas is small. In contrast, search expenditures could increase if an overlap extension produced only a small reduction in the number of Loran-A users who do not convert by termination, and if the increase in incidents within newly covered areas is large. In the first instance, the ommission from this module of equations to predict SAR expenditures means that the net social benefits of a short (for instance, one year) overlap extension would be biased downward. In the second case, however, the omission means that net social benefits for overlap extensions are biased upward.

These findings are important, since a specially prepared summary of data on SAR incidents in both existing Loran-A and expanded Loran-C coverage areas revealed that only 2% to 4% of SAR incidents have recently occurred in areas that will be newly covered by Loran-C.[8] In addition, vessels involved in these incidents are members of user groups that now plan to convert before the termination of Loran-A. For short overlap extensions, therefore, they would be expected to postpone their conversions to only a limited extent, thereby increasing the present value of SAR expenditures very little. As a consequence, net social benefits estimated by the present model will be biased downward for short overlap extensions that significantly reduce the number of Loran-A users who do not convert by termination. But, for longer extensions, the omission of SAR expenditure equations from the model will bias net social benefit estimates upward.

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[7] Coast Guard personnel involved with SAR activities on a day-to-day basis persuasively argue that the increased benefits and reduced costs of more efficient searches with Loran-C-equipped Coast Guard search craft will be very much larger than the net effect of expenditure changes (1) and (2).

[8] Letter with enclosed SAR data from J.M. O'Connell (13), provided the information needed to estimate the percentage of incidents that have occurred in newly covered areas.

appendix VII the benefit-cost model

This appendix specifies and describes the benefit-cost model developed for this study (the structure and use of the model are broadly characterized in the main text). In this appendix, the first section presents the equations for each module and explains how they are used to predict, measure, and evaluate the benefits and costs of alternative Coast Guard actions. The second section specifies the parameter values used in the benefit-cost analysis. The final section of the appendix explains how alternative Coast Guard actions will change parameter values in the model and thereby affect the net private and social benefits involved in the termination of Loran-A.

DESCRIPTION OF THE MODEL

The benefit-cost model has four modules to predict the impact on private U.S. Loran-A users of alternative Coast Guard actions that could reduce the burdens involved in the termination of Loran-A and the conversion to Loran-C. The model is not designed to evaluate the original decision to terminate Loran-A and implement Loran-C, and therefore includes the benefits of the Loran-C system to Loran-A users who convert, but excludes the costs of operating the Loran-C system, since these are independent of the termination of Loran-A service.

The model consists of seven equations to predict the behavior of Loran-A users and 11 identities to calculate the net private and social benefits and costs associated with alternative Coast Guard actions. We indicate the limitations of the model in the discussion of each module, but show that the model's weaknesses do not impair its usefulness for this study.

Retail Price Module

The Loran-C retail price module includes two equations designed to predict the future prices of the typical fully automatic and manual (i.e., less-than-fully-automatic) Loran-C receivers:

$$(1)\quad pa_t = pa_o\left(\frac{T_{q_{t-1}} + Q}{Q}\right)^{\ln\alpha/\ln 2}$$

$$(2)\quad pm_t = pm_o\left(\frac{T_{q_{t-1}} + Q}{Q}\right)^{\ln\beta/\ln 2}$$

where pa_t, pa_o = retail price of typical fully automatic Loran-C receivers in year t and year o, respectively,

pm_t, pm_o = retail price of typical less-than-fully automatic Loran-C receiver in year t and year o, respectively,

$T_{q_{t-1}}$ = cumulative total purchases of Loran-C receivers from t=o to t-1,

Q = total Loran-C receivers manufacturered prior to start of overlap period, i.e., prior to t=o, and

$\alpha<\beta<1$.

The functional form and variables of equations (1) and (2) are selected for simplicity and consistency with (a) recent pricing practice and (b) expectations by the Loran manufacturing industry of future receiver prices. Our survey showed that Loran manufacturers typically establish the prices of their sets with the expectation that these prices will not change for at least a year; therefore, the price equations postulate that prices are set at the beginning of each year and do not change during the year. The survey also revealed that, as sales increase, manufacturers expect the real prices of automatic receivers to decline relatively more than those of manual sets. As a consequence, the functional form selected is the same as the one associated with progress functions or learning curves, and the parameter α will be smaller than β in simulations with the model.

The analysis reported in Appendix II provides the justification for no capacity variables in equations (1) and (2) and no capacity constraint elsewhere in the model. The Loran-C manufacturing industry has excess capacity at the present time. If Loran usage were to grow in the future as it has in the recent past, and if current Loran-A users convert to Loran-C as the user surveys and demand module predict, the probability is very low that present excess capacity will be fully utilized in the near future.

Demand Module

The module for Loran-C receiver demand is based on information obtained from the surveys of Loran-A users reported in Appendix I. The surveys established three important points: (1) all Loran-A users will eventually convert to Loran-C if the price of Loran-C sets becomes sufficiently low; (2) the expected time of purchase will vary with the length of the overlap of Loran-A and Loran-C service and with Coast Guard education and information activities; and (3) the typical Loran-A user expects Loran-C to perform better than Loran-A, even if he or she plans to purchase a less-than-fully-automatic receiver. Each of these findings is reflected in the equations specified in Exhibit VII-1. The forms of the equations were specified following a review of the relevant professional literature (2,4,8,16, and 18). These equations predict annual purchases of Loran-C receivers by region.

EXHIBIT VII-1

DEMAND MODULE EQUATIONS

$$(3)\quad qa^*_{jt} = a_j - ba_j\, pa_t$$

$$(4)\quad qm^*_{jt} = fm_j - \phi_{jt}(fm_j - m_j) - bm_j pm_t$$

$$(5)\quad qa_{jt} = \lambda_{jt}\left(qa^*_{jt} - \sum_{0}^{t-1} qa_{jt}\right) + \psi_{jt}(fm_j - m_j)$$

$$(6)\quad qm_{jt} = \lambda_{jt}\left(qm^*_{jt} - \sum_{0}^{t-1} qm_{jt}\right)$$

$$(7)\quad \lambda_{jt} = \lambda(lop_j;\ cge_t)\quad o<\lambda_{jt}\leq 1$$

$$(8)\quad \phi_{jt} = \phi(t;\ cge_t)\quad o<\phi_{jt}\leq 1$$

$$(9)\quad \Psi_{jt} = \phi_{jt} - \phi_{jt-1}\ \text{ except for } t=o \text{ when } \Psi_{jo} = \phi_{jo}$$

where qa^*_{jt} = long-run equilibrium number of fully automatic Loran-C receivers demanded by existing Loran-A users in region j, in year t,

pa_t = retail price of fully automatic Loran-C receivers in year t,

qm^*_{jt} = long-run equilibrium number of less-than-fully-automatic Loran-C receivers demanded by existing Loran-A users in region j in year t,

pm_t = retail price of less-than-fully-automatic Loran-C receivers in year t,

qa_{jt} = number of fully automatic Loran-C receivers purchased in region j in year t,

qm_{jt} = number of less-than-fully-automatic Loran-C receivers purchased in region j in year t,

lop_j = length of overlap of Loran-A and Loran-C service in region j,

cge_t = expenditures by Coast Guard Loran-C education and information program in year t

$\left.\begin{array}{l}\lambda_{jt}\\ \phi_{jt}\\ \psi_{jt}\end{array}\right\}$ = adjustment coefficients for region j in year t

The first survey result implies a dynamic adjustment process and the existence of negatively sloped long-run equilibrium demand curves for Loran-C receivers. Equations (3), (4), (5), and (6) follow common economic practice by assuming linear long-run demand functions and a simple adjustment process. Sensitivity analysis at an early stage in model construction showed that the height of the demand curves, rather than their curvature, materially affected the evaluation of alternative Coast Guard actions. Therefore, the linear form was selected, and equation parameters were specified very cautiously (see below for more discussion concerning this matter).

The second point established by the user surveys was that the adjustment process itself must be regarded as a function of Coast Guard actions. Therefore, λ, ϕ, and Ψ in equations (3) and (6) are specified as functions of Coast Guard actions in equations (7) and (8). No particular functional form is postulated for equation (6) because Loran-A user responses to survey questions can be applied to infer the values for the coefficients under currently scheduled and alternative Coast Guard actions. Equation (8) is discussed below.

Figure VII-1 depicts the relationships discussed to this point. The long-run demand curve Da^*_j is linear, and the two paths of price quantity pairs represent alternative outcomes of the process of Loran-A users adjusting to lower Loran-C prices. The upper path characterizes expected prices and cumulative purchases of receivers with a two-year overlap schedule. The lower path illustrates the expected prices and cumulative purchases with a three-year overlap. The different paths reflect the survey finding that Loran-A users will generally respond to an extension in the overlap of Loran-A and Loran-C service by postponing their purchases of Loran-C receivers.

The third major finding from the surveys of Loran-A users, that of the widespread misunderstanding concerning the performance of less-than-fully-automatic Loran-C receivers, is reflected in equations (4) and (6). Many survey respondents believed that less-than-fully-automatic Loran-C receivers will provide navigational service quite superior to that given by Loran-A, and, in fact, that such receivers will deliver the full performance advertised for the Loran-C system. As a consequence, the perceived current and near-term long-run demand for such receivers will exceed the long-run demand based on complete information concerning receiver characteristics. Over time, however, increased information about Loran-C receivers and their capabilities may be expected (1) to reduce the gap between the currently perceived and true long-run demand curves for less-than-fully-automatic receivers and thereby (2) to increase purchases of fully automatic receivers.

These findings and hypotheses are illustrated in Figure VII-2 by the successively smaller gaps between the perceived demand curves Dm_{j0}, DM_{j1}, and Dm_{j2} and the true curve Dm^*_j. The perceived demand curves are postulated to shift leftward over time as potential users acquire more knowledge of Loran-C and the Coast Guard undertakes effective educational and information efforts. Equation (4) represents the initial gap between the perceived and true long-run demands as the difference between a false intercept value fm_j and the true intercept m_j (see Figure VII-2), and equation (8) treats the gap as a function of the passage of time and Coast Guard educational and informational activity. No specific functional relationship is specified for equation (8) because no directly relevant empirical studies exist to justify one form rather than another. Therefore, alternative forms and coefficient values were specified after the model was programmed, and sensitivity analyses were conducted. The results of these analyses are characterized below.

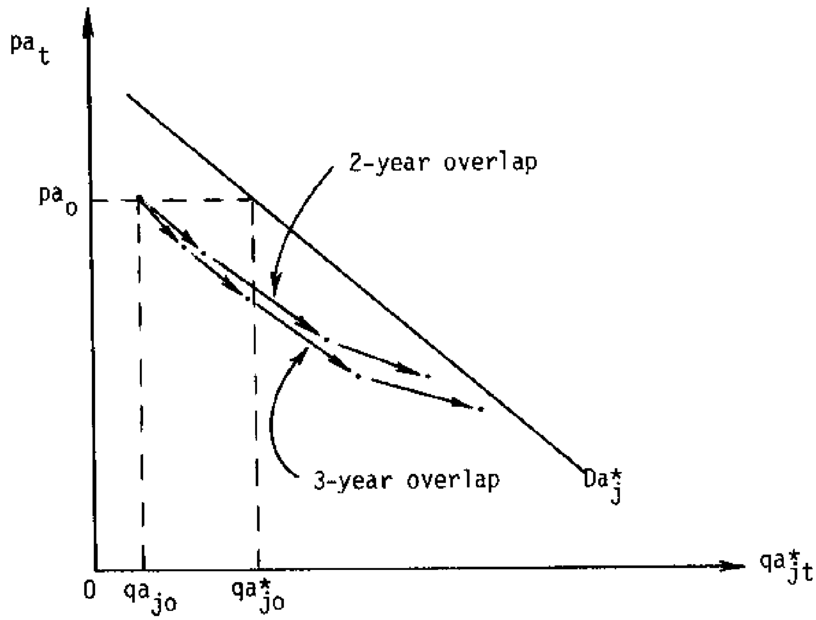

Fig. VII-1.

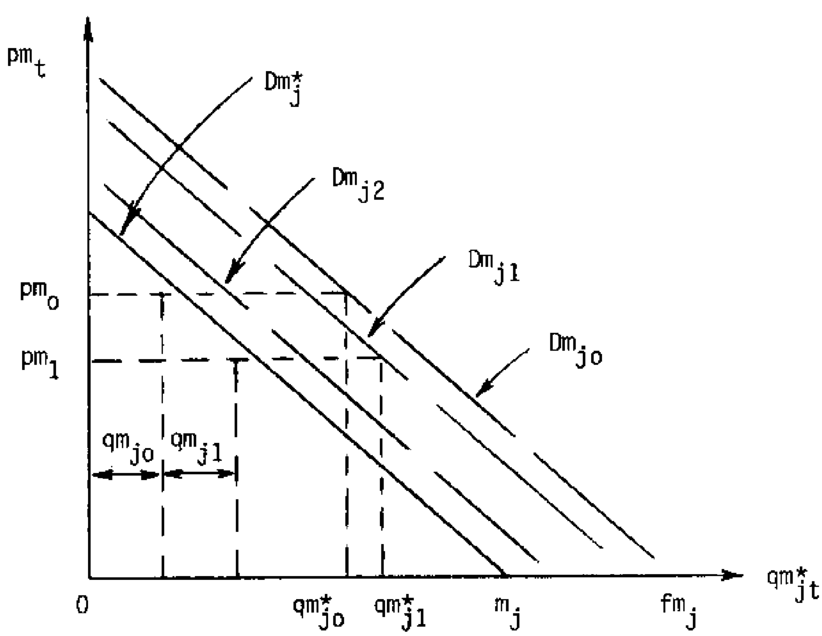

Fig. VII-2.

Finally, we postulate that improved knowledge concerning Loran-C receiver capabilities will increase purchases of fully automatic Loran-C sets. The second term of equation (5) reflects this effect by translating the shift in the estimated demand for less-than-fully-automatic receivers into demands for and purchases of fully automatic receivers.

Net Private Benefits Module

The net private benefits module measures the value of Loran-C service to existing Loran-A users in conventional economic fashion. Since the value of the basic navigation, operations, and safety services of Loran-C cannot be directly measured, and can only be obtained if one has a Loran-C receiver, the benefits of Loran-C service are estimated indirectly as the net benefits deriving from the purchase and use of the Loran-C receivers. More precisely, net private benefits of Loran-C receivers are defined and measured here as the difference between the maximum amount that purchasers would pay to acquire and use their receivers and the costs they actually incur to purchase and use them.

The maximum amount that Loran-A users are willing to pay for Loran-C receivers is reflected by the demand curves for such receivers. These demands reveal the valuations of the expected future streams of services provided by Loran-C. Existing Loran-A users are willing to purchase Loran-C receivers only because the expected value of the receivers equals or exceeds the costs of acquiring and using them. The marginal purchaser is indifferent to purchasing or not purchasing because his or her expected costs (which equal the retail price of receiver plus present discounted value of expected future maintenance and repair costs) match the present discounted value of the future stream of services that he or she expects to obtain from his receiver; net benefits of the purchase to him are therefore zero. For all other purchasers, however, net benefits are positive, for they would be willing (though not required) to pay more than the current retail price to acquire and use the receivers.

The first two terms in equation (10) of Exhibit VII-2 represent the net private benefits of Loran-C service to existing Loran-A users who convert and purchase Loran-C receivers. The first term represents net benefits for those who purchase fully automatic receivers, while the second term represents net benefits obtained by those who purchase less-than-fully-automatic receivers.

Although the user surveys revealed that most Loran-A users will convert to Loran-C by purchasing new receivers, many now plan to do so after the termination of Loran-A service. Therefore, the third term in equation (10) captures the impact of termination on private Loran-A users who will not convert before Loran-A termination and thus will be without Loran service. This term will be zero during the overlap of the two Loran services and positive after termination so long as some present Loran-A users have converted.

Equations (11), (12), (14), and (15) in Exhibit VII-2 calculate net private benefits by type of set, region, and year according to principles outlined above. The first term within the brackets of equations (11) and (12) measures the maximum amount that buyers would be willing to pay for the receivers they purchase, while the second term measures what they did pay.

Equations (11) and (12) differ from their counterparts in the usual benefit-cost analysis in two respects. First, the benefits of Loran-C service will accrue over time, but here they are expressed in terms of their present values in the year that the receivers are purchased. This procedure simplifies the calculation of benefits in a disequilibrium situation. It is appropriate in the context of this present policy analysis, though not in others.

Second, gross benefits per year (the first term within the brackets of equations (11) and (12)) are measured as the difference in areas under successive estimates of short-run demand curves rather than successive estimates under the long-run demand curve. A disequilibrium situation requires this method because the long-run demand curve becomes relevant for benefit measurement only when all short-run adjustments are complete and disequilibrium no longer exists. Here the successive short-run demand curves are estimated under the assumption that the long-run demand curve reveals the maximum amount buyers would be willing to pay but that purchases in any given year are randomly distributed.

Figure VII-3 illustrates the net benefit measurement procedure described above. Suppose that the price of receivers declined through time as shown in Figure VII-3. Buyers adjust to the lower prices and

EXHIBIT VII-2

NET PRIVATE BENEFITS MODULE EQUATIONS

$$(10)\quad npb_{jt} = npba_{jt} + npbm_{jt} - cnc_{jt}$$

$$(11)\quad npba_{jt} = [(wa_t \sum_{o}^{t} qa_{jt} - wa_{t-1} \sum_{o}^{t-1} qa_{jt}) - pa_t\ qa_{jt}]$$

$$(12)\quad npbm_{jt} = [(wm_t \sum_{o}^{t} qm_{jt} - wm_{t-1} \sum_{o}^{t-1} qm_{jt}) - pm_t qm_{jt}]$$

$$(13)\quad cnc_{jt} = [\delta_{jt}\ (Q_j - \sum_{o}^{t} qa_{jt} - \sum_{o}^{t} qm_{jt})]$$

$$(14)\quad wa_t = [(0.5)\ (a_j/ba_j + pa_t)]$$

$$(15)\quad wm_{jt} = [(0.5)\ (m_j/bm_j + pm'_{jt})]$$

$$(16)\quad pm'_{jt} = [pm_t - (bm_j)^{-1}\ (1 - \phi_{jt})\ (fm_j - m_j)]$$

where npb_{jt} = net private benefits in region j in year t,

$npba_{jt}$ = net private benefits to Loran-A users who purchase fully automatic Loran-C receivers in region j in year t;

$npbm_{jt}$ = net private benefits to Loran-A users who purchase less-than-fully-automatic Loran-C receivers in region j in year t;

cnc_{jt} = total cost in region j in year t to existing Loran-A users who do not convert to Loran-C and are without Loran service following Loran-A termination;

wa_t = willingness-to-pay of existing Loran-A users for fully automatic Loran-C receivers in year t;

wm_t = willingness-to-pay of existing Loran-A users for less-than-fully-automatic Loran-C receivers in year t;

δ_{jt} = annual cost per user in region j in year t to existing Loran-A users who do not convert to Loran-C and are without Loran service following Loran-A termination (δ_{jt} = o during overlap, $\delta_{jt} >$ o after termination);

Q_j = number of existing Loran-A users with nonconvertible and other than A/C combination receivers in region j; and

pm'_{jt} = willingness-to-pay of the marginal buyer in region j in year t after he or she understands the true value of less-than-fully-automatic Loran-C receivers.

gradually move toward the long-run demand curve. Substituting areas labeled A, B,... F in the figure for the terms they represent in equation (11), areas A, C, and E become graphic representations of net private benefits as calculated in this study:

$$npba_{jo} = [(A + B) - B] = A$$

$$npba_{j1} = [(A+B+C+D-A-B) - D] = C$$

$$npba_{j2}=[(A+B+C+D+E+F-A-B-C-D) - F] = E$$

Third, buyer misunderstanding concerning the performance of less-than-fully-automatic receivers requires that the benefits from such receivers must be measured with

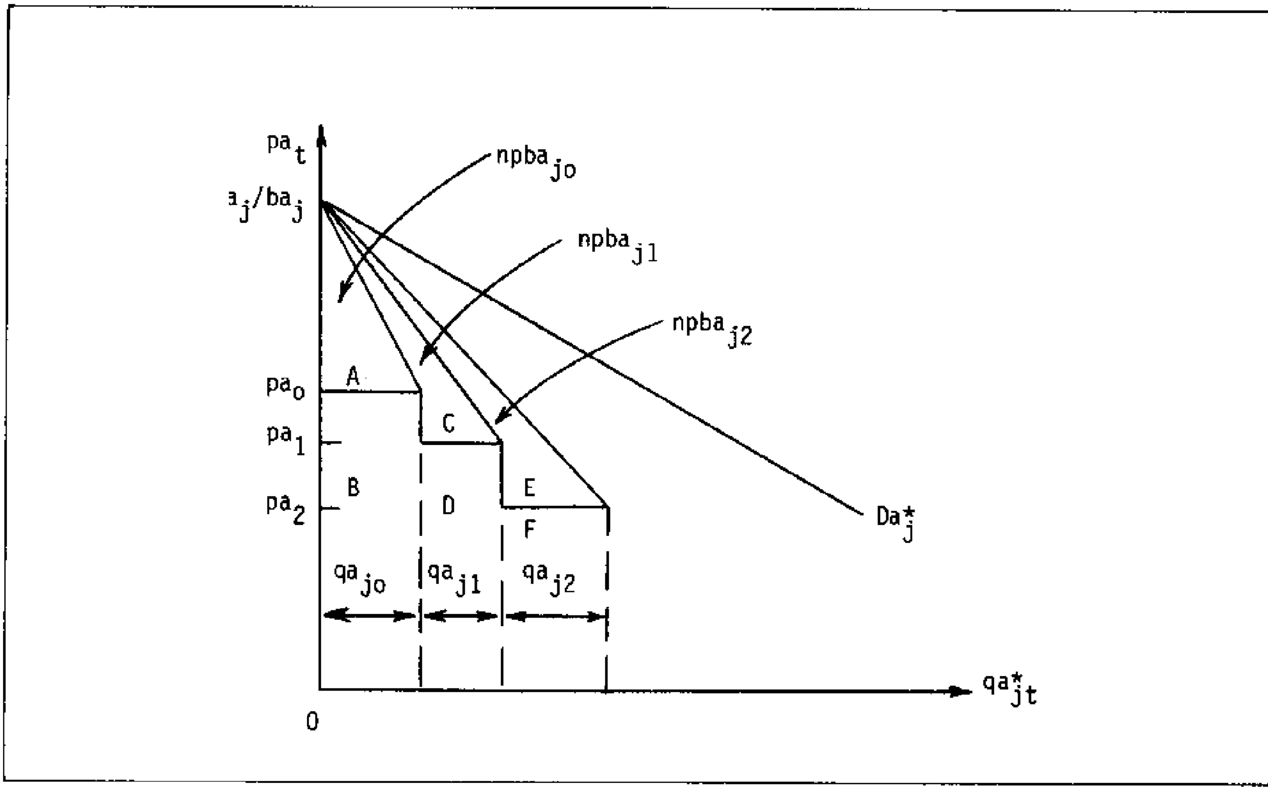

Fig. VII-3.

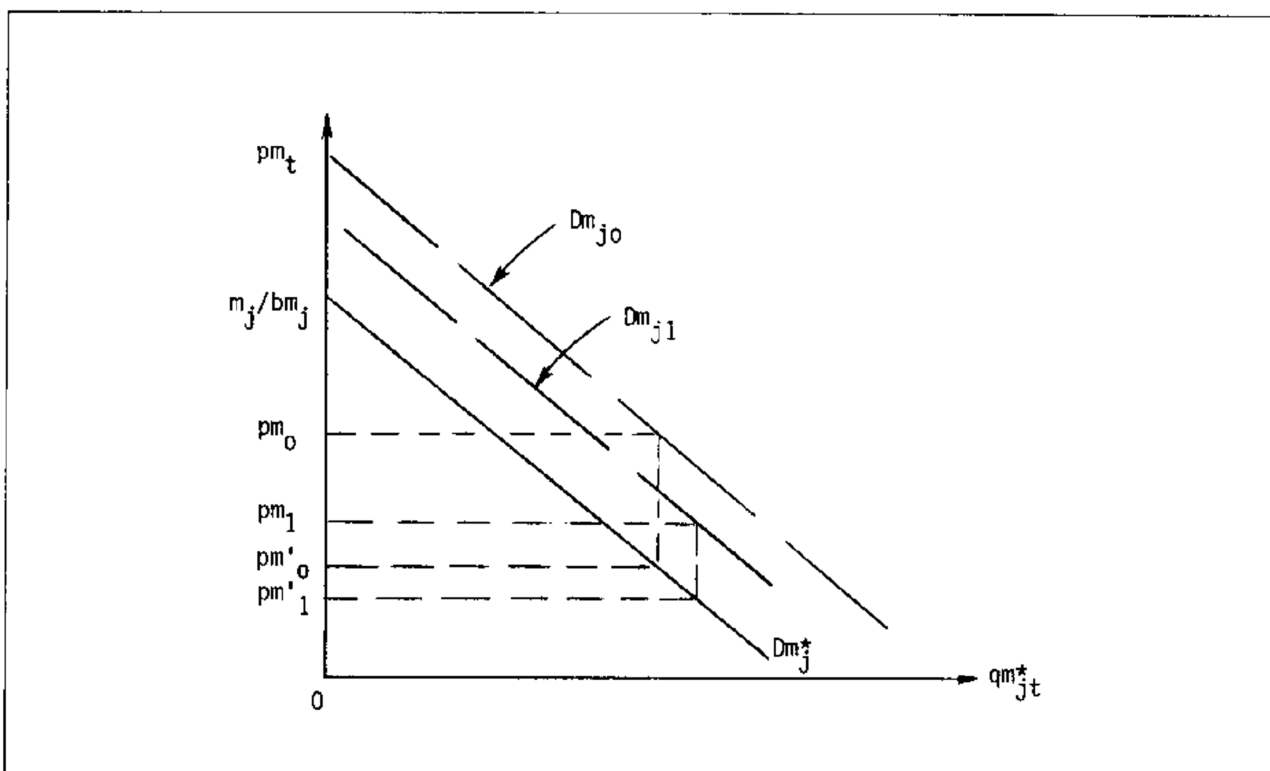

Fig. VII-4.

estimated marginal valuations and estimated short-run demand curves, where both of these are derived from the true long-run demand curve. Net benefits would in fact be incorrectly overestimated, if actual prices paid and short-run demand curves estimated from inaccurately perceived long-run demand curves provided the data for the measurements. Here inaccurate information is postulated as uniformly distributed among potential buyers of less-than-fully-automatic receivers, and an accurate valuation for the marginal buyer is found by estimating the maximum amount that the buyer would be willing to pay, pm'_{jt}, from the true long-run demand curve. Equation (16) specifies the formula to calculate pm'_{jt}, and Figure VII-4 illustrates the postulated relationship between the market prices of less-than-fully-automatic receivers, pm_{jt}, and their true marginal value, pm'_{jt}, for periods t=0, 1. Once the true marginal valuation, pm'_{jt}, is inserted into equation (15), however, the measurement principles underlying equations (12) and (15) are identical to those underlying equations (11) and (14).

Equation (13) is the final component of the net private benefits module. This equation makes the cost of being without Loran service after Loran-A termination directly proportional to the number of existing Loran-A users who do not convert to Loran-C. The annual cost per user who does not convert, δ_{jt}, would vary between users according to the alternative navigation aid or aids each selected. No equation to predict δ_{jt}, is specified here because users were unable to indicate the benefits and costs of the alternative aid they intend to substitute for Loran service. Therefore, a reasonable range of values for δ_{jt} were inserted in the model to determine the sensitivity of net private benefit estimates to variations in a module element that, unfortunately, had to be treated as if it were a parameter.

Finally, we should note that the net private benefits module does not include equations to estimate the benefits to existing owners of convertible Loran-A, Loran A/C combination, and Loran-C receivers of Coast Guard activities related to termination. Users of these receivers constitute perhaps 25% to 35% of the present Loran marine community, a large group that would benefit, in some cases substantially, from Coast Guard programs to acquaint Loran users with the broad range of applications for Loran-C, ways to cope with reconfiguration of the East Coast chain, and others. Therefore, omitting benefits from Coast Guard actions to this group means that the estimates of net private benefits of education and information programs are understated.

Net Social Benefits Module

The net social benefits module measures the net gain or loss to society that results from the termination of Loran-A service, by subtracting the cost of Coast Guard activities related to termination from net private benefits calculated with equation (10) in the immediately preceding module. In this module, the only Coast Guard costs considered are (1) operation, maintenance, and repair costs for operation of Loran-A stations during both the currently scheduled and the extended, or longer, overlap periods included in the benefit-cost analysis, and (b) the costs of education and information activities undertaken by the Coast Guard to facilitate conversion to Loran-C.

Some Coast Guard costs are attributable to specific activities in particular areas; for example, the operating costs for the Loran-A chain or Loran-C demonstrations along a certain coast. Net regional social benefits would equal net private benefits minus those costs directly attributable to Coast Guard actions in the region. Total social benefits for the nation, however, would equal the sum of regional net social benefits minus those national Coast Guard costs that cannot be regionally allocated. Unallocable costs would typically include some of those costs incurred at Coast Guard Headquarters.

The net social benefits module therefore includes two equations:

(17) $nsb_{jt} = npb_{jt} - co_{jt} - ce_{jt}$

(18) $tsb_t = \sum_j npb_{jt} - cos_t - ce_t$

where nsb_{jt} = net social benefits in region j in year t,

co_{jt} = total costs of operating Loran-A stations in region j in year t,

ce_{jt} = total cost of education and information activities in region j in year t,

tsb_t = national net social benefits in year t,

cos_t = total unallocable costs of operating the Loran-A system in year t, and

ces_t = total unallocable costs of education and information activities in year t.

SPECIFICATION OF MODEL PARAMETERS

The benefit estimates in this report are based on parameter values specified here. Table VII-1 presents the parameter values required by and selected for the retail price, demand, and net private benefit modules, as well as the subjective probabilities assigned to predictions from retail price and demand modules. Table VII-2 presents the adjustment and learning coefficients for the demand module. Parameters and probabilities have been selected to assure that the estimated benefits of alternative Coast Guard actions would be realistic. However, if there is any bias in these parameter values, it is one that understates the estimated benefits derivable from Coast Guard actions other than those currently scheduled.

Of course, possibly a conservative approach to parameter selection and benefit estimation could affect the ranking among alternative actions. If this occurred, then the parameter selection procedure could mean that truly inferior actions would appear more desirable than they actually are. To determine whether this was possible, a sensitivity analysis was conducted, which showed that substitution of parameter values less conservatively selected than those in Table VII-1 would increase the estimated benefits of the actions reported in Table 3 of the main text, without affecting their ranking.

Parameters for Retail Price Module

The prices for Loran-C receivers listed in Table VII-1 are expected median prices for summer 1977. Information obtained from the survey of Loran manufacturers, as well as current advertised prices, is reflected in the specification of these prices.

The number of Loran-C receivers manufactured to June 1977 is the high estimate in Table II-1. Selection of the high estimate for the number of Loran-C receivers (Q) is conservative because, other things being equal, the larger the Q, the smaller the decline in receiver prices, and the smaller the net benefits to the Loran-A user who converts by purchasing a Loran-C receiver.

The low and high values for α were selected on the basis of the most pessimistic and optimistic retail price predictions by Loran-C receiver manufacturers for 1978. The most pessimistic prediction stated that the price of fully automatic receivers would decline by about 20%, or to approximately $3,000. The most optimistic predictions suggested prices in the range of $2,000-$2,500. Given the demand functions presented below, the low and high values for α generate price predictions for 1978-79 (t=1 in the model) close to the predictions of manufacturers. The values for β are set at midway between α and 1.0 and reflect industry's judgment that prices of less-than-fully-automatic receivers will decline, in relative terms, much less than those of fully automatic receivers. Again, these values generate price predictions for Loran-C manual receivers for 1978-79 within the range of $800-$900 suggested by manufacturers.

The probabilities assigned to price predictions from the module are discussed in the main text.

Parameters for Demand Module

The estimated numbers of Loran-A users who must purchase Loran-C receivers reflect findings reported in Appendix I as well as the judgment of the investigators. High probabilities are attached to the low and median estimates because these are based primarily on data collected specifically for this study. Table 4 in the main text shows that the estimated incremental net social benefits of Coast Guard actions vary directly with the estimated number of users. Therefore, the high probabilities assigned to the low and median estimates mean that the expected net benefits of Coast Guard actions other than those currently scheduled are estimated conservatively.

The parameters given in Table VII-1 for the demand functions are based on six assumptions that are considered to be valid in the long run for both regions:

(1) the demand functions for both types of receivers are linear;

(2) the price at which the demand for fully automatic Loran-C receivers would be zero is $6,000;

Parameters, by Module	Estimates, by Characteristic		
	Low	Medium	High
<u>Retail Price Module</u>			
pa_0 (in $)		3,700	
pm_0 (in $)		1,100	
Q (no. of sets)			5,000
α	0.85	0.75	0.65
β	0.92	0.87	0.82
Probability	0.10	0.30	0.60
<u>Demand Module</u>			
East and Gulf Coasts:			
N	21,350	25,550	29,950
a	24,030	28,290	33,690
ba	4.00	4.72	5.62
m	8,010	9,430	11,230
fm	16,020	18,860	22,460
bm	4.45	5.24	6.24
West Coast and Alaska:			
N	8,950	9,950	11,150
a	10,080	11,190	12,540
ba	1.68	1.97	2.09
m	3,360	3,730	4,180
fm	6,720	7,460	8,360
bm	1.87	2.07	2.32
Probability	0.40	0.50	0.10
<u>Net Private Benefit Module</u>			
δ		200	

Table VII-1. Parameters for the retail price, demand and net private benefits modules and the probabilities assigned to predictions from the retail price and demand modules

(3) 75% of those who must purchase a Loran-C receiver to convert would be willing to do so by purchasing a fully-automatic-receiver if its price were $2,000;

(4) the price at which the demand for less-than-fully-automatic Loran-C receivers would be zero is $1,800;

(5) with complete information concerning the capabilities of Loran-C receivers, 25% of those who must purchase a Loran-C receiver to convert would be willing to do so by acquiring a less-than-fully-automatic receiver if its price were $600; and

(6) with today's information on Loran-C receiver capabilities, 50% of those who must purchase a receiver to convert would be willing to do so if its price were $600.

Evidence from the surveys of Loran users suggests that these assumptions provide estimated demand functions, by type of receiver and region, that are lower and less price-elastic (i.e., less responsive to price than the true demand function). Loran-A users value the services of Loran highly and would be willing ultimately to pay higher prices than they have previously paid for receivers in order to secure superior navigation. Moreover, Loran-A users at present do not understand well the Loran-C system or receiver capabilities, and therefore perhaps half of those who now plan to purchase less-than-fully-automatic receivers would not do so if they had complete information.

The implications of the demand functions for benefit measurement deserve comment. Because the estimated demand functions are relatively low and price-inelastic, the benefits of extensions in the overlap of Loran-A and Loran-C service are smaller than they would be with higher and more price-elastic demand functions. Similarly, the relatively small (25%) estimated true demand for less-than-fully-automatic receivers means that the benefits of both overlap extensions and an education-information program are also small. As a consequence, the net benefit estimates for alternative Coast Guard actions are conservatively estimated by the demand functions used in this study.

Table VII-2 presents the adjustment and learning coefficients in the demand module. The adjustment parameters, λ_t, are based on

Period	Adjustment Coefficients (λ_t), by Region: West Coast and Alaska	Adjustment Coefficients (λ_t), by Region: East and Gulf Coasts	Learning Coefficients (ϕ_t), by Region: West Coast and Alaska	Learning Coefficients (ϕ_t), by Region: East and Gulf Coasts
0	0.20	0.13	0.10	0.10
1	0.43	0.30	0.30	0.25
2	0.70	0.70	0.60	0.50
4	0.10	0.10	1.00	0.85
	.	.	.	.
	.	.	.	.
	.	.	.	.
10	0.10	0.10	1.00	1.00

Note: 1977-78 is period zero.

Table VII-2. Adjustment and learning coefficients for the demand module, by region information from the Loran-A user surveys in Appendix I. The coefficients for the first three periods come from user responses to questions about their plans to convert to Loran-C. The timing of conversions predicted with the adjustment coefficients is broadly consistent with the intentions expressed by the Loran-A users who responded to questions on our surveys.

The learning coefficients, ϕ_t, in Table VII-2 are based on the findings of economists and sociologists who have investigated the diffusion of knowledge and innovations (7, 8, 17). This body of research has established that diffusion often begins slowly, then proceeds rapidly, and finally increases at a diminishing rate. The longer time period before termination and the problems associated with reconfiguration suggest that the learning process on the East and Gulf Coasts will be slower and longer than on the West Coast and in Alaska. Therefore, we assume that the learning coefficients have an S-shaped pattern over a five-year period on the East and Gulf Coasts, whereas for the West Coast and Alaska we assume that learning will proceed more rapidly.

The learning coefficients in Table VII-2 are not based on empirical evidence developed specifically for this study, but, rather, on the investigators' judgment that the gaps between the true and perceived demand curves for less-than-fully-automatic receivers are substantial throughout the country and will not disappear within one or two years. However, no one can assert with great confidence precisely how long the gaps will exist.

We believe that we are conservative in assuming that these gaps will last two years beyond termination. The diffusion of knowledge concerning Loran-C will probably spread more rapidly among the Loran-A user group. To the extent that this is true, the benefit estimates for Coast Guard actions based on the postulated learning coefficients understate the true benefits of these actions, because the shorter the learning period, the larger the learning coefficients closest to the present, and the larger will be the marginal impact of longer overlap periods and education/information efforts in the model.

Parameters for Net Private Benefit Module

The annual cost to existing Loran-A users who do not convert and are without Loran service after termination is set at $200 per year. The logic behind this parameter selection is simple: a user who does not convert before termination, but does so within one or two years thereafter, initially rejects and then makes an investment that provides a service comparable to, or better than, that provided by a less-than-fully-automatic Loran-C receiver. This type of user may reasonably be regarded as a marginal beneficiary of Loran service, and as such will derive benefits just barely sufficient to justify the purchase of the least expensive Loran-C receiver. Letting the expected life of the receiver equal six to eight years and the interest rate faced by users 8%-10%, the annual net benefits sacrificed by users who initially reject conversion will be about $200 per year.

IMPACT ON MODEL PARAMETERS OF COAST GUARD ACTIONS

Coast Guard actions to extend the overlap of Loran-A and Loran-C service and/or to undertake the education/information program suggested in Appendix V will affect the Loran-A user community by changing the expected timing of their conversions to Loran-C and by increasing their knowledge of Loran-C receiver capabilities. These actions, individually or in combination, will change the adjustment and learning coefficients in Table VII-2 as described in this section, and therefore will affect the private and social benefits involved in the termination of Loran-A.

Overlap Extensions

Two findings from the surveys of Loran-A users provide the basis for specifying the impact of overlap extensions on the timing of conversions to Loran-C. The surveys reveal that existing Loran-A users who plan to convert in the near future typically plan to do so even if the Coast Guard would announce an extension in the overlap period of Loran-A and Loran-C service. In contrast, most users who intend to convert shortly before or after the currently scheduled termination would also postpone their conversion to a date closer to any reset date for termination.

The first finding implies that the adjustment coefficient in early years of the currently scheduled overlap will not change if the overlap is extended. The second finding, however, implies that adjustment coefficients for later periods will be comparable to those in early periods, but unchanged for the periods immediately prior and after the new termination date. The following equations reflect these findings and specify the impact on adjustment coefficients of overlap extensions postulated in the benefit-cost analysis:

(19) $\lambda(oe)_{jt} = \lambda_{j,\ t-oe}$

(20) $\lambda(oe)_{jo} = \lambda_{jo}$

where $\lambda(oe)_{jt}$ = adjustment coefficient in year t for an overlap extension of length oe in region j;

$\lambda_{j,t-oe}$ = adjustment coefficient for region j in year t-oe (from Table VII-2); and

oe = length of overlap extension (in years).

Education/Information Program

We predict that an education/information program with the elements suggested in Appendix V will (a) require time for initiation and full effectiveness and (b) increase the rate of adjustment and learning by the Loran-A user community.[9] Previous research provides supports for these predictions (8,17).

The following equations calculate the impact of the education/information program on model parameters:

(21) $\phi(ei)_{jo} = (1 + 0.5e)\phi_{jo}$

(22) $\phi(ei)_{jt} = (1 + e)\phi_{jt}$ for t-1,2,...,n

(23) $\lambda(ei)_{jo} = (1 + 0.5)\lambda_{jo}$

(24) $\lambda(ei)_{jt} = (1 + e)\lambda_{jt}$ for t=1,2,...,n

where $\phi(ei)_{jt}$ and $\lambda(ei)_{jt}$ = learning and adjustment coefficients for region j in year t with the education/information program;

ϕ_{jt} and λ_{jt} = learning and adjustment coefficients for region j in year t (from Table VI-2); and

[9] That is, the basic relationships in the model are not changed by the program, but rather an effective program is predicted to assist and intensify them.

e = 0.10, 0.20. and 0.30, or three alternative levels of effectiveness postulated for the education/information program.

The program is postulated to be only one-half as effective in its first year as it will be in later years.

Three alternative levels of effectiveness are postulated because no such education/information effort has previously been undertaken in a comparable situation. An equal probability of 0.33 has been assigned to each level of effectiveness postulated, and the results reported in Tables 3 and 4 of the main text are weighted averages calculated with these probabilities as the weights. Table VII-3 reveals the sensitivity of the results to the different levels of effectiveness postulated.

Combined Actions

When the education/information program is combined with an overlap extension, the following equations replace (23) and (24) above and are used with (21) and (22) to calculate the impact on model parameters of combined Coast Guard actions:

(25) $\lambda(oe\text{-}ei)_{jo} = (1 + 0.5)\lambda(oe)_{jo}$

(26) $\lambda(oe\text{-}ei)_{jo} = (1 + e)\lambda(oe)_{jt}$

where $\lambda(oe\text{-}ei)_{jt}$ = adjustment coefficient for region j in year t with an education/information program combined with an overlap extension of oe years.

Table VII-4 indicates the results' sensitivity to the different levels of educational program effectiveness.

Costs of Coast Guard Actions

The costs of extending Loran-A service beyond its currently scheduled termination are estimated in Appendix III. Table III-2 provides the cost estimates, by region and year, used in the benefit-cost analysis of alternative extensions of Loran-A service.

Elements of the education/information program are characterized and assigned cost estimates in Appendix V. Discussions with Headquarters personnel led to various refinements in those estimates. The annual costs of the scheduled four-year program are estimated as follows for the benefit-cost analysis:

1977-78	142
1978-79	123
1979-80	115
1980-81	115

These cost estimates are expressed in thousands of 1977 dollars, and the year is defined as 1 July - 30 June.

Estimated Declines in Loran-C Receiver Prices	Program Effectiveness	Incremental Net Social Benefits, by Estimated Number of Users			Benefit-Cost Ratio, by Estimated Number of Users		
		Low	Median	High	Low	Median	High
Low	Low	726	859	1,001	2.67	2.98	3.31
	Median	1,311	1,501	1,695	4.02	4.46	4.91
	High	1,577	1,797	2,011	4.63	5.14	5.63
Median	Low	235	281	324	1.54	1.65	1.75
	Median	463	509	539	2.07	2.17	2.24
	High	502	548	572	2.16	2.23	2.32
High	Low	-87	-74	-63	0.80	0.83	0.85
	Median	-60	-62	-69	0.86	0.86	0.84
	High	-101	-96	-89	0.77	0.78	0.79

Table VII-3. Incremental net social benefits and social benefit cost ratios for the *Scheduled 4-Year Education and Information Program*, by estimated number of Loran-A users, estimated education-information program effectiveness, and estimated decreases in Loran-C receiver prices (benefits and costs discounted at 10 percent and expressed in thousands of 1977 dollars)

Estimated Declines in Loran-C Receiver Prices	Program Effectiveness	Incremental Net Social Benefits, by Estimated Number of Users			Benefit-Cost Ratio, by Estimated Number of Users		
		Low	Median	High	Low	Median	High
Low	Low	-382	-201	28	0.69	0.84	1.02
	Median	734	1,011	1,335	1.59	1.81	2.07
	High	1,495	1,833	2,215	2.20	2.47	2.78
Median	Low	-239	-75	118	0.81	0.94	1.09
	Median	380	555	746	1.31	1.45	1.60
	High	754	932	1,118	1.61	1.75	1.90
High	Low	-168	-29	126	0.86	0.98	1.10
	Median	6	219	339	1.00	1.18	1.27
	High	243	345	454	1.20	1.28	1.36

Table VII-4. Incremental net social benefits and social benefit-cost ratios for *combined overlap extension of one year on West Coast (but not Alaska) and scheduled four year education-information program*, by estimated number of Loran-A users, estimated education-information program effectiveness, and estimated decreases in Loran-C receiver prices (benefits and costs discounted at 10 percent and expressed in thousands of 1977 dollars)

Coast Guard review

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

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16500
11 OCT 1977

Dr. Daniel A. Panshin
Extension Oceanographer
Oregon State University
Corvallis, Oregon 97331

Dear Dr. Panshin:

The report TERMINATION OF LORAN-A: AN EVALUATION OF ALTERNATIVE POLICIES is a careful analysis of a complex subject. I congratulate you and your associates for the high quality of this work. You have provided a forthright report which represents the needs and viewpoints of Loran-A users, balanced with an objective appreciation of the problems of the Coast Guard and the interests of the American taxpayer.

The methodology in the analysis has been discussed separately with your associates, and so I will confine my comments to the eight recommendations contained in the report:

Recommendation 1. Conduct the Loran-C Education Program specified in Appendix V. This recommendation has been accepted and is presently being implemented. I expect that the full details of the program will be announced shortly. I recognize that Oregon State University has been active for some time in an effort to help mariners make the transition from Loran-A to Loran-C. I am sure these efforts will continue, and will be an important complement to our own attempts to promote better understanding of the benefits and use of Loran-C.

Recommendation 2. Extend Loran-A service for Washington, Oregon and California one year beyond the presently scheduled termination date. We are giving careful consideration to your recommendation to extend Loran-A service on the West Coast. If we decide that such an extension is indicated, we will make appropriate recommendations to the Secretary of Transportation. I would like to point out, however, that our review of this question must consider not only the costs and benefits addressed in the report but also the effect upon other Coast Guard services to the public if we should divert additional resources to extend Loran-A services on the West Coast.

Recommendation 3. Develop a coordinated Loran Plan with Canada. We are in communication with the Canadian Coast Guard, and I am confident that a coordinated Loran plan will be developed with Canada.

Subj: Termination of Loran-A

Recommendation 4. Do not reconfigure the East Coast as presently planned. We must disagree frankly with this recommendation. Reconfiguration in some form, with consequent inconvenience to some Loran-C users, is necessary to achieve complete coverage of the East Coast. The plan which we have announced represents, in our view, the best possible compromise among conflicting considerations of short term needs and inconvenience, and accurate Loran-C service in the long term. The alternative suggested in the report would reduce the inconvenience in the southern part of the East Coast waters at the expense of both more serious inconvenience in the Northeast and marked degradation in the quality of the permanent Loran-C service along much of the East Coast. Optimizing overall safe navigation is a major overriding consideration in Coast Guard decision-making.

Recommendation 5. Terminate Loran-A service at a time of year when marine operations in the area are at a minimum. We are considering adjustments to the schedule, to make the termination of Loran-A service coincide with a period of low marine activity. I expect such adjustments will be approved.

Recommendation 6. Ensure that nautical charts fully support Loran-C service. We agree that Loran-C service must be supported adequately by nautical charts, and we are coordinating our efforts closely with those of other Government agencies which have a major role in their production. Unfortunately, realization of the maximum possible accuracy for Loran-C charts requires collecting and analyzing a rather large quantity of data which cannot be obtained until Loran-C chains are in operation. I must point out, however, that the Loran-C charts and services which are available now, provide broader coverage and more accurate navigation than Loran-A. Furthermore, the progressive improvement of Loran-C charts will have no effect upon those users who acquire their own data for use of Loran-C in the repeatable mode.

Recommendation 7. Publish Loran-C system specifications. We are working with the Radio Technical Commission for Marine Services (RTCM) to develop, for public use, specifications for the minimum performance of Loran-C receivers. I believe that this work, representing the collective efforts of Loran-C equipment manufacturers, the maritime users, and the Government, will contribute to better understanding by manufacturers and users alike. It should also improve results for users of these Loran-C receivers since they can be "tailored" to the purpose for which they will be purchased. The Coast Guard is also developing a technical specification for the Loran-C signal.

Subj: Termination of Loran-A

Recommendation 8. Provide two years of overlapping Loran service in all locations. As you know, it is our intention generally to provide two years of overlapping coverage wherever Loran-A service exists now along the coasts of the continental United States. According to the original schedule announced in 1974, reconfigured Loran-C service would have become available on the East Coast in 1978, two years before the planned termination of Loran-A service in 1980. When we recognized the difficulties which this plan would present to the significant number of fishermen who began using Loran-C on the East Coast before the reconfiguration, we developed and announced a compromise plan which provides a one-year overlap of the existing and new Loran-C service along the East Coast, beginning in 1978. Unfortunately, along that segment of the coast which lies between the Loran-C stations at Carolina Beach, North Carolina and Jupiter, Florida, we can not provide the new Loran-C service until the existing East Coast chain ceases operation in 1979. If Loran-A in this area is terminated, as scheduled, in 1980 there will be only one year of overlap with the new Loran-C service. At the present time we have no evidence that this shortened period of overlap would present a hardship sufficient to justify the cost of extending Loran-A service in this area for an additional year. We shall examine this question more closely, however, before a final decision is made.

Finally, I wish to express my sincere appreciation to Oregon State University for this thorough, objective study. Please include the text of this letter in the formal printing of the report. We in the Coast Guard look forward to the possibility of future relationships with OSU which again will benefit the U. S. Mariners.

Sincerely,

O. W. SILER
Admiral, U. S. Coast Guard
Commandant