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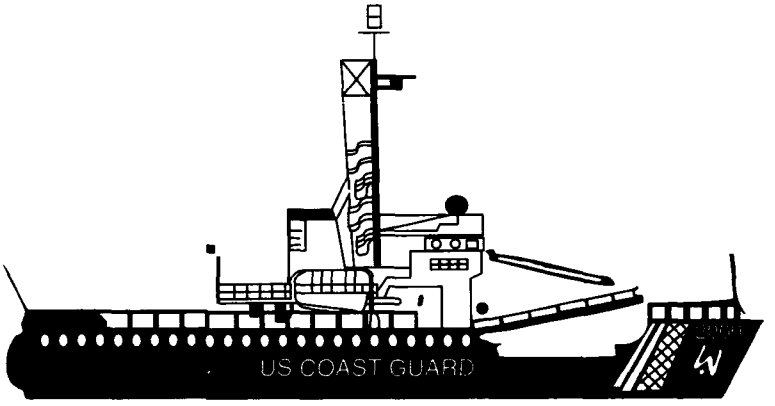
Aids to Navigation Service Force Mix 2000 Project

Overview



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Cambridge, MA 02142-1093

July 1992

U.S. Department
of Transportation
United States
Coast Guard

Office of Navigation Safety and Waterway Services
Washington, DC 20593

The Aids to Navigation Service Force Mix 2000 Project is documented in a Project Overview and three separately bound volumes. Volume I, "Development and Application of an Aids to Navigation Service Force Mix Decision Support System -- Final Report" documents the Volpe Center's analysis and development of the proposed replacement buoy tender fleet. Volume II, "Development and Application of an Aids to Navigation Service Force Mix Decision Support System -- Aid Assignments and Vessel Summary Reports" contains the DSS outputs associated with the findings of Volume I. Volume III, "Analysis of Multi-Mission Requirements and Development of Planning Factors for the Replacement Buoy Tender Fleet", documents the USCG's analysis and development of baseline multi-mission requirements of the replacement buoy tender fleet. All four documents are available from the National Technical Information Service, Springfield, VA 22161.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	July 1992	Final Report: May 1992 - July 1992

4. TITLE AND SUBTITLE
Aids To Navigation Service Force Mix 2000 Project
Project Overview

5. FUNDING NUMBERS
CG269/B2006

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Department of Transportation
Research and Special Programs Administration
Service Assessment Division
John A. Volpe National Transportation Systems Center
Cambridge, MA 02142-1093

8. PERFORMING ORGANIZATION REPORT NUMBER
DOT-VNTSC-CG-92-2

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
USCG Office of Navigation Safety and Waterway Services
Short Range Aids to Navigation Division
2100 2nd Street, SW
Washington, DC 20593-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
DOT-CG-N-01-92-1.1

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
This document is available to the public through the National Technical Information Service, Springfield, VA 22161

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The Aids to Navigation (ATON) Service Force Mix (SFM) 2000 Project is documented in a Project Overview and three separately bound volumes.

The Project Overview describes the purpose, approach, analysis, and results of the ATON SFM 2000 Project conducted by the USCG's Office of Navigation Safety and Waterway Services, Short Range Aids to Navigation Division.

Volume I, "Development and Application of an Aids to Navigation Service Force Mix Decision Support System -- Final Report", documents the Volpe Center's analysis and development of the proposed replacement buoy tender fleet. The document describes current ATON operations, the concept, development, and operation of the Decision Support System (DSS), the data utilized by the DSS, validation of the DSS, and the proposed service force mix.

Volume II, "Development and Application of an Aids to Navigation Service Force Mix Decision Support System -- Aid Assignments and Vessel Summary Reports", contains the DSS outputs associated with the findings of Volume I. Included are maps of the aid assignments for each vessel in both the current and proposed fleets and the associated one-page DSS summary printouts.

Volume III, "Analysis of Multi-Mission Requirements and Development of Planning Factors for the Replacement Buoy Tender Fleet", documents the USCG's analysis and development of baseline multi-mission requirements of the replacement buoy tender fleet. The document describes buoy tender employment categories, historical tender employment data, the determination of underway hours per underway day, and projected impacts on multi-mission requirements resulting from alternative replacement fleet scenarios.

14. SUBJECT TERMS
Aids to Navigation, Bouy Tender, Decision Support System, Geographic Information System

15. NUMBER OF PAGES
32

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

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LIST OF ACRONYMS

ANB	aids to navigation boat
ANT	aids to navigation team
AOPS	abstract of operations
ATON	aids to navigation
ATONIS	aids to navigation information system
BRIDGE	bridge administration
BU	buoy boat
BUSL	buoy boat - stern loading
BUSLR	buoy boat - stern loading replacement vessel
CADET/OC	cadet and officer candidate training
CO	commanding officer
COOP	cooperation with other agencies
COTP	Captain of the Port
DBN	day beacon
DGPS	differential global positioning system
DOM ICE	domestic icebreaking
DOT	Department of Transportation
DSS	decision support system
ELT	enforcement of laws and treaties
FY	fiscal year
G-CPA	USCG Programs Division
G-E	USCG Office of Engineering & Development
G-M	USCG Office of Marine Safety, Security, & Environmental Protection
G-N	USCG Office of Navigation Safety & Waterway Services
G-NSR	USCG Short Range Aids to Navigation Division
G-O	USCG Office of Law Enforcement & Defense Operations
G-P	USCG Office of Personnel & Training
G-R	USCG Office of Readiness & Reserve
GIS	geographic information system
KDP	key decision point
LB	lighted buoy
LT	fixed light
MER	marine environmental response
MIL OPS	military operations
MIL TRA	military training
MIO	marine inspection operations
MISC	miscellaneous and other operations
MNS	mission needs statement
MTMC	Military Traffic Management Command
MSA	marine science activities
MSO	Marine Safety Office

NOAA	National Oceanic and Atmospheric Administration
O&M	operating and maintenance
OP TRA	operational training
PC	personal computer
PIA	public and international affairs
PSS	port safety and security
RADNAV	radionavigation
RBS	recreational boating safety
RESERVE	reserve training
RHIB	rigid hull inflatable boat
RSPA	Research and Special Programs Administration
SAR	search and rescue
SFM	service force mix
SRA	short range aids
SRD	sponsor's requirements document
TANB	trailerable aids to navigation boat
ULB	unlighted buoy
USCG	United States Coast Guard
VNTSC	Volpe National Transportation Systems Center
WLB	seagoing buoy tender
WLBR	seagoing buoy tender replacement vessel
WLI	inland buoy tender
WLIC	inland construction buoy tender
WLM	coastal buoy tender
WLMR	coastal buoy tender replacement vessel
WLR	river buoy tender

PURPOSE

To develop estimates of the required number and mix of the new generation of seagoing and coastal buoy tenders for Key Decision Point Four (KDP-4) of the Office of Management and Budget's Circular A-109 acquisition process, and prior to that for the March 1992 Congressional budget hearings, the USCG Office of Navigation Safety and Waterway Services, Short Range Aids to Navigation Division (G-NSR) undertook the "Aids to Navigation Service Force Mix 2000" (ATON SFM 2000) project. G-NSR has worked closely with the Office of Acquisition from the onset of this project, developing a detailed Mission Needs Statement, Sponsor's Requirements Documents, Circulars of Requirements, and Requests for Proposals. The U.S. Department of Transportation, Research and Special Programs Administration, Volpe National Transportation Systems Center (Volpe Center) was asked to assist the project by developing and exercising a decision support system.

This document provides an overview of the ATON SFM 2000 project conducted by the USCG. The project report is contained in three volumes, which describe the underlying analysis in detail:

Volume I:	*Development and Application of an Aids to Navigation Service Force Mix Decision Support System -- Final Report*;
Volume II:	*Development and Application of an Aids to Navigation Service Force Mix Decision Support System -- Aid Assignments and Vessel Summary Reports*;
Volume III:	*Analysis of Multi-Mission Requirements and Development of Planning Factors for the Replacement Buoy Tender Fleet.*

BACKGROUND

One mission of the U.S. Coast Guard (USCG) is to provide and service short range aids to navigation (ATON). ATON are used by mariners to navigate U.S. waterways in and around the continental U.S., Alaska, Hawaii, and U.S. territories, such as those in the Caribbean and the western Pacific. To service ATON, the USCG uses a variety of resources ranging from four-person Aids to Navigation Teams to 55-person 180-foot seagoing buoy tender vessels.

The Coast Guard is in the process of acquiring new vessels to replace the capabilities of its aging seagoing and coastal buoy tender fleet. Thirty-two of the 37 buoy tenders in the two largest classes -- the seagoing buoy tenders, known as WLBs, and the coastal buoy tenders, known as WLMs -- were built in the 1940s and are beyond their design service lives. The remaining five tenders will begin reaching the end of their design service lives in 1995. Acquisition projects are underway for the design of

the replacement WLBs (WLBRs) and replacement WLMs (WLMRs), with anticipated initial deliveries of these vessels in 1996. The replacement vessels will incorporate many improvements over the current vessels, including faster cruising speeds, automated chain in-haul systems, dynamic positioning systems, differential global positioning systems, and spilled oil recovery capabilities.

G-NSR and the Volpe Center first studied fleet size and mix alternatives with a computer model in 1988. Limitations in the model's functionality, combined with technological advances in computer hardware and software since 1988, have made the model obsolete. The ATON SFM Decision Support System (DSS) developed by the Volpe Center in support of the ATON SFM 2000 project has overcome the limitations of the 1988 model by combining a detailed analysis of buoy tender operations with current computer technology to achieve a better representation of ATON activities.

Because of the project schedule requirements and the complexity of ATON servicing and waterways management, the analysis was limited to ATON currently serviced by WLBs and WLMs. The analysis did, however, address the possibility of reassigning some of these ATON to the smaller, less expensive buoy boats (BUSLRs) that are also being acquired by the USCG. In these instances, an increase in the number of needed BUSLRs was estimated.

CURRENT OPERATIONS

Federally owned ATON located throughout the U.S. waterway system fall into four categories: lighted buoys, unlighted buoys, lights, and day beacons. Buoy tenders perform four basic ATON services: aid inspection, battery recharge, mooring inspection, and buoy relief.

There are 26 WLBs servicing approximately 4,450 ATON. Figure 1 shows a representative WLB, the Sassafras, home ported in Honolulu, HI. WLBs are large, stable, heavy-lift vessels, and typically service the largest buoys in U.S. waterways located in the roughest waters, farthest from shore. The WLB is considered a multi-mission platform due to its endurance and offshore seakeeping capabilities. Currently, 59% of the underway time of the WLB fleet is devoted to servicing ATON and 27% is devoted to multi-mission activities, including enforcement of laws and treaties, search and rescue, ice breaking, and marine environmental response.

The WLM class of coastal buoy tenders consists of 11 vessels servicing about 3,050 ATON. Figure 2 shows the 157-foot WLM Red Birch, currently home ported in Baltimore, MD. Since the WLM cannot withstand as severe an environment as the WLB, the aids it services are generally smaller, and it typically does not travel far offshore. The WLM is a focused mission vessel devoting about 88% of its underway hours to servicing ATON.

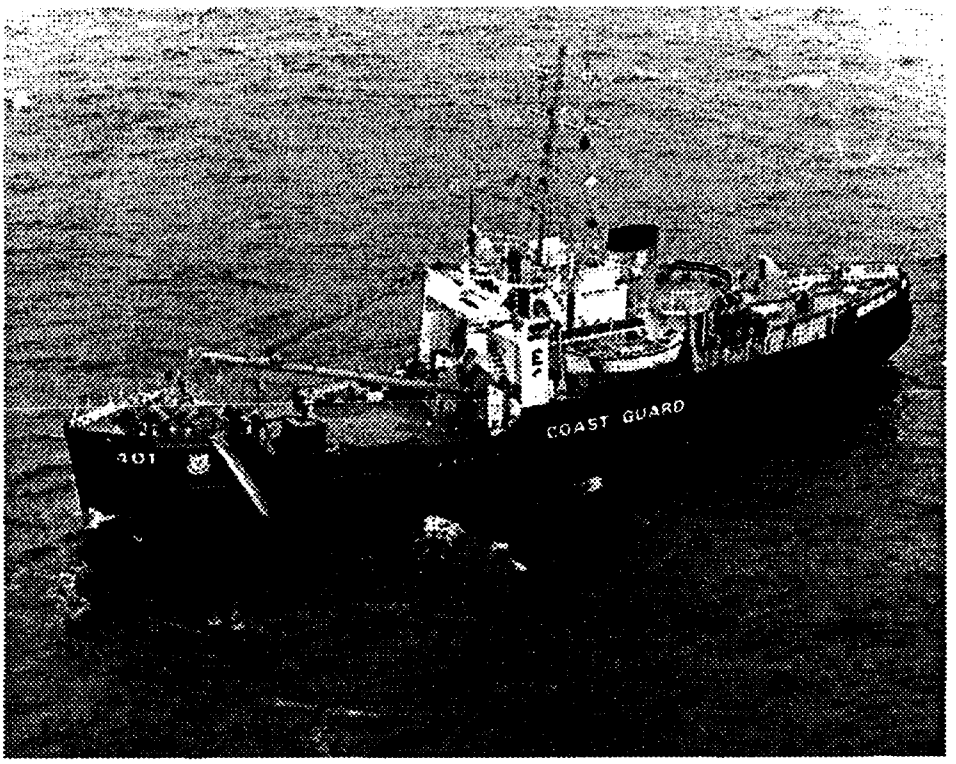

Figure 1. SEAGOING BUOY TENDER (180 FT. WLB CLASS)

Figure 2. COASTAL BUOY TENDER (157 FT. WLM CLASS)

Figure 3 shows the current WLB/WLM fleet distribution and home ports.

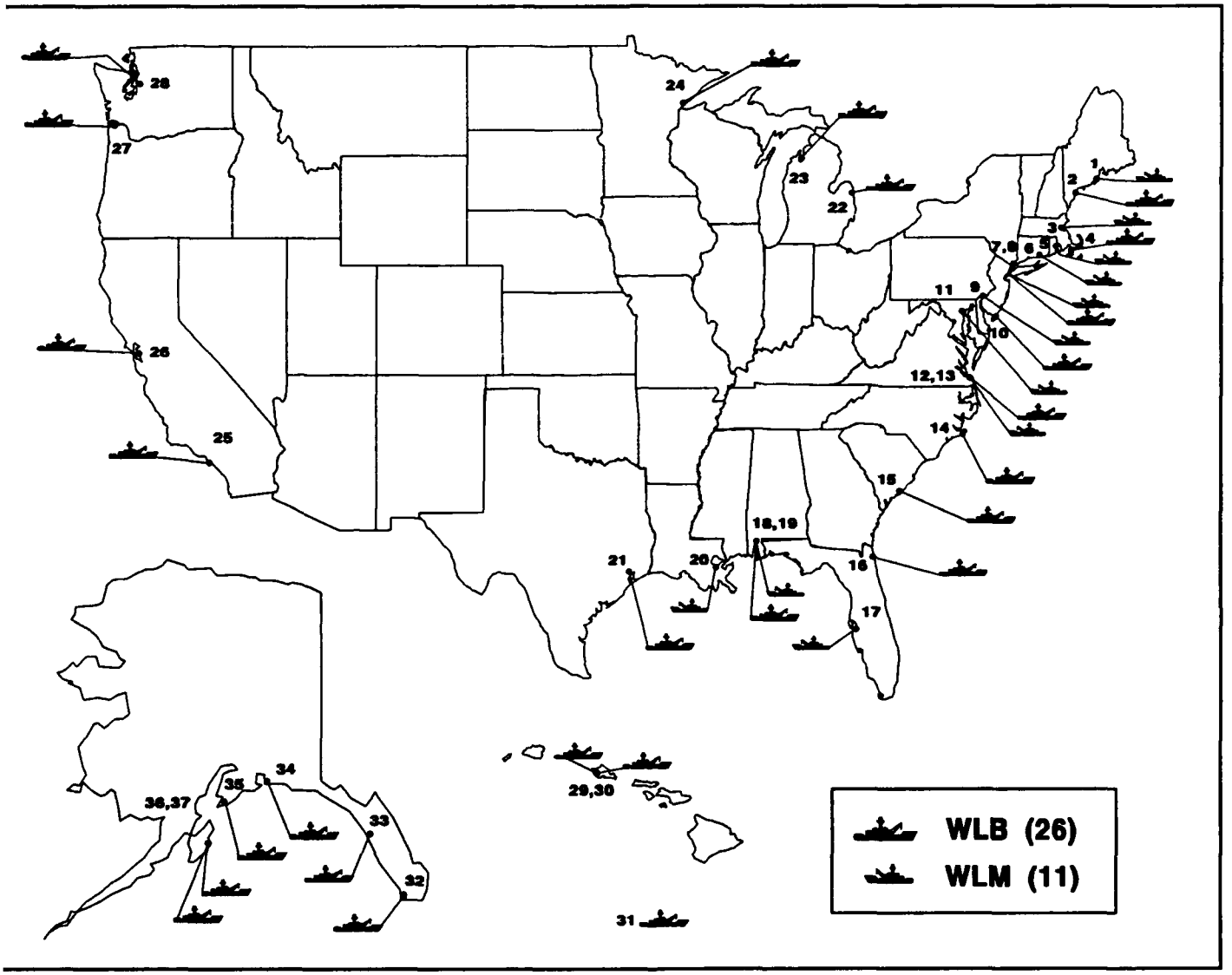

Figure 3. CURRENT USCG WLM/WLB FLEET

(continued on next page)

USCG District	Map Location Number	Current Home Port	Vessel Type
1	1	Rockland, ME	WLM
	2	South Portland, ME	WLB
	3	Boston, MA	WLM
	4	Woods Hole, MA	WLB
	5	Bristol, RI	WLM
	6	New London, CT	WLM
	7	New York, NY	WLM
	8	New York, NY	WLB
5	9	Philadelphia, PA	WLM
	10	Cape May, NJ	WLB
	11	Baltimore, MD	WLM
	12	Portsmouth, VA	WLM
	13	Portsmouth, VA	WLB
	14	Atlantic Beach, NC	WLB
7	15	Charleston, SC	WLB
	16	Mayport, FL	WLB
	17	St. Petersburg, FL	WLM
8	18	Mobile, AL	WLM
	19	Mobile, AL	WLB
	20	New Orleans, LA	WLM
	21	Galveston, TX	WLB
9	22	Port Huron, MI	WLB
	23	Charlevoix, MI	WLB
	24	Duluth, MN	WLB
11	25	San Pedro, CA	WLB
	26	San Francisco, CA	WLB
13	27	Astoria, OR	WLB
	28	Seattle, WA	WLB
14	29	Honolulu, HI	WLB
	30	Honolulu, HI	WLB
	31	Guam	WLB
17	32	Ketchikan, AK	WLB
	33	Sitka, AK	WLB
	34	Cordova, AK	WLB
	35	Homer, AK	WLB
	36	Kodiak, AK	WLB
	37	Kodiak, AK	WLB

APPROACH

Determining the optimal size and mix of the buoy tender fleet is a complex task. ATON servicing requirements can be only approximately defined due to varying impacts of weather and other factors which are difficult to quantify and predict accurately. As the buoy tender fleet ages, maintenance requirements and availability of individual vessels become less predictable. The impacts of improved features being designed into the replacement vessels cannot be precisely forecast. There is some overlap in the abilities of the different classes of tenders such that more than one tender type sometimes can be used to service specific ATON. In summary, there is no simple best way to assign specific ATON to specific buoy tenders.

The ATON SFM 2000 Project took a multi-faceted approach to the ATON Service Force Mix problem. The Mission Needs Statement (MNS) was reviewed to identify mission requirements. The Sponsor's Requirements Documents (SRD) provided operating profiles and vessel characteristics. Abstracts of Operations (AOPS) for FY-86 to FY-90 provided historical employment data. The USCG Aids to Navigation Information System (ATONIS) provided data on the location and characteristics of the ATON included in the study. The Volpe Center developed the analytical capabilities required for the analysis. Finally, G-NSR's Expert Study provided field inputs for current operations, projections of operational impacts of the replacement fleet capabilities, and model validation. Figure 4 illustrates the approach to the ATON SFM 2000 project.

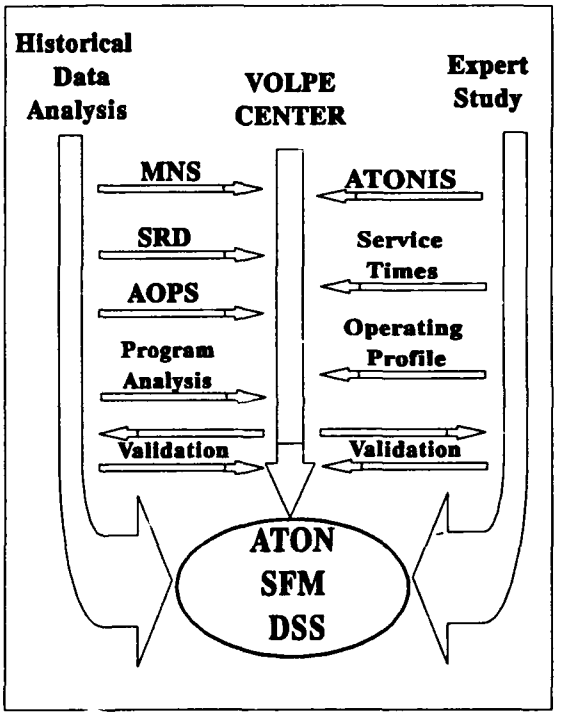

Figure 4. THE ATON SFM 2000 PROJECT APPROACH

The goal was to develop one or more efficient fleet size and mix scenarios, and to estimate and evaluate associated costs, performance measures, and other impacts. The need was for a set of efficient, flexible, analytical tools with which to examine the likely performance of a variety of fleet size and mix options under a variety of operating conditions. This information, along with estimates of the sensitivities of these measures to input assumptions, would then be arrayed for use by decision-makers and other interested

parties. In essence, this is the concept of a decision support system -- a set of analytical resources with which to generate information needed to support decision-making.

THE DECISION SUPPORT SYSTEM (DSS)

Development of the DSS

A key consideration behind the development of the ATON SFM DSS by the Volpe Center was that recent technological advances in geographic information systems (GISs) and computer hardware provided the opportunity to evaluate a range of alternative WLMR/WLBR fleet size and mix options relatively quickly and inexpensively.

The determination was made that a decision support system could be developed for ATON analysis by building on a commercial GIS. GISs are data base management systems for spatially oriented data (e.g., aid locations, shorelines, navigable waterways, home ports). The GIS selected, "TransCAD", facilitates the display, manipulation, and analysis of spatial data and includes built-in transportation analysis routines, such as "traveling salesman" and shortest path algorithms. These routines provided the foundation for developing customized vehicle routing procedures representing buoy tender operations.

The DSS incorporates parameters to account for key factors and constraints affecting buoy tender operations. These include:

- discrepancy response (non-scheduled maintenance);
- variations in servicing times for different types of ATON and services;
- duration of trips and workdays;
- simultaneous servicing of ATON by small boats carried on tenders;
- weather conditions;
- vessel speed;
- deck space limitations;
- buoy preparation times;
- special requirements of seasonal buoys;
- surge response (periods of high discrepancy response requirements due to extreme weather conditions);
- lighthouse maintenance requirements; and
- physical serviceability of buoys by specific vessel types.

Operation of the DSS

Figure 5 summarizes the operation of the DSS. The DSS user first assigns aids to an individual vessel based upon which aids are physically serviceable by the vessel, the proximity of the aids to the vessel's home port, and any prior DSS outputs showing either over or under-utilization of the vessel.

The primary output of an individual DSS run is the number of annual underway hours required by the vessel to service its assigned population of ATON. When validating the DSS against current operations, the DSS underway hours are compared with the historical averages for vessels of the current fleet. When determining the replacement fleet, the DSS underway hours are compared to the target number of underway hours for replacement fleet vessels. If the DSS shows a replacement vessel as being either over or under-utilized, the DSS user adjusts the vessel's aid assignments accordingly, and runs the DSS again.

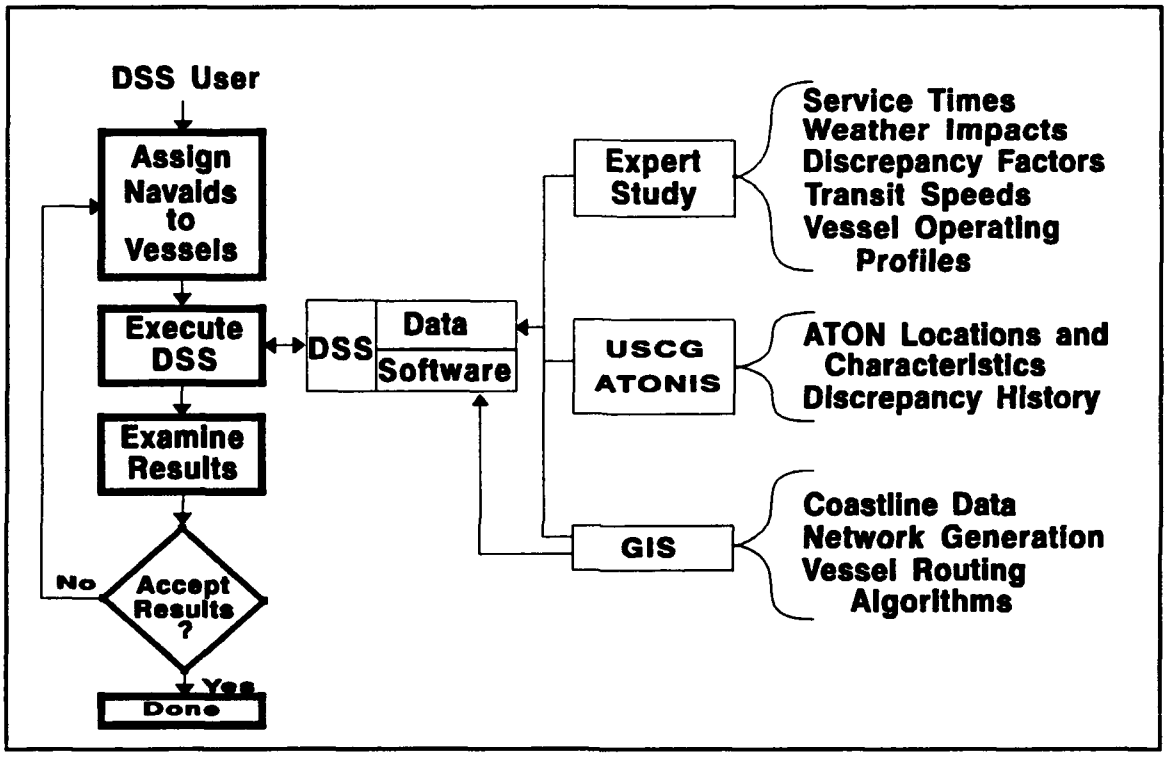

Figure 5. OPERATION OF THE ATON SFM DSS

Validation of the DSS

To validate the DSS, it was used to "predict" current operations by district. Overall, the DSS predicted 39,592 ATON hours for the current fleet compared to the historical five-year average current fleet total of 41,358; i.e., the predicted hours were about 96% of the actual hours. Volume II of the Service Force Mix Project Report includes maps of the current vessel/aid assignments and the corresponding DSS validation results.

Using the DSS to Determine the Replacement Fleet

The underlying objective in determining the size and mix of the replacement fleet is to minimize total life cycle cost while successfully accomplishing all operational requirements. These requirements include ATON as well as support of other USCG mission areas, such as enforcement of laws and treaties, search and rescue, and marine environmental response. To achieve this goal, consideration must be given to the performance and cost features of the WLMR and WLBR platforms. Table 1 summarizes the major differences between these two platforms.

FEATURE	WLMR	WLBR
Crew Size	18	40
Area of Operation	Coastal	Seagoing
Seakeeping Ability	3 feet	8 feet
Maximum Lift	10 tons	20 tons
Average Transit Speed	10 knots	12 knots
Buoy Deck Space	1200 ft^2	2500 ft^2
Minimum Operating Depth	12 feet	18 feet
Target ATON Underway Hours	1275 hours	1260 hours
Mission Classification	Focused ATON	Multi-Mission
Lead Ship Cost*	$25 Million	$70 Million
Each Following Ship Cost*	$20 Million	$50 Million
Annual Operating Cost*	$1.3 Million	$2.5 Million

* Estimated 1992 Dollars

Table 1. WLMR AND WLBR COMPARISON

As shown in the table, there is a large difference in acquisition and operating costs between the WLBR and WLMR. In the absence of conditions necessitating use of a WLBR, deployment of a WLMR minimizes life cycle cost. Conditions necessitating a WLBR are lift requirements of greater than ten tons, the requirement to service ATON in seas of greater than three feet, long transits across open seas, and multi-mission requirements (including open-ocean spilled oil recovery).

Initial DSS results showed that, in the absence of multi-mission, discrepancy response, and surge response requirements, only eight WLBRs would be needed; the remaining ATON requirements could be met by WLMRs. This number was based upon the following considerations: District 14 (Hawaii) and District 17 (Alaska) require two and four WLBRs, respectively, due to long open ocean transits and generally high seas

that prohibit the use of WLMRs; one WLBR could cover the WLBR ATON requirements of the West Coast; and one WLBR could cover the combined WLBR ATON requirements of the East and Gulf coasts. Based solely on the physical servicing requirements of the District 9 ATON, no WLBRs would be required in the Great Lakes.

However, from a practical perspective, this number is unrealistic. Discrepancy response, surge response, and the inability of WLMRs to work reliably under the winter ice conditions associated with the Northeast and the Great Lakes necessitate a fleet with more than eight WLBRs to adequately perform the ATON mission.

In the event of an ATON discrepancy, assuming the WLBR on either coast could be underway immediately, as many as five days could be required to reach the discrepancy site. Depending on the nature of the discrepancy, the delay might severely impact vessel navigation.

Surge response, which results from the impacts of extreme weather conditions such as ice storms and hurricanes, requires quick response to unusually high amounts of discrepancies. Depending upon the magnitude of the surge, the ability of a buoy tender to meet both its routine ATON requirements and the surge may be jeopardized. Surge response often requires that buoy tenders from other areas postpone their routine ATON requirements and take part in the surge response. As a result, the ability of all tenders involved with the surge response to perform their routine ATON requirements is affected.

In addition to weather effects, surge response also occurs when a buoy tender must support another tender undergoing maintenance or training. Although COs can schedule routine ATON work around scheduled maintenance and training, ATON discrepancies do not conform to schedules and, as has been demonstrated by the current fleet, unscheduled buoy tender maintenance can have a significant impact on ATON mission performance.

Due to these considerations, the USCG developed its minimum baseline requirement for WLBRs incorporating multi-mission requirements, discrepancy response, surge response, and winter operating conditions. Key inputs to determining the baseline were received from the G-NSR Expert Study.

EXPERT STUDY

G-NSR conducted an Expert Study to support the ATON SFM 2000 Project. The purpose was to take advantage of the knowledge and experience of USCG ATON professionals - district ATON staffs, buoy tender commanding officers (COs), Captains of the Port (COTPs), Marine Safety Offices (MSOs), and other district elements - to address some of the complexities of ATON servicing that are difficult to model. This was accomplished through extensive use of electronic mail and telephone conference calls.

Figure 6 summarizes schematically the Expert Study.

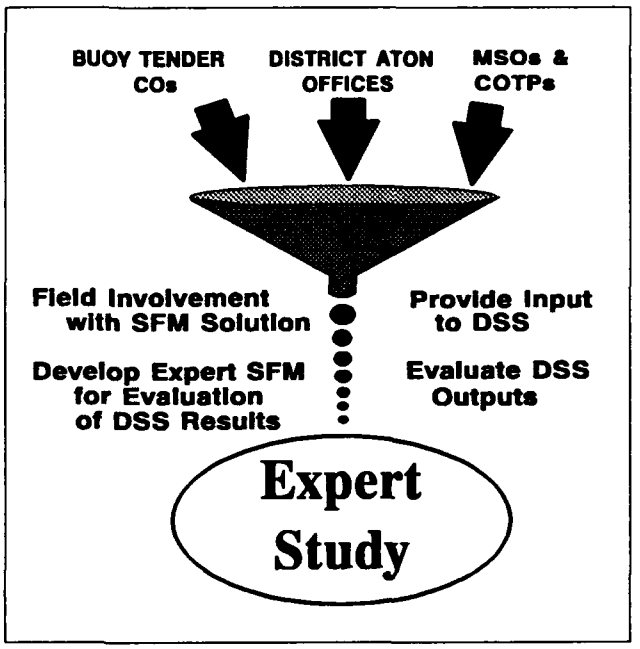

Figure 6. EXPERT STUDY OF ATON SERVICE FORCE MIX

Expert Service Force Mix

Each district was asked to review their ATON responsibilities and identify specific factors affecting operations in their geographic regions. Based on the capabilities of the replacement buoy tenders, they were then asked to describe the Service Force Mix that would meet their operational requirements. These Expert Service Force Mix results were used to refine inputs to the DSS and as a basis for evaluating DSS results.

Buoy Tender Operations Survey

In addition to generating district service force mix proposals, field inputs were used in developing several input parameters used in the DSS. The Expert Study included the Buoy Tender Operations Survey, conducted jointly by G-NSR and the Volpe Center in October 1991, which had three major objectives:

- obtain individual district and vessel perspectives on buoy tender operations;
- validate buoy tender data from other USCG sources; and
- collect data on buoy tender operations not available from any other source.

The Buoy Tender Operations Survey queried persons having expert knowledge and experience with buoy tender operations: the vessel COs and representatives of each of the district's ATON offices. The survey forms consisted of two sections: a district section requesting information on buoy service times; and a buoy tender section requesting information on operations, discrepancies, weather effects, and the fixed structures serviced by buoy tenders.

Telephone conference calls were conducted jointly with each district by personnel from the Volpe Center and G-NSR to review the information in the survey. These calls were an effective mechanism for resolving questions, clarifying the nature and intended use of the survey questions, completing the surveys, and discussing key ATON issues.

Hard copy or electronic versions of all survey forms were forwarded to the Volpe Center and incorporated into a data base of survey responses.

Follow-up discussions were conducted with district personnel during the DSS validation stage whenever DSS outputs revealed significant differences from expected results. Those instances generally resulted in either further enhancements to the DSS or in the collection of more accurate input data.

Multi-Mission Employment

Multi-mission employment projections were provided by the districts. Each district was asked to review historical employment data, analyze current employment trends, and project multi-mission employment requirements for the WLBRs. These projections were developed as a combination of per-ship and geographic requirements. Analysis of these projections is addressed in the Service Force Mix 2000 Project Report, Volume III.

WLMR AND WLBR ATON TARGET UNDERWAY HOURS

Focused-Mission versus Multi-Mission Employment

The USCG has identified in its Mission Needs Statement for the Seagoing and Coastal Buoy Tender Replacement Project that the WLBRs will be "multi-mission" and the WLMRs will be "focused mission". The buoy tender employment figures from the USCG Abstract of Operations, which contains employment data for all USCG ships, boats, and aircraft, provide a framework for examining buoy tender utilization. The data have been divided into four employment category groupings, shown in Table 2:

Primary Mission Categories	Training and Miscellaneous Operations Categories	Essential Multi-Mission Categories	"Other" Multi-Mission Categories
ATON RADNAV	MIO PSS RBS OP TRA PIA RESERVE MISC BRIDGE CADET/OC	SAR DOM ICE MER MSA	ELT (All) MIL OPS MIL TRA COOP (All)

Table 2. BUOY TENDER EMPLOYMENT CATEGORY GROUPINGS

For buoy tenders, the Primary Mission categories are Short Range Aids to Navigation (ATON) and Radionavigation Aids (RADNAV).

Training and Miscellaneous Operations categories include Marine Inspection Operations (MIO), Port Safety and Security (PSS), Recreational Boating Safety (RBS), Operational Training (OP TRA), Public and International Affairs (PIA), Reserve Training (RESERVE), Miscellaneous and Other (MISC), Bridge Administration (BRIDGE), and Cadet and Officer Candidate Training (CADET/OC).

Essential Multi-Mission categories include Search and Rescue (SAR), Domestic Icebreaking (DOM ICE), Marine Environmental Response (MER), and Marine Science Activities (MSA). MSA includes activities such as traditional NOAA buoy servicing requirements and International Ice Patrol.

The "Other" Multi-Mission categories are more discretionary for buoy tenders than the previous categories. They include Enforcement of Laws and Treaties (ELT), Military Operations (MIL OPS), Military Training (MIL TRA), and Cooperation (COOP) with Other Agencies (FED, STATE, and LOCAL).

As focused mission ships, WLMRs would not normally be assigned missions in the Other Multi-Mission employment categories except as vessels of opportunity. WLBRs could be assigned missions in all of the employment categories. Based on the employment category definitions, even focused mission ships are employed to some extent in USCG missions above and beyond their primary employment categories.

Use of Underway Hours Per Underway Day

In the Abstract of Operations reports, employment data are discussed both in terms of resource hours and days. Time spent in support of an employment category is reported in terms of hours. The number of underway days is reported in total, but not for particular employment categories.

For example, a buoy tender gets underway to service aids to navigation. The tender transits for two hours, works two hours servicing one buoy and one light, responds to an SAR call, and then finds and rescues a person from a sunken boat. The tender spends two hours performing the rescue and transporting the person to the nearest town for medical attention. The tender then spends two hours cleaning up a small oil slick coming from the sunken boat and transits the two hours back to home port. The AOPS report for that day's work would reflect six resource hours for ATON, two for SAR, and two for MER (total: 10 resource hours) and one underway day. Although each figure is accurate, to conclude for modeling purposes that the tender's ATON work day was either six hours, 10 hours, or one day would not adequately represent the true picture of its employment.

The ratio of total resource (underway) hours to total underway days provides a more accurate representation of a tender's work day. A cutter that gets underway infrequently but for long trips would have a higher ratio than one that does many shorter

day-trips. Based on historical data, seagoing buoy tenders average 14 underway hours per underway day and coastal tenders average 10 underway hours per underway day. These operational profiles reflect the shorter endurance of coastal buoy tenders and the geographically concentrated nature of coastal ATON servicing. In comparison, a medium endurance cutter involved in law enforcement patrols over a wide geographic area may average over 20 underway hours per underway day.

Determination of Target Underway Hours

To model a vessel of the replacement fleet, a measure is needed by which a vessel can be judged to be either over or under-utilized. Target Underway Hours are used by the DSS for this purpose.

The AOPS data provide the best description of how the USCG has historically employed buoy tenders. As shown in Figure 7, total resource hour employment in the primary employment categories (i.e. ATON) has been about 59% and 88% for the WLB and WLM platforms, respectively. Approximately the same ATON employment rates, 60% and 85%, are planned for the WLMR and WLBR platforms.

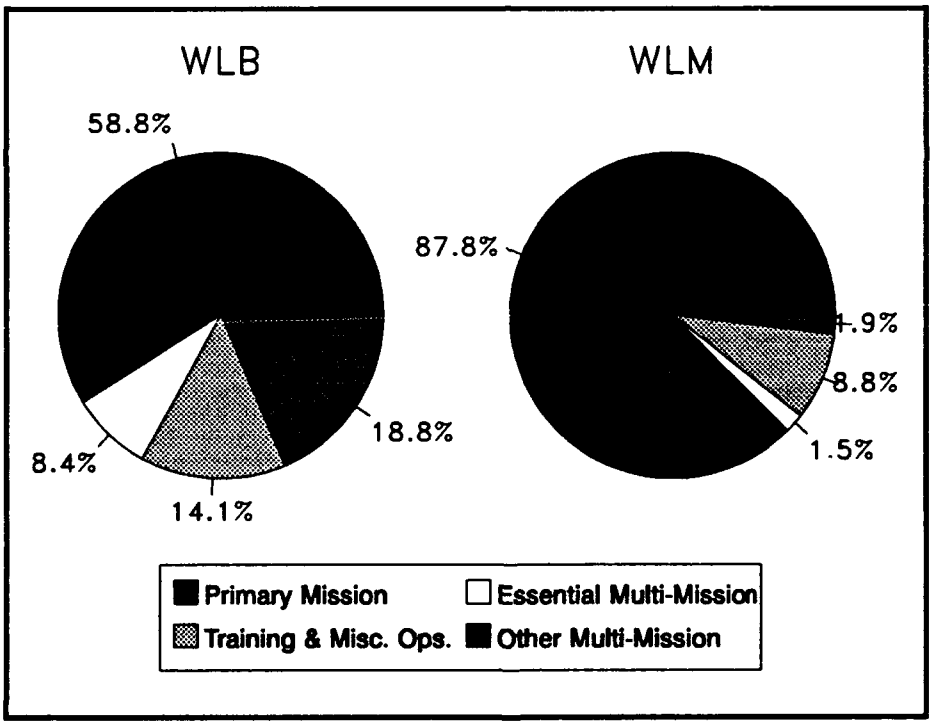

Figure 7. HISTORICAL UNDERWAY RESOURCE HOURS FY-86 TO FY-90

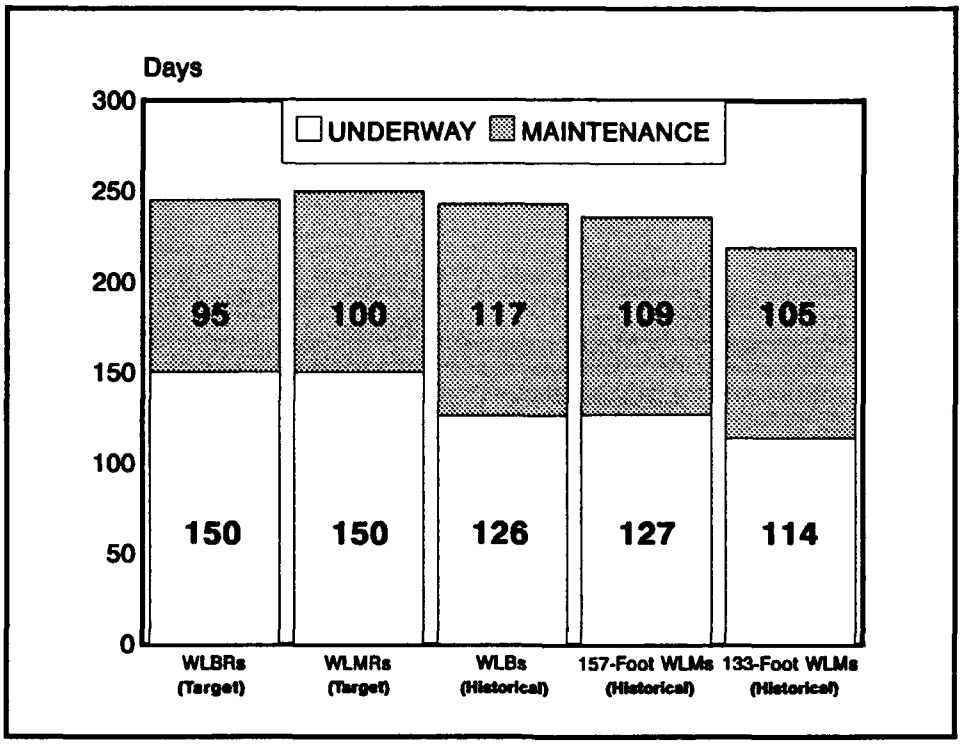

Figure 8. SRD UNDERWAY & MAINTENANCE TARGETS and HISTORICAL PATTERNS [1]

Figure 8 shows the improvement in reliability expected from the replacement fleet compared to the current fleet. Both the WLMR and the WLBR are expected to deliver 150 underway days of employment. For WLBRs, 60% of the 150 target underway days (90 days) will be in ATON employment. At 14 hours per underway day, the ATON employment target for WLBRs is 1260 underway hours per year. For WLMRs, 85% of the 150 target underway days (127.5 days) will be in ATON employment. At 10 hours per underway day, the ATON employment target for WLMRs is 1275 underway hours per year. This is summarized in Table 3.

Replacement Platform	Underway Days Target	Target % ATON	ATON Target Days	Underway Hours per Underway Day	ATON Target Hours
WLMR	150	85	127.5	10	1275
WLBR	150	60	90	14	1260

Table 3. DETERMINATION OF ATON TARGET HOURS

[1] The employment categories of In-Port Operations, Stand-By, and High-Readiness are not included.

The ATON Target Hours, when compared with the underway hours projected by the DSS, are the basis for determining whether a replacement vessel is either over or under-utilized.

BASELINE WLBR REQUIREMENT

Analysis of WLBR Multi-Mission Requirements

As focused-mission resources, coastal buoy tenders historically provide little multi-mission employment. In contrast, seagoing buoy tenders are multi-mission resources, and spend a significant amount of underway time in non-primary mission employment. Since fewer seagoing buoy tenders would reduce available multi-mission time, a detailed analysis of multi-mission requirements was conducted. Requirements were developed by analyzing historical data, future operational requirements estimated from the Expert Study, and requirements anticipated by Coast Guard Program Directors.

Multi-mission capacity was analyzed by the USCG in terms of the number of WLBRs in various fleet mix scenarios, ranging from 12 to 19 vessels. A 12 WLBR scenario results in a USCG-wide shortfall of 206 multi-mission days, including 45 "essential multi-mission" days. A 16 WLBR scenario results in a shortfall of 115 multi-mission days, but only one "essential multi-mission" day. A 19 WLBR scenario reduces the shortfall to 49 days. With cross-district sharing of multi-mission requirements and capacity, this scenario shows virtually no shortfall on the East and Gulf coasts, and a shortfall of only six days per ship in all other areas. Based on the small shortfalls in each geographic region, the USCG determined that increasing the number of WLBRs beyond 19 to cover all projected multi-mission requirements was an inefficient use of resources.

Analysis of WLBR ATON Requirements

Initial exercising of the DSS indicated that the total number of ships required to accomplish the ATON mission remained relatively constant regardless of the mix of WLBRs and WLMRs. Figure 9 summarizes alternative fleet mix scenarios.

Based upon an analysis of routine ATON servicing requirements, discrepancy response requirements, surge response requirements, and winter operating conditions, the USCG determined that a fleet mix consisting of 16 WLBRs would provide adequate geographic coverage for ATON requirements. In addition, 16 WLBRs will allow a sufficient distribution of WLBRs to meet Marine Environmental Response requirements.

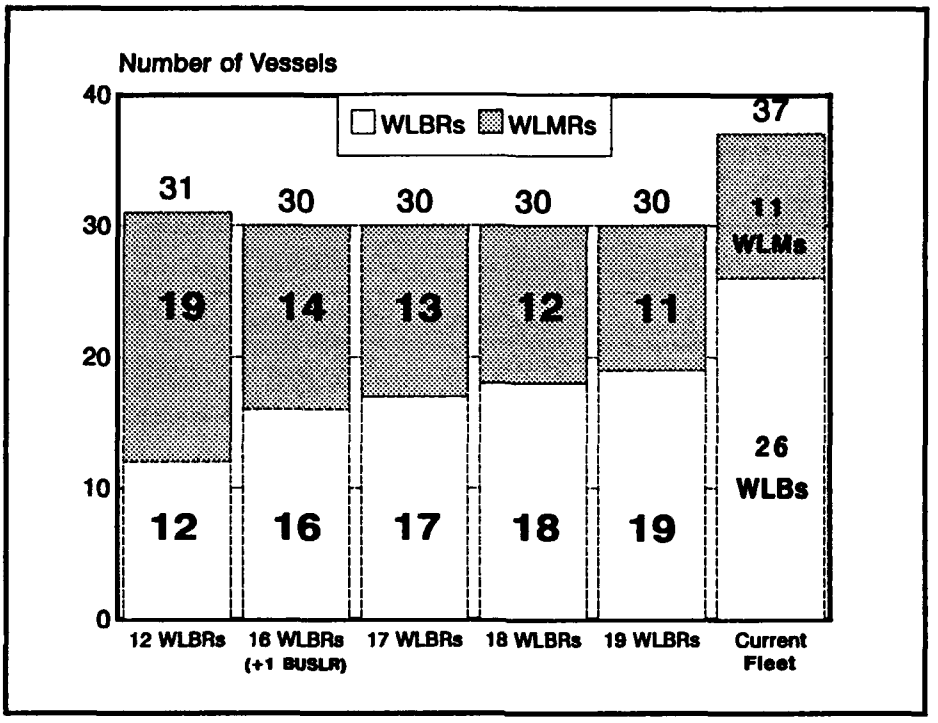

Figure 9. FLEET MIX SCENARIOS

Determination of Combined Multi-Mission and ATON Baseline WLBR Requirement

A working group of USCG Program Directors' representatives from the USCG Programs Division (G-CPA), and the Offices of Engineering and Development (G-E), Marine Safety, Security, and Environmental Protection (G-M), Navigation Safety and Waterway Services (G-N), Law Enforcement and Defense Operations (G-O), Personnel and Training (G-P), and Readiness and Reserve (G-R) was convened to review the multi-mission analysis and address the impacts of the possible mix scenarios on engineering and personnel support.

The following criteria guided the review:

- At least one heavy-lift capable ship must be able to reach the scene of an ATON discrepancy or major oil spill within 24 hours.
- The WLBR fleet must be able to meet all essential multi-mission requirements.

As a result of their review, the Operating Program Directors determined that the multi-mission capacity provided by 16 WLBRs would meet future program requirements.

Based on the multi-mission analysis and Program Directors' review, 16 WLBRs is the recommended baseline, or minimum requirement. Fewer WLBRs would result in

an unacceptable shortfall in essential multi-mission capacity and an unacceptable level of ATON support due to lack of sufficient geographic distribution for surge response capabilities.

While three additional WLBRs (and three fewer WLMRs) would provide more multi-mission capacity to accomplish identified requirements, this does not appear to be cost-effective. Obtaining 66 additional other multi-mission underway days would require about $90 million more in ship acquisition costs alone.

The shortfall in multi-mission employment capacity provided by 16 WLBRs is acceptable to the Program Directors. Alternative resources such as patrol boats and medium endurance cutters will be considered by the Program Directors to overcome any operational shortfalls as required.

FINDINGS

Impact of Baseline WLBR Requirement on Proposed Service Force Mix

The deployment of WLMRs wherever WLBRs are not necessary produces the lower fleet life cycle cost. Because the baseline WLBR requirement sufficiently covers all of the aids serviceable by only WLBRs, any remaining aids serviceable by WLBRs can also be serviced by WLMRs.

Compared to a WLMR, a WLBR can transit faster, carry more buoys on its deck, and stay at sea for longer periods of time. The WLBR's advantages, however, do not offset its greater cost and the relatively equal target ATON underway hours of the two platforms (1275 hours for the WLMR and 1260 hours for the WLBR). As a result, DSS outputs show that for every change in the baseline number of WLBRs there is a corresponding inverse change to the required number of WLMRs. (See Figure 9). The total number of ships required in the WLBR and WLMR fleet is a function of ATON requirements. The mix of WLBRs and WLMRs is driven by the WLBR baseline requirements.

Proposed Service Force Mix

The proposed service force mix is 16 WLBRs, 14 WLMRs, and one BUSLR (in District 8). Excluding the BUSLR, this represents a reduction of seven buoy tenders from the current fleet of 26 WLBs and 11 WLMs. Figure 10 shows the proposed replacement fleet distribution and home ports. The proposed home ports represent one set of locations that would permit the USCG to accomplish its ATON mission requirements efficiently with the proposed service force mix. It is probable that the same fleet size and mix could accomplish the ATON mission requirements with minor changes in home port locations. This would allow some flexibility in home port decisions to

account for local considerations such as port access, pier space, and shore-based support services.

Additional BUSLRs may be required to provide secondary response capabilities where current WLB or WLM home ports are not projected to have an equal number of replacement vessels. Specifically, New York, Woods Hole, Philadelphia, Portsmouth, Mayport, and Duluth would be candidate locations for BUSLRs. Analysis of future BUSLR requirements is being conducted by the USCG.

A detailed accounting of the proposed fleet results is incorporated in the Service Force Mix 2000 Project Report, Volume I. The proposed vessel/aid assignments and the associated DSS summary report outputs are in the Service Force Mix 2000 Project Report, Volume II.

Estimated Life Cycle Costs

To analyze life cycle costs of the buoy tender fleet, all costs associated with the acquisition and operation of all system components -- i.e., capital costs plus operating and maintenance (O&M) costs -- were estimated over the expected lifetimes of the vessels. O&M and capital cost parameters were based on USCG estimates for the future fleet and historical expenditures for the current fleet. The annual costs were estimated in constant or base year (1992) dollars, then discounted back to the present.

The most significant factors affecting the life cycle costs of the buoy tender fleet are the size of the fleet and the mix of WLBRs and WLMRs. Another relevant factor is the phase-in schedule for replacing the current fleet with the replacement vessels. Based on the proposed fleet of 16 WLBRs, 14 WLMRs and one BUSLR, a 10% discount rate, and a phase-in schedule of three replacement vessels of each type per year beginning in 1996, the life cycle cost of the replacement buoy tender fleet for the period 1992 through 2025 is $1,233.2 million in constant 1992 dollars.

Work Force Impacts

The replacement fleet will significantly impact the work force. Both replacement ship classes will be crewed with fewer people. Whereas the current WLB and WLM require about 57 and 30 crew members respectively, the WLBR will require only 40 crew members, and the WLMR, only 18.

Reduced crewing levels will necessitate pipeline training (the training of new crew members prior to reporting for duty) and the addition of non-shipboard billets for shore-based maintenance support. The decrease in the number of ships also will require augmented Aids to Navigation Teams or stations with billets for ATON discrepancy response and augmented district staffs to provide waterway management functions previously provided by ship personnel.

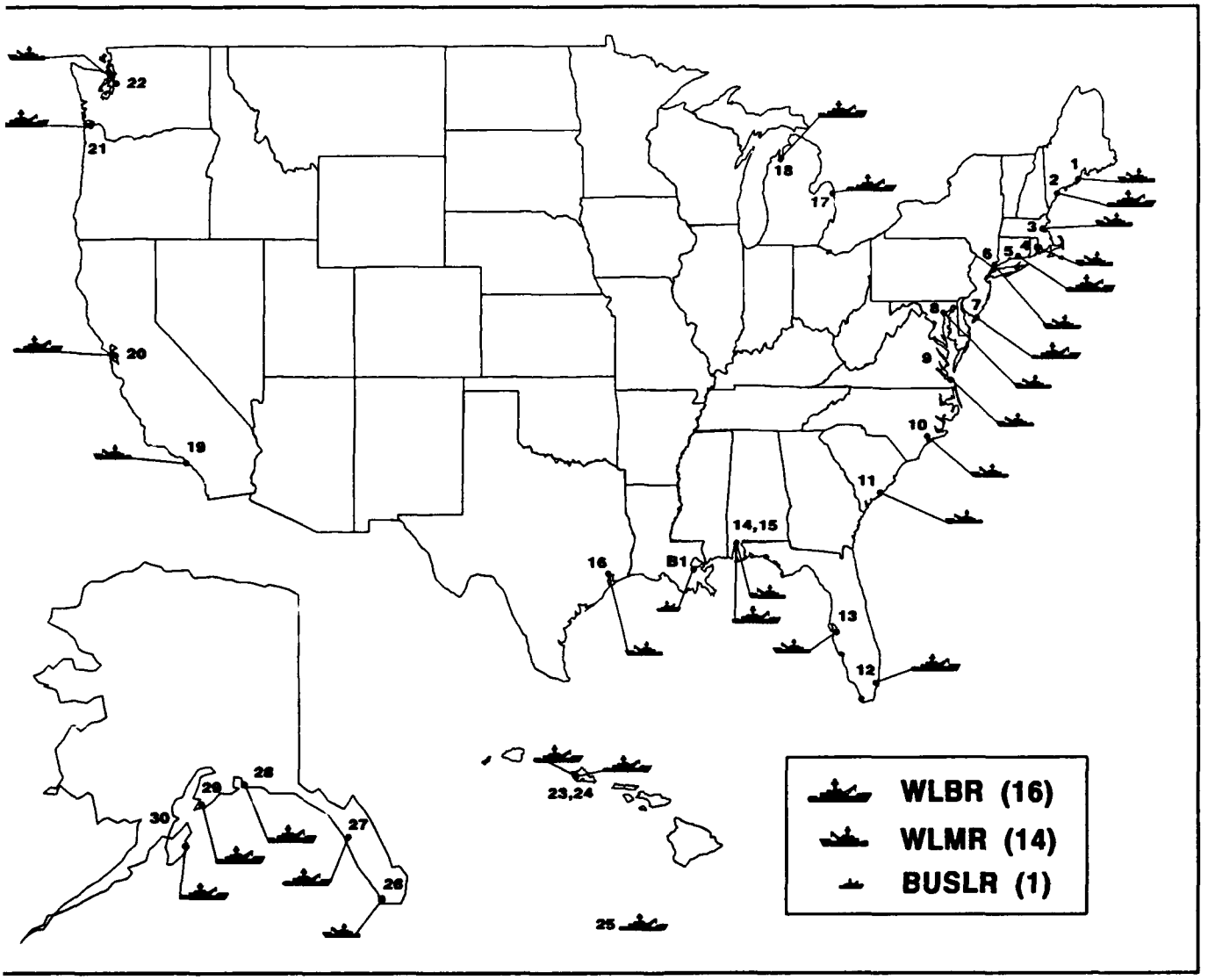

Figure 10. PROPOSED USCG WLMR/WLBR FLEET

(continued on next page)

USCG District	Map Location Number	Current Home Port	Vessel Type
1	1	Rockland, ME	WLMR
	2	South Portland, ME	WLBR
	3	Boston, MA	WLMR
	4	Bristol, RI	WLMR
	5	New London, CT	WLBR
	6	New York, NY	WLMR
5	7	Cape May, NJ	WLBR
	8	Baltimore, MD	WLMR
	9	Portsmouth, VA	WLMR
	10	Atlantic Beach, NC	WLMR
7	11	Charleston, SC	WLMR
	12	Miami, FL	WLBR
	13	St. Petersburg, FL	WLMR
8	14	Mobile, AL	WLMR
	15	Mobile, AL	WLBR
	B1	New Orleans, LA	BUSLR
	16	Galveston, TX	WLMR
9	17	Port Huron, MI	WLBR
	18	Charlevoix, MI	WLBR
11	19	San Pedro, CA	WLMR
	20	San Francisco, CA	WLBR
13	21	Astoria, OR	WLBR
	22	Seattle, WA	WLMR
14	23	Honolulu, HI	WLBR
	24	Honolulu, HI	WLBR
	25	Guam	WLBR
17	26	Ketchikan, AK	WLMR
	27	Sitka, AK	WLBR
	28	Cordova, AK	WLBR
	29	Homer, AK	WLBR
	30	Kodiak, AK	WLBR

Table 4 shows a comparison of the work forces required for the current and replacement fleets, developed by the USCG. Based on engineering estimates, approximately 140 shore-based maintenance support billets would be required. An additional 70 billets are needed to augment Aids to Navigation Teams (including those required for new buoy boat assets), groups, and district staffs. Including these 210 additional support billets, the proposed replacement seagoing and coastal buoy tender fleet will require about 1100 billets. This represents a savings of over 550 billets when compared with the current fleet. These figures do not include general detail billet counts which, due to the offsetting effects of reduced fleet size and increased pipeline training, are not expected to experience significant change.

	Current Fleet (26 WLBs, 11 WLMs)	Proposed Future Fleet (16 WLBRs, 14 WLMRs)
Commissioned Officers	154	64
Warrant Officers	68	46
Enlisted	1436	782
Total on Ship	1658	892
Additional Support	–	≈210
System Total	1658	1102
Work Force Reduction	–	≈556

Table 4. WORK FORCE IMPACTS

Fleet Transition

In addition to determining the number and mix of new ATON resources, the DSS will allow the USCG to manage the transition from the current fleet to the new fleet. This transition will occur over a ten year period starting approximately in 1996.

CONCLUSION

The Aids to Navigation Service Force Mix 2000 Project provides a comprehensive analysis of USCG requirements for the replacement seagoing and coastal buoy tender fleet. The project's innovative approach combined the analytical capabilities of the Volpe Center with the expertise of USCG Aids to Navigation professionals in developing and applying the Aids to Navigation Service Force Mix Decision Support System.

Based on mission requirements determined by Coast Guard program directors, the Volpe Center exercised the DSS to develop the proposed service force mix for the

replacement buoy tender fleet. As expected, the new technologies and capabilities incorporated in the new ships result in less than one-for-one replacement of the current fleet.

The proposed service force mix of 16 WLBRs and 14 WLMRs, a total of 30 ships, is a significant reduction from the current fleet of 37 ships. The reduction in seagoing buoy tenders from 26 to 16 is especially significant. An increase of one buoy boat is also identified in the proposed service force mix. Additional buoy boats may be required to provide secondary response capabilities. Analysis of future buoy boat requirements is being conducted by the USCG.

Several key planning factors directly affecting the replacement buoy tender fleet have been approved by the USCG Commandant and are fully described in Volume III of the ATON SFM 2000 Project Report. One particular concern, reduced ship-board crewing levels, will require careful attention to the staffing of shore-based personnel and pipeline training for ship-board personnel. If the work force considerations of the proposed service force mix are met, the USCG will be able to successfully accomplish the operational requirements of the replacement buoy tender fleet.