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Overview of the U.S. Coast Guard Short Range Aids to Navigation Mission

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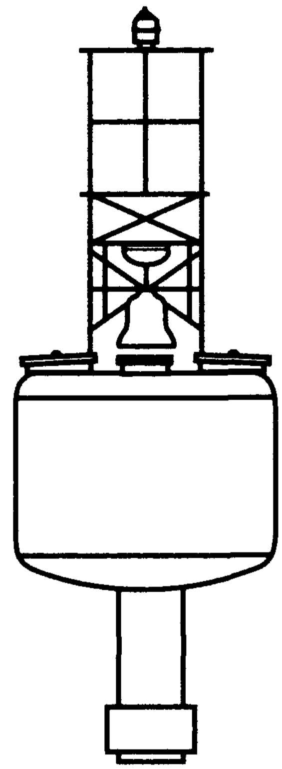

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13. ABSTRACT (Maximum 200 words)

This document provides an overview of the Coast Guard's Aids to Navigation (ATON) mission. Specific components of the mission described within include: the history of the mission; the supporting Coast Guard organizational structure; the resources employed in servicing ATON; the types of ATON is use by the Coast Guard; and the Coast Guard's preparations for the 21st Century.

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PREFACE

One mission of the United States Coast Guard 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. ATON have been used in the U.S. since the 18th century.

The average American is familiar with two of the more visible elements of the ATON mission; lighthouses and buoys. These ATON types, however, represent only the surface of the ATON mission. The Coast Guard is responsible for over 50,000 federal aids to navigation and monitors the operation of another 48,000 privately owned ATON that serve private concerns. More than 4,000 personnel, over 75 buoy tender vessels, and a variety of small boats are employed by the Coast Guard in accomplishing the ATON mission.

This document provides an overview of the Coast Guard's ATON mission, including the history of the mission; the supporting Coast Guard organizational structure; the resources used to service ATON; the types of ATON in use by the Coast Guard; and the Coast Guard's preparations for the 21st Century.

The Coast Guard hopes that this document will be of value to the many individuals and organizations served by the Short Range Aids to Navigation mission.

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LIST OF ACRONYMS

ANB	aids to navigation boat
ANT	aids to navigation team
ATON	aids to navigation
BU	buoy boat
BUSL	buoy boat - stern loading
DGPS	differential global positioning system
ECDIS	electronic chart display and information system
ELB	exposed location buoy
ELT	enforcement of laws and treaties
G-C	USCG Commandant
G-E	USCG Office of Engineering, Development, and Logistics
G-N	USCG Office of Navigation Safety and Waterway Services
G-NRN	USCG Radionavigation Division
G-NSR	USCG Short Range Aids to Navigation Division
G-P	USCG Office of Personnel and Training
G-T	USCG Office of Command, Control, and Communications
HQ	Headquarters
LNB	large navigational buoy
MER	marine environmental response
MLC	USCG Maintenance and Logistics Command
NMI	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
OAN	USCG District Operations Division, Aids to Navigation and Waterways Management Branch
R&D	Research and Development
Racon	radar beacon
SAR	search and rescue
TANB	trailerable aids to navigation boat
USC	United States Code
WAMS	Waterways Analysis and Management Studies
WLB	seagoing buoy tender
WLI	inland buoy tender
WLIC	inland construction buoy tender
WLM	coastal buoy tender
WLR	river buoy tender
WTGB	icebreaking tug

1. MISSION DEFINITION

SHORT RANGE AIDS TO NAVIGATION

Short Range Aids to Navigation (ATON) are used by vessel navigators to determine their position, follow a safe course, and avoid dangers and obstructions. Short Range ATON are external to vessels and are located along coasts and navigable waters; examples include buoys, daybeacons, lights, radar beacons, and sound signals. Other types of ATON include nautical charts, satellite navigation systems, and LORAN-C, a radionavigation system. The type of ATON depends on specific conditions and requirements of a location. This document addresses Short Range ATON; from this point on the term "ATON" will refer to Short Range ATON only.

Within the Coast Guard, the Office of Navigation Safety and Waterway Services, Short Range Aids to Navigation Division (G-NSR) is responsible for establishing and servicing ATON to meet the needs of marine commerce, the Armed Forces, and the boating public.

HISTORY OF ATON

ATON have been used in the United States since the 18th century. The first permanent lighthouse was constructed in Boston Harbor in 1716, while small wooden buoys (known as "spar buoys") were used for the first time in the Delaware River near Philadelphia in 1767. ATON were officially legislated through the Ninth Act of the First Session of Congress in 1789, which mandated construction and maintenance of lighthouses under the Lighthouse Service. At that time 12 lighthouses and 7 spar buoys were transferred from state to federal control. A new type of ATON was introduced in 1792 when floating beacons were used for the first time in Chesapeake Bay.

Between 1789 and 1903 the Department of the Treasury was responsible for maintaining ATON and supervising the Lighthouse Service. During this period several "firsts" occurred: a parabolic reflector for lighthouses was introduced in 1812; lighthouse fog bells were introduced in 1820; and, also in 1820, the first lightship was commissioned for Chesapeake Bay.

In 1838, under an Act of Congress, the Atlantic coast was divided into six lighthouse districts, and the Great Lakes into two. A naval officer was assigned to each district to inspect all aids to navigation, report on their condition, and make recommendations. In 1840 the first lighthouse tenders of the U.S. Lighthouse Service were introduced to assume buoy tending and lighthouse supply activities formerly performed by chartered vessels, under contract, or by other government ships. The Lighthouse Service was transferred to the Revenue Marine Bureau in 1845.

In 1852 a Lighthouse Board was created to administer the lighthouse system, made up of officers of the Navy, Army, and civilian scientists under the jurisdiction of the Treasury.

During the latter part of the nineteenth century the impact of the board could be seen in the introduction of different types of iron buoys, including lighted, whistle, bell, can, and nun buoys; steam fog whistles; siren fog signals; improved lighthouse construction; iron and steel in lightship construction; more precise channel markings; and the Lateral System of Buoyage in which colored marks indicate the port and starboard sides of the route to be followed, based on the agreed direction.

In 1877 kerosene became the principal illuminant in lighthouses; further lighting improvements were seen in 1881 when oil gas was used to light beacons and buoys for the first time. The invention of electricity led the Lighthouse Board in 1884 to try unsuccessfully to illuminate part of the East River in New York City. Electricity was nevertheless used four years later to light buoys in New York Harbor and eight years later to light incandescent lamps on lightships. The first lighthouse powered by electricity was the Navesink Lighthouse off the coast of New Jersey in 1898.

The early twentieth century saw several administrative changes. In 1903 the Lighthouse Board and the Lighthouse Service moved from the Revenue Marine Bureau in the Treasury to the Department of Commerce and Labor. In 1910 the Lighthouse Board was abolished and the Bureau of Lighthouses was created and given control of the Lighthouse Service. The Bureau was consolidated with the Coast Guard under the Treasury Department in 1939.

The early twentieth century also saw the introduction of acetylene gas buoys, reinforced concrete lighthouses, diaphones for producing air fog signals, semaphore signals, radiobeacons, metal cone buoys, radio fog signals, gong buoys, range lanterns, aluminum buoys, battery-powered electric solenoid fog bell strikers, and radiobeacon buoys. By 1939 there were almost 30,000 ATON maintained by the Coast Guard.

The Coast Guard was transferred to the Department of Transportation in 1967. During the latter part of the twentieth century, technology improvements resulted in the introduction of new types of ATON: battery and solar-powered buoys and beacons, radar beacons, sound signals, sector lights, and ranges. Over the last twenty years the number of federal ATON supporting marine navigation has risen from 45,000 in 1972 to 46,000 in 1982 to over 50,000 in 1993[1].

SERVICING ATON

The Coast Guard uses several types of vessels to service ATON:

- *WLB*. A large, stable, heavy-lift seagoing buoy tender servicing the largest buoys located in the roughest water farthest from shore.

[1] Number excludes racons, fog signals, and private aids to navigation. Source: *Quarterly Report of the Operation of Short Range ATON, Quarter ending December 1992*. USCG, G-NSR-1, February 1993.

- *WLM*. A lighter coastal buoy tender servicing medium-sized buoys in coastal waters (bays, harbors, coastal channels).
- *WTGB/Barge*. An icebreaking tug pushing a crane-equipped barge servicing heavy buoys in semi-exposed locations.
- *WLI*. An inland buoy tender operating in rivers and less exposed inland waterways, servicing small to medium-sized buoys.
- *WLIC*. An inland construction tender that builds, or rebuilds if destroyed, fixed aids to navigation, including daybeacons and minor lights.
- *WLR*. A river buoy tender consisting of a towboat with an attached barge carrying ATON equipment and a crane.

In addition, *Aids to Navigation Teams (ANTs)* are shore-based units that use a variety of small boats to service smaller ATON in protected waterways and provide discrepancy response support for ATON normally serviced by vessel units. ATON servicing resources are discussed in more detail in Chapter 3.

Coast Guard review of ATON servicing is ongoing. A 1970 study of the ATON servicing system concluded that restructuring of the existing system was needed to resolve two issues: high annual costs of servicing aids, and the advanced age of many of the large seagoing buoy tenders. Implemented recommendations from the study included changing from a two-year to a six-year buoy relief cycle, annual to biennial buoy mooring inspections, and semi-annual to annual daybeacon/light/buoy inspections. Another implemented recommendation was the introduction and use of ANTs to service smaller ATON and provide backup support to buoy tenders[2].

G-NSR is currently acquiring new vessels to replace its aging buoy tender fleet. Thirty-two of the 37 buoy tenders in the two largest classes, WLBs and WLMs, were built in the 1940s and are beyond their design service lives. The other five tenders will reach the end of their design service lives by 1995. The phase-in of the replacement vessels will begin in 1996 and calls for the delivery of 30 new vessels, representing a fleet size reduction of seven tenders.

Between 1970 and 1993 there have been major changes in both the mix of servicing vessels and the number of ATON. Figure 1 illustrates how today's Coast Guard is maintaining an increased number of ATON using fewer, more efficient servicing vessels. This pattern is expected to continue as the Coast Guard moves into the 21st Century.

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[2] Booz-Allen Applied Research, Inc., *Servicing System for Short-Range Aids to Navigation*, November 1970. DOT-CG-90506A.

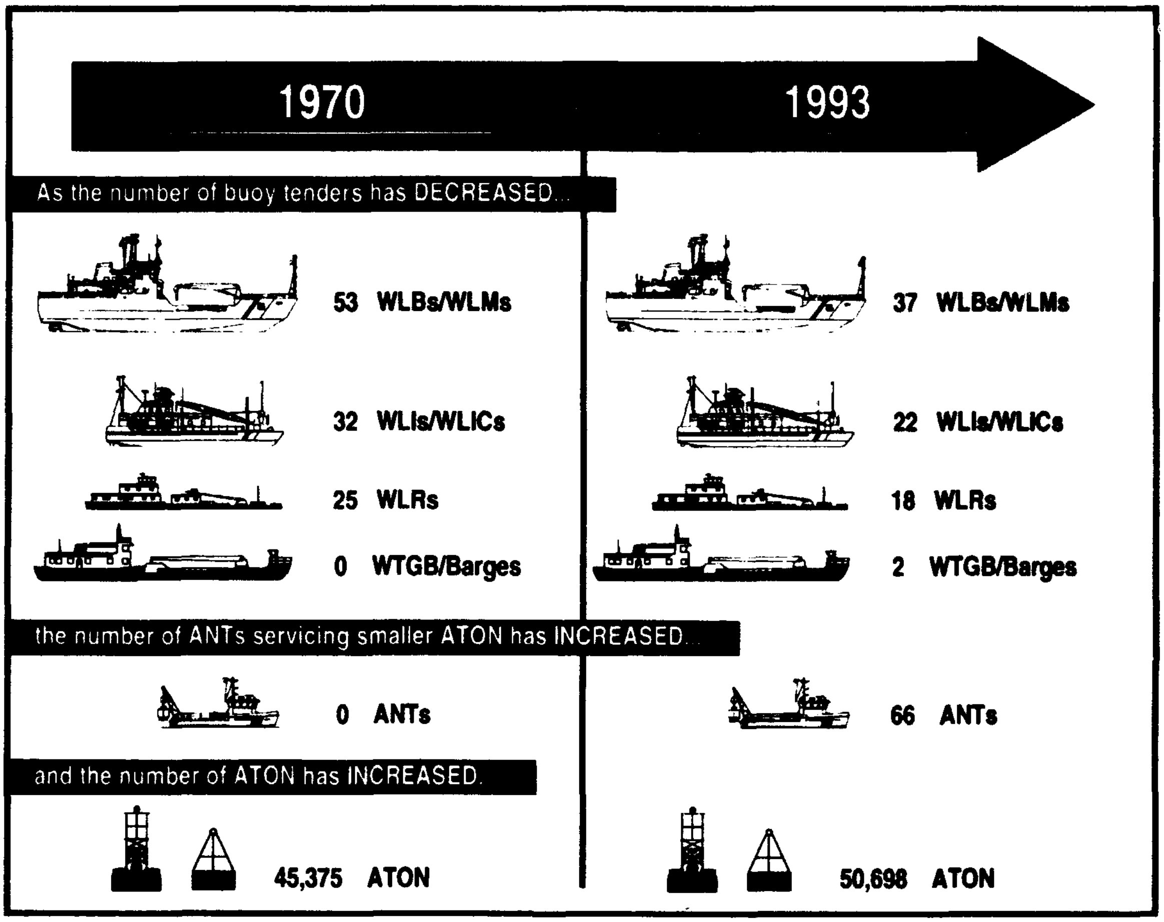

Figure 1. SERVICING ATON: 1970 TO 1993

2. ORGANIZATIONAL STRUCTURE

The Coast Guard has a unique operational role within the federal government, functioning under the Department of Transportation during times of peace and under the Navy in times of war. One of the Coast Guard's missions set by Congress is to promote navigation safety by developing and operating aids to maritime navigation; the Short Range Aids to Navigation program is part of this mission.

Title 14, Sections 2 and 81 of the United States Code (USC) is the statutory authority for defining the Coast Guard's ATON mission. In FY 1993 operating expenses for the ATON program were $382 million[3] supported by almost 4,000 personnel. Staff relationships exist between the Commandant of the Coast Guard and numerous headquarters (HQ) offices and units in support of the ATON mission. The operational chain of command extends from the Commandant to the Area Commanders and from there to both District Commanders and Maintenance and Logistics Commanders (MLC). From the Districts and MLCs the chain of command leads to Coast Guard groups and operating units. Figure 2 is an organizational overview of the Coast Guard's ATON mission.

HEADQUARTERS

The Commandant (G-C) is directly responsible to the Secretary of Transportation and administers all operational, administrative, and financial Coast Guard activities. G-C supervises all activities within the two area commands (Atlantic and Pacific), the 10 HQ offices, and the 32 HQ units attached to HQ offices.

There are three HQ offices directly supporting ATON: Navigation Safety and Waterway Services (G-N), Engineering, Development, and Logistics (G-E), and Command, Control, and Communications (G-T). Attached to these offices are several HQ units.

Office of Navigation Safety and Waterway Services (G-N)

G-N supports Coast Guard operations relating to navigation safety and waterway services: radionavigation aids, bridge administration, waterways management, ice operations, search and rescue, recreational boating safety, and short range aids to navigation. The G-N division responsible for administering and supervising the operation and maintenance of ATON is G-NSR.

G-NSR

G-NSR is responsible for establishing, changing, and discontinuing ATON; maintaining and distributing Light Lists to mariners, which describe all federal and private ATON (private

[3] This figure is for Short Range ATON only; if LORAN-C is included, the expenditure is $497.3 million.

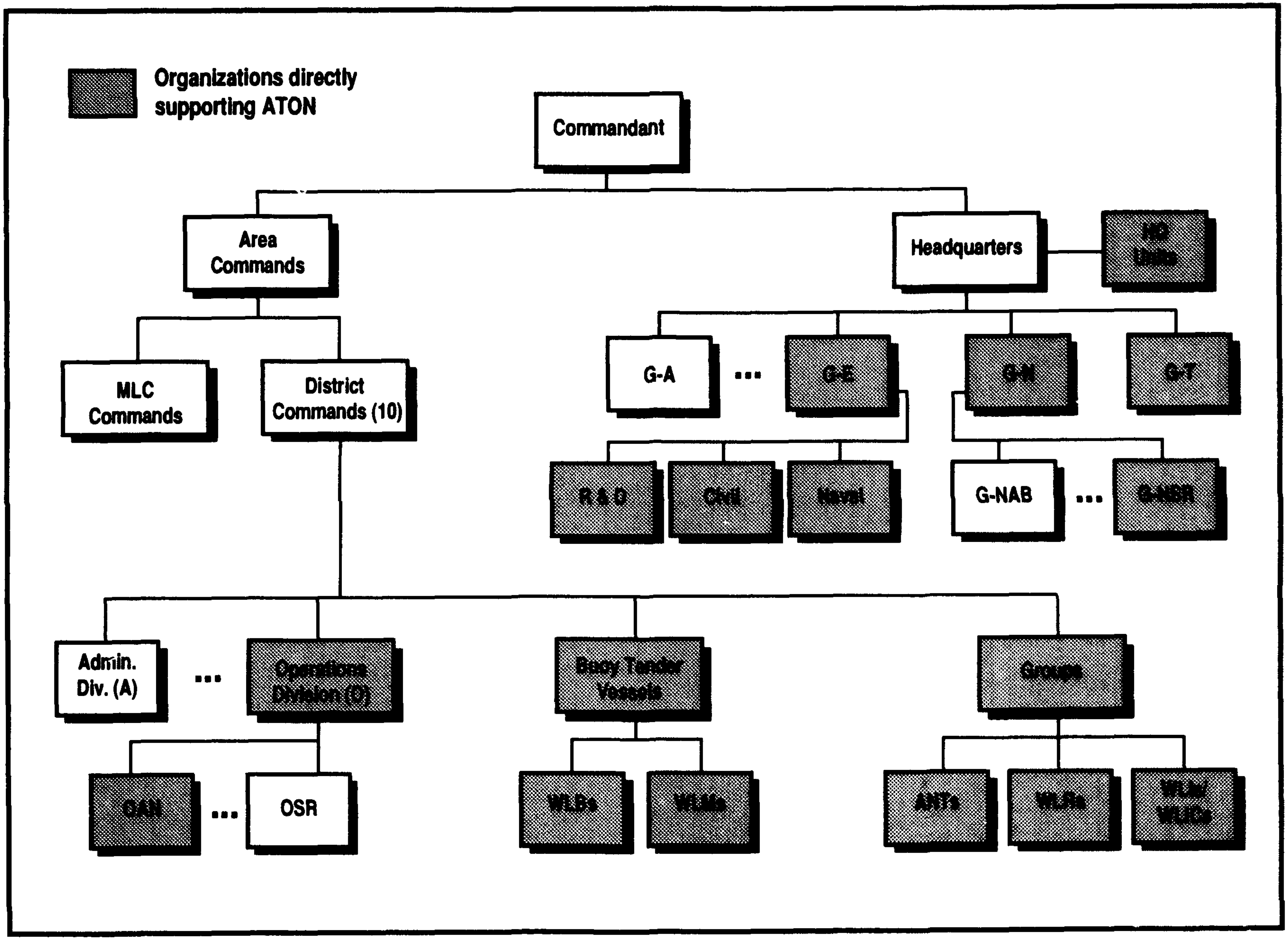

Figure 2. COAST GUARD FUNCTIONAL ORGANIZATIONS RELATING TO ATON

ATON are operated and maintained by individuals or organizations other than the Coast Guard, but conform to the standard U.S. system); preparing ATON publications; managing ATON funding; and training ATON personnel.

The Fleet Development Team (G-NSR/t) is a temporarily authorized team that will remain in place for the duration of the buoy tender replacement projects. The team reports to the chief of G-NSR, and represents G-NSR with the Office of Acquisition.

There are three permanent branches of G-NSR: Signal Management, Facility Management, and Navigation Rules and Information.

Signal Management (G-NSR-1)

G-NSR-1 develops policies, procedures, and criteria for establishing, altering and maintaining federal and private buoys, daymarks, and lights; and shares responsibility with the Office of Navigation Safety and Waterway Services, Radionavigation Division (G-NRN) for radar beacons (racons). The branch also ensures that federal ATON regulations reflect current policies and procedures.

Facility Management (G-NSR-2)

G-NSR-2 manages programs and projects relating to acquisition and disposition of ATON facilities and resources. The branch also coordinates personnel training for installing and servicing ATON facilities.

Navigation Rules and Information (G-NSR-3)

G-NSR-3 develops policies and procedures for providing ATON information to mariners. The branch issues the Light Lists, the Aids to Navigation Manual, Notices to Mariners, and miscellaneous ATON information. G-NSR-3 also develops rules and regulations relating to waterway safety.

Office of Engineering, Development, and Logistics (G-E)

G-E supports ATON design, construction, maintenance, and Research and Development (R&D) through the efforts of the Civil Engineering Division, the Naval Engineering Division, and the R&D Staff.

The Civil Engineering Division (G-ECV) develops policy and standards for design, maintenance, construction, and inspection of all fixed and floating ATON, buildings, shops, docks, antennas over 100 feet, and ATON signalling equipment. The Ocean Engineering Branch (G-ECV-3) develops, evaluates, and maintains technical standards for ATON equipment and systems; designs, acquires, and consolidates hardware into signalling systems; and maintains the ATON Technical Manual.

The Naval Engineering Division (G-ENE) is responsible for the alteration, maintenance, and repair of buoy tenders and ATON boats, and supports the Office of Acquisition Project Managers in designing ATON vessels.

The Research and Development Staff (G-ER) plans, controls, and administers R&D projects relating to ATON; provides technical advice; and manages R&D funds with guidance from G-NSR.

Office of Command, Control, and Communications (G-T)

G-T provides electronics support for racons, radiobeacons, and other electronic hardware through the Electronics System Division and the Telecommunications System Division.

The Electronics System Division (G-TES) acquires, installs, and maintains electronic ATON. The Telecommunications System Division (G-TTM) provides landline, radio communication, and radio spectrum management support, and liasons with national and international radio policy-making organizations.

Headquarters Units

Headquarters units are functionally attached to headquarters offices but are directly responsible to the Commandant. Of the 32 units, five directly support ATON functions.

Under G-E, the following four units support ATON. The Research and Development Center, Groton, CT focuses on operational techniques, concepts, systems, equipment, and materials. The Coast Guard Yard, Curtis Bay, MD manufactures, services, and installs navigation equipment not readily available from commercial sources. Supply Center Baltimore, MD is a central stocking and shipping point for centrally procured ATON electronic equipment. Finally, Supply Center Curtis Bay, MD purchases and stocks standard buoy hardware.

Under the Office of Personnel and Training (G-P), the National Aids to Navigation School located at the Coast Guard Reserve Training Center, Yorktown, VA provides training in ATON equipment, systems, maintenance, and policy for officer, enlisted, and civilian personnel.

AREA COMMANDS

There are two area commands, the Atlantic and the Pacific. Area Commanders are responsible for overall mission performance in their areas, and supervise the Maintenance and Logistics Commands and District Commands.

Maintenance and Logistics Commands (MLC)

There are two MLCs, each attached to an Area Command, providing support services and technical support directly to districts and area units. For ATON, MLCs manage the repair, maintenance, and approved alteration of ATON and ATON cutters and boats[4].

DISTRICT COMMANDS

There are 10 Coast Guard Districts. Each District Commander is responsible for providing regional direction and assigning responsibility for establishing and servicing ATON. Reporting to the District Commander are five staff divisions, WLBs and most WLMs, Groups, and WLICs in District 5.

District Commanders periodically schedule Waterways Analysis and Management Studies (WAMS) by commanding officers of buoy tenders to ensure that ATON meet federal standards. Waterways can be either critical or non-critical. Critical waterways are analyzed at least once every three years and fall into one of three categories: military (servicing military facilities), environmental (transporting hazardous materials or dangerous cargoes, such as chemicals), and navigational (waterways where there are difficulties in navigating and/or establishing ATON). Waterways are defined as non-critical if ATON discrepancies (off position or not functioning according to federal standards) will not severely impact marine safety.

Each District Commander is also responsible for issuing weekly[5] Local Notices to Mariners describing new, changed, or deficient ATON, as well as additional information relating to the navigational safety of waterways (for example, construction of oil rigs and deteriorating channel conditions). In addition to district units, distribution includes other federal agencies such as the National Ocean Service (NOS) and the Army Corps of Engineers, and both commercial and non-commercial waterway users.

Operations Division

The Aids to Navigation and Waterways Management Branch (OAN) within the Operations Division is primarily responsible for planning, coordinating, and reviewing all federal and private ATON in the district. OAN reviews waterways requirements (for example, port access routes, rules of the road, and regulated navigation areas), directs the operation of all district ATON, and initiates or reviews requests to establish, change, or eliminate ATON. OAN also promotes navigational safety by collecting data for Light Lists, nautical charts, and Notices to Mariners, and works with the MLC in maintaining operating standards for ATON.

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[4] Cutters have a permanently assigned crew; boats have temporary crews.

[5] District 9 ceases publication of Local Notices to Mariners at the end of the navigation season.

Buoy Tenders

The seagoing (WLB) and coastal (WLM) buoy tenders are used to service buoys offshore and in coastal waters. With the exception of District 2, WLBs are stationed in all districts. WLMs are currently stationed in the Atlantic and Gulf Coast districts. In the past they have also been stationed in West Coast districts and are projected to be stationed in those districts again in the future.

Groups

Group Commanders provide direction, support, and coordination for operationally focused units. The number of groups varies by geographic area; District 14 (Hawaii) has only one, whereas District 1 (Northeast) has eight.

Individual units under the Group Command provide the support needed to maintain ATON. There are several types of ATON units included within groups: ANTs, WLRs, WLIs, most WLICs, and some WLMs.

3. ATON SERVICING RESOURCES

There are approximately 98,000 ATON throughout U.S. waterways. Of this number about 48,000 are privately owned and maintained[6]. The remaining 50,000 ATON are federally owned and the responsibility of the Coast Guard.

Each federally owned ATON is inspected and serviced annually by the Coast Guard. The Coast Guard also corrects reported problems called "discrepancies" such as off-station buoys or malfunctioning lights. To service ATON the Coast Guard uses vessels (WLBs, WLMs, WTGBs, WLIs, WLICs, WLRs) and ANTs. The servicing resource used depends on the ATON location and type and the operational environment (weather and sea conditions). For example, a WLB would be required to service a 24,000-pound 9x38-foot whistle buoy located in rough waters offshore. A WLR would be more suited for handling a 170-pound seven-foot sixth class can buoy located in a shallow river. In general, all ATON have an assigned primary servicing unit and a secondary servicing unit. ANTs are often the secondary unit. In this capacity, ANTs make temporary repairs to discrepant ATON that remain in effect until the ATON can be visited by the primary servicing unit. Sometimes a large vessel such as a WLB is assigned small buoys if they are near larger buoys assigned to the tender, as long as the buoys are located in water deep enough for the WLB to operate.

All of the WLBs and the majority of the WLMs were built in the 1940s. These vessels are beyond their design service lives and need replacement by new-generation vessels; the remaining WLMs will reach this point in 1995, as will the BU and BUSL buoy boats used by ANTs. The Coast Guard has already initiated the procurement of replacement WLBs, WLMs, and BUSLs. The first replacement WLB and WLM deliveries are expected in 1996, and the first replacement BUSL delivery in 1994.

Table 1 summarizes major operating differences among the servicing vessels[7].

[6] Privately owned ATON often serve a special purpose, such as marking private channels, docks, and offshore oil drilling platforms. More than half the nation's private ATON are located in District 8.

[7] U.S. Department of Transportation, U.S. Coast Guard, *Register of Cutters of the U.S. Coast Guard, 1992.* COMDTINST M5441.51.

Table 1. ATON SERVICING VESSELS

TENDER CLASSES	OPERATING CHARACTERISTICS	SPECIFICATIONS*
WLB · Seagoing buoy tender · Fleet size: 26	· Services heaviest buoys (12 tons) in seas up to six feet · Endurance of 21 days · One to two week work trip · Crew of 49 to 57 · Multi-mission vessel · Services 4,450 ATON	· Draft: 13 ft. · Length: 180 ft. · Lifting capacity: 20 tons · Econ./max. speed: 11/13.7 knots · Econ. range: 7,980 nautical miles
WLM · Coastal buoy tender · Fleet size: 11	· Services all but largest buoys · Endurance of seven days · Three to five day work trip · Crew of 24 to 33 · Focused-mission vessel · Services 3,050 ATON	· Draft: 7 ft. · Length: 133; 157 ft. · Lifting capacity: 10 tons · Econ./max. speed: 5.1/9.8; 11.6/12.8 knots · Econ. range: 4,500; 3,055 nautical miles
WTGB · Ice breaking tug/barge · Fleet size: 2	· Services the heaviest buoys · Four to eight day work trip from home port, spring and fall only · Crew of 17 (+ 10 for ATON barge) · Multi-mission vessel · Number of ATON serviced included in WLB total	· Draft: tug: 12 ft.; barge: 5 ft. · Length: tug: 140 ft.; barge: 120 ft. · Lifting capacity: 20 tons · Econ./max. speed: 12/14.7 knots · Econ. range: 4,000 nautical miles
WLI · Inland buoy tender · Fleet size: 6	· Services smaller ATON in rivers and less exposed inland waterways · Crew of 6 to 14 · Focused-mission vessel · Services 2,350 ATON	· Draft: 4 to 5 ft. · Length: 100; 65 ft. · Lifting capacity: 5; 2 tons · Econ./max. speed: 5 to 7.3/9 to 11.9 knots · Econ. range: 1,500 to 2,700 nautical miles
WLIC · Inland construction tender · Fleet size: 16	· Constructs fixed structures in inland waterways · Services smaller ATON in protected inland waterways · Crew of 13 to 19 · Focus is ATON construction · Services 4,950 ATON · Responsible for rebuilding over 7,000 ATON	· Draft: 4 to 5 ft · Length: 160; 100; 75 ft. · Lifting capacity: 5 to 8 tons · Econ./max. speed: 5 to 7/8.6 to 11 knots · Econ. range: 2,100 to 5,350 nautical miles
WLR · River buoy tender · Fleet size: 18	· Services smaller ATON (up to 3,000 lbs.) in rivers within Second District · Five to 15 day work trip · Crew of 19 · Focused-mission vessel · Services 20,100 ATON	· Draft: 4 to 7 ft. · Length: 115; 75; and 65 ft. · Lifting capacity: 1 to 3 tons · Econ./max. speed: 5 to 9.2/7.6 to 12 knots · Econ. range: 3,100 to 11,600 nautical miles

* Speed, lift capacity, and range variations are based on different subclasses of vessels

SEAGOING BUOY TENDERS (WLB)

The large, stable, heavy-lift WLBs service the heaviest buoys and fixed aids in the roughest seas farthest from shore. WLBs also provide ATON logistics support, including refueling for isolated lights and light stations, and National Oceanic and Atmospheric Administration (NOAA) data buoys. For increased flexibility, WLBs have two small boats onboard to permit crews to work on smaller buoys simultaneously and to service fixed structures. Approximately 9% (4,450) of the 50,000 federally owned ATON are currently serviced by WLBs. Because of size, draft, and maneuverability limitations, they are unsuitable for most inshore ATON work. Figure 3 illustrates a representative WLB, *USCGC Firebush,* whose home port is Kodiak, AK.

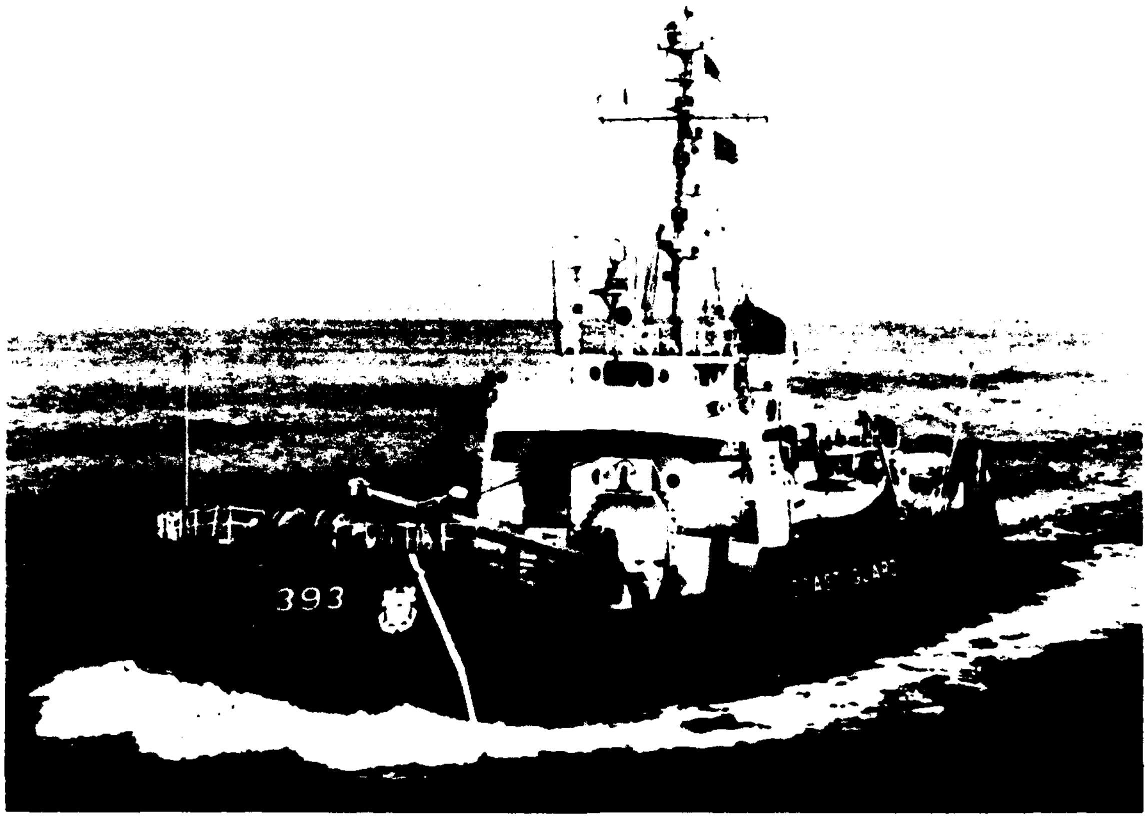


Figure 3. SEAGOING BUOY TENDER (180 FT. WLB CLASS)

WLBs are multi-mission vessels; because of their 21-day endurance and offshore sea-keeping capabilities they are called upon to perform non-ATON tasks. WLBs spend approximately 59% of their time servicing ATON and 14% of their time performing standard Coast Guard vessel activities such as operational training. WLBs spend the remaining time on enforcement of laws and treaties (ELT), defense operations, search and rescue (SAR), marine science, marine environmental response (MER), and, in the Great Lakes and the Northeast, domestic ice breaking. One very visible MER activity in which WLBs played a major role was the cleanup of the 1989 Valdez oil spill in Alaska. WLBs served as platforms for small vessel operations, deployed the protective boom in Prince William Sound, coordinated air traffic, and functioned as Command, Control, and Communications platforms.

WLBs are the only tenders with a wartime role outside United States ports and coastal areas. Because of their endurance, stability, and precise navigational capabilities, WLBs have been deployed to support mine countermeasures, surveillance patrols, overseas ATON, and salvage operations. Home ports by district for the current fleet are listed in Table 2.

Table 2. WLB FLEET HOME PORTS

USCG DISTRICT	CURRENT HOME PORT
1	South Portland, ME Woods Hole, MA New York, NY
5	Cape May, NJ Portsmouth, VA Atlantic Beach, NC
7	Charleston, SC Mayport, FL
8	Mobile, AL Galveston, TX
9	Port Huron, MI Charlevoix, MI Duluth, MN
11	San Pedro, CA San Francisco, CA
13	Astoria, OR Seattle, WA
14	Honolulu, HI (2) Guam
17	Ketchikan, AK Sitka, AK Cordova, AK Homer, AK Kodiak, AK (2)

COASTAL BUOY TENDERS (WLM)

Compared to WLBs, WLMs are smaller vessels with shallower drafts and more limited endurance. They operate in coastal waters and, under ideal weather conditions, can service all but the largest buoys. Like WLBs, WLMs have small boats onboard to service fixed structures and small buoys. In the New England and Chesapeake Bay areas, WLMs have also been used in ice breaking operations. WLMs are effective logistics/supply vessels, and, like WLBs, provide ATON logistics support for isolated lights. Their shallow draft also makes them suited to inshore operations. Approximately 6% (3,050) of all ATON are currently serviced by WLMs. Figure 4 illustrates a representative WLM, the 157-foot *USCGC Red Birch,* whose home port is Baltimore, MD.

Figure 4. COASTAL BUOY TENDER (157 FT. WLM CLASS)

Unlike WLBs, WLMs are focused-mission vessels with over 88% of their time spent servicing ATON. Standard Coast Guard vessel activities take up 9% of the remaining time and the balance is spent on ELT, defense operations, SAR, and MER. Home ports by district for the current WLM fleet are listed in Table 3.

Table 3. WLM FLEET HOME PORTS

USCG DISTRICT	CURRENT HOME PORT	VESSEL TYPE
1	Rockland, ME Boston, MA Bristol, RI New London, CT New York, NY	133-foot 133-foot 133-foot 157-foot 157-foot
5	Philadelphia, PA Baltimore, MD Portsmouth, VA	157-foot 157-foot 157-foot
7	St. Petersburg, FL	133-foot
8	Mobile, AL New Orleans, LA	133-foot 133-foot

The 157-foot WLMs are less stable than other tenders and service the more sheltered bays and rivers of the Northeast and Mid-Atlantic coast. The 133-foot WLMs are closer in stability to the WLBs and service the more exposed locations on the Atlantic and Gulf coasts.

ICEBREAKING TUG (WTGB)/BARGES

The buoy tender fleet is supplemented by WTGBs. WTGBs are ice breaking tugs that take on extra crew for the ATON mission. Two of these vessels are equipped with a 120-foot barge capable of lifting heavy ATON in semi-exposed locations[8]. Due to the adverse weather conditions of the Great Lakes, buoys are primarily serviced in the Spring and Fall only, allowing the WTGB to focus on ice operations in the winter. The number of ATON serviced by WTGBs is included in the total number serviced by WLBs. Home ports by district for the current WTGB fleet are listed in Table 4. Figure 5 illustrates a representative WTGB/Barge, the *USCGC Bristol Bay,* whose home port is Detroit, MI.

Table 4. WTGB FLEET HOME PORTS

USCG DISTRICT	CURRENT HOME PORT
9	Detroit, MI Sturgeon Bay, WI

[8] Because of motion between the tug and barge in rough weather, operations are limited to relatively calm weather.

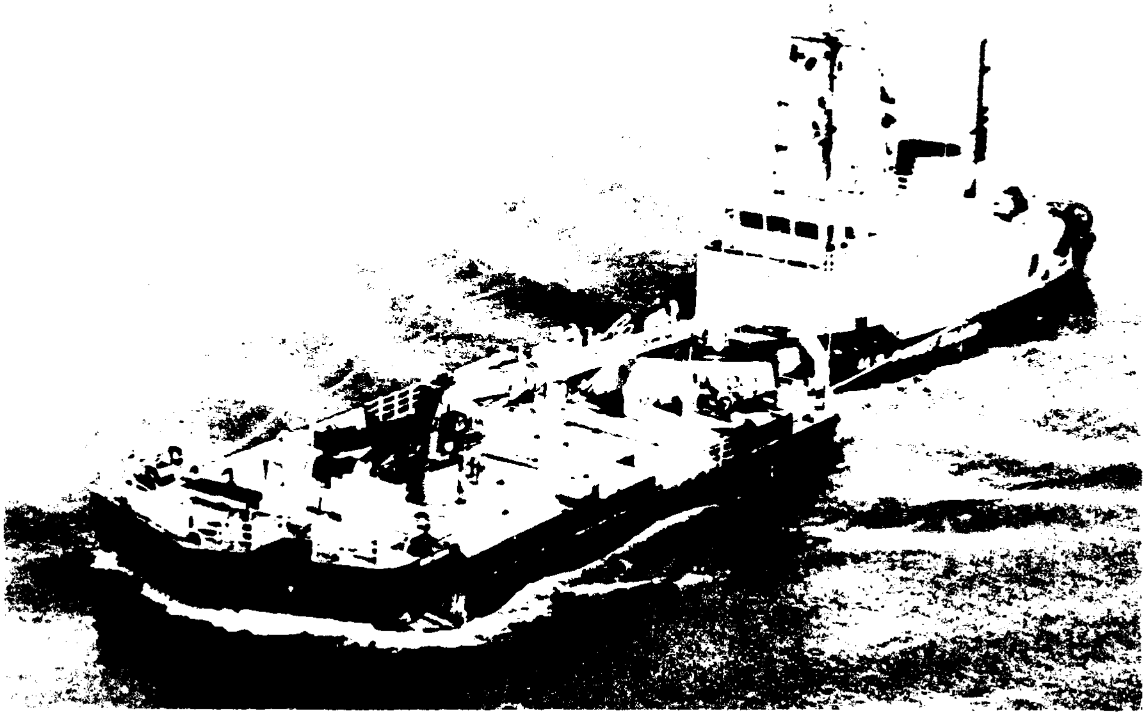


Figure 5. ICEBREAKING TUG WITH ATON BARGE

INLAND BUOY/INLAND CONSTRUCTION TENDERS (WLI/WLIC)

WLIs are single-unit buoy tenders, which are limited to servicing ATON in calm waters and transiting moderately exposed bays and inlets. The 65-foot WLIs service small buoys, while the larger 100-foot WLIs service small and medium buoys in sheltered waters.

WLICs may be single-unit tenders or two-unit combinations of pusher vessels and construction barges. The three 100-foot WLICs are actually 100-foot WLIs converted for construction. Two of these WLICs are combinations of tenders and construction barges; the tenders are able to operate separately from the barges and service the same types of buoys as 100-foot WLIs. The third 100-foot WLIC is a tender with a construction rig installed. The 160-foot WLICs are single-unit tenders. Their design allows them to transit moderately exposed water, unlike two-unit WLICs that may experience motion between the vessels and the barges. The 75-foot WLICs are combinations of tugs and construction barges, but unlike the two-unit 100-foot WLICs, their tugs are not sufficiently stable to operate separately from the barges. Steel legs ("spuds") lowered to the seabed are used to keep WLICs stationary during construction operations. Spuds are easily damaged in heavy seas, limiting construction operations to near calm conditions.

Figure 6. INLAND CONSTRUCTION TENDER (100 FT. WLIC CLASS)

Like WLMs, WLIs/WLICs are focused-mission vessels with over 88% of their time spent servicing ATON. Standard Coast Guard vessel activities take up another 9% of the remaining time and the balance is spent on ELT, defense operations, SAR, and MER.

There are six WLIs currently servicing ATON; three vessels were built in the 1940s, the latest in the 1960s. Likewise, the majority of today's WLICs are older vessels; the oldest were built in the 1940s, the latest in the 1970s. Coast Guard preparations are under way for replacing the pre-1970 vessels of the WLI and WLIC fleet.

Table 5 lists home ports by district for the current vessels of the WLI/WLIC fleet.

Table 5. WLI/WLIC FLEET HOME PORTS

USCG DISTRICT	CURRENT HOME PORT	VESSEL TYPE
5	Baltimore, MD Portsmouth, VA Atlantic Beach, NC Crisfield, MD Southport, NC	WLIC (75-foot) WLIC (160-foot) WLIC (100-foot) WLI (65-foot) WLI (65-foot)
7	Charleston, SC Brunswick, GA Mayport, FL St. Petersburg, FL Miami Beach, FL	WLIC (100-foot) WLIC (100-foot) WLIC (75-foot) WLIC (75-foot) WLIC (160-foot)
8	Mobile, AL New Orleans, LA Galveston, TX Corpus Christi, TX	WLIC (2) (75-foot, 160-foot) WLIC (2) (75-foot, 160-foot) WLIC (2) (75-foot, 75-foot) WLIC (2) (75-foot, 75-foot)
9	Sault Ste. Marie, MI	WLI (100-foot)
13	Portland, OR Seattle, WA	WLI (100-foot) WLI (65-foot)
17	Petersburg, AK	WLI (65-foot)

RIVER TENDERS (WLR)

WLRs are single-unit pusher boat/barge combinations servicing ATON located in District 2, which includes the Mississippi, Missouri, Tennessee, Arkansas, Illinois, Red, and Ohio Rivers and their major tributaries. With a three-ton lifting capacity, WLRs service over 15,000 river buoys. This total represents over 30% of all federally maintained ATON, the highest percentage of any district. Figure 7 illustrates a representative WLR, the *USCGC Kickapoo,* whose home port is Vicksburg, MS.

The changeable nature of the river channels results in a variable number of ATON throughout the year and a high percentage of ATON with no fixed locations. As the river bottom and banks shift over time, ATON must be relocated to mark the existing channel. In addition, bucys must be added when the water level drops and removed during floods. The changeable river channels combined with their length (6,500 miles) and heavy usage (carrying 583 million short tons of cargo in 1987) require District 2 to place and maintain nearly twice as many ATON as any other district.

The majority of ATON in District 2 are unlighted buoys, minor lights, and daybeacons. The district has the highest percentage of unlighted buoys of any district since these buoys are more capable of surviving in a current and avoiding the moving debris common to rivers. They are also relatively inexpensive to manufacture because they are foam-filled.

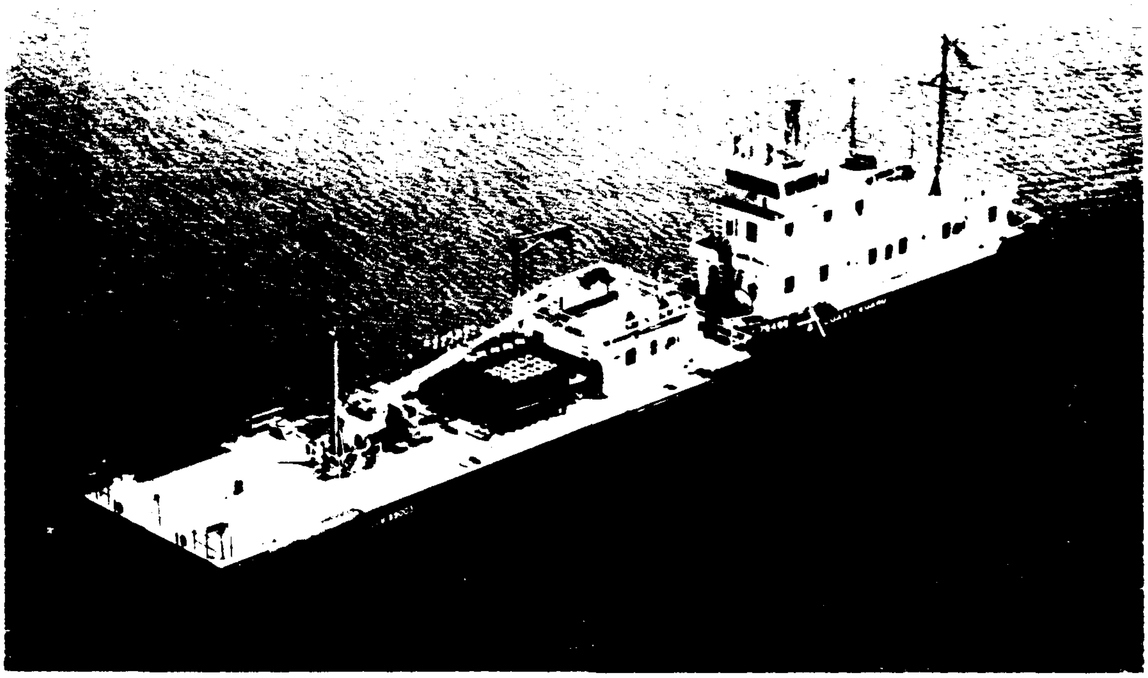


Figure 7. RIVER TENDER (75 FT. WLR CLASS)

Each WLR uses a shoreside depot as its home port, combining WLRs and depots into one facility. Normally a WLR leaves part of its crew at the depot to carry out support operations.

WLRs are focused-mission vessels with over 97% of their time spent servicing ATON. However, because they are the only major floating resource on the inland rivers, they also perform SAR. There are currently 18 WLRs; the earliest were built in the 1940s and will soon need replacing; the two newest WLRs were built in 1989 and 1990, as part of an ongoing replacement project.

Home ports by district for the current WLR fleet are listed in Table 6.

Table 6. WLR FLEET HOME PORTS

USCG DISTRICT	CURRENT HOME PORT
2	Omaha, NE St. Louis, MO (3) Dubuque, IA Keokuk, IA Peoria, IL Sallisaw, OK Memphis, TN Hickman, KY Pine Bluff, AR Natchez, MS Vicksburg, MS Greenville, MS Owensboro, KY Sewickley, PA Chattanooga, TN Buchanan, TN

BUOY TENDER FLEET DISTRIBUTION

The current buoy tender fleet distribution by district is shown in Figure 8. Each district has certain characteristics that impact the distribution.

- *District 1 (Boston, MA).* New England's long, hazardous, and often fogbound rocky shores, combined with high commercial, fishing, and recreational maritime activities, explain the large number of ATON and buoy tenders in District 1. Maintaining and restoring the district's many historic lighthouses are significant activities of all buoy tenders. Although unfavorable weather conditions are often anticipated and avoided, buoy tender operations, once undertaken, are sometimes hampered by fog, sudden changes in sea conditions, wind, and precipitation, adding hours to planned activities. Approximately every other year, the region is plagued by severe icing conditions, which cause discrepancies to occur at higher than average rates.
- *District 2 (St. Louis, MO).* District 2 is responsible for over 15,000 ATON, the highest number in any district. The area of operations includes the upper Mississippi River and the Missouri, Tennessee, Arkansas, Illinois, Red, and Ohio Rivers. WLRs are used to position ATON throughout the year and to mark the changing contours of the river channels.
- *District 5 (Portsmouth, VA).* The Middle Atlantic coastal waters also experience heavy maritime usage, but experience generally milder weather conditions than New England. District 5 is usually able to schedule its three WLBs and three WLMs around weather problems, losing relatively few ATON resource hours to weather impacts. In District 5, as well as Districts 7 and 8, many fixed ATON are small inexpensive structures built by WLICs, which require relatively little maintenance.

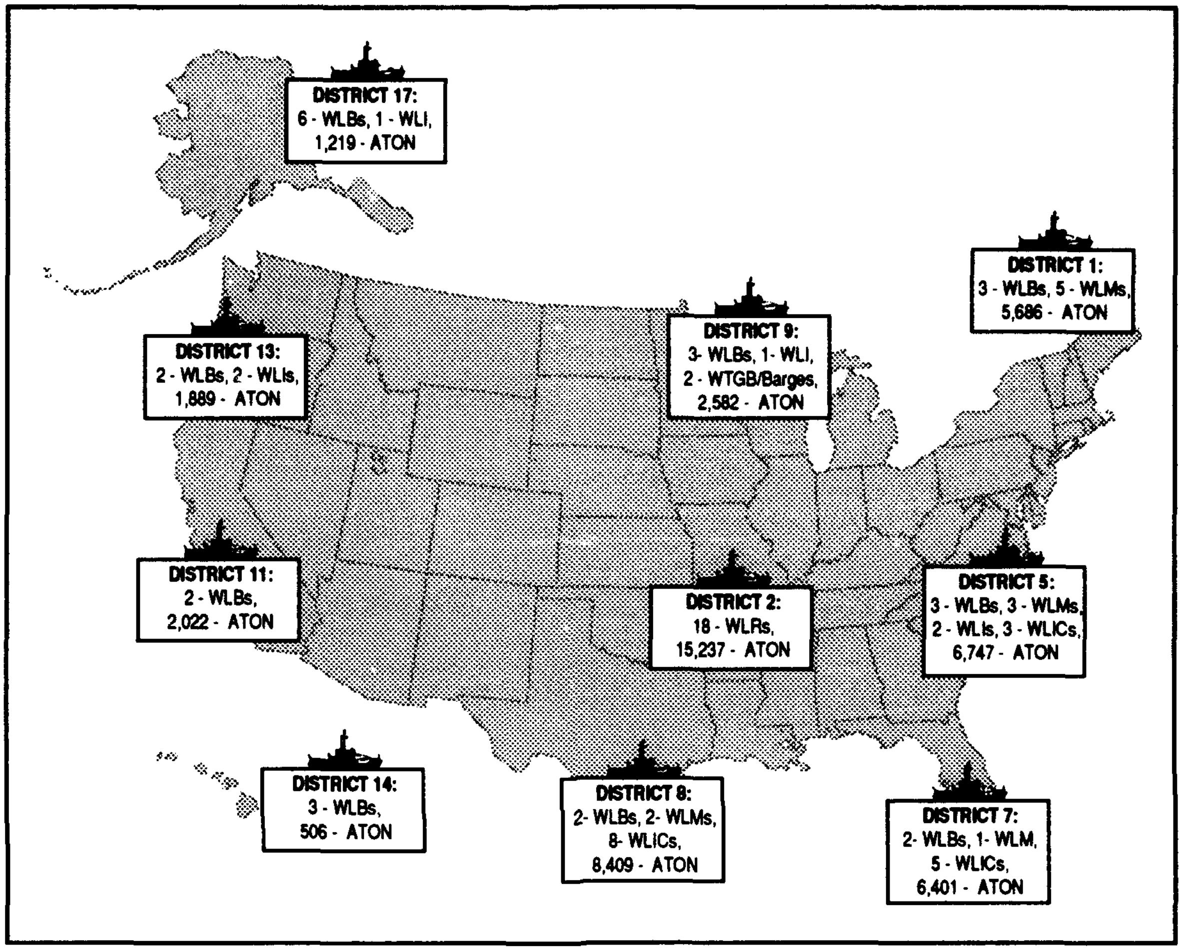


Figure 8. CURRENT COAST GUARD BUOY TENDER FLEET BY DISTRICT

- *District 7 (Miami, FL).* Generally shallow waters and calm weather produce shorter servicing times per aid in District 7 than in other regions. The servicing area includes the Florida Keys, the Bahamas, Puerto Rico, and the Greater Antilles. Each year, three to four-week vessel trips are scheduled to service ATON in the Caribbean.
- *District 8 (New Orleans, LA).* Although buoy tender operations in Gulf waters are similar to those in District 7, District 8 has to contend with the lower Mississippi River, which presents unique challenges. Like WLRs in District 2, WLMs are used to position ATON throughout the year and to mark the changing contour of the river channels.
- *District 9 (Cleveland, OH).* Great Lakes operations include the commissioning and decommissioning of a large number of seasonal buoys due to severe winter icing. Buoy tenders use local staging points to minimize the distances required to pick up

and store seasonal buoys. Lighthouse restoration is also a significant activity, requiring a three to four-week trip annually by each vessel. A WLB may also serve for two to three weeks as a "floating hotel" for an ANT performing lighthouse maintenance.

- *District 11 (Long Beach, CA).* The California coastline covered by the district's two WLBs is over 800 miles long. Because of entrance tides in the northern part of the district, many moorings are checked annually when inspections are performed, to reduce the likelihood of discrepancies.
- *District 13 (Seattle, WA).* The Pacific Northwest poses unique challenges to buoy tending operations. Normal working conditions consist of a six to eight-foot swell in five knots of current. In some locations, such as the Columbia River bar, where the ocean swell meets river outflows, large breakers submerge buoys and trap tenders in bays for days. The deep waters of Puget Sound mandate exceptionally long chains, which add hours to buoy servicing times. Some buoys located in especially turbulent waters have double sinkers to hold them in place. Like District 11, this district has many buoys on a one-year mooring check cycle.
- *District 14 (Honolulu, HI).* The distances that District 14's buoy tenders must travel are greater than those in any other district. Trips to distant destinations, such as Midway Island, the Marshall Islands, American Samoa, the Philippines, and the Solomon Islands, are scheduled according to historical weather patterns, sometimes years in advance. Typically, such trips take three to four weeks. The rough waters around the islands and the great distances that must be traveled are the main reasons why District 14, like several other districts, performs annual mooring checks along with inspections. In addition, the district emphasizes crew training on all trips.
- *District 17 (Juneau, AK).* The six WLBs in this district endure the most severe climate and sea conditions in the country. Daylight ranges from 18 hours a day in the summer to six hours a day in the winter. Tides range up to 38 feet. These challenges are combined with a coastline that extends over 4,000 miles. As a result, both travel and service times are the longest of any district. One of the most time-consuming tasks occurs when a crew places a buoy in a location where only National Ocean Service markers are available for sighting. The tender sends a small boat ashore where the crew searches for the markers (which may be under snow or on a cliff's edge), and positions orange dayboards that can be seen from the tender. After completing the work, the crew returns to retrieve the dayboards. In addition to buoy tending, the vessels perform a large amount of multi-mission work including many SAR cases and fishery patrols.

AIDS TO NAVIGATION TEAMS (ANT)

In contrast to buoy tender crews who work exclusively on their assigned vessels, ANTs are shore-based teams of between 4 to 27 crew members, often collocated with other Coast Guard shore units. ANTs service smaller ATON in protected waterways using various types of vessels.

The concept of an ANT originated from the 1970 study of the ATON servicing system for the National Planning Staff of the Coast Guard. One of the study recommendations was to cut the operating costs of the ATON mission by off-loading onto ANTs a large portion of the ATON maintenance activities performed by WLMs and WLBs. This would reduce but not eliminate the need for buoy tenders. ANTs would maintain buoys within the lift capability of ANT vessels, maintain fixed ATON, and provide emergency services not requiring heavy lifts. WLMs and WLBs, on the other hand, would continue to service heavier ATON and work the exposed waterways.

ANTs are considered focused-mission units, since 89% of their available time is spent servicing ATON; the remaining time is spent on SAR, ELT, and defense operations. ATON serviced include minor shore structures, such as daybeacons and lights, and small lighted and unlighted buoys within the lift capability of ANT vessels. ANTs also provide secondary response support for discrepancies of ATON assigned to tenders within their operating area.

There is no "typical" ANT. Each has a mix of resources including boats and vehicles based on mission requirements in the assigned geographic area of responsibility. ANTs in Districts 14 and 17 even use Coast Guard aircraft to service ATON located in remote areas. Vessels used by ANTs include 65-, 55-, and 34-foot aids to navigation boats (ANBs), 45-foot buoy boats (BUs), 46-foot stern loading buoy boats (BUSLs), and 21-foot trailerable aids to navigation boats (TANBs). The 55-foot ANB has an economical speed of 18 knots and is often used for fast response requirements, but has a maximum lift capability of only 1,000 pounds. To service heavier buoys, BUs and BUSLs, with lifting capacities of between 4,000 to 5,000 pounds, are used. Because it can be put on a trailer and be towed by a truck to accessible coastal locations, the 21-foot TANB is a versatile ANT platform. Frequently, ANTs use different vessel types to service the same ATON, based on weather conditions and other factors.

The number of ANTs escalated from nine in 1974 to 67 in 1980. During the 1980s the number stabilized and today, 64 ANTs service over 36% (17,700) of all ATON. The highest number of ANTs (17) is in District 8 where there are thousands of miles of intracoastal waterways, rivers, bayous, bays, and inlets. District 8's characteristically shallow water and soft bottom conditions are suited to the low-cost fixed ATON serviceable by ANTs. Locations by district for the current ANTs are listed in Table 7.

Table 7. ANT LOCATIONS BY DISTRICT

USCG DISTRICT	CURRENT HOME PORT	
1	Southwest Harbor, ME South Portland, ME Boston, MA Woods Hole, MA Bristol, RI	New Haven, CT East Moriches, NY New York, NY Saugerties, NY Burlington, VT*
5	Cape May, NJ Philadelphia, PA St. Inigoes, MD Baltimore, MD Chincoteague, VA	Portsmouth, VA Hudgins, VA Atlantic Beach, NC Hatteras, NC
7	Georgetown, SC Fort Screven, GA New Smyrna Beach, FL Fort Pierce, FL St. Petersburg, FL	Jacksonville, FL Miami Beach, FL Key West, FL San Juan, PR
8	Chattahooche, FL Panama City, FL Gulf Breeze, FL Selma, AL Mobile, AL Eufaula, AL Demopolis, AL Gulfport, MS Dulac, LA	New Orleans, LA Venice, LA Morgan City, LA Port O'Connor, TX Galveston, TX Sabine, TX Corpus Christi, TX Port Mansfield, TX
9	Buffalo, NY Huron, OH Grand Haven, MI Sault Ste, Marie, MI Escanaba, MI Detroit, MI	Portage, MI* St. Ignace, MI* Kenosha, WI Green Bay, WI Duluth, MN
11	San Diego, CA Rio Vista, CA	Long Beach, CA San Francisco, CA
13	Astoria, OR Portland, OR Charleston, OR	Port Angeles, WA Kennewick WA
14	Honolulu, HI	
17	Sitka, AK	

* Coast Guard SAR stations with ATON primary mission responsibilities

REPLACEMENT VESSELS

Next-generation seagoing buoy tenders (Juniper Class WLBs), coastal buoy tenders (Keeper Class WLMs), and buoy boats (BUSLs) will start to be phased in during 1994 for BUSLs and 1996 for WLBs and WLMs. The proposed replacement buoy tender fleet will consist of sixteen 220-foot Juniper Class WLBs and fourteen 175-foot Keeper Class WLMs, a reduction of seven buoy tenders when compared to the current fleet of 26 WLBs and 11 WLMs.

The new WLBs and WLMs will be more efficient than the buoy tenders they will be replacing. Buoy tending capabilities will be improved through such innovations as a dynamic positioning system for more accurate station-keeping capabilities, a chain in-haul system for raising moorings more quickly, and a differential global positioning system (DGPS) for more precise buoy positioning. DGPS will also facilitate the positioning of buoys during periods of poor visibility. Other improvements will include the ability to operate with smaller crews and increased vessel speed.

Figures 9 through 11 are drawings of the replacement vessels.

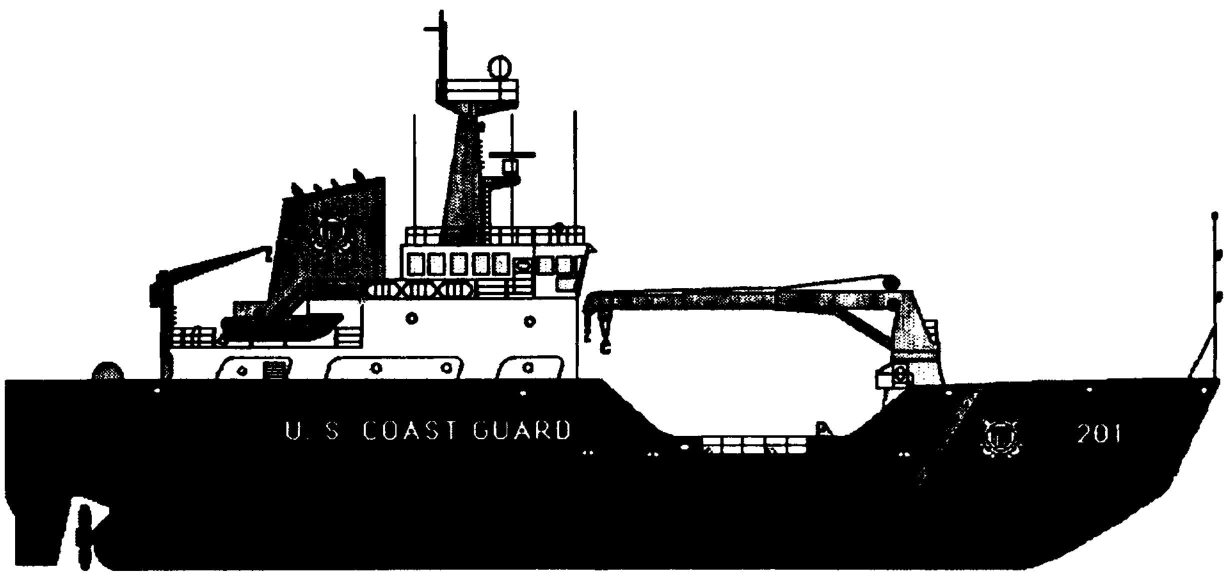


Figure 9. JUNIPER CLASS WLB

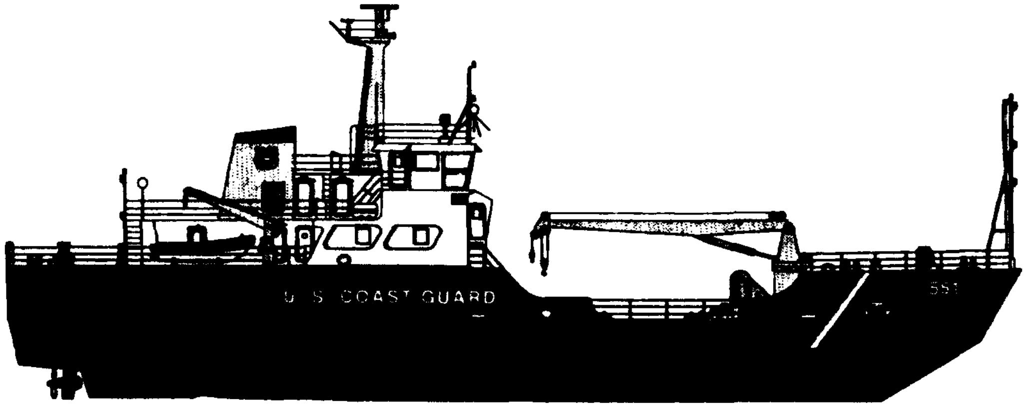


Figure 10. KEEPER CLASS WLM

Figure 11. 49-FOOT BUSL

4. ATON TYPES

In transiting a waterway a mariner uses a group of interacting ATON to provide information with which to navigate safely. The configuration of ATON deployed in a location depends on several factors, including the visual range of the ATON and the environmental conditions. Dimensions and operating environments for each of the four major ATON types (buoys, daybeacons, lights, and special signals) follow.

BUOYS

Buoys are specially marked floating ATON that can be either lighted or unlighted. They are moored to the seabed by concrete anchors called "sinkers"; chain or synthetic rope moorings connect the sinkers to the buoys. When marking channels, buoys are placed inside the channel edge; when marking obstructions, they are placed on the channel or navigable side of the obstruction. Buoys can shift location due to sea conditions and can be struck and dragged by passing vessels. For these reasons, and because it is difficult to position buoys and their sinkers in precise geographical locations, buoy positions are verified during scheduled maintenance visits. Buoy positions as indicated on nautical charts should be taken by mariners as only approximate.

Some unlighted buoys (85 to 780 pounds) are manufactured from plastic because plastic is less expensive than steel, easier to handle, and requires no maintenance. Steel is still more effective than plastic for larger buoys and buoys subjected to ice, flotsam, and severe service environments, because steel's greater weight provides better stability in rough seas and greater resistance to damage from collisions.

Buoy technology has changed over the last thirty years. Acetylene and primary (lead-acid) batteries were used to illuminate buoys until the mid-1960s when they were phased out in favor of non-rechargeable carbon zinc batteries. In the 1970s the era of electronics saw radar reflectors, transistorized flashers, and photo cell daylight controls being used as standard buoy equipment. Solar-powered buoys were introduced in 1983, reflecting the decade's commitment to alternative energy sources.

Buoys are classified into lighted, unlighted, and ice. Unlighted buoys are classified by shape: cylindrical (can), conical (nun), and spherical; and by sound.

- *Lighted Buoys*. Buoys that are powered by solar power, lead-acid batteries, conventional batteries, wind, and waves. Light colors and rhythms have special meanings and are described in the subsection on Aid Markings and Light Characteristics. Lighted buoys have a tower on top of the buoy body. In addition, some also have colored shapes on top called *topmarks*.

- *Can Buoys*. Cylindrical-shaped buoys that mark the port (left) side of the channel when proceeding from seaward. They have solid green or green and red horizontally banded marks (green on top).
- *Nun Buoys*. Conical-shaped buoys that mark the starboard (right) side of the channel when proceeding from seaward. They have solid red or red and green horizontally banded marks (red on top).
- *Spherical Buoys*. Round-shaped unlighted buoys with red and white vertical stripes that mark safe water. They are also used as mooring buoys, when painted appropriately.
- *Sound Buoys* (also called Fog Signals). These buoys use sound to warn mariners of danger when visibility is restricted. They are identified by their tone. Horns produce sound using a disc diaphragm vibrated by electricity. Since other sound signals are activated by the motion of the sea, they do not have a regular sound pattern. *Whistles* produce sound by forcing air through a slot into a cylindrical bell chamber. *Bells* produce sound using a tapper activated by waves. *Gongs* are activated by waves, producing sounds of various tones. Most sound buoys are also lighted.
- *Ice Buoys*. These buoys are seasonal, replacing lighted or unlighted buoys in the fall. Lighted ice buoys have a short heavy mast supporting a lamp with a heavy waterproof lens, enabling the buoy to endure icy conditions much better than conventional buoys of the same size. Ice buoys incur less damage in icy conditions than other buoys, but their drawback is that they are less visible to mariners.

The Coast Guard also maintains other types of special buoys for operational and developmental use. *Fast Water Buoys* (*FNPR* and *FCPR*) are unlighted foam-filled plastic nun and can buoys used to mark fast flowing water and are used primarily in District 2. *Discrepancy Buoys* are plastic buoys with a daymark (daytime ATON identifying marks) that temporarily replace discrepant buoys in protected locations. *Exposed Location Buoys* (9x35-foot ELBs) are very large buoys equipped with lights, sound signals, radiobeacons, and radar beacons (racons). They support the complex navigational equipment of large ocean-going vessels.

Buoy selection depends on the environmental conditions in the area (wind, wave, depth, and current) and the physical characteristics of the buoys available (such as weight, draft, and required sinkers). Figures 12 through 14 illustrate lighted, can, and nun buoys.

Table 8 and Table 9 summarize the operating characteristics of standard buoys.

Figure 12. LIGHTED BUOY

Figure 13. CAN BUOY

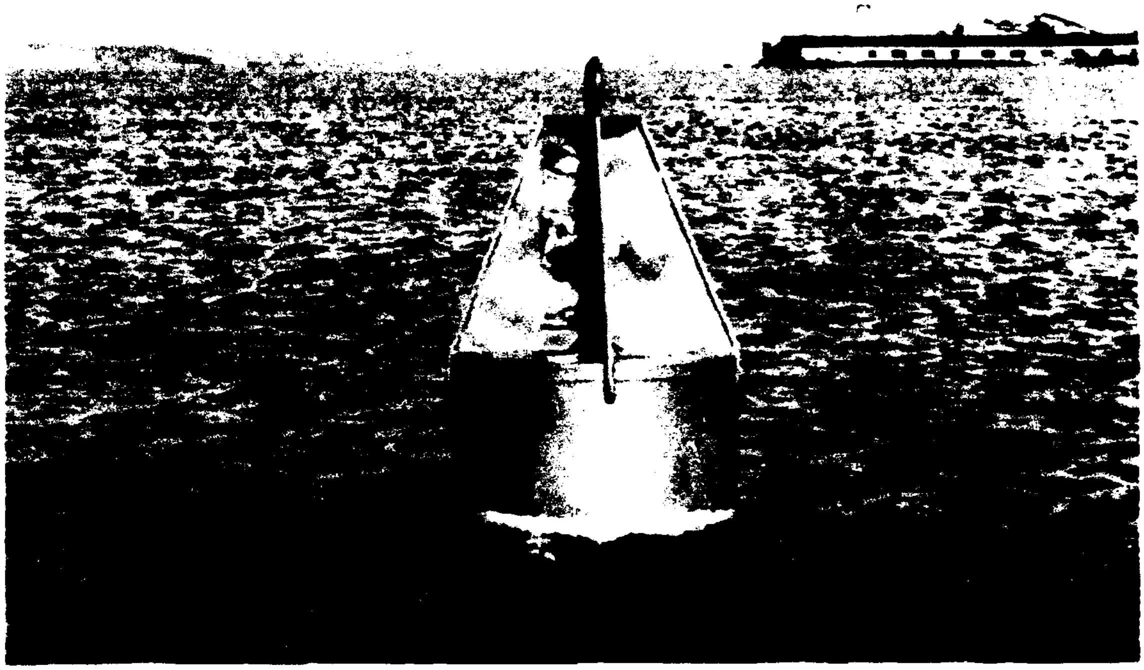


Figure 14. NUN BUOY

Table 8. STANDARD LIGHTED BUOYS: CHARACTERISTICS

TYPE (WIDTH X HEIGHT [ft])	APPROX-IMATE NUMBER IN USE	OPTIONS*	AVERAGE WEIGHT (LBS)	NOMINAL VISUAL RANGE (NMI)**	OPERATING ENVIRONMENT
9X35	50	B, H, R, W	18,350	3.9	Exposed
9X32	50	B, H, R, W, H	18,640	3.8	Exposed
9X20	50	B, G, R	8,100	3.0	Exposed
8X26	1,700	B, G, R, W, H	11,820	3.2	Exposed
7X17	550	B, H, R	7,810	2.3	Semi-exposed in shallow water
6X20	1,050	B, H, R	6,070	2.1	Semi-exposed
5X11	750	C, N, R	3,000	1.4	Protected in shallow water
$3^1/_2$X8	275	C, N, R	1,490	1.4	Most protected locations in shallowest water

* W = Whistle, H = Horn, G = Gong, B = Bell, C = Can, N = Nun, R = Radar Reflector

** Nominal visual ranges indicate typical distances in nautical miles (NMI) at which lighted buoys can be seen.

Table 9. STANDARD UNLIGHTED BUOYS: CHARACTERISTICS

TYPE (WIDTH X HEIGHT [ft])	APPROX-IMATE NUMBER IN USE	OPTIONS*	AVERAGE WEIGHT (LBS)	OPERATING ENVIRONMENT
STEEL				
1st Class 5X20	300	C, N, R	5,500	Most exposed
2nd Class 4X14	1,200	C, N, R, S	2,550	Exposed
3rd Class 3X9	2,400	C, N, R, I	1,150	Semi-exposed, ice conditions, or where non-radar reflective buoys required
4th Class 2X10	6,500	C, N, R	230	Rivers
5th Class 2X9	2,650	C, N, R, I, P	120 (Plastic) 700 (Others)	Ice conditions or where small non-radar reflective buoys re-quired. Plastic buoys temporarily used in protected locations. Not suitable in ice.
6th Class 2X8	1,870	C, N, R, I, P	180	Western rivers. Lighter weight plastic buoys temporarily used in protected locations. Not suitable in ice.
FOAM				
2nd Class 6X13	4	C, N, R	80	Semi-exposed locations in fast water. Not suitable in ice.
3rd Class 5X11	8	C, N, R	550	Semi-exposed locations in fast water. Not suitable in ice
4th Class 4X9	30	C, N, R	230	Semi-exposed locations in fast water. Not suitable in ice.
5th Class 3X7	185	C, N, R	130	Protected locations in fast water. Not suitable in ice.
6th Class 2X5	26	C, N, R	40	Most protected locations in fast water. Not suitable in ice.

* C = Can, N = Nun, R = Radar Reflector, P = Plastic, S = Special, I = Ice Top

DAYBEACONS

In contrast to buoys, which are floating ATON structures, daybeacons are permanently attached to the earth's surface. Daybeacons are support platforms made up of single or multiple piles with an attached daymark to ensure the structure is visible during the day. Piles are long slender columns, usually constructed of wood, steel, or concrete, driven into the bottom of the waterway to support daybeacons and lights. The color and shape of a daybeacon's daymark depends on the marking system used in the waterway. Figure 15 illustrates a daybeacon with an attached daymark.

Figure 15. DAYBEACON

MAJOR LIGHTS

Major lights are lights of moderate to high power located on a fixed structure. Lighthouses are major lights. Coastal major lights assist vessels during coastal navigation and when making landfall. Inland major lights are found in bays, sounds, and coastal approaches and function as leading lights, obstruction marks, sector lights, or reference marks from which to obtain a visual bearing. Most lights are inspected annually or semi-annually, depending on the intensity of the light.

Major lights range from the familiar seacoast lighthouse to the screw pile Thomas Point Light in Chesapeake Bay (Figure 16) to the newer lighthouse replacement structure Seven Foot Shoal Light in the approach to Baltimore harbor (Figure 17). In general, they are unmanned and are constructed from granite, brick, cast iron plate, stone, concrete, or steel. Lighthouses with no lateral significance display a white light, except where *sector lights* are used to warn of dangers to navigation, such as shoals. When viewed from different directions, the sector light lens changes color. Since sectors provide approximate bearing information, the mariner should note where the color change occurs and consider it a warning rather than use it to determine his/her exact location.

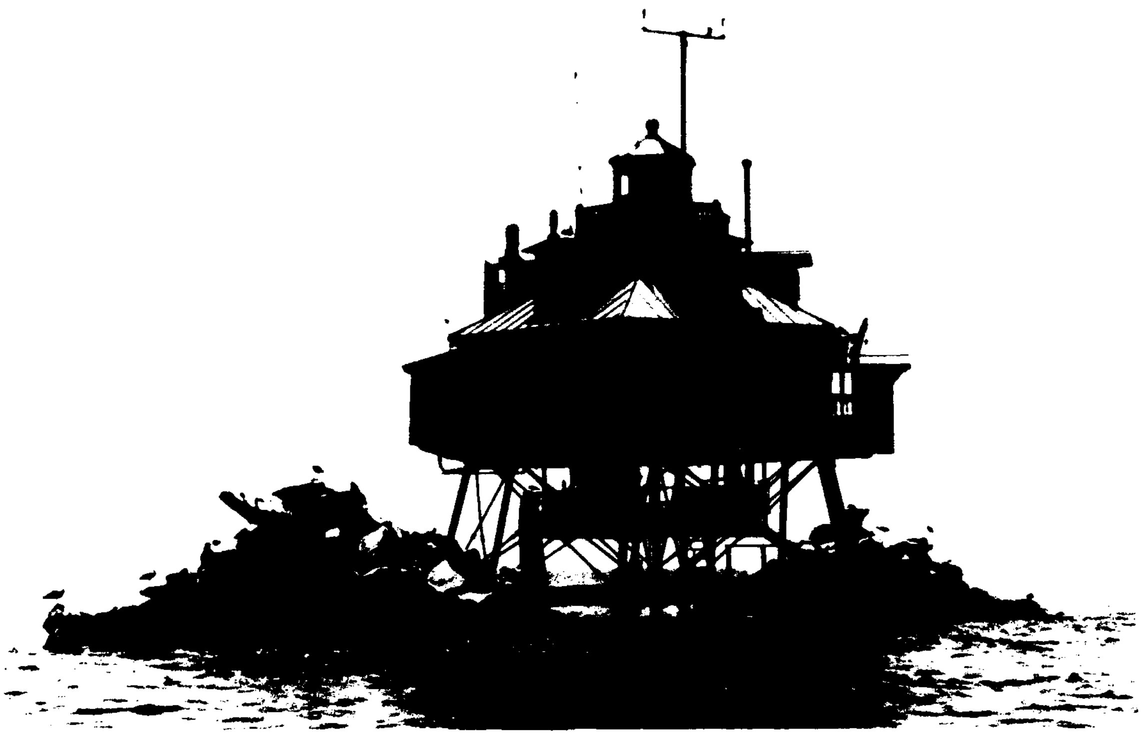


Figure 16. SCREW PILE MAJOR LIGHT

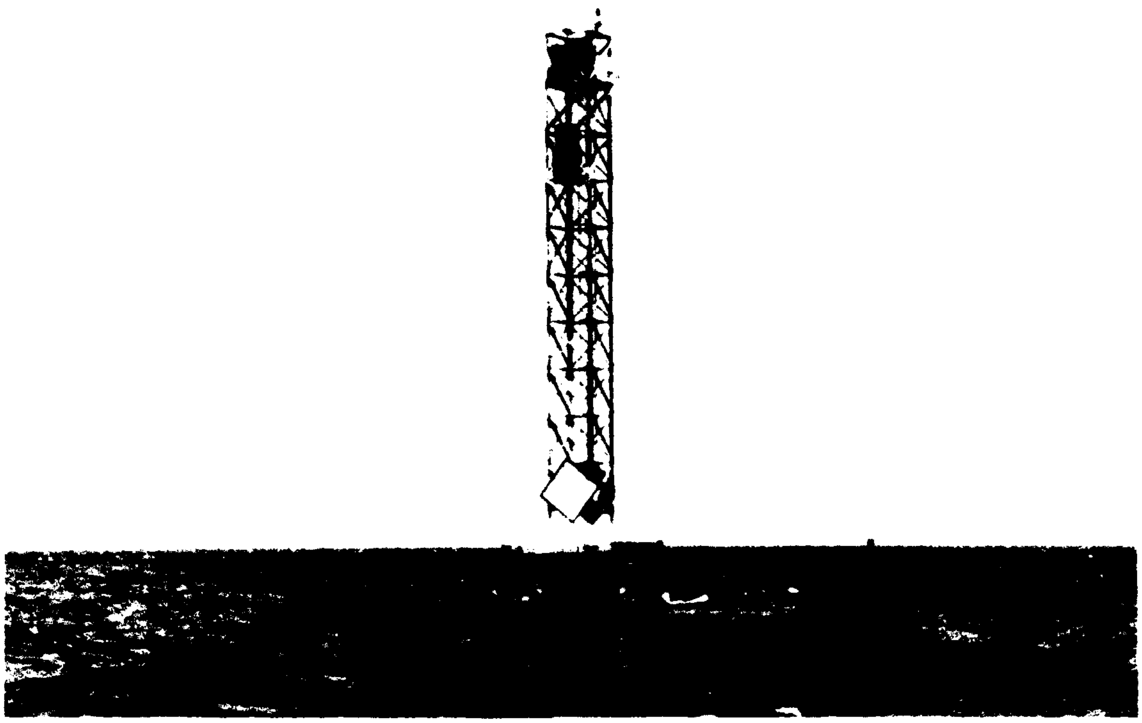


Figure 17. LIGHTHOUSE REPLACEMENT STRUCTURE

MINOR LIGHTS

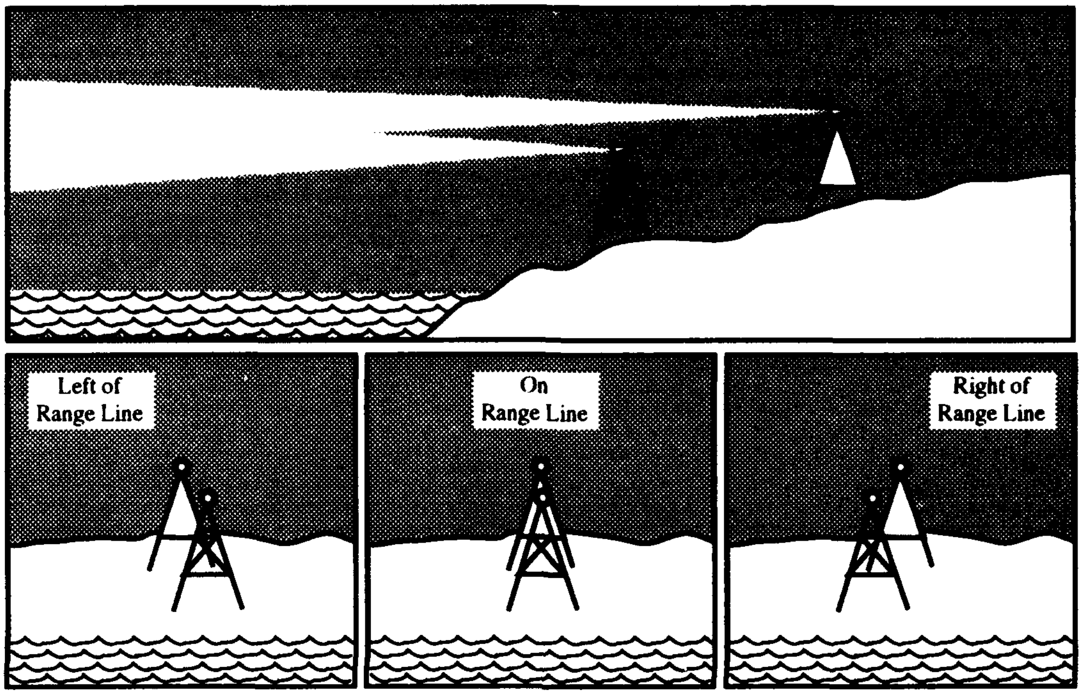
All lighted structures, other than major lights, are termed minor lights.

Lighted beacons are minor lights and are located in water or set back from channel edges. Compared to bucys, beacon signals are more stable, providing a higher quality signal to the mariner, and, in most cases, also cost less to maintain. Beacons are chosen over buoys where water depths and bottom surfaces permit the building of a light structure, where severe ice conditions do not routinely threaten the structure, where there are infrequent collisions with vessels, and where buoy positioning is difficult. As a result of the recommendations of the 1970 Booz-Allen study[9], over the past two decades the emphasis has shifted in favor of more beacons and fewer buoys.

Ranges consist of two beacons positioned so that, when they appear in line, the viewer is on a specific line of position. Ranges are generally, but not always, lighted and display rectangular daymarks of various colors. The appropriate nautical chart must be consulted when

[9] Booz-Allen Applied Research, Inc., *Servicing System for Short-Range Aids to Navigation.*

using ranges in order to determine if the range marks the centerline of the navigable channel, and also to ascertain what section of the range may be safely traversed. Figure 18 illustrates a range.



Range lights may be white, red or green, and display various characteristics to differentiate them from surrounding lights.

Figure 18. RANGE

SPECIAL SIGNALS

Radar Beacons (*racons*) are special ATON devices that transmit a Morse-code reply when triggered by a radar signal. Racons identify their locations, provide radar enhancement, and help vessels transit from ocean to inland navigation. They are most useful during periods of poor visibility and are placed on other ATON, on prominent points of land, and even on bridges. Racons operate in the marine X-band from 9,300 to 9,500 MHz and in the 2,900 to 3,000 MHz marine radar S-band. Reception varies from six to eight nautical miles when mounted on a buoy to as much as 17 nautical miles for a racon with directional antenna mounted at a height of 50 feet on a fixed structure. There has been a recent increase in the number of operational racons.

Radar Reflectors are fixtures attached to buoys and fixed structures that reflect radar signals and enable radar-equipped vessels to detect ATON (although a vessel's radar system cannot positively identify a radar target as an ATON).

Sound Signals warn mariners of danger during periods of reduced visibility. Diaphones, horns, sirens, whistles, bells, and gongs are located on fixed structures or buoys to produce sound. The sound range of the signal varies from one-half to three nautical miles. Fixed structure sound signals have a different sound pattern than buoy signals, producing a specific number of blasts and silent periods each minute when operating. Other than horn buoys, there is no established sound pattern to buoy signals, since they are activated by the motion of the sea. Distance cannot be accurately determined by sound intensity and mariners should not rely exclusively on sound to determine their position. Mariners should also not rely on wave-powered sound buoys to produce signals when the sea is calm. Most sound signals are inspected semiannually.

AID MARKINGS AND LIGHT CHARACTERISTICS

Light colors and markings on buoys and fixed structures alert the mariner to various navigation features. COMDTPUB P16502.8 *Coast Guard Aids to Navigation* contains further information on types of marks, characteristics of lights (patterns), and characteristics of ATON (colors, rhythms, and numbers).

ATON DISTRIBUTION

The number of federal ATON under Coast Guard control and operation has increased moderately from 45,375 in 1970 to 50,698 at the beginning of 1993. Almost 50% of all ATON are buoys; of this total, over 80% are unlighted. Twenty-three percent of federal ATON are lights, 21% are daybeacons, and 5% fall into the "Other" category, consisting of ATON maintained by either other federal agencies or private contractors. Table 10 shows the ATON distribution by district.

PRIVATE ATON

There are 48,000 private ATON used throughout the United States, operated and maintained by individuals or organizations other than the Coast Guard, but conforming to the standard United States system. The owner of an obstruction to navigation is required to maintain private ATON if the Coast Guard determines that marking by the Coast Guard would benefit only a limited number of users and cost far more than the resulting expected benefits. Private ATON are frequently erected along the Gulf Coast to mark offshore oil drilling platforms. Other uses include the marking of marinas, commercial marine facilities, and wrecks. The Coast Guard has responsibility for inspecting private ATON to verify they are on station and are exhibiting the correct signals. Private ATON may be established, changed, or discontinued only with the permission of the appropriate Coast Guard District Commander.

Table 10. ATON DISTRIBUTION BY DISTRICT

DISTRICT	BUOYS			LIGHTS	DAY-BEACONS	OTHER*	TOTAL ATON
	LIGHTED	UNLIGHTED	TOTAL				
1	1,082	3,663	4,745	659	279	3	5,686
2	12	9,928	9,940	2,051	1,519	1,727	15,237
5	865	1,245	2,110	2,173	2,464	0	6,747
7	624	326	950	2,009	3,442	0	6,401
8	459	3,331	3,790	2,100	2,519	0	8,409
9	596	1,036	1,632	691	104	155	2,582
11	241	174	415	571	133	903	2,022
13	286	319	605	1,026	241	17	1,889
14	84	133	217	185	104	0	506
17	182	247	429	619	165	6	1,219
TOTALS	4,431	20,402	24,833	12,084	10,970	2,811	50,698

* Includes Large Navigational Buoys (LNBs), contract-maintained ATON, and ATON managed by other federal agencies.

5. HOW BUOYS ARE SERVICED

In most cases, the Coast Guard schedules regular annual visits to all ATON, with the exception of seasonal buoys located in areas with severe winters, which are visited twice a year. However, there are occasions when there are ATON discrepancies (the ATON fails to produce the proper signal in the assigned location) and the Coast Guard must respond to the problem.

SCHEDULED SERVICING

There are four types of routine servicing performed on ATON: inspection, mooring inspection, recharge, and relief.

- *Inspection.* An ATON is painted, cleaned, its position and voltage checked, material and lamps replaced, and solar panels cleaned. Inspections are performed annually and whenever an ATON is visited for any reason.
- *Mooring Inspection.* The underwater mooring of lighted and unlighted buoys is examined, and, if necessary, replaced, cleaned, and/or repaired. Scheduled mooring inspections occur every two years.
- *Recharge.* Batteries of a lighted aid (lighted buoys and lights) are replaced. Scheduled recharges occur every three years for ATON powered by standard batteries, and every five years for solarized ATON.
- *Relief.* The body of a lighted or unlighted buoy is replaced. Reliefs are scheduled every six years.

A seasonal buoy requires at least two annual visits, the first for placing the buoy, and the second for its removal or replacement. Servicing schedules for seasonal buoys depend on the type of ATON, environmental conditions, and local requirements. In locations where icy winter conditions damage or drag ATON from their positions, common practice is to remove ATON from the water in the fall and replace them in the spring.

The length of a servicing trip by a buoy tender depends on the number of ATON deployed. District 1 (Northeast) with its long, rocky, and often fogbound coastline and many commercial, fishing, and recreational activities, has both the highest number of ATON serviced by WLBs and WLMs, and the largest WLB/WLM fleet. This dense population of ATON results in servicing trip lengths of only one to three days, in comparison to trip lengths of three to four weeks in the large geographic areas of District 14 (Hawaii) and District 17 (Alaska) where ATON are widely dispersed.

SERVICING AN ATON

Figure 19 sequentially illustrates the 157-foot WLM *USCGC Red Birch* relieving a 7X17LR buoy in District 5. Buoy reliefs consist of lifting the buoy, chain, and sinker up onto the vessel deck, disconnecting and inspecting the mooring, positioning and placing the sinker and chain, and lowering the new buoy into the water.

UNSCHEDULED SERVICING

A discrepancy occurs when an ATON fails to produce the proper signal in the assigned location. Examples of discrepancies include an ATON drifting off position, a dead battery, and damage caused by vessel collisions.

Discrepancy response policy is described in the Coast Guard's *Discrepancy Response Decision Guide*[10]. Response levels depend on the criticality of the ATON, the nature/severity of the discrepancy, and operating policies within individual districts. The unique nature of District 2, for example, makes that District's discrepancy response policy very different from that of other districts. In descending level of priority, discrepancies are either Immediate (respond immediately), High Priority (within 18 hours), Priority (within 36 hours), Routine (within 72 hours), or Decision/Deferred (beyond 72 hours). District Commanders are also responsible for listing both existing discrepancies and corrected discrepancies in the weekly *Local Notices to Mariners*.

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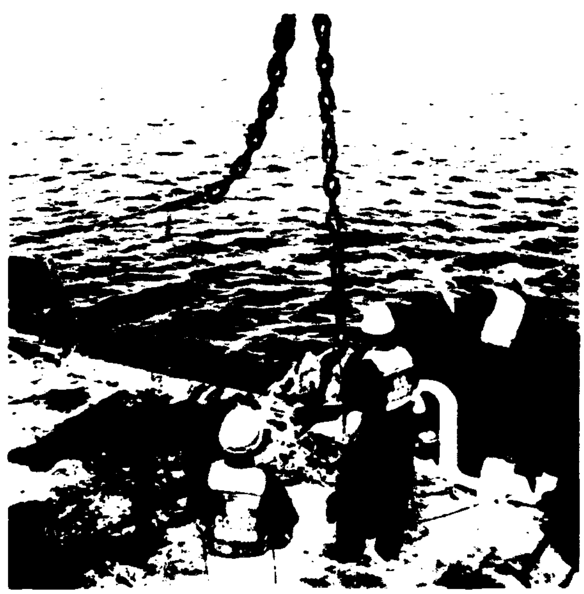
[10] U.S. Department of Transportation, U.S. Coast Guard, *Aids to Navigation Administrative Manual*, COMDTINST, M16500.7.

1. The WLM crew prepares a buoy lantern prior to relieving a 7X17LR.

2. A cage line hooked into the buoy cage is led through the hoisting bail and the hook pulled into place.

3. The buoy is hoisted aboard. Fluctuations caused by the seas are controlled by the wire rope from the cross deck winch and hand tended cage lines.

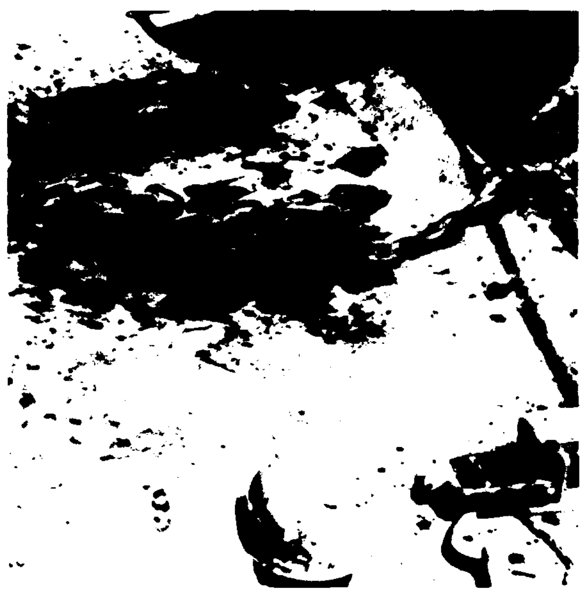


4. The mooring chain is hoisted on board.

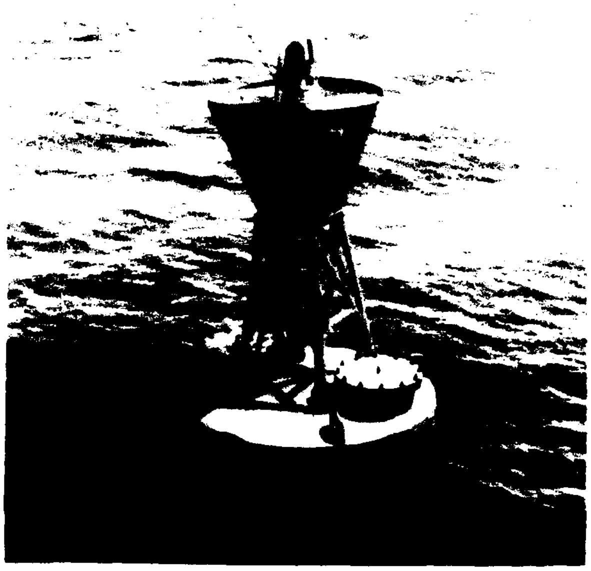
5. The concrete sinker is hoisted, washed off, and brought aboard.

6. The mooring is disconnected and inspected.

7. Worn chain is replaced using heated and riveted shackles.



8. After repairing the mooring, the sinker is released and the mooring allowed to run. The upper end is secured on deck.



9. Once the sinker is on the bottom of the sea floor, the new buoy is lowered into the water and released.

Figure 19. *USCGC RED BIRCH* SERVICING A BUOY

6. ATON IN THE 21ST CENTURY

The Service Force Mix 2000 Project (SFM 2000) is a recent Coast Guard initiative to analyze fleet mix requirements for buoy tender replacements. A major assumption in developing the fleet mix was that there should be sufficient buoy tending capability to meet multi-mission requirements (SAR, MER, ELT) while maintaining the existing Short Range ATON system.

SFM 2000 recommended a fleet mix for replacement buoy tenders of 16 WLBs and 14 WLMs, a reduction of seven from the current fleet of 37 vessels. The reduction of WLBs from 26 to 16 is especially significant because it eliminates virtually all redundancy in the heavy lift discrepancy response capability in order to minimize overall fleet costs. SFM 2000 also recommended that additional BUSLs may be required to provide secondary response capabilities. The Coast Guard is currently analyzing future BUSL requirements produced by SFM 2000 impacts. The analysis is also addressing the required number of BUSLs needed for the buoy work of ANTs, inland tenders (WLIs), and inland construction tenders (WLICs).

Since the phase-in process of the replacement vessels will be ongoing for the next ten years, it is likely that changes will occur in SRA mission requirements. These changes will result in reassessments of fleet requirements. Efforts are under way to determine the likely fleet mix based on projected changes in ATON hardware, servicing platforms, navigation technology, and maritime commerce.

ATON HARDWARE TECHNOLOGY

Over the past forty years ATON hardware technology improvements, such as switching from acetylene lamps requiring quarterly servicing to solar-powered electric lamps requiring only annual servicing, have partially accounted for the gradual reduction in the servicing fleet from 110 vessels (WLBs, WLMs, WLIs, WLICs, and WLRs) in 1970 to 77 in 1993. The Coast Guard continues to research technology improvements in beacon types, lighting, and buoys.

Buoyant Beacons

The Coast Guard is testing buoyant beacons, which are float chambers or plastic floats attached to a large sinker. They resemble a fixed structure since the tension from the sinkers keeps the beacons upright. These types of beacons could replace buoys as well as some fixed aids since they offer smaller watch circles (the area in which a buoy's attached chain permits the buoy to move) and better collision tolerance. Other advantages include a stable platform and signal, and the ability to mark narrow channels with greater precision than conventional buoys. Buoyant beacons are currently in widespread use off the Italian coast, the Mediterranean coast of France, and throughout the Suez Canal.

The Coast Guard is currently testing buoyant beacons in water depths of 60 feet and may test them in deeper water in the future. Projections are that the beacons will require service by

WLBs/WLMs only once every ten years (excluding discrepancies), with ANTs providing interim servicing. Figure 20 is a diagram showing a buoyant beacon currently being tested by the Coast Guard on the left and a conventional buoy on the right. It illustrates the narrower watch circle of the buoyant beacon compared to that of the conventional buoy.

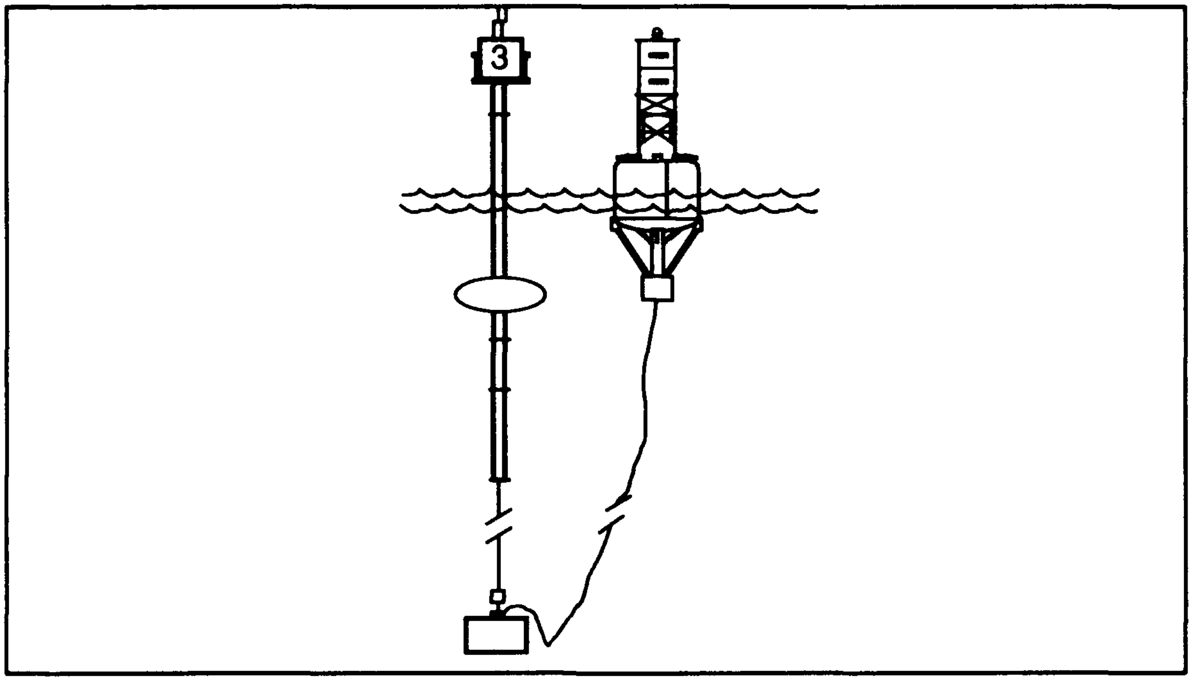


Figure 20. BUOYANT BEACON AND CONVENTIONAL BUOY

Several issues relating to buoyant beacons have emerged. First, it is not known how well they can tolerate ice conditions. If an ice top is used, a lift may be required for installing the ice top for winter and for redeploying the regular beacon top in the spring (the same procedure used now for ice buoys). Second, fleet requirements could change since it is possible that only WLBs could deploy this type of beacon. This would reduce the need for WLMs but could possibly increase the need for WLBs. The Coast Guard is continuing to study the capability and impacts of buoyant beacon technology.

Improved Lighting

The Coast Guard has long recognized the limitations of current ATON lighting technology. Commercially powered ATON are relatively inexpensive compared to other power sources, but require lengthy submarine cables or long spans of Coast Guard owned and maintained power lines. Diesel generators used for ATON with large power requirements need to be serviced frequently since they operate around the clock; some remote sites must even be serviced by helicopters. High voltage solar arrays powering newer ATON require many panels and supporting structures, a large number of batteries, and complex electronic charge controllers. Finally, lamp life is approximately one year for the current six-lamp system. Research is underway into longer-lasting lights capable of emitting higher intensities with less power. Longer lasting lights, along with improvements in chain and paint life, could increase ATON servicing intervals and reduce servicing resource requirements.

Lighting improvements for minor lights and buoys is expected to be less significant since many of these ATON are already solar-powered by inexpensive 12-volt systems. The exception is minor lights powered by batteries. Batteries have been a potential environmental hazard since their introduction. They may be lost in the water due to collisions and must be disposed of as a hazardous waste. The switch from carbon-zinc primary batteries to lead-acid solar batteries has improved the situation, because the batteries are inherently less hazardous. The Coast Guard is looking into replacing batteries with other power sources and is researching ways of simplifying lantern hardware, such as using smaller but more powerful batteries.

Plastic Buoys

Buoys manufactured from plastic may offer some advantages over steel buoys in certain circumstances. In general, they are easy to handle and require significantly less maintenance and replacement than steel.

The Coast Guard has experimented with unlighted plastic and foam buoys between 85 to 780 pounds, and has found them to be very cost-effective. Nevertheless, they have limitations within their working environment and are more easily damaged by collisions and ice. Other countries, including England, have tested fiberglass hulls for larger buoys up to 18,350 lbs (9X35), but their cost-effectiveness is not yet proven.

For lighted buoys in exposed locations where ATON stability is critical, buoy and mooring (sinker and chain) weight become an issue. Too heavy a chain can submerge some small plastic buoys. Braided nylon is one answer to lightweight moorings and is in limited use in very deep water such as Puget Sound. However, observations have shown that buoys moored with nylon line rather than metal chain in shallow water have a greater possibility of dragging their sinkers and ending up off-station.

It is unclear whether or not large plastic buoys can be cost-effective or can reduce servicing requirements. The Coast Guard is performing further research into the capability and applicability of plastic buoys.

SERVICING PLATFORM TECHNOLOGY

Next-generation seagoing buoy tenders (Juniper Class WLBs), coastal buoy tenders (Keeper Class WLMs), and buoy boats (BUSLs) will begin to be phased in during 1994 for

BUSLs and 1996 for WLBs and WLMs. Vessel design, mechanical equipment, vessel electronics, and mission needs have all had an impact on the replacement buoy tenders.

Vessel Design

Advanced vessel design technologies such as swath and hydrofoil were considered for the replacement WLB and WLM buoy tenders but were found to be impractical for the ATON mission. Research is still ongoing to identify possible improvements to hull shapes and propulsion plants. To date, no new hull technology can meet the draft, seakeeping, stability, and loading flexibility requirements simultaneously. Even though operating efficiency is likely to improve (resulting in cost reductions), there is expected to be little impact on fleet requirements.

Sensitivity analysis of vessel speeds was performed in 1989 and again in 1992 as part of the SFM 2000[11,12,13]. Results showed that only in areas characterized by long open ocean transits, such as Alaska and Hawaii, would greater vessel speeds or multiple vessel types significantly lower fleet requirements. However, naval engineering studies have shown the added costs of acquiring vessel speeds beyond those specified for the replacement vessels would be prohibitive.

Mechanical Equipment

Buoy deck technology has improved significantly since the 1940s when much of the current buoy tender fleet was constructed, yet future operational requirements will still be labor intensive. The replacement buoy tenders will offer improved chain-hauling systems and larger working areas. In addition, human engineering of weight handling systems will reduce personnel requirements for deck operations and will automate some labor intensive processes. Examples currently under development include buoy washing systems, improved and clustered machinery controls with automatic tensioning and feedback, and automatic buoy tie-down systems.

Vessel Electronics

A differential global positioning system (DGPS) will be implemented on the replacement buoy tenders, significantly reducing the time and labor required to position buoys. In addition, DGPS will enable the Coast Guard to position buoys during poor visibility conditions.

Engineering concepts such as vibration analysis, trend monitoring, self-test equipment, failure prediction through artificial intelligence, and other predictive maintenance techniques are

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11 Naval Engineering Division, U.S. Coast Guard, *Feasibility Study for Seagoing Buoy Tenders (WLB).* CG-ENE-5-89-0003, November 1989.

12 Office of Navigation Safety and Waterway Services, U.S. Coast Guard, *Seagoing Buoy Tender (WLB) Requirements Trade Off Analysis,* December 1989.

13 Volpe National Transportation System Center, U.S. Department of Transportation, *Aids to Navigation Service Force Mix 2000 Project, Volume I: Development and Application of an Aids to Navigation Service Force Mix Decision Support System, Final Report.* DOT-VNTSC-CG-92-2.1, June 1992.

being examined. Results from these studies will help reduce crew requirements and increase reliability. Related developments in the commercial sector may produce further efficiencies in buoy tender operations.

A new dynamic vessel positioning system is being introduced on the replacement buoy tenders that will, in effect, be able to keep the vessel stationary. Dynamic positioning represents a significant improvement over the current labor-intensive process of continuously recording positions and repositioning the vessel until the buoy handling equipment is properly situated for placing a buoy on its assigned position.

Missions

WLBs and WLMs have played important roles in MER over the last few years. Environmental concern is of growing national importance. To improve their MER capabilities, WLBRs will be equipped with on-board oil recovery devices, making them valuable resources for oil spill response.

Responsibilities imposed by the Oil Pollution Act of 1990 require the new Coast Guard buoy tenders to be able to recover spilled oil. Until the new vessels have been deployed, it is difficult to project accurately the amount of effort that will be devoted to oil recovery.

NAVIGATIONAL NEEDS

During the past fifty years, increased use of electronic navigation (such as radar and LORAN) has reduced the need to rely solely on visible ATON. At the same time, the needs of maritime commerce and the size of ships have grown. To date, these two impacts have balanced relatively well, resulting in a modest average growth in the number of ATON since 1980 of 1% a year. The Coast Guard is currently studying the projected impacts on ATON that will be produced by improved navigation systems and the growth in maritime commerce.

Navigation Technology

Merchant vessel navigation is expected to improve significantly through the new Electronic Chart Display and Information System (ECDIS) using DGPS.

The degree of market penetration of this navigation technology will be driven by cost and regulation. The marginal user will be less likely to buy technology when alternatives exist. However, as merchant vessels become more certain of their position through ECDIS, the need for some buoys primarily used by these vessels (for example, traffic separation buoys in offshore areas) may become less critical.

Developments in Maritime Commerce

Passenger vessel transits are forecasted to exceed the 1987 level by 43% in the year 2010 and commercial vessel transits by 194% according to a 1991 Coast Guard vessel traffic study[14]. The forecasted percentage increase in commercial transits is not evenly distributed across the various vessel types (see Figure 21). For example, tanker barge tow transits are projected to increase 24% between 1987 and 2010, whereas the tug/tow boat projection is 67%.

To accommodate the annual increase in marine traffic, in recent years there has been a trend towards marking secondary waterway channels for smaller vessels. The end result is that a single waterway can have separate marking systems for three different vessel classes: large deep draft vessels; smaller commercial vessels (usually towboats); and pleasure or small commercial users. As vessel sizes continue to increase, the large deep draft vessel class may become two classes in the future.

New waterways are still being established and existing waterways are being expanded and improved. For example, the Chesapeake channel was deepened to 50 feet. This trend is expected to continue, but a lower service level may be provided in newer waterways than the "traditional" service provided in older waterways, since newer waterways are marked according to a reduced set of user needs. Due primarily to improved electronic navigation systems, it is possible that users of waterways in the future may be able to operate safely with a decreased level of Short Range Aids to Navigation than that required when existing waterways were developed.

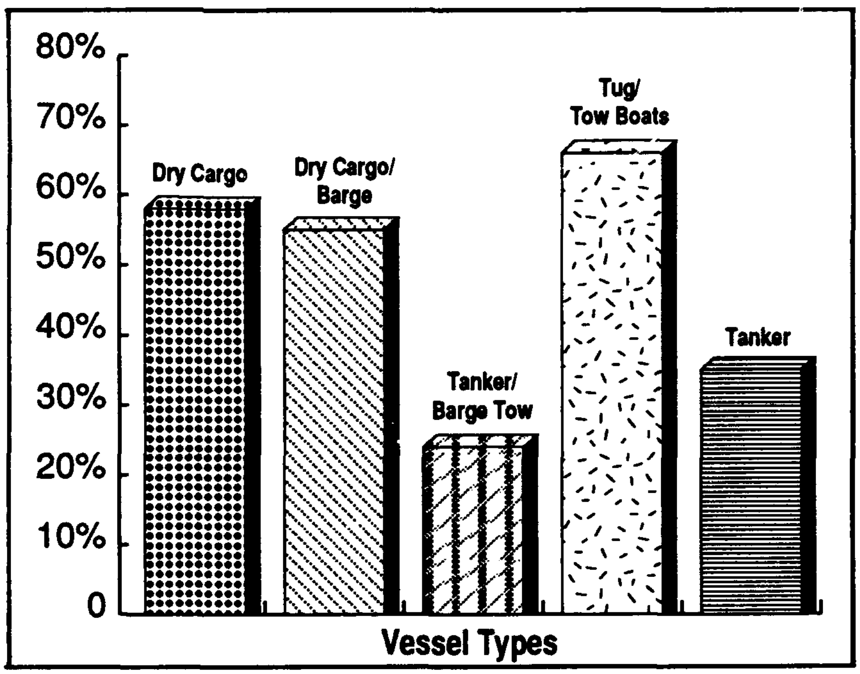

Figure 21. PROJECTED PERCENTAGE INCREASES IN VESSEL TRANSITS 1987-2010

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[14] U.S. Department of Transportation, U.S. Coast Guard, *Ports Needs Study (Vessel Traffic Services Benefits)*, DOT-1-CG-N-01-91-1.2, August 1991.