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The Coast Guard's VHF-FM National Distress System: analysis for recapitalization.

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THE COAST GUARD'S
VHF-FM NATIONAL DISTRESS SYSTEM:
ANALYSIS FOR RECAPITALIZATION

by

William C. Glidden

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In this thesis the author first details the C^2 structure of the Coast Guard and identifies it major missions, and then relates history of the NDS. An examination of the NDS' current configuration is performed, the requirements are identified, and applicable technology is explored.

The author concludes that present technology and commercially available equipment is available to solve the present and anticipated requirements placed upon the NDS. The author provides a model of the proposed system and presents an implementation schedule for replacement of the NDS.

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The Coast Guard's VHF-FM National Distress System: Analysis for Recapitalization

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ABSTRACT

Twenty years ago the U. S. Coast Guard established the National Distress System (NDS) of VHF–FM remote–controlled transceivers to provide nationwide maritime distress coverage and Coast Guard C^2 communications. The NDS was designed to provide radio coverage along the coasts, the inland waterways, and the Great Lakes. The current NDS equipment is reaching the end of its useful life and the new requirements placed upon the system have mandated its replacement.

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I. INTRODUCTION

A. BACKGROUND

Approximately 20 years ago the United States Coast Guard established a network of coastal and inland Very High Frequency–Frequency Modulated (VHF–FM) transceiver sites for the purpose of monitoring the National VHF–FM Maritime Distress Frequency, 156.8 Mhz, CH 16. This network was originally called the "National VHF–FM Radio-telephone Safety and Distress System," later shortened to the "National VHF–FM Distress System" (NDS), and now commonly referred to as the "high sites." This system was installed to:

> ...provide distress, safety, and command and control VHF–FM communications coverage... in all areas of boating activity (including inland waters) in which the Coast Guard has SAR responsibilities... [Ref. 1:p. 1]

This NDS has served the Coast Guard well over the past 20 years for Search and Rescue (SAR), internal command and control (C^2), and interaction with the boating public. However, the increase in the number of VHF–FM "marine band" channels used by the public, the improvements in VHF–FM technology, and the aged condition of the original equipment has resulted in the need to replace the current outdated hardware with "state of the art" technology.

In addition to the improvements in technology, there have been increased requirements placed upon the Coast Guard and the VHF–FM communications system. The initiation of the Digital Selective Calling (DSC) standard, a demand for Radio Direction Finding (RDF), the concept of dependent surveillance, and the need for using secure internal communications for Coast Guard C^2 have all worked together to precipitate the NDS replacement project or "recapitalization."

B. RESEARCH OBJECTIVE

The purpose of this research is fourfold. First, to examine the original purpose and configuration of the NDS. Second, to identify both the established and potential additional requirements placed upon the NDS since its inception. Third, to investigate and summarize the technology that is applicable for fulfilling those new requirements. Finally, to make conclusions and recommendations regarding the configuration and capabilities of the new system.

C. RESEARCH APPROACH

The research portion of this thesis includes a literature search, a review of Coast Guard directives and policy regarding the NDS, collection of information from Coast Guard Engineers and Project Managers regarding current Coast Guard initiatives, and a survey of available technology. This survey will include obtaining manufacturers' information and specifications regarding equipment currently in production or planned for production.

D. IMPORTANCE TO THE COAST GUARD

This thesis will represent a complete analysis of the present NDS, the new requirements placed upon it, and the applicable technology available to fulfill those requirements. The NDS is a vital communications system, and as such supports a large part of the Coast Guard's C^2, especially at the Group/Air Station/Captain of the Port level and below. (The term Group will be used throughout this thesis but will generally mean all three). Need for increased utility of the system, coupled with a more restrictive budget climate, mandates that the replacement of the NDS be performed in the most cost-effective manner while still fulfilling the requirements of the system.

Current Coast Guard initiatives in several areas may have an influence on the NDS upgrade. These initiatives include (but are not limited to) the Differential Global Positioning System (dGPS), the Vessel Traffic Service (VTS), Radio Direction Finding (RDF), Digital Selective Calling (DSC), Geographical Display Operations Computer (GDOC), the Hybrid Data Network (HDN), the Secure Data Network System (SDNS), and the Remote Data Satellite System (RDSS). The managers of these projects have an interest in the NDS recapitalization and must be able to provide input prior to the finalization of the system specifications. Lack of participation by all users or potential users of the NDS could lead to the design and installation of a system that would not effectively fulfill the needs of those users.

E. THESIS OUTLINE

1. Chapter II: Present Coast Guard C^2 Structure and Missions

In Chapter II the author will review the current Coast Guard missions and the administrative and operational C^2 structure used to support the execution of those missions. The author will provide a basic concept of the command and control structure that depends on the NDS to provide communications to operational units, and the important role that the Program Managers play in the command and control structure.

2. Chapter III: National VHF-FM Distress System Background

Chapter III contains an overview of the present NDS and related VHF-FM installations including:

- History of the NDS.
- Current statutory requirements placed upon the NDS.
- Current NDS configuration.
- Other Non-NDS local-use VHF-FM installations.

3. Chapter IV: Established and Potential NDS Operational Requirements

Chapter IV details requirements that the NDS upgrade will need to address. These are the additional requirements that have been placed upon the system since its original installation. These requirements are separated into two groups, those that have already been established for the new system and those that have the potential to be placed upon the system. These are addressed in two general areas: internal Coast Guard communications requirements; and NDS public interaction requirements.

4. Chapter V: Evaluation of Selected Technology

Chapter VI investigates and describes the emergent technologies that would enable the NDS to fulfill both its established and potential requirements. In this investigation the author will discuss currently available systems that can fulfill requirements similar to those outlined in Chapter IV.

5. Chapter VI: Summary and Recommendations

Chapter VI provides recommendations as to which technologies should be used to fulfill the established and potential requirements of the NDS and the steps necessary to implement the recapitalization. The author will provide these recommendations in generic terms in order to not prejudice them towards or away from any one manufacturer or system.

II. PRESENT COAST GUARD C^2 STRUCTURE AND MISSIONS

A. COAST GUARD C^2 STRUCTURE

In order to comprehend how the VHF-FM National Distress System is used, it is essential to appreciate the scope and missions of the Coast Guard, and the Program Managers who administer those missions. It is especially important that the reader understand the Coast Guard's Command and Control (C^2) structure. In this chapter, the author explains the Coast Guard's C^2 structure, its missions, and the applicable Program Managers.

1. Coast Guard Command and Control Structure

The Coast Guard's Command and Control structure is shown in Figure 1. General tasking for mission execution is set forth in regulations and directives created at the Headquarters level. More specific tasking is provided by the Commanders at each subordinate level, with the units' direct superiors in the chain of command assigned the responsibility for developing specific operational orders for the units under their control. At each level the commanders are aided by their staffs, who carry out the commanders' orders in the day-to-day operation of that command.

The Command and Control structure is flexible, and can be changed as a result of mission needs or specific events. For example, a vessel will depart its home District or home Group and voyage to another Group or District to carry out its orders. When the vessel arrives at the location where it will be working, it Changes Operational

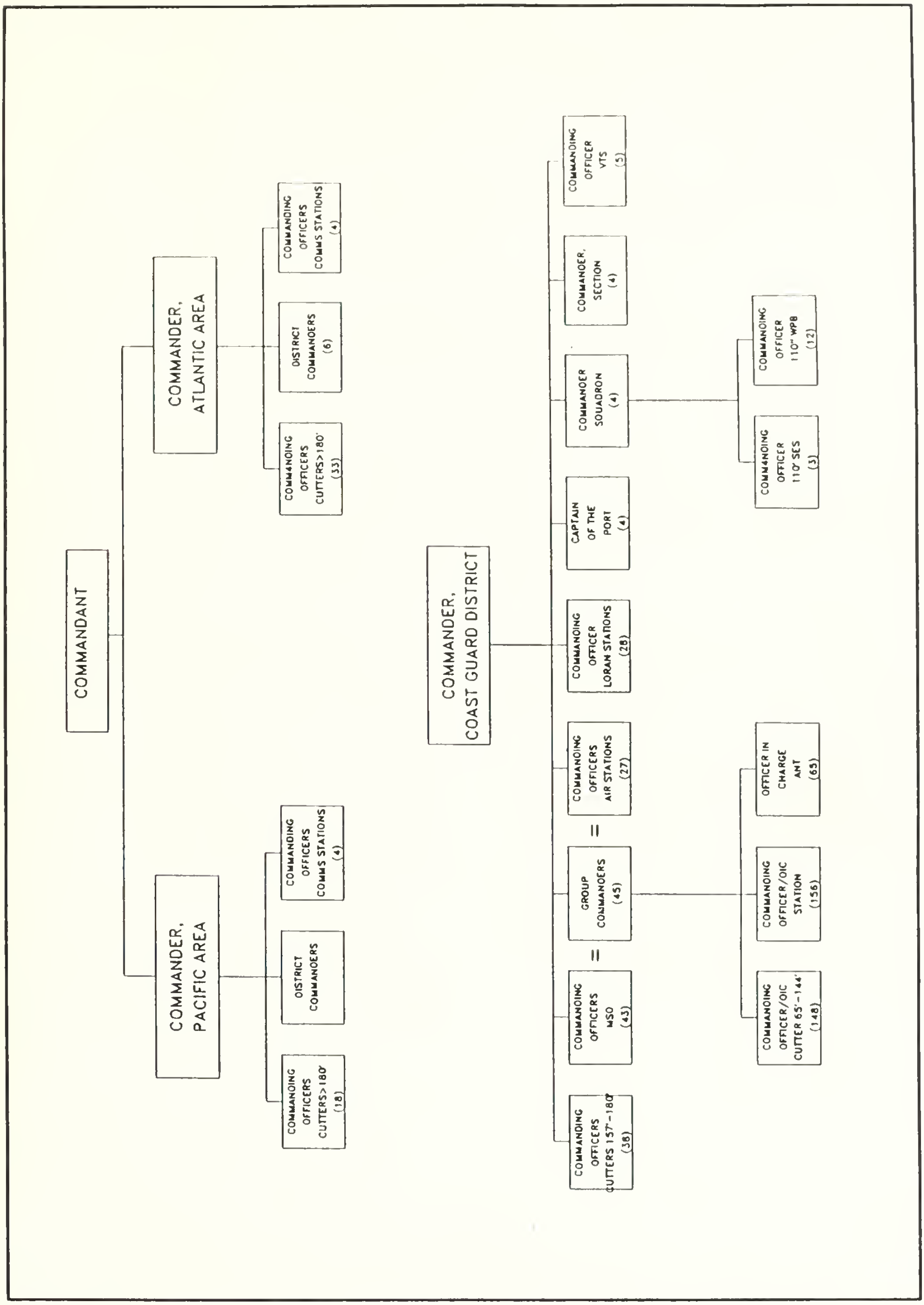

Figure 1 Coast Guard Command and Control Structure

Control (CHOP) to the new region, and works for the appropriate superior in the execution of its missions until finished, and then returns to its home and CHOPs back to its original command.

2. Coast Guard Communications Structure

The communications structure in the Coast Guard can be divided into two broad areas. The first is tactical communications. The Coast Guard's primary tactical short range communications system is the National VHF–FM Distress System. VHF–FM is the communications medium of choice for mobile short–range communications. It is used for communications between shoreside Marine Safety Offices and crews dispatched in vehicles. It is also used for communications between cutters at sea and their dispatched boarding teams and boat crews. It is usually the only communications link between a Group/COTP or station and their underway vessels. It is also used, along with UHF equipment, for communications between aircraft and cutters or between aircraft and Groups.

The second communications area is that of long range communications. There are five major systems, those of terrestrial record message traffic, terrestrial data and electronic mail traffic, terrestrial voice traffic, ship–shore/shore–ship message and voice traffic, and the radio navigation control system.

The terrestrial record message traffic system consists of micro–computer––based terminals connected via leased lines to centralized message processing centers located at the District Offices, Areas and Headquarters. This network interconnects with the DOD AUTODIN network at the District level, and provides connectivity with the

DOD and other Government agencies. A second part of the terrestrial network is the Secure Command and Control Network (SCN), which provides secure teletype services to the Districts, Headquarters, and the Coast Guard Communications Stations. A second, limited shore-side secure message transmission capability has recently been developed using Secure Telephone Units (STU-III) connected to facsimile machines, now upgraded to terminals connected to each other via dial-up STU III data units.

The terrestrial data and electronic mail service is named the Hybrid Data Network (HDN). The HDN is comprised of a combination of dial-up and dedicated lines connecting the Coast Guard Standard Workstations with the SprintNet X.25 packet switching network. The HDN permits the transmission of data from individual units to other units or to mainframe computers.

The primary terrestrial voice communications network used is the Federal Telephone Service. In order to enable secure voice communications over FTS, units use STU III's. A second, smaller terrestrial phone system is the Search and Rescue Telephone (SARTEL) network, which provides dedicated connectivity between Group Offices, District Operations Centers, and associated command centers from other agencies involved in Search and Rescue. The Coast Guard also has limited access to the DOD's Automatic Voice Network (AUTOVON), usually at District, Area and HQ Operations Centers and at Communications Stations.

Ship-shore and shore-ship traffic, both message and voice, is generally handled through high frequency (HF) systems. The Coast Guard operates Communications Stations (COMMSTA) which provide the interface between the terrestrial networks and the deployed vessels. The Coast Guard uses both secure and non-secure HF teletype communications, and has developed a polled, packet-switched data link called the High Frequency Data Link (HFDL) for secure record traffic communications. Secure ship-shore/shore-ship voice traffic uses both Parkhill and Vinson equipment over HF radios. Some of the larger cutters are equipped with DOD-provided satellite communications equipment, and therefore can receive the Navy Fleet Broadcasts and messages via the Naval Communications Processing and Routing System (NAVCOMPARS) and Naval Communications Stations.

B. COAST GUARD MISSIONS

The Coast Guard has acquired many varied missions throughout its 200 year history. Although these missions can be separated into rather distinct areas, the very nature and size of the Coast Guard mandates that most units be "multi-missioned," i.e., able to carry out more than one specific task. As a result, a floating unit underway may be enforcing laws one minute, conducting search and rescue literally the next minute, and then later the same day be performing an aids-to-navigation mission. However, the responsibility for the management of the various missions are given to the separate "Program Managers," and it is by this separation that the missions are classified.

1. Search and Rescue

The Coast Guard is probably best known for their activities involving Search and Rescue (SAR). The Coast Guard has been tasked by the National SAR Plan with conducting Maritime SAR, which includes search planning and execution along the coasts; in Hawaii, Guam, Alaska, and Puerto Rico; as well as on the Great Lakes and internal U.S. waterways.

The key component of the SAR mission within 30 miles of the coasts are the 156 Coast Guard Stations and 12 Search and Rescue Detachments (SARDET). These stations and SARDETs, crewed with 10 to 45 people and equipped with versatile multi-missioned boats, form the primary link with the boating public. Handling the SAR responsibilities farther offshore are the more than 80 patrol boats, ranging from 82' to 110' long. These cutters are used to rescue or tow larger vessels and to patrol offshore for several days at a time. Short range helicopters are also used close inshore for SAR, longer-range helicopters perform missions as far out as 200 miles. Out on the open sea, long-range fixed-wing aircraft and large cutters manage the SAR mission. The Coast Guard also maintains communications stations to monitor distress calls on VHF-FM, HF, and MF frequencies. The Program Manager for SAR is the Search and Rescue Division, Office of Navigation Safety and Waterway Services at Coast Guard Headquarters.

2. Maritime Law Enforcement

Although SAR has been the most visible mission of the Coast Guard, the service's very origins were in Maritime Law Enforcement (MLE). The Coast Guard began as the "Revenue-Marine Service" in 1790 to put a halt to the smuggling of goods into the fledgling United States. Since that time, the MLE mission has grown to include enforcement of all applicable laws and treaties in the navigable waters of the United States and aboard U.S. flag vessels on the high seas.

Currently the MLE mission involves enforcement of Federal regulations relating to the Continental Shelf and the Exclusive Economic Zone of the U.S., and other territory or possession of the U.S.. Historically all Coast Guard cutters have been tasked with law enforcement duties. To carry out its MLE mission now the Coast Guard has added E2-C "Hawkeye" planes -- AWACS-type aircraft used to track drug smuggling aircraft; Fast Coastal interceptors (FCI) -- Cigarette-type speedboats to chase them; and Aerostats -- balloon-carried radars used to track drug smuggling vessels. Recently the Coast Guard has also employed small Law Enforcement Detachments (LEDET) as boarding teams embarked upon Naval vessels to combine the advanced sensors and intelligence capabilities of those vessels with the law enforcement power of the LEDET. The Program Manager for MLE is the Law Enforcement Division, Office of Law Enforcement and Defense Operations at Coast Guard Headquarters.

3. Recreational Boating Safety

The Coast Guard's mission of Recreational Boating Safety (RBS) exists to reduce the risk of injury, property damage or loss of life associated with the use of recreational boats in the U.S.. The RBS program involves certification of vessels, life jackets, and safety devices for the boaters. It also involves the efforts of the Coast Guard Auxiliary who volunteer their time and facilities, including vessels, to conduct boating safety classes and Courtesy Marine Examinations (CME). Station personnel are frequently involved in RBS as part of their SAR and MLE missions. The Program Manager for RBS is the Boating Safety Division, Office of Navigation Safety and Waterway Services at Coast Guard Headquarters.

4. Ice Operations

The Ice Operations mission for the Coast Guard began with the an Executive Order in 1936 which established a national policy of using vessels for icebreaking duties in U.S. channels, rivers, and harbors. Presently domestic icebreaking is carried out by 140 ft and 65 ft icebreaking tugs, which maintain ice-free channels on the Great Lakes and the Atlantic Coast. Also breaking ice on the Great Lakes is the 290 ft USCGC MACKINAW (WAGB 83). The polar icebreaking duties are shared by the 399 ft USCGC POLAR SEA (WAGB 11) and USCGC POLAR STAR (WAGB 10). The Program Manager for ice breaking is the Ice Operations Division, Office of Law Enforcement and Defense Operations at Coast Guard Headquarters.

5. Waterways Management

The objective of the Waterways Management (WWM) mission is to develop and implement traffic management techniques and navigation safety procedures for U.S. ports and waterways. These include both passive techniques such as navigation regulations and rules, and active programs like Vessel Traffic Services (VTS). There are VTSs established presently in six harbors in the U.S., they provide traffic management using VHF-FM radio, radar, and closed-circuit video cameras to collect, evaluate, coordinate and disseminate information on vessel movements to other vessels.

Another part of the WWM mission is that of Bridge Administration. The Coast Guard has responsibility for approving the location and plans of bridges and causeways constructed across navigable waterways in the U.S.. The Coast Guard is responsible for enforcing regulations concerning lighting for navigation, structure modifications, and temporary obstructions for over 18,000 bridges in the U.S.. The Program Manager for WWM is the Office of Navigation Safety and Waterway Services, CG Headquarters.

6. Aids to Navigation

The Aids to Navigation (ATON) mission actually predates the MLE mission by one year. In 1789 the Lighthouse Service was started, at that time the Federal Government took over the maintenance of lighthouses from the individual states. The Lighthouse Service became part of the Coast Guard in 1939. Presently the mission of ATON is divided into two major areas. These are:

a. Short Range ATON

Short range aids to navigation are lighthouses, buoys, daymarks, fog signals and ranges. Present-day lighthouses are no longer manned, the status of the light, generators, and associated signalling devices is tracked by the Automated Control and Monitoring System (ACMS) equipment and transmitted back to a Group office. Short-range aids to navigation are maintained by over 80 buoy tenders, from 65 ft to 180 ft, and the 65 Aids to Navigation Teams (ANT) located throughout the U.S., which use smaller buoy tenders from 18 ft to 47 ft.

b. Long Range ATON

Long range aids to navigation all use some form of radio-navigation. Shore-based radio-beacons were the first radio-navigation aids established, now about 200 shore-based radio-beacons transmit a medium frequency "homing" signal out as far as 50 miles. Later came the Long Range Navigation (LORAN) network, LORAN–A, which was used in World War II. Nowadays 42 LORAN stations, 38 manned by Coast Guard personnel, comprise the current low frequency Loran–C network. This network provides one–quarter mile navigational accuracy for vessels and aircraft worldwide in selected areas of the Northern hemisphere. The navigational system called Omega was developed to provide global oceanic navigational coverage. Omega uses very low frequency radio waves to provide four–mile accuracy. There are currently eight Omega stations, two manned by the Coast Guard, the other six manned by the host countries.

The Coast Guard also publishes the Notice to Mariners and broadcasts the Broadcast Notice to Mariners, both vehicles used to inform mariners of changes in channels, channel markings, obstructions, or other issues of marine safety and navigation within the local areas. The Program Manager for ATON is the Office of Navigation Safety and Waterway Services at Coast Guard Headquarters.

7. Marine Environmental Response

The Coast Guard's mission of Marine Environmental Response (MER) exists to minimize the pollution damage and reduce the threat of potential pollution through planning and response. The Coast Guard maintains the National Response Center (NRC) in Washington, DC. The NRC acts as a centralized reporting point for spills of oil or hazardous substances in U.S. waters, and coordinates the cleanup of spills when they occur. Management and operation of the MER mission at the unit level is carried out by the 42 Marine Safety Offices (MSO), four Captains of the Port (COTP) and 17 Marine Safety Detachments (MSD) located in the major ports of the U.S.. They patrol the harbors and shoreside facilities using cutters and boats from 12 ft up to 110 ft and numerous vehicles. The Commanding Officer of the MSO also acts as the COTP for that location.

The MER also includes the mission of Marine Science Activities (MSA). MSA operates the International Ice Patrol to track icebergs, the data buoy project to provide weather reporting buoys for offshore locations, and the weather observation project to provide weather observations from selected cutters and stations directly to the National Weather Service. The Program Manager for MER is the Office of Marine Safety, Security and Environmental Protection at CG Headquarters.

8. Port Safety and Security

The Port Safety and Security (PSS) program involves three elements, port safety, port security, and environmental protection. As a result of the similarities with the MER program, the two are usually conducted by the same units, the MSO's, MSD's, and COTP's. The primary activities of the PSS include the monitoring of oil or hazardous cargo transfer operations to prevent spills, the inspection of vessels to ensure compliance with Federal regulations, the examination of waterfront facilities to prevent fires, explosions or other accidents, safeguarding vessels and port areas from sabotage or terrorism, responding to maritime emergencies or natural disasters affecting the ports of the U.S., and preparing for mobilization, including handling of hazardous cargos and providing land–side and waterside port security. The Program Manager for Port Security is the Office of Readiness and Reserve, Coast Guard Headquarters.

9. Commercial Vessel Safety

The mission of Commercial Vessel Safety (CVS) includes the missions of Marine Inspection and Marine Licensing. Marine Licensing involves the licensing and certification of U.S. Merchant Marine Officers and Seamen. This is administered at 17 Regional Examining Centers nationwide. Marine Inspection includes the inspection of U.S. flag vessels from design to decommissioning. Inspection is carried out by a team from an MSO, Marine Inspection Offices (MIO), COTP, or MSD. The Program Manager for MER is the Office of Marine Safety, Security and Environmental Protection at CG Headquarters.

10. Defense Operations

In accordance with 14 USC 2 and 14 USC 145, the Coast Guard has the responsibility to act as an armed Naval force. Toward that end the Defense Operations (DO) mission has been established. Included in the mission is military readiness, small arms training, and weapons system proficiency. The Coast Guard is also responsible for the maintaining the Maritime Defense Zones (MDZ) for coastal warfare, defense planning, and exercises. In war, or when the MDZs are activated, the Coast Guard MDZ commanders have responsibility for port security and coastal defensive operations within 200 miles offshore. The Program Manger for DO is the Office of Law Enforcement and Defense Operations at Coast Guard Headquarters.

C. COAST GUARD PROGRAM MANAGER MISSION SUPPORT

Within each Headquarters Office are the Program Managers, who manage the missions and programs. Program Managers make decisions regarding the planning, funding and execution of the programs, and provide mission support to the subordinate units. They work through their counterparts on the Area or District staffs in dealing with the units for which they are responsible. The Program Managers at each level are usually not specific individuals, but are the members of the staff elements assigned to the division or branch that manages the program. The organizational structure of Coast Guard Headquarters is shown in Figure 2.

Area Staffs have some Program Manager counterparts, however Areas are not heavily staffed and therefore do not have Program Managers for all the missions. A representative Area organization is shown in Figure 3.

District Staffs have Program Managers for each of the programs being carried out within their district. A typical District staff organization is shown in Figure 4.

As it can be seen, the various staff elements and organizational levels create a complex interconnecting network, which is dependent upon the C^3 structure of the Coast Guard to manage the missions assigned. In general, the vision of the Program Managers in regards to C^3 issues is focused upon the administration and execution of their specific missions. As a result, systems which serve several missions must be able to fulfill the requirements for each of those missions without adversely affecting other missions. Any project which changes the C^3 structure must be sensitive to the needs and demands of the various mission areas, and be formulated accordingly.

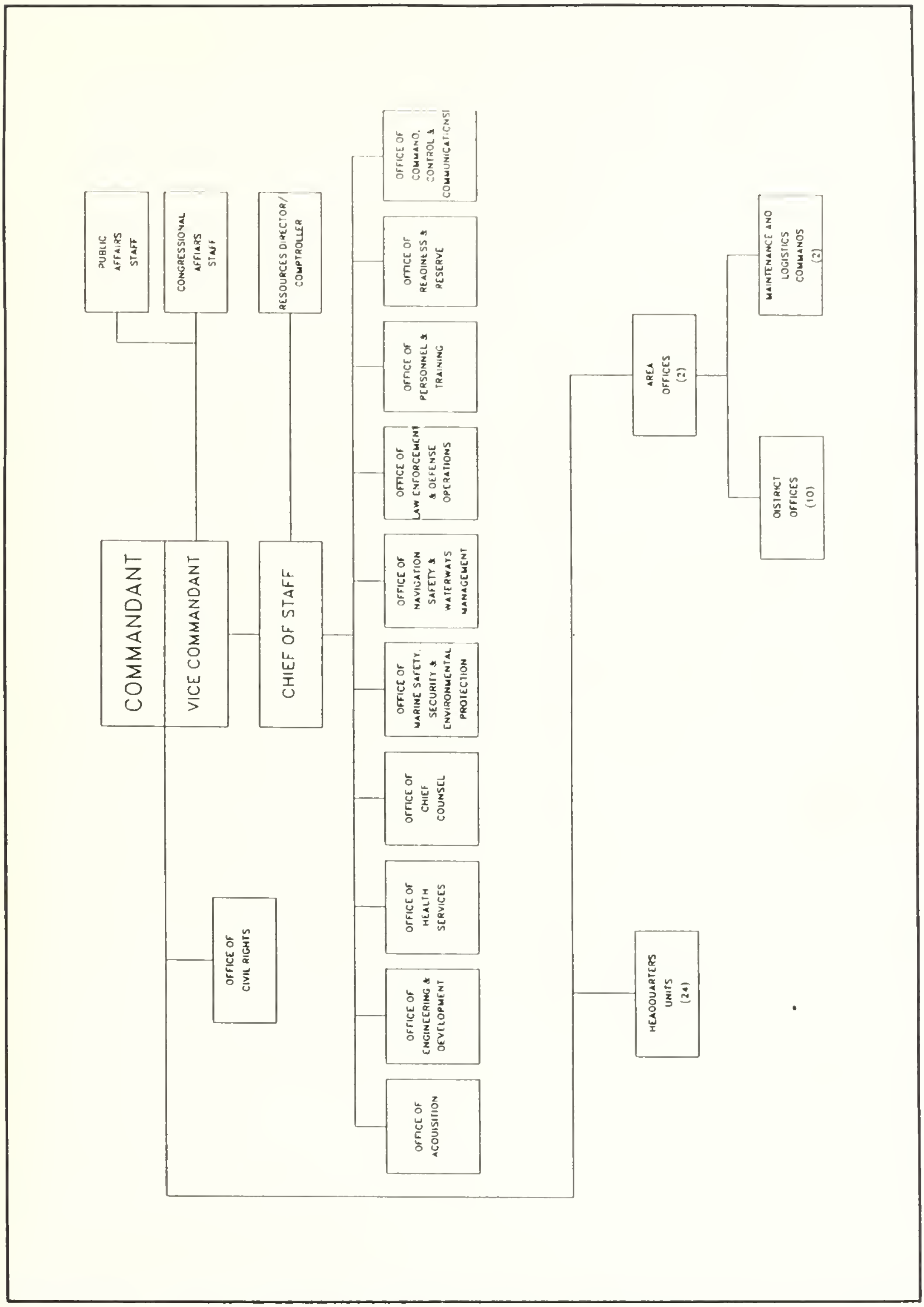

Figure 2 Coast Guard Headquarters Organization

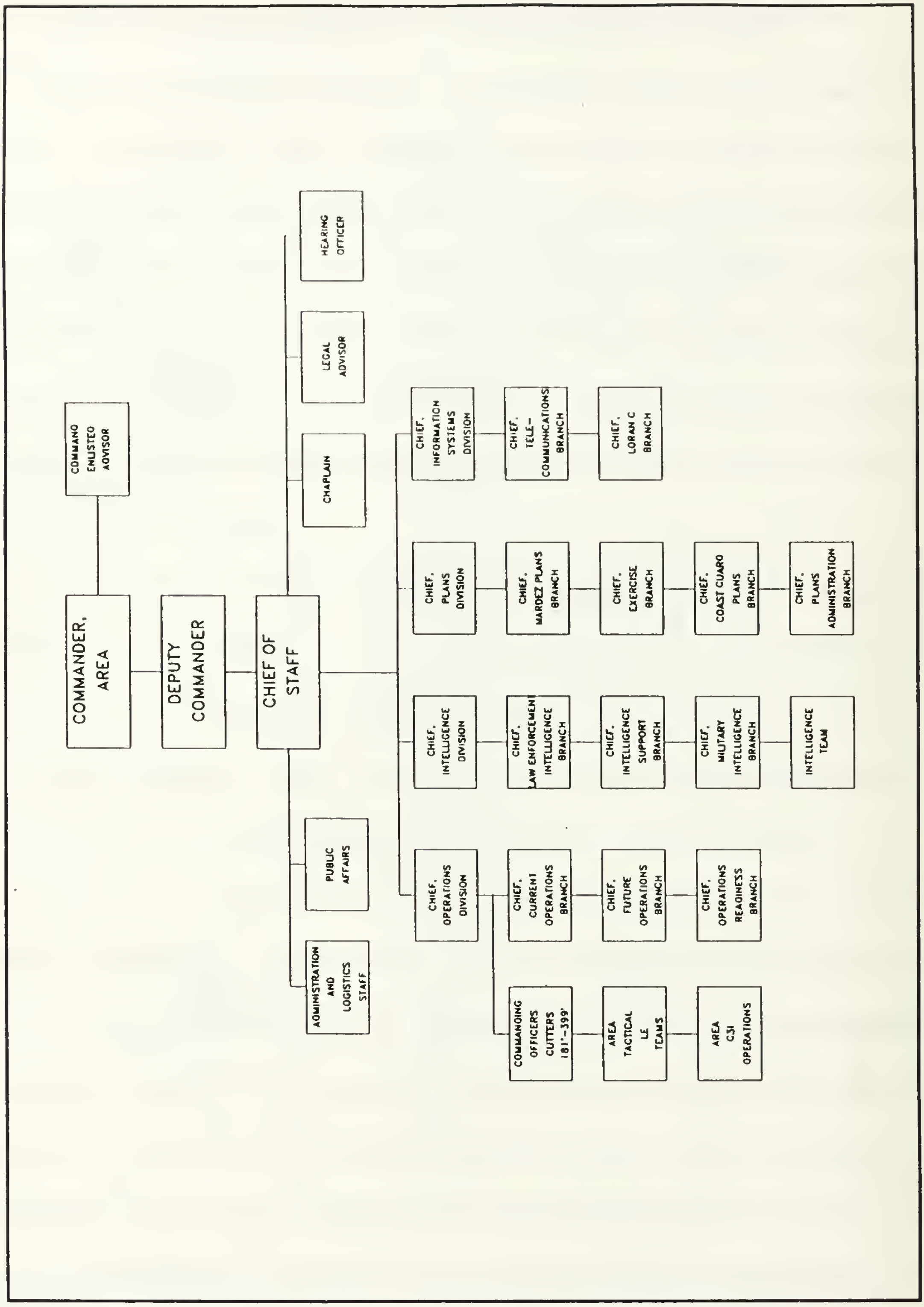

Figure 3 Coast Guard Area Staff Organization

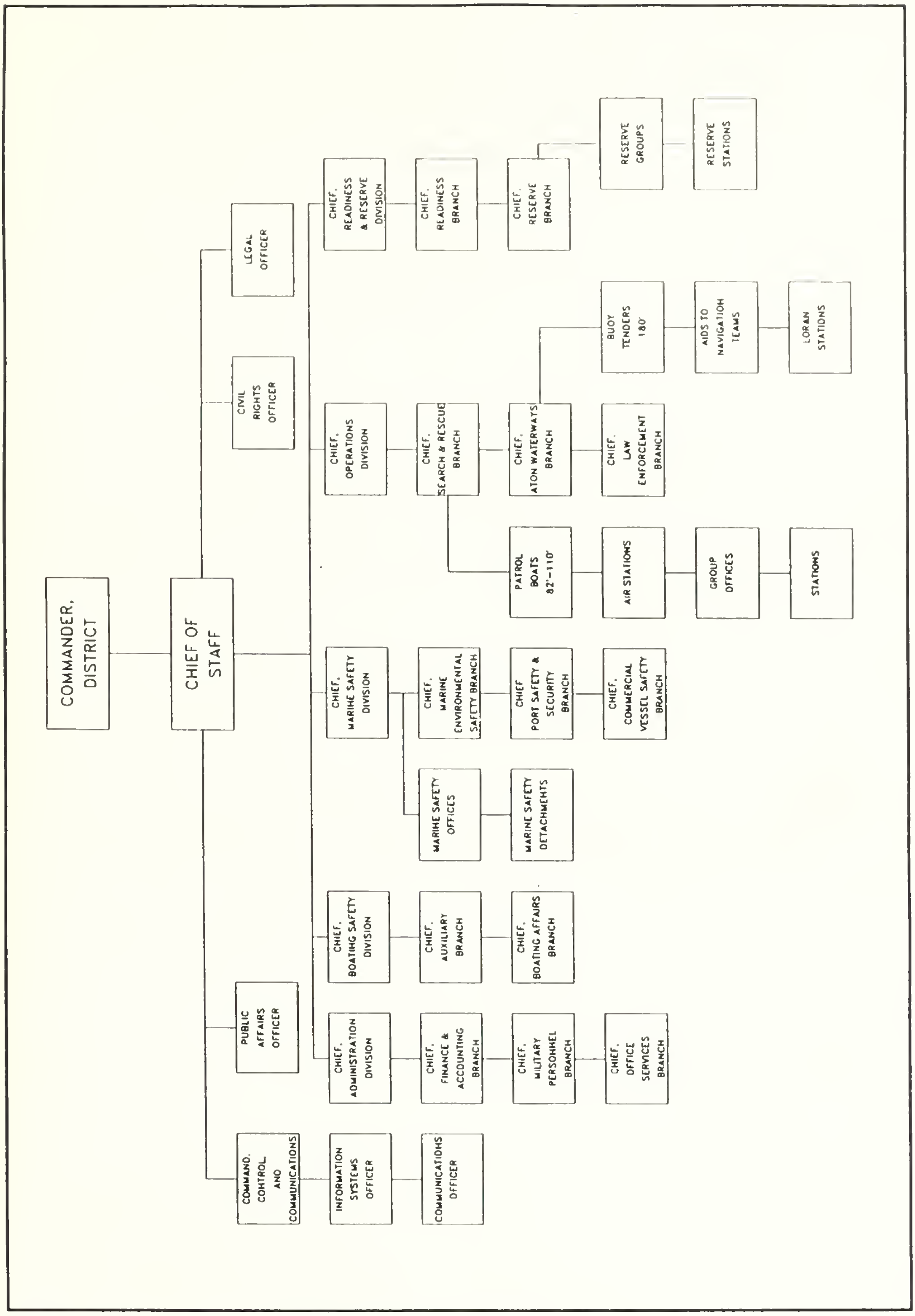

Figure 4 Coast Guard District Staff Organization

III. NATIONAL VHF-FM DISTRESS SYSTEM BACKGROUND

In this section the author details the origins of the National Distress System (NDS) and its present configuration. Included are descriptions of related VHF-FM systems that are in use as part of the Coast Guard's C^2 communications, but not currently part of the NDS.

A. HISTORY OF THE NDS

The material for sections 1 and 2 below, the history of the NDS and the actions that caused its formation, has been drawn collectively from References 2, 3, and 4.

1. Creation of Network

The Coast Guard has the statutory responsibility for the:

> ... development and operation of rescue facilities for the promotion of safety on and over the high seas and waters subject to the jurisdiction of the United States. [Ref. 5]

As a result, the Coast Guard's communications systems must be capable of handling both internal Coast Guard traffic and external traffic between the Coast Guard and the mariner.

Creation of the NDS was a long and involved process, beginning shortly after World War II. The first step was the designation of the frequency 156.8 MHz in 1946 as the international frequency for distress and calling. Once this designation was made, the United States began work to carve out a maritime mobile band somewhere around this 156.8 MHz frequency. Prior to 1948, there were two separate bands, 152–162 MHz for non–Government radio services and 162–174 MHz for Government radio services. This separation of Government and non–Government frequencies was worthwhile to most agencies, but it proved a hinderance to the Coast Guard. The Coast Guard needed a frequency band for communications with the public in the 152–162 MHz range, and was willing to surrender frequency allocations within the 162–174 MHz range in trade. In 1948 the Interdepartment Radio Advisory Committee (IRAC) and the Coast Guard agreed that the sub–band at 157.050–157.25 MHz, later specified to be Channel 22A at 157.10 MHz, would be used for safety purposes for government–nongovernment liaison communications. This initiated the marine VHF–FM band for use between the Coast Guard and the mariner, and eventually resulted in the creation of the NDS to use that band.

Since that time the Coast Guard has been committed to development and use of a VHF–FM radiotelephone network for short–range maritime distress and safety communications. At first, progress in creating that network was stalled due to low public acceptance of VHF–FM as the mariner's medium of choice. It was a classic "chicken–or–egg" dilemma––the mariners would not purchase VHF–FM equipment unless they could use it to talk to the Coast Guard, and the Coast Guard would not fully invest in the network unless there were marine radios in common use. The Coast Guard finally started implementation of the network when the Federal Communications Commission (FCC) and IRAC expanded the versatility of the system by permitting the Coast Guard to use

VHF–FM for short–ranged command and control communications in addition to distress and safety traffic. Once that decision had been made, the Coast Guard started to establish the NDS network in earnest.

Three specific actions then increased the mandate for using VHF–FM marine radios onboard vessels. First, in 1968 the FCC and IRAC designated 156.8 MHz (Channel 16) as the National Maritime Distress Frequency. Prior to that time Channel 16 had the designation of being a safety frequency, but not a distress frequency within the United States, although it had been internationally both a safety and distress frequency since 1946. Second, Congress passed the Vessel Bridge–to–Bridge Radiotelephone Act in 1971. This act required that the masters of certain commercial, salvage and passenger vessels monitor the designated channels within the VHF–FM marine band (156 MHz – 162 MHz) while underway. Channel 13, 156.65 MHz, was selected to be the designated bridge–to–bridge channel. Third, in 1972, the FCC solidified the use of VHF–FM as the primary short–range maritime communications system by limiting the issuance of single sideband (SSB) licenses to vessels. Until that time, boaters had used double sideband (DSB) radios in the 2 MHz band for communications. The FCC action forbade the use of these DSB radios completely and prohibited installation of SSB radios unless the vessel already had a VHF–FM marine band radio installed and the vessel's owner could show a need for the SSB radio. These three factors increased the pressure upon the Coast Guard to establish their VHF–FM network.

In order to prepare for the full conversion to VHF–FM, the Coast Guard started a project in the fall of 1970 to develop the National VHF–FM Radiotelephone Safety and Distress System, as originally named. The project objectives were:

- Define the Coast Guard's policy, both short and long term with regard to VHF–FM coverage, facilities, and services.
- Present a comprehensive survey of existing facilities, requirements, and needs.
- Forecast the future operational requirements of the Coast Guard with considerations of SAR coverage, boating trends, legal restrictions, international treaties, requests of other government agencies both federal and local and operational capabilities. [Ref. 4:p. 3]

As a result of the project, the communications requirements of the system were determined to be:

- Coastal area coverage must be provided to at least 20 miles offshore, and in adjacent tidal waters. In areas where heavy concentrations of boating activity exist greater than 20 miles offshore, coverage will also be provided to the extent practicable;
- Complete coverage of all large bodies of inland water such as Puget Sound, Long Island Sound, Chesapeake Bay and the U. S. waters of the Great Lakes is necessary;
- Coverage of the navigable waterways where commercial or recreational traffic exists and the Coast Guard has SAR responsibility;
- Provide improved VHF–FM coverage in coastal areas of Alaska and Hawaii to the extent it is feasible considering the geographical characteristics of these areas. [Ref 3:p. 3]

The system was planned to provide this extensive coverage economically through the use of remotely controlled, relatively high-elevation antenna sites, thus the unofficial name of "High Site System." Concentration was on maintaining a high state of readiness and optimizing the receiving capability. The assumption was made that transmissions from mariners to the antenna high site locations would be made from transmitters operating at one watt of power with a half-wave dipole antenna at sea level. This ensured that even weak transmissions would be detectable within the design parameters of 20 miles offshore. The original design criteria for the system is provided in Appendix A, Original National Distress System Design Criteria.

2. Initial NDS Installation

Prior to the installation of any new system, a survey of the existing Coast Guard VHF-FM installations was made. This survey showed a variety of antenna heights, receiver sensitivities, and effective ranges for the installed systems, most unsuitable for use with the NDS. Plans were then made to standardize these installations and incorporate them into the NDS. Upon completion of the final plan, site locations were finalized and equipment was ordered. The transceiver had six channels which could be remotely controlled from another unit called the remote control unit (RCU). Selection of the channels was made using in-band signalling via 15 audio control tones. The first site became operational in the fall of 1971, and shortly afterwards another 40 sites were installed and operating. These early sites provided radio coverage for Long Island Sound, Chesapeake Bay, the coasts of Maine, Florida, North Carolina, most of the Gulf Coast, selected areas of the Great Lakes, the Northern California coast, and Puget Sound.

Some of the more remote sites lacked telephone service and had to be linked via a duplex UHF circuit for the transceiver signal and control functions and a VHF repeater for the channel 16 guard receiver. Other sites were linked via Coast Guard--owned, shared or leased microwave systems. Most of the routine installations were able to be remotely controlled from more than one RCU, giving the operators flexibility and multiple access to the individual sites. Customarily both the Group COMMCEN and the nearest small-boat station had control over the local NDS transceiver, permitting control and use by either.

A second phase of 40 more sites was ordered for July 1973 and a third phase of 40 more sites was scheduled for the following December, subject to budget restrictions. Most of these were eventually installed.

Since the initial installation there have been numerous changes made as empirical data located geographical areas that were not covered by the NDS. Many of these VHF-FM "holes" have since been corrected, but the research regarding VHF-FM coverage and the modification of the system continues. The present configuration of the NDS is contained in Appendix B, National Distress System Transceiver Location Information.

B. NDS STATUTORY REQUIREMENTS

As indicated above, the Coast Guard has the statutory responsibility for the

> ... development and operation of rescue facilities for the promotion of safety on and over the high seas and waters subject to the jurisdiction of the United States. [Ref. 5]

Included in the operation of those rescue facilities is the need for communications, both between the Coast Guard and the public and within the Coast Guard. The VHF–FM NDS network exists to provide those communications on a short-range basis.

1. VHF–FM Channel 16 Monitoring

The Coast Guard's responsibility for monitoring the VHF–FM Distress Frequency, Channel 16 (156.8 MHz) is based upon international agreements and federal regulations. The United States is a member of the International Telecommunications Union (ITU), and therefore adheres to its obligations as a member. The ITU states:

> The frequency 156.8 MHz is the international distress, safety and calling frequency for radiotelephony for stations of the maritime mobile service when they use the frequencies in the authorized bands between 156 MHz and 174 MHz... It is used for the distress signal, the distress call, and distress traffic, as well as for the urgency signal, urgency traffic and the safety signal... Safety messages shall be transmitted where practicable on a working frequency after a preliminary announcement on 156.8 MHz. The class for the emission to be used for radiotelephony on the frequency 156.8 MHz shall be G3E. [Ref. 6:Sec. 10.(1)]

In addition to the designation of 156.8 MHz as the VHF–FM distress, safety and calling frequency, the ITU requires that all vessels maintain a watch on CH 16 for distress traffic. The ITU states that

> ... ship stations should, where practicable, maintain watch on 156.8 MHz when within the service area of a coast station providing international maritime mobile radiotelephone service in the band 156–174 MHz. [Ref. 6:Sec. 87.(3)]

The Coast Guard Telecommunications Manual (TCM), which provides guidance for telecommunications matters, indicates

> The Coast Guard will provide a comprehensive distress telecommunications system along the coast and on large inland waters of the United States and its possessions. [Ref 7:Sec. 2.B.3.m]

Additionally, the TCM requires that

> Area and District Commanders shall organize the communications facilities in their area of responsibility and provide:
> ... Maintenance of continuous radio watches on the distress frequencies by as many units as necessary to provide adequate coverage. All activities shall be alert to intercept distress messages and relay them to the appropriate operations center... [Ref. 7:Art. 15.A.4]

and

> Each Group Commander shall have a COMMCEN to serve as the focal point of all communications activities within the Group... Continuous guards of the distress frequencies 2183.4 (2182) kHz and/or VHF–FM Channel 16 are required... VHF–FM working frequencies should be guarded when units are underway to minimize calling on Channel 16... [Ref. 7:Art. 7.G.1]

The Coast Guard Telecommunications Plan (TCP) provides more guidelines regarding the NDS by stating:

> The National VHF–FM Distress System, operated on the maritime mobile band (~156 MHz) by the Coast Guard, is designed to provide distress calling, maritime safety information broadcast, and command and control coverage out to 20 nautical miles (NM) offshore. Guard receivers for channel 16 (156.8 MHz) and multi–channel transceivers are normally operated by group commanders. Vessels and aircraft guard channel 16 and are equipped with a transceiver. [Ref 8:Sec. 4.B.1.b.(3)(a)]

2. Internal Command and Control

As indicated above, the Coast Guard was given permission by the FCC and IRAC to use the NDS for internal command and control. In addition to international directives, the Coast Guard has established its own guidelines for the use of the NDS and VHF–FM Marine Band transmissions. The TCM guidelines regarding communications in general state that:

> Operational Commanders shall have the capability to communicate rapidly with operating units under their control. [Ref. 7:Art. 2.B.3.i]

The use of radios is specified as part of the Group C^3 system when the TCM states that:

> Group Commanders are each supported by an indigenous telecommunications center which functions as the communications nodal point for all Group command, control,

> and communications (C3) support activities. Connectivity with shore units is provided by landline and to mobile units by radio.... [Ref. 7:Art. 4.C.1.e]

This use of the VHF–FM NDS radio network for C^3 has expanded over the years to make the NDS system the primary C^3 system at the Group level for communicating with underway resources.

3. Public Safety Broadcasts

The Coast Guard is required to transmit Marine Information Broadcasts as part of their marine safety mission. The TCM states:

> The Coast Guard will maintain a capability to transmit Marine Information Broadcasts (MIB) into its areas of responsibility in a form usable by the recipient. [Ref. 7:Art. 2.B.3.k]

Group communications centers use the NDS to transmit scheduled Marine Information Broadcasts four times a day and weather and Urgent Marine Broadcasts on demand.

4. Public Communications

As an integral part of the SAR mission, it is necessary for the Coast Guard to be able to communicate with vessels underway, for both the Marine Information Broadcast and for general communications with the boating public. The TCM states:

> The Coast Guard will maintain a capability to communicate directly with merchant ships, fishing vessels and recreational boats. [Ref. 7:Art. 2.B.3.1]

This Coast Guard–to–public communications is also an integral part of the Vessel Traffic System (VTS) mission. The vessels participating in the VTS itself are required to maintain contact with the VTS Center via Channel 13 or any VHF–FM channel designated by the VTS for its use. Many VTS's have sites in addition to the NDS that they use for communicating directly with their participating vessels. The VTS sites are contained in Appendix C, Vessel Traffic System Transceiver Location Information.

C. CURRENT NDS CONFIGURATION

1. Architecture

Figure 5 shows a representative configuration for the NDS. In this example the three transceiver sites have the ability to be controlled by either of two remote control units (RCU). Primary control is usually at the Group COMMCEN, which maintains a 24–hr watch on CH 16 for the three sites. Secondary control is possible at the local control sites. These local control sites are usually at the Coast Guard stations that are closest to the NDS transceiver locations. This redundancy reduces the loss of communications capability should the link between the transceiver site and the Group fail. It also permits the station to use the NDS for command and control of their deployed resources if their own low–power VHF–FM transceivers are unable to contact those resources.

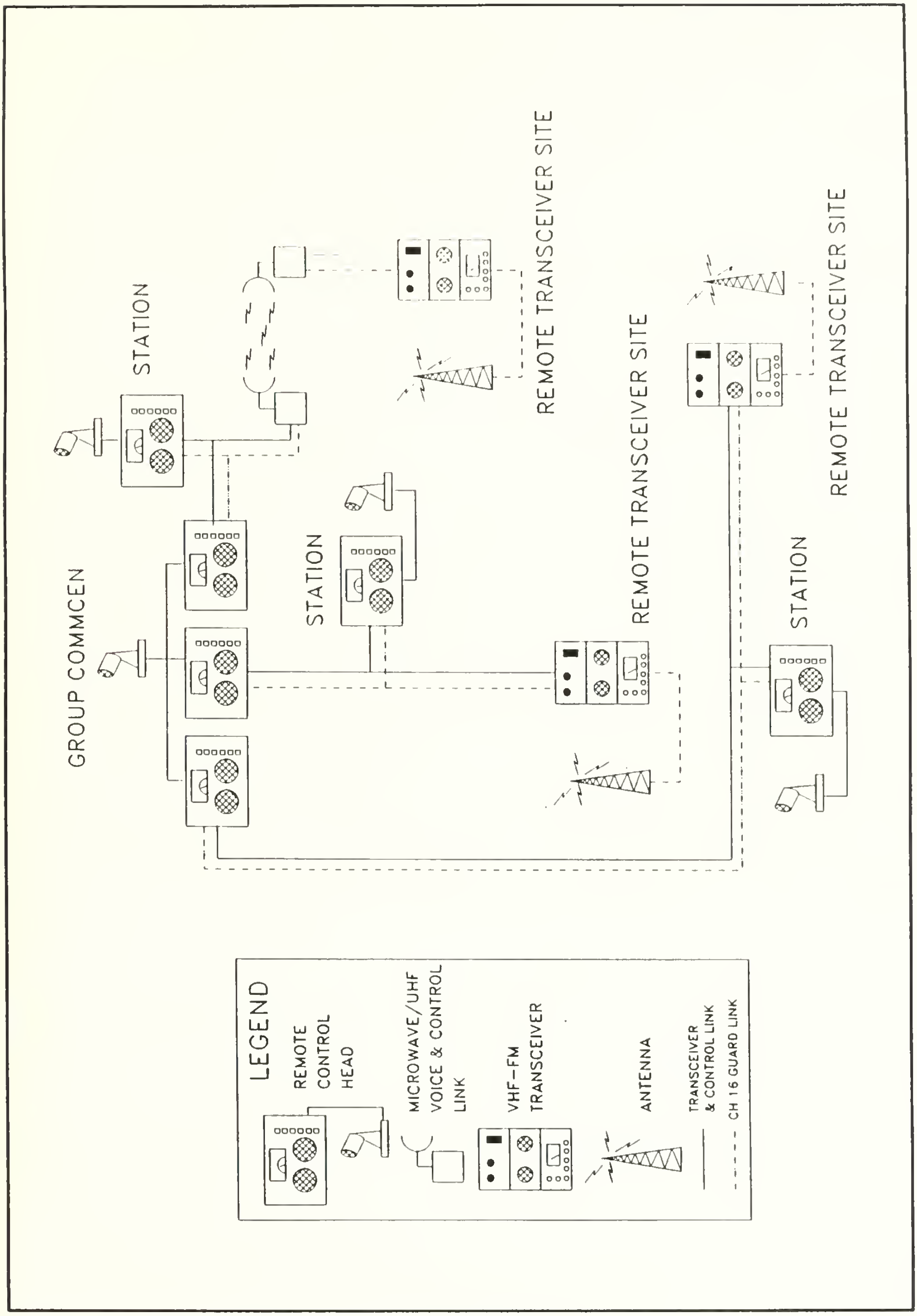

Figure 5 National Distress System Configuration

2. Hardware

Because the installation of the hardware has occurred over a span of time, there are several variations to the initial installation. As noted, there have also been modifications made to the system as operational demands have been changed. Groups have identified the need for additional coverage, or additional channel capacity, or even the need for secure repeaters to handle the lower-power DES transmissions.

a. Transceivers

The transceivers, located at the antenna sites, are typically Motorola 6-channel base stations, assigned either the model number C53 RTB 3146 SP1 (MICOR) or C53 MHB 1106 AR (MOTRAC). Either one provides up to 100 watts of output power. Most installations have the output power adjusted to be 50 watts at the antenna. Power to the transceivers is usually provided by the local electrical utilities, with only some sites having installed standby generators available in case of power failure. In Alaska, however, the sites are so isolated that special low-power transceivers using electricity supplied by propane-gas fueled thermal electric generators are employed.

b. Remote Control Units

The original Remote Control Units (RCU) are Motorola Model CGG-T-1616AM, which have the capacity to monitor the Channel 16 Guard Receiver and also remotely control the 6-channel transceiver. Motorola updated the original RCUs and newer equipment goes under the Motorola name of CENTRACOM, which has the same capabilities but occupies less console space.

c. Antennas

As indicated in Appendix B, the majority of the antenna installations are folded dipoles. The installations have been tailored, however, to the local conditions such that various other types of antennas have been used. The reader should note the directivity of the antennas, in most cases the highest antenna gain is directed towards the nearest body of water and away from the adjacent shoreline. This increases the probability of detecting vessels offshore but hinders communications to vehicles on shore or operations that might occur right on the beach itself. Also, the altitude of the antennas has an effect upon the antenna coverage. The Commander, Fourteenth District has had to install a downwardtilting (3–degree) antenna at their highest antenna site in order to not "overshoot" vessels that are close–in to the shore.

d. Control and Communications Circuits

The primary control and communications circuits consist of two twisted pair telephone lines. One line establishes the CH 16 Guard receiver circuit to the RCU and the other pair functions as the tunable transceiver circuit connection, carrying audio control signals toward and voice both toward and from the RCU. These lines can be "conditioned" voice grade lines, but various problems have been noted if lines other than "data–grade" are used for the circuit. In some installations the circuit between the transceiver site and the RCU is established using a microwave transmission system.

3. Transceiver and Remote Control Locations

a. Equipment Locations

Appendix B, Current NDS Transceiver Locations, contains a summary of the NDS locations, their control sites, antenna types, antenna heights and antenna gains. Information was obtained from both the NTIA database and each individual Districts. Discrepancies were resolved by the applicable District.

b. Geographical Coverage

The current geographical coverage by the NDS is not accurately known. In the past, individual Districts and Groups have collected empirical data and prepared reports regarding coverage "holes" in their areas of responsibility (AOR). The most recent official study available, conducted by the National Telecommunications and Information Administration NTIA, was performed in 1980 [Ref. 9]. The results of this study show the predicted propagation for both a 1–watt transmitter with a 0dB gain antenna located 6 ft above the water and a 25–watt transmitter with a 6dB gain antenna located 15 ft above the water. Currently the Telecommunications Division of Commander, Atlantic Area Maintenance and Logistic Command (MLC) is working to acquire the software used by the NTIA in order that plotting can be done in–house. Once available, this will enable the MLC to determine the theoretical coverage of NDS sites, evaluate modifications, and provide the information to districts for their use.

4. System Integration

a. Connectivity Within the NDS Network

As indicated in Figure 5, the individual transceiver sites connect remotely to primary and, in most cases, secondary RCUs. The multiple RCUs at the Group Communications Center are usually connected in a way such that input from a single microphone is fed to all of the transceivers controlled from that COMMCEN. This enables the Radioman to perform his Marine Safety Broadcasts for the entire Group Area of Operations (AOR) with one transmission. Besides the common microphone, there is no other connection between individual transceiver sites or RCUs. There is limited connectivity between primary and secondary control sites for the same NDS transceiver site, however. The RCUs usually include an intercom feature which permits operators at the primary and secondary sites to communicate between the two locations using a simple push-to-talk intercom.

b. Connectivity With Other Networks

At this present time, there is little connectivity beyond the Group COMMCEN/secondary RCU sites. As can be seen by the information provided regarding primary and secondary remote control locations, some transceivers are remoted to both the Group COMMCEN and another operations control center, usually an MSO or COTP. Other than these additional remote control facilities, there is no connectivity between transceiver sites from different COMMCENs, and only limited connectivity is provided to any other outside network. In some installations the COMMCENS have a VHF-FM telephone patch capability which enables a user to communicate over the NDS from a remote location via the telephone system.

5. Non-Standard/Special NDS Installations

a. Secure Communications

Due to increased pressures for secure communications during law enforcement operations, there have been some upgrades made to the NDS to provide for voice encryption. These upgrades include remote bases and repeaters. The repeaters are used in the duplex mode in government frequencies above the marine VHF–FM band. They are essential for operating when in the DES encrypted mode due to the lower transmission power output in the DES mode. These installations have been done by the Districts and are not part of the NDS system. Therefore, their existence is not reflected in the information contained in Appendix B. The upgrade of the NDS, as indicated later in this thesis, requires the inclusion of DES equipment, which will then likely incorporate the capabilities of the secure communications equipment currently installed.

b. Data Channel Usage

In an effort to provide data communications to deployed vessels, several locations in the Coast Guard have experimented with data communications via the NDS. Systems have included radio packet–switched technology and simple transmission of ASCII characters over a VHF–FM channel using standard 300bps audio frequency shift keying (AFSK) modems. Presently only one system is in use, that of transmitting ASCII using the AFSK modems over the NDS. [Ref. 10:p. 7] *c. VHF-FM Direction Finding Installations*

At this time there are no VHF-FM radio direction finding (RDF) capabilities using the NDS. There are no directional antennas, links to the Group COMMCEN, or direction indicators installed. Commander, Pacific Area is working to install a system that would use remote readout direction-finding antennas installed at the high sites in Hawaii for direction finding.

D. LOCAL USE VHF-FM SYSTEMS

1. Shore Unit Equipment

Standard shore-station VHF-FM equipment usually consists of a Motorola MCX1000 DES encrypted radio. The MCX1000 mirrors the NDS equipment in that it contains both a transceiver and a channel 16 "guard" receiver. The units therefore have two speakers, one for just channel 16 and the other for the switchable transceiver. The MCX1000 is capable of operating in the government frequencies above the VHF-FM Marine Band, and is therefore compatible with DES radios used by the U. S. Customs and other government agencies. These radios are capable of transmitting 25 watts PEP in normal voice operations but are reduced to approximately 12 watts PEP when in encrypted mode. Most shore unit local sites transmit through whip antennas having a 3dB gain.

2. Shore Unit VHF–FM RDF Capabilities

a. Individual RDF sites

Many commands have provided various radio direction finding capabilities for their shore units. The two primary manufacturers of RDF receivers used are SIMRAD/TAIYO and Polaris. Each uses an Adcock antenna and a directional display to indicate the direction of the received transmission. Neither make use of any capability to capture the bearing data and manipulate it or transmit it on to a processor for further analysis.

b. RDF Networks

There are currently two operational RDF networks in the Coast Guard, both located in Florida. These non–NDS systems are identical in configuration, only differing by the location. They each consist of three directional antenna locations which send back the received audio and the direction bearing to remote speakers and an Apple II computer respectively. The bearing information from the antennas is fed into the computer, which processes it and provides: 1) the lines of position (LOP) from each antenna site to the transmission source location; 2) a probability ellipse, within which there is greater than a (typically) 95% probability that the transmitter is located; and 3) both the LOPs and the ellipse overlaid upon a chart of the RDF coverage area. A representation of the RDF display for the installation at Coast Guard Group Miami is shown as Figure 6.

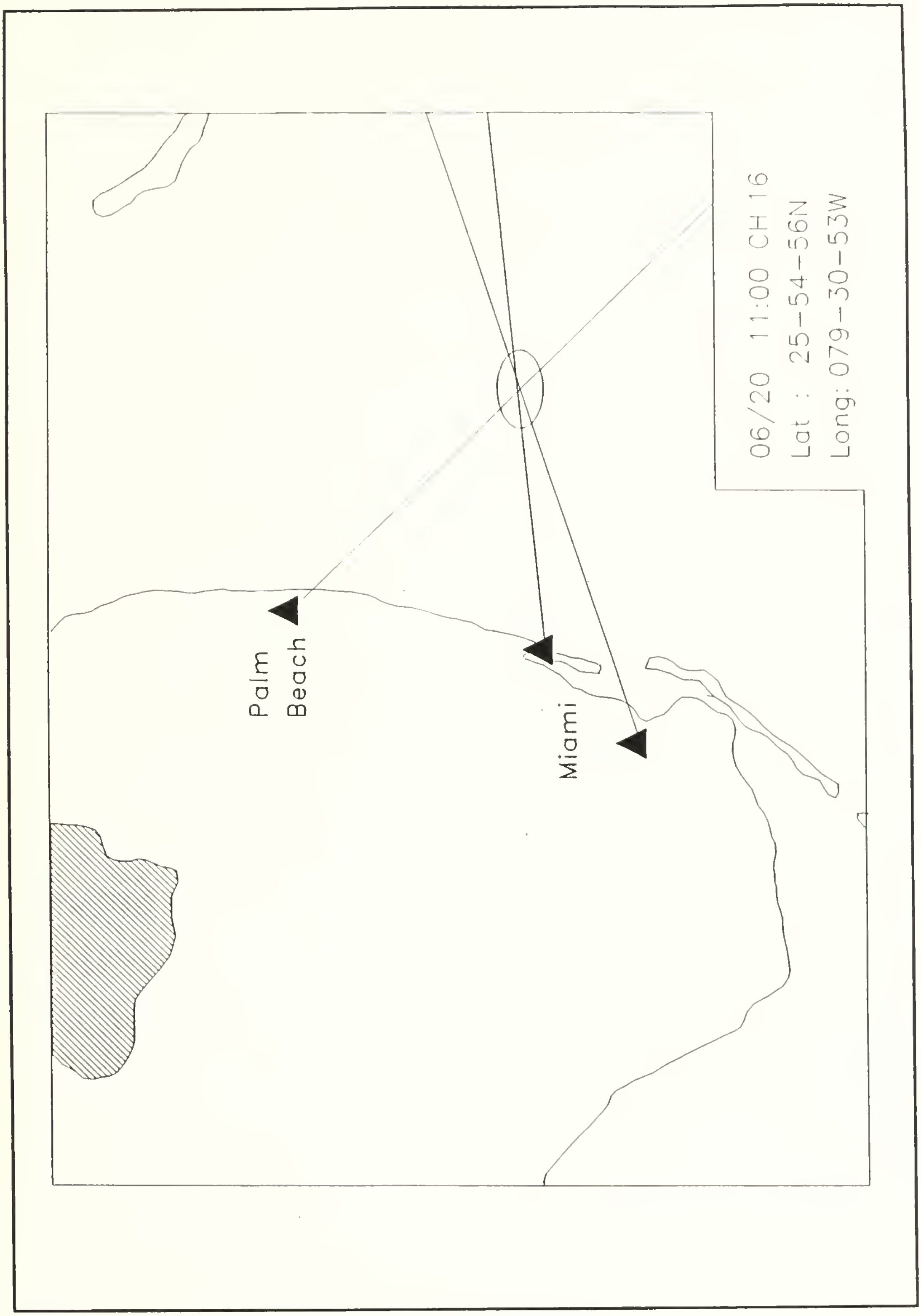

Figure 6 Group Miami Representative RDF Display

IV. ESTABLISHED AND POTENTIAL NDS OPERATIONAL REQUIREMENTS

As indicated previously, the NDS serves as both the Coast Guard's primary short-range command and control communications circuit for deployed resources and the public interface network on the VHF-FM marine band. As such, the NDS is fulfilling certain statutory requirements, which were detailed in Chapter III. Recently there have been initiatives which, if implemented, would place additional requirements on the current NDS or its replacement. In this chapter the author analyzes the established and potential operational requirements placed upon the NDS, separated into the areas of internal communications requirements and CG-public communications requirements.

A. INTERNAL COAST GUARD NDS-RELATED REQUIREMENTS

1. Established Requirements

a. Group/COTP Command and Control

As noted previously, the NDS is a primary communications resource for the Group/COTP Commander (called just Group here) to use in controlling his operational resources. In order to do this, the NDS has to provide communications channels to and from the Groups' operating units. The communications requirements fall under three specific categories: communication on the assigned channels; communication to all of the Group Area of Responsibility (AOR); and communication via secure means.

(1) Communicate on Assigned Channels. An essential requirement of the NDS in regards to the Group Operations Center (OPCEN) is that the Group has to be able to communicate with its units on the assigned CG working frequencies. If the NDS does not permit the Group to do that, then it is not fulfilling its C^2 mission at the Group level. The current NDS fulfills this requirement, although there are locations where there are not enough working frequencies to prevent inter- or intra-Group interference. It also does not permit communications with other agencies that use the government band above 162 MHz for secure communications. Specifically the DEA and Customs have DES-capable radios that use the frequencies above 162 MHz for joint communications with the CG over the Motorola MCX1000 radios. The present NDS sites, however, lack DES capability at this time. It should be noted that the NDS may not be the most effective method of Group C^2 communications with its units. Other technology, such as cellular telephones, may be a solution, but is outside the scope of this thesis.

(2) Communicate to All of Group AOR. Another essential criterion for the NDS is that it enables the Group COMMCEN and OPCEN to communicate with its deployed units within its entire geographical AOR. The current NDS is not configured to completely fulfill this requirement. Numerous Groups and Districts have identified locations or "holes" where VHF-FM NDS coverage is weak or altogether non-existent, and work is being done to remedy the problems. References 11-14 are examples of this effort. Until the problem is corrected, Groups will have to rely on secondary means (e.g., low sites) to maintain communications throughout their entire AOR's. It should be obvious to the reader, but bears mentioning here, that this ability to communicate

throughout the Group's entire AOR mandates the use of either remote transceivers controlled from a central location or an extensive network of repeaters.

A second issue is that Group or COTP AORs are not totally coordinated with the NDS site locations. There are areas where the NDS site is controlled by one Group but the area it covers is partially within another Group. Coordination of operations is difficult in these situations. There are also instances of MSOs/COTPs that do not have their own communications networks and must rely on the NDS. In some of these areas, the MSO/COTP AOR stretches across several Group AORs. Communications between the MSO/COTP must be handled through any of several separate groups, depending upon the location of the underway unit. Access to all the NDS sites covering the COTP's AOR is essential.

A third issue is that of communications with aircraft. Aircraft are dispatched by CG air stations but are usually working for Groups in the execution of their operational missions. This requires that the Groups be able to communicate with the aircraft to coordinate searches, pass information, etc. For most Groups the only communications link with the aircraft is via the NDS using VHF-FM, which presently functions well. At the same time, however, the air stations are attempting to maintain communications with their deployed aircraft via UHF radio. The line-of-sight UHF communications suffer from limited range, especially when the aircraft are operating at low (e.g., 500 ft) altitudes. The air stations need to remain in contact with their aircraft, and therefore need access to the NDS, which most do not have.

(3) Communicate Using Secure Means. A recent requirement of the NDS is that it permit communications between the Group or Station and its resources via secure means. Two directives, Presidential Directive 24 and National Security Director Directive-145 require that all government internal communications be conducted over secure circuits [Ref. 15, 16]. In the case of VHF-FM communications at the stations, this has resulted in the installation of the aforementioned MCX1000 DES encrypted transceivers on the vessels and at the station low sites. As of yet, the NDS has not been officially upgraded to provide secure communications on a system-wide basis. Certain districts have, however, provided their own upgrades in the form of encrypted base stations and encrypted duplex repeaters to provide interim secure communications until the NDS is brought to the secure level. Of all the districts, the Seventh has probably the largest network of remote secure transceivers and repeaters to provide covered communications throughout the southeast U. S.

b. Record Message Traffic

Related to the Group Command and Control issue is the requirement for using the NDS to pass so-called record message traffic, i.e., written messages passed either as data or voice over the NDS to and from deployed units. In the case of vessels which lack teletype capabilities, the only method available for passing the traffic is using voice over the NDS. The NDS is used to send messages from the deployed unit to the nearest Group COMMCEN for further transmission over the Coast Guard's teletype circuits. The NDS is also used by the same underway units for receipt of message traffic from the Group COMMCEN's teletype network. In both cases, the usual way of transmitting the message is using voice which is a slow, labor intensive and error-prone method.

Several districts have experimented with using modems or packet radio terminal node controllers (TNCs) to automatically transmit the messages as data vice text, with limited success [Ref. 10]. The Coast Guard's Information Systems Center conducted a pilot project using amateur radio TNCs and MCX 1000 DES encrypted radios to transmit data over VHF-FM channels. This Low Cost Packet/SITOR Communications Project found that data could be transmitted in covered mode at speeds up to 1200 baud without error [Ref. 17:p. 13]. More information on recent research regarding the VHF-FM system and data transmission is provided in Chapter V.

2. Potential Requirements

a. Dedicated Data Channel

As indicated above, the NDS is currently used to pass record message traffic using both just voice and data-over-voice channels. The need for certain vessels to transmit and receive data while underway already exists, and the present solutions are adequate but temporary. The need for an established separate data channel becomes more and more evident as the matter is investigated.

Certain vessels have neither the manpower nor the equipment space to be able to operate an HF radioteletype facility in order to transmit and receive messages. None of the cutters on the Great Lakes or inland waters and most of the cutters 180' and smaller are unable to send or receive administrative or operational record message traffic while underway. Many of the new 110' cutters are equipped with High Frequency Data Link (HFDL) equipment to overcome this limitation, but the older vessels are not scheduled to receive HFDL equipment.

The establishment and use of a master law enforcement database for boarding histories and violation information, Law Enforcement Information System (LEIS II) encourages the need for a data link between afloat vessels and the shoreside networks, especially the Hybrid Data Network (HDN). Long deployments of cutters coupled with the mandated use of automated online procurement software drives the requirement that vessels be in regular data communications with the shore. Creating a VHF–FM data channel would enable this link without overloading the long–distance HF networks. This data link could be used for two–way access to the teletype network, the ARMS service, electronic mail, online LEIS II, and message traffic.

Use of the NDS for this data channel would enable communications from shoreside mobile terminals to the network. This would permit CG members in vehicles, onboard merchant vessels, or at emergency command posts to access the network using laptop computers and the appropriate radio equipment.

b. Geographical Display Operational Computer

The Coast Guard's Electronics Engineering Center is currently working on a Geographical Display Operational Computer (GDOC) system, formerly known as the Geographical Tactical Computer (GTC). This system, to be placed at each Group OPCEN, would serve as an electronic chart and database to provide positional and facilities information within the Group's AOR. It is scheduled to also have search planning and plotting features, as well as the ability to exchange data with other systems [Ref. 18]. The GDOC would also be used to process RDF information from remote RDF receivers, if available. If constructed as designed, it would have need for some sort of data link between the NDS sites, Group resources and the GDOC in order to efficiently pass information to and from underway resources and RDF receivers. There is also a shipboard version of GDOC planned, called the Shipboard Command and Control System (SCCS), which would have similar capabilities and would need data connectivity with other units and the shoreside network.

c. *NDS Network*

As indicated in Chapter III, the current NDS is not a network, but a system of independently-controlled transceivers remoted to Group offices. If the data channel capability was added to the NDS, it would be necessary to connect all the NDS sites together into a true network, and then provide connectivity between the NDS data network and the other CG networks, probably via the Coast Guard's X.25 Hybrid Data Network (HDN). Data would have to be routed dynamically from the network to the closest data transceiver for transmission to the deployed unit.

The presence of an integrated VHF-FM direction-finding system would require that the individual NDS sites were networked together, at least at the Group level, in order to provide several lines of position and the resultant accurate RDF positional fix. Logically Groups would also need to access adjacent Groups' sites in order to provide satisfactory three-bearing RDF fixes.

The NDS' various users (Groups, MSOs, COTPs) also need to have the flexibility of being able to control other NDS users' sites. This would enable overlapping access and the resultant ability for these units to contact their resources throughout their AOR's, without intervention by operators from the other units.

B. NDS PUBLIC COMMUNICATIONS REQUIREMENTS

Because the NDS also functions as a communications interface with the public, there are certain present and future requirements placed upon the NDS from a CG–public aspect.

1. Established Requirements

a. Digital Selective Calling

The United States, as signatories to the International Maritime Organization (IMO) conventions, has agreed to participate in the Future Global Maritime Distress and Safety System (FGMDSS). The FGMDSS

> ... will provide comprehensive distress and safety communications and require establishment of new procedures. The system will take advantage of recent technological advances to significantly improve the safety of life at sea. [Ref. 19:p. I–1]

The FGMDSS is a complete system which will provide seven functions through use of MF, HF, VHF and satellite communications technology. Those seven functions are:

- alerting
- SAR coordination communications
- on-scene communications
- meteorological, navigational, and urgent information
- locating
- general business communications
- VHF-FM bridge-to-bridge communications

The FGMDSS includes in its communications and alerting capabilities Digital Selective Calling (DSC) and Narrowband Direct Printing (NBDP). DSC is an alerting and circuit establishment feature very similar in function to the public switched telephone network's signaling system. It enables the automatic initialization of communications from one transceiver to another. The DSC message contains an address field that rings another receiver (either a specific receiver or all ships within radio range of the transmitter); an identification field for the unit initiating the call; a field indicating the nature of the distress, if any; a field for the location of the initiating unit; and a field for the frequency to use for further communications.

Narrow Band Direct Printing (NBDP) is a single-channel, automated telegraph system using transmissions at 50 baud. The transmissions are either duplex using the Automatic Repeat Request (ARQ) mode or simplex broadcast using the Forward Error Correction (FEC) mode. The Coast Guard is currently operating two NBDP systems. NAVTEX is a broadcast system in the MF band transmitting navigational warning information to ships at sea using NBDP. Simplex Teletype Over Radio (SITOR) is used in the HF band for two-way communications in the duplex (ARQ) mode between Coast Guard COMMSTAs and ships at sea, and in the simplex (FEC) mode to broadcast NAVAREA notices, hydrographic reports, and high seas weather broadcasts.

The system capabilities and vessel carriage requirements are delineated based upon the areas in which the vessels will be operating. The region which involves VHF communications is Area 1, which is defined to be within the coverage of shore-based VHF stations [Ref 19:p. II-17]. The requirements placed upon the Coast Guard's VHF-FM portion of its Telecommunications System include VHF-FM Digital Selective Calling (DSC) on Channel 70. The following requirements are anticipated:

> The VHF remote stations under Group control will need to operate a dedicated DSC watch on 56.525 MHz (Channel 70)... The current VHF base stations are overloaded during peak periods. New base stations will be required to support the proposed FGMDSS frequencies if the current command and control (C2) system operates in parallel with the FGMDSS. [Ref. 19:p. III-11]

Implementation of these capabilities is scheduled for the mid-1990's, any replacement of the NDS will have to take these treaty obligations into account and add DSC capability to the NDS.

b. Broadcast NTM

As per the Coast Guard Telecommunications Manual, the Coast Guard is required to transmit voice safety and information broadcasts on VHF-FM at specified intervals. These broadcasts are usually carried out by Group COMMCEN radiomen simultaneously on the NDS sites and the Group's local MF transmitter (using 2670 kHz USB). Scheduled broadcasts can last as long as 10 minutes and must be repeated twice a day (every 12 hours) with unscheduled broadcasts made frequently during the day. This requires a considerable amount of air time for both the personnel and the equipment, preventing their use for other communications.

Another issue regarding safety broadcasts is that of communicating with foreign vessels. The Coast Guard transmits safety broadcasts over Channel 22A. The "A" after the channel indicates that it is used for duplex operation, according to the ITU. The Coast Guard only uses one of the duplex channels within the U.S., causing any radios configured for international use to be unable to receive the safety broadcasts sent out by the Coast Guard. This inability has resulted in several near-misses and calls for some sort of legislation to solve the problem [Ref. 20]. This inconsistency with international practices and frequency assignments causes problems for foreign vessels transiting U.S. waters. Any resulting legislation or regulations would place additional requirements on the NDS. The general incompatibility issue is discussed further below in the section regarding all-channel selectability.

c. Distress Communications

Most of the communications between the public and the Coast Guard involves some sort of distress communications, either between the Coast Guard and a distressed vessel or between the Coast Guard and a third vessel acting as a communications relay for a nearby distressed vessel. Because the NDS public interface is primarily a distress communications system, it is essential that the NDS have the capability to communicate with distressed vessels anywhere within the design parameters (Appendix A). This is equivalent to the intra-CG requirement that Groups be able to communicate with their units anywhere within their AORs, just on different frequencies.

The primary CG distress communications requirement is that of guarding Channel 16. This requirement is currently being fulfilled by the NDS through use of the separate guard receivers at each NDS site, with one particular operational exception. Group COMMCENs have the ability to guard Channel 16 no matter to what channel the controllable transceivers are tuned, however they cannot hear traffic on Channel 16 when they are transmitting on the NDS. For technical reasons, when the controllable NDS transmitters are keyed, the Channel 16 receivers are muted. This prevents the reception of distress traffic during the periods when the NDS is being used for Broadcasts or other transmissions, and creates the probability of a distress call being missed during a broadcast.

d. All-Channel Selectability

As indicated in Chapter III, the current NDS remote transceivers permit a choice of only six channels. These channels are crystal-controlled, and can only be modified through replacement of crystals at the NDS remote transceiver sites.

The institution of Channel 9 as a supplemental hailing channel [Ref. 21], and frequent need to contact vessels on channels they normally monitor has made the six-channel limit unbearable. The six-channel maximum forces most NDS transceivers to select only six channels from the channels listed in Appendix E. NDS transceiver locations that serve two Groups would have to include both group working channels in the available six channels in order to provide service on both Groups' working frequencies.

The channel limitations of the present system act to heighten the overcrowded state of Channel 16. Distressed vessels that are willing or able to shift to other frequencies frequently do not have the frequencies available at the NDS sites for use, and the NDS equipment does not have the frequencies available that the distressed vessels can use. As indicated above, there are also problems regarding communications with foreign vessels carrying radios configured according to the ITU international VHF–FM guidelines. The need for access to all channels is evident.

e. VHF–FM Radio Direction Finding

Past incidents of distressed transmission location detection and present incidents of distress/hoax transmissions have initiated a need for a VHF–FM Radio Direction Finding (RDF) ability, at least on VHF–FM Channel 16 [Ref. 22:p. 1]. As previously mentioned, many CG stations have localized RDF capabilities for obtaining a RDF bearing on the marine band or EPIRB/ELT frequency, but the NDS currently has no RDF network. The creation of a RDF network for the NDS has now become a priority for the Coast Guard [Ref. 22:p. 1].

The cost benefit of coastal RDF networks was investigated in a study performed in 1986 [Ref. 23]. The study examined the cost of installing RDF equipment versus the savings in operating expenses resulting from reduced search operations because the location of the distressed vessels was provided by the RDF network. The general results indicated that:

> ... the installation of VHF–DF in some Coast Guard Groups is a very favorable proposition. In a least nine of the groups studied, a VHF–DF system will pay for itself in reduced operating costs in less than five years. An investment in VHF–DF made now will save money well into the foreseeable future. [Ref. 23:p. 28]

It should be noted that *no* analysis was made of possible additional lives or property saved as a result of the use of the RDF net, only the reduced operational costs. Any benefits in additional lives or property saved would be over and above the savings indicated in the study. The conclusions of the study echo this concept:

> One should also consider the potential for saving additional lives and property through use of VHF–DF. Although it was not possible to predict the savings in lives and property, it is possible to look at the historical potential. For those areas (cells) that have a payback period of less than five years, based on the benefit–cost analysis in Appendix D, there were 42 lives and $7.4 million worth of property lost during FY83 and 84. The savings of only one life or even of only ten percent of the property lost would compensate for the $250,000 to $350,000 cost of VHF–DF equipment for the cell during the first year of operation. [Ref. 23:p. 28]

As mentioned above, there is not at this time any capability for performing VHF RDF using the NDS sites. Considerable interest, however, has arisen in having RDF capabilities added to the NDS. A pilot project between MLC Pacific and Commander, Fourteenth Coast Guard District will be installing remote RDF bearing equipment at the four NDS sites in Hawaii in the near future. The recent incident with the F/V Sol E Mar off of Cape Cod accentuates the need for some sort of RDF network along the coasts for SAR and hoaxes, and has sparked Congressional interest and funding towards the establishment of a VHF–FM RDF network [Ref. 22]. And a project has been proposed to evaluate the various RDF technologies at the Coast Guard Academy [Ref. 24].

2. Potential

a. Differential Global Positioning System Transmissions

The Global Positioning System (GPS) satellite navigation network permits accurate terrestrial positioning to within 100 yards for civilian vessels at sea. A value added service of GPS, called Differential GPS (DGPS), permits transmission of a localized correction factor from terrestrial transmitters which increases navigational accuracy to within tens of yards for maneuvering in pilotage waters. Due to limitations on the GPS satellites, this dGPS signal has to be transmitted to the GPS receiver separately from the GPS signal itself. The GPS satellites also lack the ability to blink, or notify their users when one of the satellites is transmitting incorrect signals, thereby making the navigational information from that satellite suspect. In addition to providing higher accuracy signals, the dGPS signal could also be used to carry out the GPS blink function. Both the correction and blink signals are provided by a GPS monitoring center, which monitors the status of the GPS network.

At this time there have been experiments using CG-operated MF radiobeacons to transmit the dGPS signal. Because of the lack of connectivity of the radiobeacons--most are placed in remote areas with only power connections--they are ill suited to be connected to the GPS control center for use in transmitting the dGPS signal. The NDS sites and VHF-FM transmitters may be called upon to provide better connectivity and coverage for the dGPS signals. This would be especially true if the NDS were, for other reasons noted above, provided with true network connectivity.

b. VTS/MARDEZ interface (secure)

As part of the Maritime Defense Zone (MDZ) Harbor Control system, the CG Vessel Traffic Systems (VTS) need the ability to communicate with MARDEZ resources over secure VHF frequencies. At present, most VTSs have their own remoted transceivers for use from their OPCENS while communicating with the vessels transiting the waterways under their control. These transceivers (Appendix C) do not currently have the ability to communicate via secure means. If the NDS is provided the capability to transmit and receive using secure means, access to the system by the VTSs would prevent their having to also buy secure-capable transceivers of their own.

c. Dependent Surveillance

There has been considerable interest in the Coast Guard regarding dependent surveillance of vessels [Ref. 25]. Dependent surveillance can be defined as the ability to determine the position of a vessel through transmissions from the vessel. This definition would eliminate radar, but would permit location via transmissions from the vessel itself, either providing the location from onboard navigational equipment or enabling shoreside RDF to locate the vessel.

An experiment in the early 1980's tested the possibility of dependent surveillance of CG vessels. The so-called "Hampton Roads Testbed," named for the group where the project was installed, plotted location information from CG vessels on a Graphical Analysis, Archiving and Display Station (GAADS). This information could then provide vessel track history, near-real-time positioning of resources, updated buoy locations and status, and calculation of intercept information for the vessels. Results from the experiment indicated that this dependent surveillance was beneficial to the group users [Ref. 26:p. 31].

It should be noted that Digital Selective Calling has the inherent ability to transmit positional information within its polling and ship's position calling sequences. The DSC transmitter aboard the vessel can be configured to transmit the ship's position--provided by onboard navigation systems such as dGPS or LORAN--at regular intervals or when polled. This would in effect broadcast the location of the vessel to all DSC receivers, including the NDS DSC-equipped receivers. Adoption of the DSC standard for dependent surveillance would require similarly-equipped DSC transceivers at NDS sites, but would provide near real-time positioning information for VTS dependent surveillance use.

V. EVALUATION OF SELECTED TECHNOLOGY

Due to the specific nature of VHF–FM communications, there has been only a limited amount of research regarding the topics of VHF–FM RDF, DSC and VHF packet switched networks. In this chapter, the author evaluates the available VHF–FM technology and surveys the applicable research that has been conducted.

A. RADIO DIRECTION FINDING

The primary user of large radio direction finding systems in the United States is the federal government. Various agencies maintain direction–finding equipment and networks for law enforcement and national defense. In the military, radio direction finding (RDF) falls under the general topic of electronic warfare (EW) or electronic intelligence (ELECINT). As such, it is used by ships, aircraft and land units as a passive method of locating a radio transmitter.

In the civilian world, RDF units are used by boaters and aircraft for navigational purposes. These vehicles utilize the various networks of radiobeacons established for navigation and position determination.

Because VHF is a relatively short–range line–of–site communications medium, there has been little research involving VHF DF. Considerable effort has been expended in HF DF research and HF DF networks; however, due to the differences in propagation, this research is not applicable to VHF. The author was able to locate one VHF study performed in 1978 by the Department of Transportation's Transportation Systems Center in Cambridge Massachusetts for the Coast Guard involving Coast Guard units [Ref. 27]. This study evaluated RDF techniques for shore-based position locating using discrete DF equipment. The study surveyed available DF techniques, developed an analytical model, performed error analysis of the equipment, and conducted a field test of the systems. The conclusions of the study were that:

- shore-based DF was shown to be a valuable SAR tool
- shore-based DF was valuable for locating EPIRBs
- DF performance is critically based upon antenna placement
- synthetic doppler antennas are better than Adcock arrays
- graphical display of bearings was preferred over digital
- it was desirable to remote the DF antenna via phone lines

[Ref. 27:Chap 5:p. 1-4]

The recommendations of the study were that:

- the CG proceed with a thorough DF test and evaluation
- the DF antenna be the same height as the comms antenna
- the DF antenna site minimize local signal reflections
- a systematic site evaluation procedure be developed
- commercial units should be modified to increase sensitivity

- the IDFM DF system should be further evaluated
[Ref. 27:Chap. 5:p. 3–4]

It should be noted that the last recommendation refers to a direction finding technique, induced doppler FM (IDFM) that can determine both the bearing to the transmitter and the range. At the time of the study there was no equipment that used the IDFM technique, but the testers believed that the technique showed promise. Unfortunately, none of the systems surveyed by this author use the IDFM technique.

1. Discrete Systems

As previously discussed, discrete systems are those that directly or remotely determine the bearing from the RDF antenna to the transmitter and display it to an operator. These systems are usually small, inexpensive, and reasonably accurate.

There are numerous manufacturers of discrete RDF systems; for a listing see Appendix D. Most of the commercial marine units are designed for use by boaters to provide lines of position from the Coast Guard's network of MF radiobeacons located at or near major nautical reference points (e.g., inlets, headlands, etc.). They are also able to receive commercial broadcast frequencies and use those transmissions for localizing their positions.

In addition to the marine units, there are numerous specialty units produced for use by military vehicles, vessels and aircraft. These units provide the ability for determining relative bearing of a transmission source and enable the unit to "home in" on the source. These are used for locating navigational beacons, emergency beacons (EPIRB/ELT) and for tactical use in locating enemy transmitter sites.

Discrete systems are compact and inexpensive, and are useful when a single line of position or bearing is desired. They are installed aboard most CG vessels and aircraft and are used for both navigation and homing in on a signal. In limited cases the bearings from multiple sites are combined manually to provide a triangulated position. It is very uncommon, though, to find a discrete system that provides any type of record of the bearings. In other words, discrete systems are definitely "real time" systems, with no method of recreating the information once the signal has ceased, unless a written record of the bearing is maintained by an operator.

In most instances, these discrete systems are unable to share information between multiple sites automatically. Any triangulation of a transmission received at more than one RDF site must be performed manually by an operator, and plotted manually on a chart of the area. It is for this reason that integrated systems have been developed to automate this process and analyze the information provided by multiple RDF receivers.

2. Integrated Systems

As indicated previously, integrated systems use bearing information from multiple receiver sites and computer technology to process the data and provide locations, not just bearing lines or lines of position (LOP). A typical result using new technology is a geographical display of the area showing lines of position from the RDF sites intersecting at a point surrounded by a probability ellipse to indicate the detected location of the transmitter (Figure 8). Additional display information includes bearings from each RDF antenna and a bearing/range from a shoref location, in this case Coast Guard Station Shinnecock. Enhancements to these systems permit the display of relative signal strengths, the manual inclusion of bearing data provided by RDF units not connected to the system (e.g., from a nearby vessel), and even spectral analysis of the signals in order to differentiate between two simultaneous transmissions on the same frequency.

The Canadian Coast Guard has had an integrated system installed in Georgian Bay, Canada for several years. This system has the capability for eight remote RDF sites but is currently in operation using only two remote sites. This system has the advantage of including a color printer which can provide a hard-copy output of the screen display, thereby solving the problem of recreating or storing the signal and bearing information.

In the U.S., the Federal Communications Commission (FCC) currently produces and operates their own integrated RDF equipment which functions over a very broad frequency range, 30 MHz to 1 GHz. The Coast Guard has made use of the FCC's installed system of four remote sites in a major coastal metropolitan area for RDF of distressed vessels, hoaxes and false alarms. The Coast Guard has also provided funding for the FCC to install a joint-use system of eight remote sites in a second coastal metropolitan area. Besides the FCC, there are several manufacturers of integrated RDF systems; these are listed in Appendix D.

The FCC system has many positive features as an integrated RDF system. The operator interface is very "user friendly." The control software permits the central computer to remotely control the frequency of the RDF receiver at the antenna site.

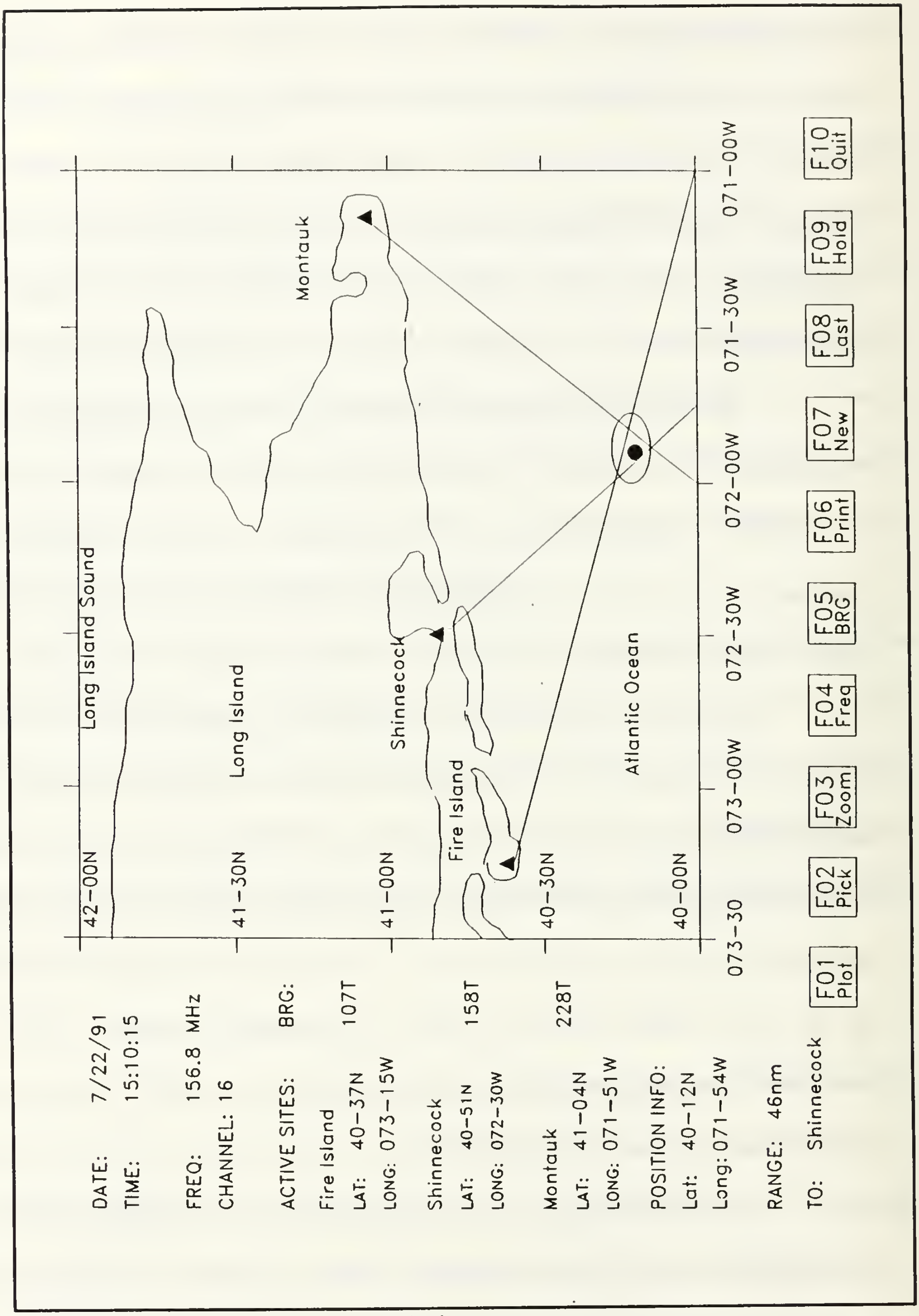

Figure 7 Typical Integrated RDF Display

Frequencies can be selected as channels instead of frequencies if desired, permitting the operator to select "channel 16" instead of trying to remember and then input 156.8 MHz. The use of dial-up modems enables the remote sites to be called and controlled by operators at an alternate central computer site. The efficient user interface also permits weak or spurious signals to be disregarded, or additional RDF LOPs from other sources to be added into the plot and subsequent calculations. Easy as the interface is, however, the operation of the network is at such a level that it would take considerable training for a user to become proficient and effective.

An issue that the FCC has successfully dealt with is the placement of the RDF antennas. If the antennas are placed near other radiating sources, they suffer from those strong signals, and are unable to effectively DF weaker signals. The FCC places their antennas in relatively quiet RF areas in order to minimize interference from other sources of electromagnetic interference.

Unfortunately, the FCC systems lack an essential feature that is necessary for the Coast Guard's use of RDF as an effective distress location tool. For economy, the FCC systems use dial-up access vice leased lines to the remote receiver sites. This requires that the operator initiate a call between the central computer and the remote sites to establish a circuit before bearings can be obtained from the RDF equipment. In the event of only one short distress call being transmitted by a vessel, as was the situation in the recent case of the F/V SOL E MAR [Ref. 28] off of Cape Cod, this system would take too long to activate. Even a feature such as an instant recall, a "go back 15 seconds" button such as installed in the RDF systems in Miami and St. Petersburg, would be too limited for truly efficient use. It is clear that some sort of permanent signal and bearing storage method needs to be included in any RDF system.

Chapter III discussed the integrated RDF systems that the Coast Guard has installed and operational. These systems have proven to be of only limited use due to reliability and sensitivity problems. Also, if the multiple antenna sites are in a relatively straight line, there are limited locations where a three-line fix can be obtained due to the strength and line-of-site nature of the signal.

Besides the Coast Guard and the FCC, another user of integrated RDF equipment is the Federal Aviation Agency (FAA). The FAA has VHF-FM RDF sites at all Automated Flight Service Stations (AFSS) and major Flight Service Stations (FSS) throughout the U.S. These units are able to control up to 24 separate stations and provide triangulation and graphics plotting capabilities to the FCC control station. The remote sites can be controlled from as many as four central units, thereby enabling more than one master unit to access remote sites. In addition, the system has the ability to track and display the locations of up to ten aircraft simultaneously, and to display data about individual airports, obstructions, or navigational aids. The FAA system also has an "emergency mode" with the ability to automatically show course and distance information from a distressed aircraft to the six nearest airports. [Ref. 29]

The FAA's system has the same benefits as the FCC's, with the addition of being able to display geographical data regarding navigational aids, facilities, etc. The FAA's system is also commercially made, and would not be restricted in its deployment by the limited production capacity of the FCC.

The FAA's system suffers from the same dial-up modem requirement that affects the FCC system. But the manufacturers of the FAA's equipment claim that their bearing data can be provided in less than one second. However, this does not solve the bearing storage and recall problems noted above. Finally, the FAA's system is optimized for the frequencies between 118 MHz and 136.975 MHz; they would have to be modified for CG use.

B. VHF-FM TRANSCEIVERS

The standard VHF-FM marine-band transceiver has matured into a very compact and feature-laden communications device as a result of advances in electronics technology and fabrication. Most units are fully synthesized, able to operate over all 54 transmit channels and 85 receive channels (including the National Weather Service weather channels) and available in either hand-held or installed configurations costing less than $500. Output is switchable and ranges from one watt to a legal maximum of 25 watts. Compact size and weatherproofing enable even an open boat to have a user-installed VHF-FM marine radio aboard.

Gone are the days when SSB or DSB AM radios had to be installed and tuned by the technician, who required large grounding plates and cumbersome antennas to make the equipment work. The VHF-FM transceivers provide clear interference-free communications between boats within line-of-site distances and with the Coast Guard's NDS out to 30 or 40 miles, as a general rule. Distressed calls are more efficiently made--the Coast Guard no longer has regular beach patrols or manned watchtowers in most areas scanning the seas for distressed flares or evidence of a wreck at sea.

The author was unable to locate any applicable research regarding VHF-FM transceivers or transmission. Like VHF-DF, this topic is so specialized that it is unlikely there is much research available. VHF-FM modulation techniques and transmission equipment has progressed to such an extent that it is a mature technology.

Despite the advances in VHF-FM radios, most of the newer features contained in these general purpose transceivers are still not available for use within the Coast Guard. As noted above, the Coast Guard needs to maintain a Channel 16 guard, to transmit and receive encrypted voice, and to have remote control of the NDS transceivers. As a result, the radio equipment purchased by the Coast Guard is usually supplied by one of the major vendors of commercial telecommunications equipment. These manufacturers are usually not as quick to provide the newer features, preferring to provide upgrades to the present equipment. This limits the capabilities of the systems provided, especially in the areas of channel selection, encryption, and Digital Selective Calling (DSC).

1. Channel Selectivity

Current technology from Motorola, the manufacturer of the installed NDS equipment, limits the number of remotely-controlled channels to 12. This limitation is caused by the availability of only 15 in-band signalling function tones. Twelve tones are used for switching among the 12 channels and the remaining three are used for other transceiver functions. The presence of this in-band signalling also precludes the use of standard 1200 baud or higher modems over these radios due to conflicts between the modem tones and function tones, as identified in the Low-Cost Packet/SITOR experiments [Ref. 17]. A shift to another manufacturer that provides out-of-band signalling would be costly, due to encryption incompatibilities discussed below.

2. Encryption

The Coast Guard presently has an installed base of DES-encrypted VHF-FM transceivers--the MCX 1000 mobile radio with channel 16 guard and the MCX 300R handheld radio. Both of these use the standard DES encryption algorithm for secure communications at the encrypted for transmission only (EFTO) level in the marine VHF-FM band.

The DES encryption provides secure but not classified communications over the radio. Other federal agencies such as the U.S. Customs Service (USCS) and the Drug Enforcement Agency (DEA) use DES radios for communications. Because the present radios are capable of operating in the government band from 162 MHz to 174 MHz, the Coast Guard has compatibility with these other agencies and can therefore establish secure radio communications with them. The radios are relatively easy to code and operate, and have proven to be very useful. They are not without their problems, however.

The implementation of the standard DES encryption algorithm by Motorola produces transmissions which are not compatible with DES radios manufactured by other companies. As a result, the Coast Guard would have to replace not only its NDS transceivers, but all its DES-encrypted radios if it were to change transceiver manufacturers for its encrypted transceivers. Because of this, the Coast Guard is limited to the technology that Motorola can provide, unless another company builds equipment that follows Motorola's DES bytestream pattern. A second problem with the DES transmission is a loss of signal strength by approximately 3dB resulting from the conversion of the analog voice signal into a digital signal at 12kbps. This limits the range of the handheld MCX 300R units to nominally only three or four miles.

3. Digital Selective Calling (DSC)

The DSC implementation is still in its infancy here in the United States, but has already been installed and tested along the Danish coast [Ref. 30]. The use of DSC will be mandatory for vessels greater than 300 tons and vessels carrying six or more passengers constructed after 1 July 1995. All similar existing vessels will be required to have DSC-compatible radios by 1999 [Ref. 31].

Little research was found regarding VHF-FM DSC technology. The CCIR standards are still in the draft stage and the technology is still being developed. The only study located proposed a mathematical model to determine if one DSC channel would suffice to provide an acceptable grade of service for both commercial calling and distress calling. The results of the study indicated that one channel was sufficient, based upon there being 19 single-frequency channels available for commercial calling [Ref. 32:p. 106]. The total number of available channels may change, however, due to the planned reduction in the VHF-FM marine channel bandwidth from 25 kHz to 12.5 kHz. This bandwidth reduction would double the number of available channels and therefore place approximately double the load upon the DSC channel. One channel may therefore no longer be enough for both distress and commercial calling.

The currently-available DSC-equipped units in the U.S. have the standard DSC features plus some additional features that would be of great value to the mariner. Because DSC permits what are in essence station-to-station circuit-switched calls, there is need for some sort of directory service. The current implementation permits this with a large (99–200 number) scrollable directory for calling other DSC radios. This scrollable directory enables the caller to scroll through the directory until the radio call sign (or alternately the registration number or vessel name) of the callee is found, and then to initiate a call to the callee with a keystroke. If the callee's radio is active, the callee is alerted and can respond to the call. If the callee does not answer, the caller's call sign is stored in a 100-number "call waiting" directory within the receiving unit. An additional 99–200 number directory is provided in which to store shoreside telephone numbers. Ultimately DSC-equipped vessels will be able to make automatic connection requests via DSC-equipped marine operators into the public switched telephone network, creating a mobile-to-shoreside phone capability similar to cellular telephones. All of this is made possible using the DSC channel 70 as a control circuit to establish radio communication circuits between two DSC transceivers.

An automatic alerting feature is also installed in the DSC transceiver. Activation of this feature transmits an emergency message packet to all radios within range, causing them to produce an audible signal and display the sender's identification (i.e., callsign, vessel name, or vessel registration number). If the distressed vessel has a navigational device (e.g., LORAN or GPS receiver) connected to the DSC radio, the vessel's position can be transmitted in the packet. This enables the distressed vessel to transmit the vessel's identification, location, and nature of distress automatically. A similar feature enables DSC transmitters to make "all ships" calls for broadcasting safety or weather information.

The Coast Guard is investigating the installation of a DSC transceiver as a remote for the NDS site in St. Petersburg, Florida. Implementation would require one receiver and two transceivers; one receiver for Channel 16 guard, one transceiver for Channel 70 (DSC channel) guard and a transceiver for general communications. Control of the equipment would be via the standard Motorola NDS remote control unit. Receipt and processing of the DSC information from the Channel 70 transceiver would be managed by an application running on a Coast Guard standard microcomputer. At this point, there are very few manufacturers of DSC equipment in the United States. The Federal regulations have not yet been adopted, and final standards have not been established. Unless its use is also mandated for recreational vessels, the DSC implementation will be only a partial solution. It could even prove to be a safety hazard for recreational vessels. Once they are DSC-equipped, commercial vessels will no longer monitor Channel 16, and there would be no way for recreational vessels to contact the commercial vessels for assistance or for preventing collisions without using DSC.

C. RADIO PACKET SWITCHED NETWORKS

In packet switched networks, data is sent using packet switching technology, where the information is broken down into small quantities, encapsulated in packets and transmitted. These packets contain both administrative information (address, routing, etc.)

and the message itself. Receivers acknowledge for and keep only the packets addressed to them, discarding any packets addressed to other stations. Packet switching is used for connectivity between computers in terrestrial local area networks (LAN) such as Ethernet (IEEE 802.3) or IBM's Token Ring networks (IEEE 802.5). These LANs use a solid medium for the transmission of the packets, usually either copper or fiber optic cable.

Radio packet switched networks (RPSN) use radio waves as the transmission to create wide area networks (WAN). The presence of radio packet switched networks is hampered by limited available frequencies and transmission bandwidth. At present, there are only a few RPSNs in existence, and only limited equipment for use with RPSNs. The military uses special packet-switched radio systems for battlefield communications, but these are not really suitable for the Coast Guard's needs.

Considerable research has been performed regarding radio packet switched networks. As far back as 1974, the Defense Advanced Research Projects Agency (DARPA) funded studies regarding radio packet switched networks. Topics investigated included network capacity, configuration, topology, routing and transmission range [Ref. 33, 34]. Further research continued to investigate these topics as well as the use of satellite links in terrestrial RPSNs and the use of broadcast networks [Ref. 35, 36].

1. ALOHA Network

The first large-scale radio packet switched network was the ALOHA system developed at the University of Hawaii in 1971. This was a packet switched system using duplex VHF-FM frequencies to connect the seven campuses on four islands to the mainframe computer on the island of Oahu. Transmissions from different remote stations to the receiver at the mainframe were subject to contention and collision, but transmissions from the mainframe to the remote sites were not subject to either contention or collision. Packets sent from the remote stations and successfully received by the mainframe were acknowledged by the mainframe. If a packet was not acknowledged in a certain amount of time, the remote station assumed that the packet was lost due to collision and, after a random time-out period, retransmitted the packet. Stations were free to transmit packets on demand; there was no monitoring of the frequency to determine if it was already in use by other stations. This transmission method is now termed Pure ALOHA. [Ref. 37:p. 182–185]

The ALOHA network was a success. It permitted efficient two-way data communications without the need for expensive and unreliable telephone lines.

The ALOHA protocol had its drawbacks, however. The best that can be hoped for is a channel utilization of 18%, which is much less than most users would find acceptable [Ref. 37:p. 123].

A variation on pure ALOHA is slotted ALOHA, which prevents stations from transmitting until a time signal is given. This essentially doubles the throughput of the ALOHA system to 36%. For a full explanation of the efficiency of ALOHA and slotted ALOHA see Ref. 37:p. 121–124.

2. Graphical Analysis, Archiving and Display Station

The Coast Guard first experimented with a radio packet switched network in 1982. This system was called the Graphical Analysis, Archiving and Display System (GAADS) [Ref. 26], and was actually an integrated system of vessel location, com–

munications and geographical data display. GAADS was better known as the "Hampton Roads Testbed," named after its test site, Group Hampton Roads (GHR) Virginia. Initially GAADS began as a project to communicate with and track underway CG vessels and to maintain a shore-side data base for storage, processing and report generation. These three systems were called the Mobile Digital Communications Subsystem (MDCS), the LORAN C Navigator (LONA) and the Shore Based Network (SBN), respectively. The system was based upon one used by the City of Miami Police Department to track and communicate with its patrol cars. GAADS used a polling scheme, communicating with each vessel at ten-second intervals to pass location information and messages back and forth via the MDCS between underway units and the SBN.

A further enhancement to the system resulted in the creation of the GAADS terminal, which enabled the shoreside operators to see the vessels' locations plotted on an electronic chart of the area. Other features of GAADS included:

- bearing and range calculations
- an electronic maneuvering board
- track histories of single and multiple vessels
- ability to change charts electronically
- ability to zoom in on charts
- vessel intercept calculations
- ability to generate search patterns

- ability to plot voyage waypoints and display buoys
- ability to store/recall data on a floppy disk

GAADS suffered from equipment reliability and vessel availability problems. Acceptance of the system by users was mixed. Communications with the vessels was considered secondary to the basic locating and plotting features. Results of the study included:

- GAADS successfully provided GHR with near real-time
- graphic displays of resource and target locations
- resource position monitoring during SAR cases was found to be important
- automatic generation of search patterns was found to be a useful capability
- the ability to zoom-in the electronic charts was valuable
- the ability to display track history was useful
- the capability to automatically plot and monitor search pattern execution saved time and effort [Ref. 26:p. 31-34]

One project that has evolved from the GAADS research is the Geographical Display Operational Computer (GDOCS). GDOCS is scheduled to have features similar to those tested in the GAADS project, with the ability to provide facility information, plot search patterns, track vessel locations, permit CG database queries, and plot RDF bearings. The present GDOC proposal does not include any data communications facilities, however. Plans are for GDOC to be placed at Groups, AIRSTAs and MSO/COTP OPCENs. [Ref. 18]

3. High Frequency Data Link (HFDL)

The High Frequency Data Link (HFDL) currently in use by Coast Guard units is a radio packet switched polling WAN, which provides data link connectivity between cutters and Coast Guard COMMSTA's designated as net master stations. Transmission is in the HF band and encryption is possible to the SECRET level using the KG84C encryption device. A diagram of the HFDL is shown in Figure 8.

The polling occurs when each secondary station is queried, in turn, by the master station. The master station sends a query packet addressed to each specific secondary station asking for a response. Secondary stations that have no traffic respond to the poll with a "no traffic" report. Secondary stations having traffic transmit their traffic when polled.

Polling of stations by a master station guarantees that the presence or absence of a station is noted by the master. Lack of a response to a poll by a secondary unit alerts the operators at the master station to the fact that contact has been lost with that particular secondary station. Polling also ensures that each station is given an opportunity to send its traffic without contention between stations. Polling is a form of time division multiple access (TDMA) where each secondary station is given a slice of time to send its traffic; the signal marking the time slice being the poll from the master.

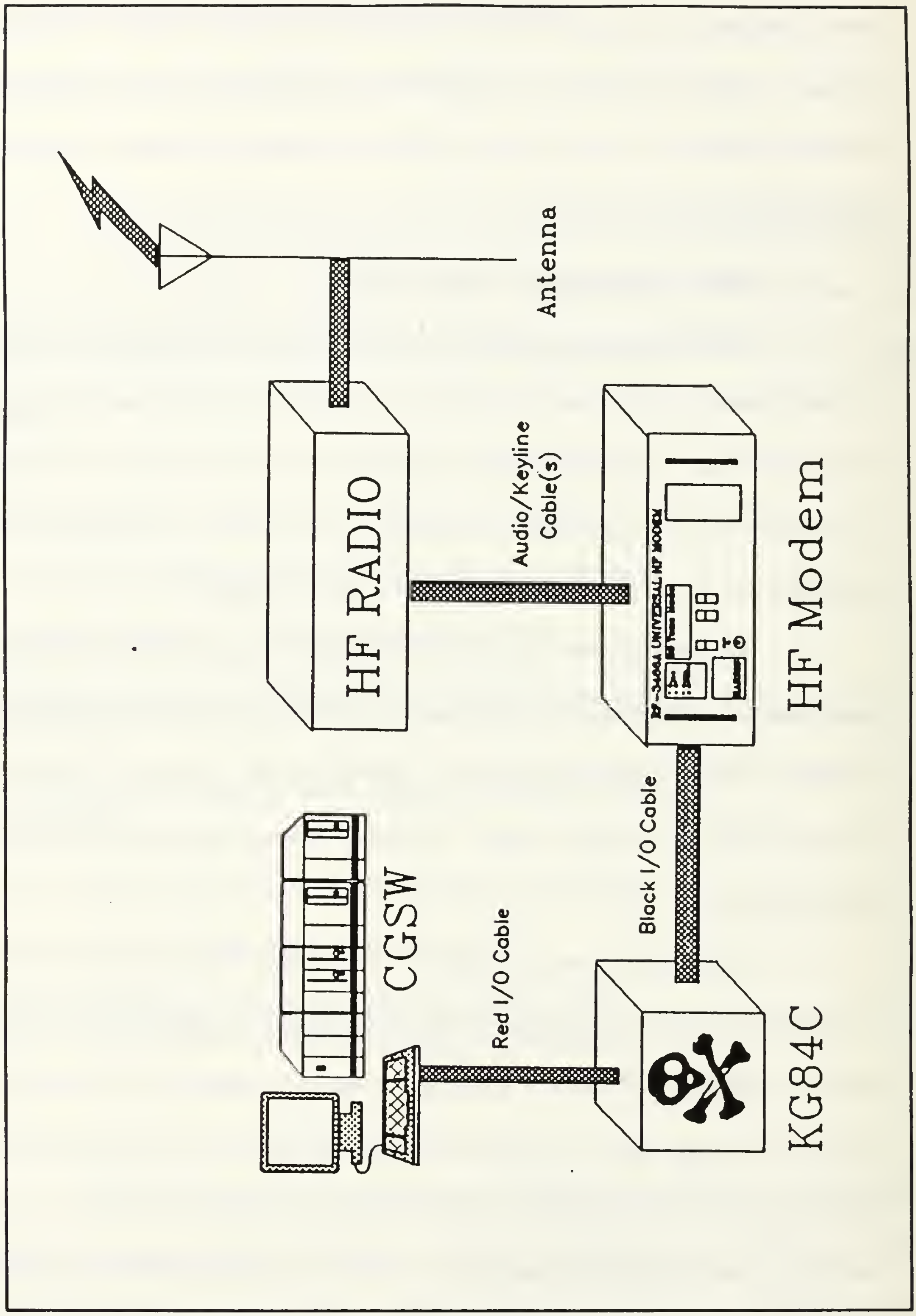

Figure 8 High Frequency Data Link Configuration

Polling, however, clutters the spectrum with polling transmissions and responses even if there is no traffic to pass and prevents the passing of traffic until a station is polled by the master. Polling also requires that the master station know the address of each of its secondary stations. Polling prevents the secondary station from transmitting traffic or alerting the master station at times other than when that secondary station is being polled. Unless used for a limited number of stations, polling would not permit a rapid two-way communications link, such as would be needed by an underway unit querying a shoreside database.

An alternative to polling is the use of a carrier sense multiple access/collision detection scheme (CSMA/CD). CSMA/CD permits traffic to be passed to the primary stations by the secondary stations on demand. Each secondary station transmits when it has traffic to pass, and only when it senses that there are no other carriers using the frequency. Note the difference here between CSMA/CD and ALOHA. ALOHA transmitted whenever there was traffic, without first checking to see if there were packets already being transmitted by another station. As can be imagined, even with CSMA/CD there will be times when two or more secondary stations would hear no carrier and both transmit simultaneously, thereby causing collisions. The collision detect algorithms must account for these collisions and provide for a method to detect them and to retransmit the traffic. The AX.25 protocol used by amateur radio packet systems is considered CSMA/CD, but is limited in its ability to "carrier sense" due to the line-of-sight nature of VHF communications and the so-called "hidden transmitter" problem. In the "hidden transmitter" problem, two transmitting stations may not be able to sense each other's carriers due to their geographical separation, but a third receiving station between the two stations would be able to receive signals from both distant stations. If one of two distant stations transmitted (the hidden transmitter), the second would not be able to sense the first's carrier and would transmit, causing a collision. In this manner, the carrier sense phase of the protocol would fail to function, but the collision detection and retransmission would correct for the collision.

4. Amateur Radio Packet Switched Networks (AX.25)

The AX.25 protocol was developed by amateur radio for use in RPSNs and is a variant of the CCITT X.25 level 2 packet protocol used by terrestrial wired packet switched networks. The additional features in AX.25 include an extended address field (to permit the inclusion of up to eight addresses for routing) and the addition of an Unnumbered Information (UI) frame for use in transmitting beacons to multiple stations.

Amateur RPSNs consist of a computer terminal, a radio (either HF or VHF) and a dedicated terminal node controller (TNC) which acts as the packet assembler/disassembler (PAD) and contains the hardware for the AX.25 protocol. TNCs are inexpensive and readily available from commercial sources, terminals can run any basic data communications program, and standard VHF–FM radios can be used. Amateur radio operators have created vast networks of VHF and HF packet radio bulletin boards and simplex FM digital repeaters (called digipeaters) and are able to transmit message traffic nationwide. The AX.25 protocol permits packets to be sent "in the blind," that is without a specific address for the receiver. This enables beacon operation and broadcasts of announcement messages without the need for polling.

Packet radio networks have a limit to their efficiency, due to the possibility of collision and packet retransmission. Heavily-loaded systems will slow down considerably due to this need for packet retransmission. Multi-hop transmissions especially suffer degradation in throughput from the "hidden transmitter" problem. The Coast Guard has experimented with Radio Packet Switched Networks using amateur radio technology [Ref. 17]. This experiment showed that secure two-way packet radio communications could be successfully conducted using Motorola DES radios and off-the-shelf TNCs. Data transmission rates of 1200 baud were easily attainable, except when using NDS equipment. The problem was an incompatibility between the NDS hardware and the modems. The standard Bell 202 modem tones used to transmit data interfere with the Motorola function control tones and prohibit transmission over the current NDS equipment at rates greater than 300 baud. Overall, however, the experiment proved the feasibility of using AX.25 protocol and inexpensive off-the-shelf equipment to transmit and receive data between Coast Guard units in a secure mode.

VI. SUMMARY AND RECOMMENDATIONS

As the preceding chapters have shown, the recapitalization of the National Distress System brings with it a myriad of details. Its replacement must be orchestrated within the Coast Guard and coordinated among other agencies in order to effectively deal with the related initiatives currently underway.

It is evident from the applicable technology that the equipment and systems exist or are being developed to fulfill the requirements put forth in this thesis. The more mature technologies of VHF–FM transceivers and radio direction finders are being joined by systems which provide DSC and radio packet communications. All of the needed technologies exist as separate pieces; what is required now is for the Coast Guard to work towards the integration of these various systems into one NDS network. The resultant system would be able to fulfill the requirements and provide options for expansion well into the next century.

A. FUNCTIONAL MODEL

A result of this research has been the development of one possible functional model of the NDS that would fulfill the requirements discussed. This model provides a graphical representation of the radio frequency information flows and the general architecture of the system up to the Group level.

The radio frequency information flows are detailed graphically in Figure 9, along with the equipment necessary to manage these flows. It should be noted that these flows carry both internal Coast Guard C^2 traffic and communications between the Coast Guard and the public. Any move to separate the internal Coast Guard C^2 communications network from the NDS will have to take this into account.

Figure 10 shows the recommended NDS remote site configuration. The equipment indicated reflects what would be needed to transmit/receive and manage the information flows shown in Figure 9, and is all readily available from commercial sources. There are two specific items that are of note, that of the RDF antenna controller and the use of Integrated Services Digital Network (ISDN) telephone technology.

The RDF antenna controller is needed to enable the Channel 16 Guard receiver to connect to both the communications antenna and the RDF antenna. It is assumed that the default configuration for the guard receiver would be for it to be connected to the RDF directional antenna, ready for use with the RDF system. The RDF antenna controller also permits the general communications transceiver to access the RDF antenna and perform RDF on any of its marine or government channels. When the general-purpose communications transceiver was using the RDF antenna, the Channel 16 guard receiver would be connected to a regular antenna on the tower to maintain the Channel 16 guard.

The use of ISDN technology enables the two voice signals and the packet switched information to flow over the same ISDN Basic Rate Interface (BRI) channel. The BRI channel contains two B (64kbps) voice/packet and one D (16kbps) packet channels. The two voice signals, the Channel 16 guard and the general communications transceiver, would share one B channel by using Adaptive Differential Pulse Code Modulation (ADPCM). ADPCM enables analog voice to be digitized and occupy only 32kbps; a

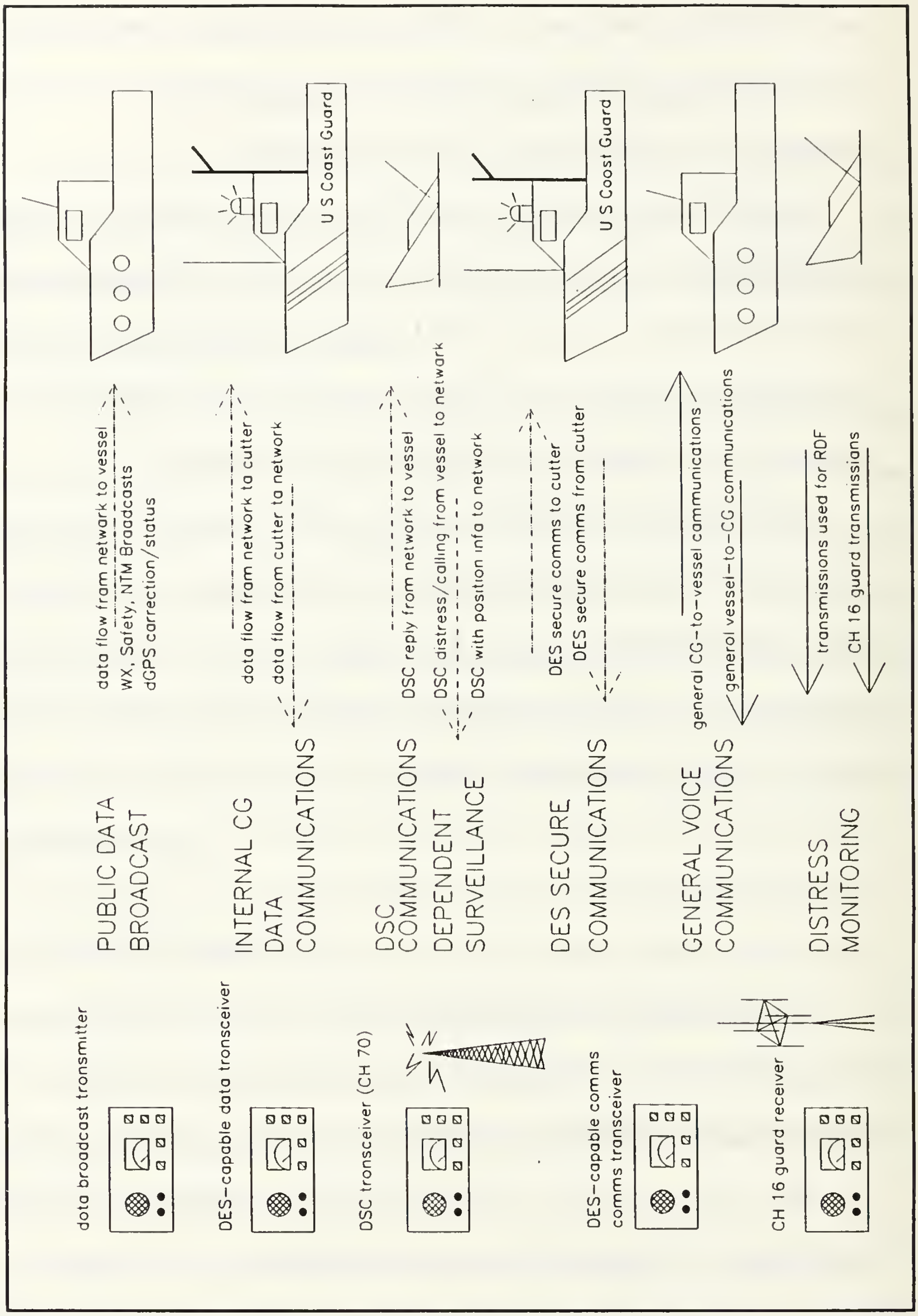

Figure 9 NDS Radio Frequency Information Flows

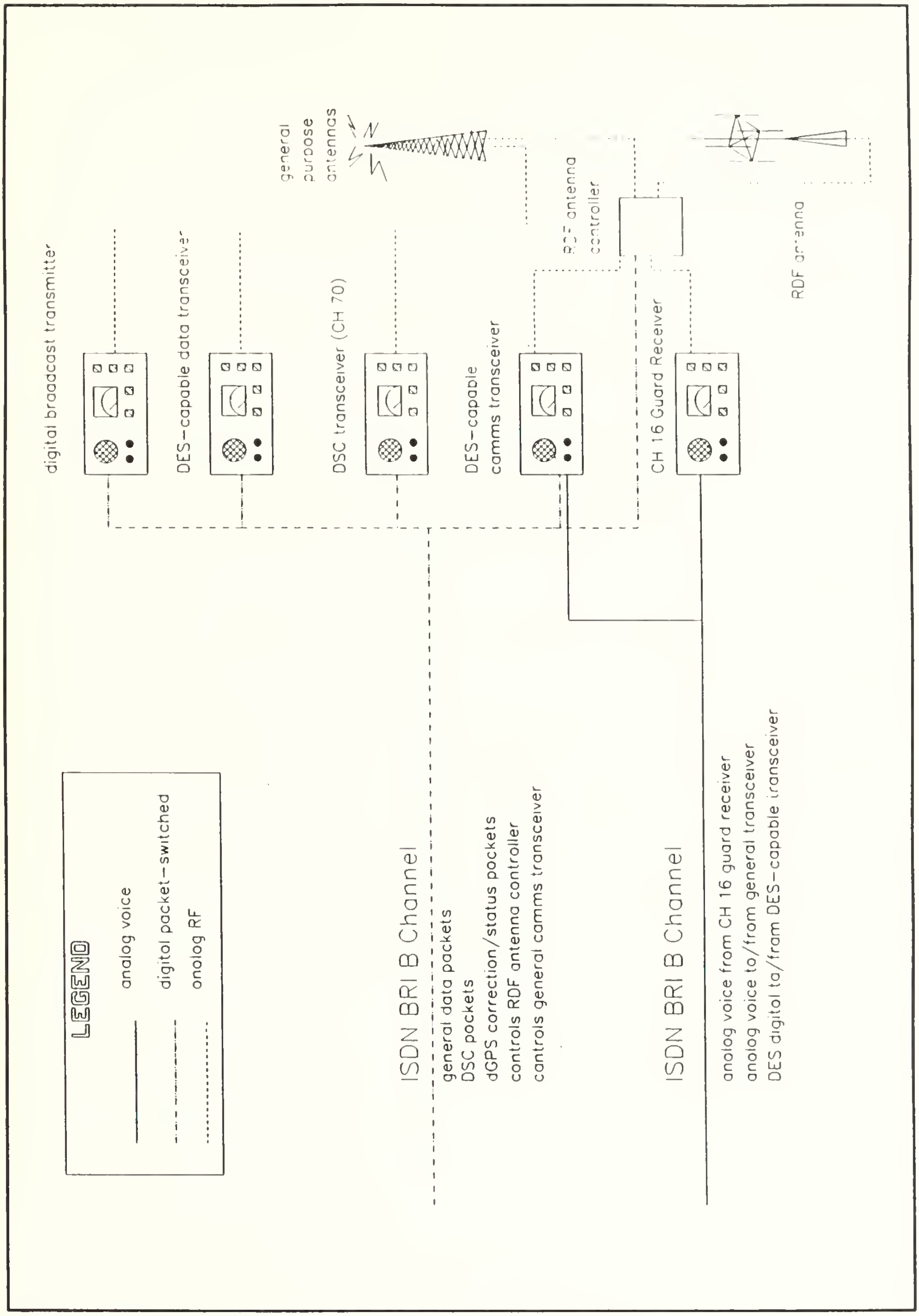

Figure 10 NDS Remote Site Configuration

multiplexer would permit both voice signals to use one ISDN B channel. The other B channel would be able to carry all the packet switched information necessary, and would still have a reserve capacity for additional data from sensors or other communications devices. The D channel would not need to be used, unless mandated by one of the systems for signalling or control.

Figure 11 shows what the configuration would be at the Group or COTP OPCEN/COMMCEN. Note again that all the equipment is available now. The only developmental items are already underway, that of integrating the data outputs from the DSC radios and the RDF receivers into the GDOC displays on the Coast Guard Standard Workstation.

Included in the connectivity of the NDS is a link to the X.25 network being installed by the Coast Guard, the HDN. In order for the NDS to be a true communications network, this connectivity is essential. All that would be needed to complete the connection would be basic routing hardware and software. Addition of dynamic routing of data from the HDN to the deployed unit via the NDS data channel would enable cellular-like communications as a unit moved along the coast. The routing tables would be updated every time the unit transmitted its location to the GDOC, which passed the routing information to the District or Area COMMCEN router. The routing information could ultimately be maintained in a centralized database, much as AT&T's Signalling System Seven will use.

A truly seamless network could be established if the routing tables were expanded to include HFDL or satellite communications. A unit within VHF-FM range would have

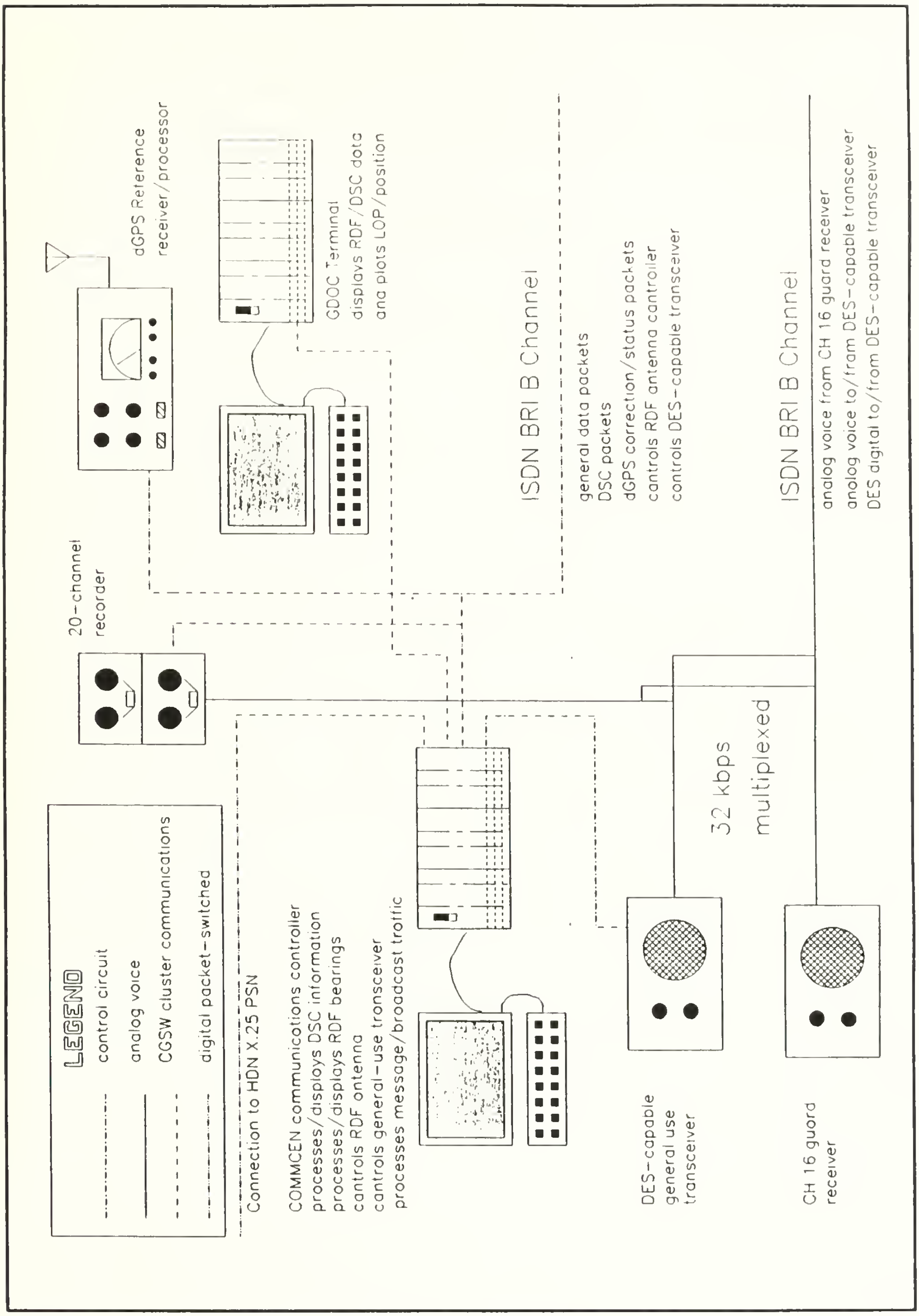

Figure 11 NDS COMMCEN/OPCEN Configuration

its data traffic routed via the VHF–FM data channel. If it moved out of VHF–FM range, its onboard communications manager would reroute the traffic via HFDL or satellite. This would reduce unnecessary HFDL load and provide communications system redundancy.

One question that arises regarding both the internal Coast Guard data channel and the public broadcast data channel is what frequency to use. As can be seen in Appendix E, all the VHF–FM marine channels are already assigned--there are no channels currently available for use in transmitting data (except DSC channel 70). There are, however, other possibilities. The Government uses frequencies above 162 MHz, in fact every Coast Guard MCX 1000 radio has some of these programmed in for use both between Coast Guard units and when communicating with other agencies. One of these frequencies could be used for internal Coast Guard simplex digital data. For the public broadcast data channel, possibly one of the weather channels could be assigned for this purpose. This would be appropriate because a portion of the Coast Guard's broadcasts would consist of weather. If a currently–available channel (i.e., a weather channel) were used, it would eliminate the need for the boater to purchase a new radio. The boater would only need to purchase the interface (e.g., terminal node controller) between the VHF–FM transceiver and his data terminal.

B. SYSTEM CAPABILITIES

In general, there are certain system capabilities that are necessary to fulfill the requirements put forth in Chapters III and IV. These are, for the most part, available with existing or planned technologies. These capabilities include:

- remote controlled transceiver all-channel selectivity
- DSC-capable transceivers
- integrated RDF systems with direction-finding data storage and retrieval
- CG data channel transceivers
- DES-capable transceivers
- Public broadcast data channel transmitters

C. SYSTEM IMPLEMENTATION

1. Phase I - System Analysis

a. Project Manager

Prior to any further work being performed towards the VHF-FM NDS recapitalization, it is imperative that a senior-level Project Manager be assigned. This research indicates that there are many independent, ongoing initiatives that affect the NDS recapitalization. These initiatives are being carried out by multiple commands scattered throughout the U.S. The Project Manager is needed to coordinate these initiatives, facilitate sharing of information and ideas among the different project officers, and direct the thrust of the activities towards the goal of improving the NDS. Considerations should be made to assigning an NDS Project Manager who would have both subject matter expertise on the system, procurement experience, and projected assignment longevity in order to provide continuity over the length of the project implementation.

b. System Baseline

The next step in the implementation of the new NDS system would have to be the creation of a system baseline, a "snapshot" of where the present system is. The author found in his research for Appendices B and C that the data on the present sites suffers from numerous discrepancies. These discrepancies cause differences in the site data maintained by the various entities involved, the Districts, the Groups, the MLCs, Headquarters, and the NTIA. One organization should be identified as the manager of the official NDS database and act as the control point for NDS information, logically within the Project Manager's office. Any and all changes to the baseline information should be passed to this Database Manager. This would require that the maintenance contracts for the NDS sites include a provision that all changes are reported to the NDS database manager.

Not only is the site data different, but each site installation is different. Reports from those involved indicate that documentation is lacking, circuits and cabling are mislabeled, bonding of equipment is substandard, and security of the sites is, in some locations, minimal. Prior to asking any contractor to bid on installing the new equipment at the sites, it will be essential to bring all the sites to a minimal configuration and documentation standard.

As previously noted, the creation of baseline information and standard configuration is currently underway east of the Rockies under the guidance of Commander, Maintenance and Logistics Command, Atlantic. This baseline project needs to be expanded to cover all the NDS sites, including the limited NDS sites in Hawaii and Alaska.

c. Standards Determination

Prior to drafting of the system specifications, it will be necessary to establish or adopt standards for encryption, radio packet formatting, RDF data transmission, and others. In many instances the standards have already been specified, in others a choice would have to be made between competing standards. These standards would be used along with the system requirements to prepare the system specifications. A key to the standards determination would be the acceptance of an appropriate international mobile data communications architecture.

d. Requirements Analysis

Concurrently with the determination of the equipment baseline should be the establishment of the system requirements. The information provided in Chapters IV and V of this thesis can form a foundation for the full analysis of the present and future requirements needed to carry out the Coat Guard's missions as they relate to the NDS and short–ranged C^2. These requirements will later be used as the basis for writing the specifications.

e. Engineering Assessment

While the baseline survey and requirements analysis are being conducted, an engineering assessment of each site should also be made. Configuration of the present installations affect the functionality of the system. It appears from an examination of Appendix B that many problems with VHF–FM coverage "holes" might be a problem with antennas instead of site locations. Use of directional antennas that point offshore reduces their effectiveness for onshore areas, including rivers, sheltered "back" bays, and other areas where CG units may operate. Engineering studies performed at this stage may solve many coverage problems without requiring the expense and problems involved with installing additional sites.

This analysis would also determine which NDS sites needed to be remoted to COTPs to provide full AOR coverage. Site surveys for additional remote control units and/or remote transceiver sites should be performed at this time and preparations made for installation of the additional equipment.

f. Systems Research

Finally, there needs to be some preliminary research performed to solve some of the potential problems that have been discussed in this thesis. These problems include RDF antenna location/interference.

A test should be made of the interference caused by nearby emitters on RDF antennas optimized and limited to the 120 MHz – 165 MHz frequency range. Problems experienced by the FCC with their broadband RDF antennas and systems may not affect the narrower frequency band with which the CG would be working.

Dependent surveillance using available DSC equipment should be investigated. This ability to determine the location of underway CG units is valuable for use with both the GDOC system and with the data network. The creation of a prototype DSC controller that would periodically send the vessel's position and operational status to the Group would provide a basis for a system-wide adoption of the technology.

Another area of examination should be routing algorithms and addressing to enable dynamic routing of packets and traffic from the HDN to the underway units via the VHF-FM data network. If a vessel transmits its location periodically as part of dependent surveillance, that transmission can be used to determine the return pathway for data being sent to the unit. This routing, stored in a routing table, would eliminate the need for communications shifts and make the network seamless.

2. Phase II - System Definition

a. Specification Generation

Once Phase I has been completed, the established requirements and selected standards should be used to write the system specifications. Compatibility with the existing base of public VHF-FM radios and C.G.-owned DES radios will have to be considered.

b. Engineering Modifications

Once the engineering analysis has been completed, it should be used to solve NDS coverage problems prior to the installation of the new equipment. Upgrading all sites to the baseline minimum for bonding, cable size, etc. may correct many perceived system problems. As previously noted, many of the AOR coverage problems experienced by the system users may also be due to use of the wrong antennas or power levels. Solving these problems by redirecting antennas, replacing directional antennas with omnidirectional antennas or increasing the output power would prevent the costly installation of additional sites.

At this time, the additional remote control units would be installed at the COTPs to provide them with access to all the NDS sites covering their AORs, and any additional remote transceiver sites would be installed.

c. *Specification Publication*

Once the systems have been brought up to baseline level and the deficiencies corrected through better engineering, it should be time to publish the specifications and permit vendors to engineer their products to fulfill the requirements. The emphasis should be on system modularity. Unlike the present system, where Motorola has the monopoly on electronic equipment, the new system can be designed to be made of separate modules that are able to communicate and interact. The DSC equipment, data transceiver, and RDF hardware can all come from non–Motorola sources and thereby increase the competitive nature of the procurement. The modularity should also be considered if the entire system is not to be procured at once, i.e., if the DES transceiver and DSC transceivers are to be purchased now, but the RDF equipment and data transceiver were to be purchased later as funds allowed.

3. Phase III - System Prototype

a. Prototype Installation

With a major system such as the NDS, it would be advantageous to be able to install prototypes for evaluation prior to deciding on a final system. It would be best to install prototypes from different vendors at different Groups or Districts, and operate them concurrently to compare performance. The prototypes would enable the individual system components to interact for the entire system to be operated by the users. Feedback from the users would be provided for the next step, the prototype evaluation.

b. Prototype Evaluation

Once the prototypes are installed, they would be operated for a period of time to determine whether they fulfilled the specifications as written. Operational capabilities would be determined for each system. Vendors would be given an opportunity to correct discrepancies and modify their systems for better operations.

c. System Selection

Once the prototype evaluation was completed, the Project Manager would then select the final system. Modifications to the prototype based upon its evaluation results would be made prior to full-scale development.

4. Phase IV - System Installation

a. System Installation

The selected system would be procured and preparations made for its installation. Installation would have to be performed in a manner to prevent the loss of radio coverage in any one area for longer than a few hours. Even then, alternate coverage would have to be provided. System installation should be performed one Group at a time, with the entire Group being converted from the old system to the new system at once. Installation throughout the entire District should be completed before commencing at another District, in order to provide compatibility and consistency within each District.

b. Initial System Evaluation

Prior to final acceptance of the systems at each site, an evaluation of the system should be made. Quality of installation, availability and timeliness of maintenance, and reliability of the system should be evaluated. Problems with system dependability should be addressed and CG-wide modifications made if necessary to correct the problems.

5. Phase V - System Evaluation

Once the entire system has been installed and operational for a few years, an evaluation should be performed. This evaluation would be conducted with the purpose of determining shortfalls in the system and recommending modifications. Periodic reevaluations of the system, resulting in system upgrades, would permit the new NDS to provide a high level of service throughout its life span.

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APPENDIX A

ORIGINAL NATIONAL DISTRESS SYSTEM DESIGN CRITERIA

A. Operational Concept Influencing Design Performance.

(1) Each base station must have the following capabilities:

(a) Each high elevation installation must be engineered to optimize the receiving ability of the site. Minimum design requirements must provide for a 1 watt signal radiated from a unity gain antenna 6 ft. above mean low water, 20 NM offshore to be discernible at a typical base station. The strength of this signal should be "Readable with only Occasional Repetition: (Circuit Merit 3). Enclosed or semi-enclosed bodies of water must have 100% coverage for this minimum condition. For inland rivers, the system will be planned on the basis of a 25 watt signal from mean low water instead of the 1 watt signal discussed above.

(b) The siting will make maximum use of existing tower structures and terrain to minimize tower erection costs.

(c) Some sites may provide even greater than 20 miles coverage in order to reduce the total number of stations. Site separation must be consistent with anticipated message traffic volume. Systems must be designed to prevent message traffic in areas of high boating concentrations from dominating the receiver and reducing wide area coverage due to the capture effect. Remote receivers on the periphery of the coverage area may be employed to prevent this.

(d) The antenna systems must be designed primarily to provide the greatest gain to weak incoming signals from ships and boats while providing the maximum suppression of noise coming from land areas. Secondarily, the antennas should provide maximum power gain to the required operating areas. It is expected that the antennas of highest performance characteristics consistent with the present state-of-the-art, cost and mechanical constraints will be employed.

(e) To insure maximum detection of incoming signals, system signal loss should be minimized. On certain very high towers, measures should be taken to provide the least possible cabling loss. In these cases, the height gain and line loss must be rationalized.

(f) each base station will normally require at least a 6 channel capability with a separate guard receiver. Exceptions to this will be examined on a case by case basis. The system should be configured so the transceiver can operate in a simplex mode with the guard receiver set on channel 16 operating with the guard receiver set on channel 16 operating in a receive only mode and muted when the transmitter is keyed. Guard receivers will not be provided on inland rivers unless specifically authorized.

APPENDIX B

NATIONAL DISTRESS SYSTEM TRANSCEIVER LOCATION INFORMATION

DISTRICT: 1 **Group Southwest Harbor**

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
BALD MT.	P: Group SW Harbor S: Sta. Rockland	44–39N	068–37W	6dB	1404ft	4–element dipole	140T
(Bald Mountain xmtr to be moved to Kings Mountain in FY 91							
KINGS MOUNTAIN		44–41N	068–45W	6dB	1050ft	collinear	none
CADDILAC MT.	P: Group SW Harbor S: Sta. Jonesport	44–21N	068–14W	6dB	1590ft	collinear	none
WEST QUODDY HEAD	P: (Group SW Harbor) S: Sta. Jonesport	44–49N	066.58W	6dB	130ft	collinear	none
BENNER HILL	P: (Group SW Harbor) S: Sta. Rockland	44–08N	069–08W	6dB	700ft	folded dipole	160T

Primary control site name in () indicates planned control point, not currently connected

DISTRICT: 1 **Group Portland**

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
MT. AGAMENTICUS	P: Group Portland S: Sta. Portsmouth	43-13N	070-19W	9dB	691ft	stacked dipole	056T
MT. INDEPENDENCE	P: Group Portland S: none	43-46N	070-19W	9dB	720ft	stacked dipole	120T
TOPSHAM	P: Group Portland S: Sta. Boothbay Hrbr.	43-57N	69-58W	6dB	912ft	stacked dipole	170T

(called BRUNSWICK in NTIA database)

DISTRICT: 1 Group Boston

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
BOSTON	P: Group Boston S: Sta. Pt. Allerton	42-21N	071-14W	6dB	825ft	collinear	090T
EASTERN POINT	P: Group Boston S: Sta. Gloucester	42-35N	070-40W	6dB	145ft	collinear	none
PLUM ISLAND	P: Group Boston S: Sta. Merrimack	42-49N	070-49W	6dB	130ft	4-element dipole	330T
MARSHFIELD	P: (Group Boston) S: Sta. Scituate	42-07N	070-43W	6dB	440ft	whip	none

Primary control site name in () indicates planned control point, not currently connected

DISTRICT: 1 **Group Woods Hole**

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
NANTUCKET	P: Group Woods Hole S: Sta. Brant Point	41–16N	070–11W	6dB	350ft	collinear	none
NEWPORT BRIDGE	P: Group Woods Hole S: Sta. Castle Hill	41–30N	070–11W	9dB	580ft	stacked dipole	none
NOBSKA POINT	P: Group Woods Hole S: none	41–31N	070–39W	9dB	161ft	collinear	170T
PROVINCETOWN	P: Group Woods Hole S: Sta. Provincetown	42–03N	070–11W	6dB	353ft	collinear	none

DISTRICT: 1 Group Moriches

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
MONTAUK POINT	P: Group Moriches S: Sta. Montauk	41-04N	071-51W	6dB	160ft	stacked dipole	none
SHINNECOCK	P: Group Moriches S: Sta. Shinnecock	40-51N	072-30W	9dB	205ft	stacked dipole	180T
FIRE ISLAND	P: Group Moriches S: Sta. Fire Island	40-37N	073-15W	9dB	185ft	stacked dipole	180T

DISTRICT: 1 **Group Long Island Sound (LIS)**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
EATONS NECK	P: Group LIS S: Sta. Eatons Neck	40–57N	072–23W	9dB	146ft	stacked dipole	045T
MILFORD	P: Group LIS S: none	41–14N	073–01W	9dB	247ft	stacked dipole	135T
GLASTONBURY	P: Group LIS S: none	41–38N	072–33W	6dB	865ft	stacked dipole	180T
MILLSTONE POINT **(Called WATERFORD in NTIA database)**	P: Group LIS S: Sta. New London	41–19N	072–10W	9dB	380ft	stacked dipole	205T

DISTRICT: 1 **Group New York**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
ALBANY	P: Group New York S: none	42-37N	073-45W	6dB	1000ft	stacked dipole	none
SAUGERTIES	P: (Group New York) S: ANT Saugerties	42-05N	073-58W	6dB	1000ft	stacked dipole	none
BLDG 844	P: Group New York S: Sta. New York	40-41N	074-01W	9dB	260ft	stacked dipole	none
BLDG 877	P: Group New York S: none	40-41N	074-01W	9db	110ft	corner reflector	280T
				3db	- - - - - -	-coaxial - -	270T
NORTH BEACON MT.	P: Group New York S: none	41-29N	073-57W	9dB	400ft	dual Yagi	180T 000T
MANSFIELD MT.	P: Sta. Burlington S: none	44-33N	072-50W	6dB	4130ft	stacked dipole	none

Primary control site name in () indicates planned control point, not currently connected

DISTRICT: 1 **Group Sandy Hook**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
SANDY HOOK	P: Group Sandy Hook S: Sta. Sandy Hook	40-28N	074-00W	6dB	170ft	stacked dipole	none
MANASQUAN	P: Group Sandy Hook S: Sta. Manasquan	40-06N	074-02W	6dB	175ft	stacked dipole	none

DISTRICT: 2 **Group Ohio Valley**

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
ATHENS, AL	P: Group Ohio Valley S: none	34–49N	086–57W	6dB	1186ft	stacked dipole	210T
BATTLETOWN, KY	P: Group Ohio Valley S: none	38–03N	086–18W	5dB	1060ft	collinear	none
CARTHAGE, TN	P: Group Ohio Valley S: none	36–19N	085–57W	6dB	1140ft	vertical dipole	none
CHARLESTOWN, IN	P: Group Ohio Valley S: none	38–22N	085–39W	6dB	700ft	stacked dipole	045T
CINCINNATI, OH	P: Group Ohio Valley S: MSO Cincinnati	39–06N	084–33W	6dB	220ft	stacked dipole	none
COAL MT. WV	P: Group Ohio Valley S: none	38–24N	081–54W	5dB	1175ft	vertical dipole	none
HENDERSON, KY	P: Group Ohio Valley S: none	37–52N	087–34W	6dB	1057ft	stacked dipole	none
HEROD, IL	P: Group Ohio Valley S: none	37–35N	088–29W	6dB	1239ft	stacked dipole	none

DISTRICT: 2 **Group Ohio Valley (cont)**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
IUKA, MS	P: Group Ohio Valley S: none	34–44N	088–14W	6dB	930ft	collinear	none
KNOXVILLE, TN	P: Group Ohio Valley S: none	36–00N	086–57W	6dB	1355ft	vertical dipole	330T
MADISON, IN	P: Group Ohio Valley S: none	38–45N	085–24W	6dB	938ft	stacked dipole	none
MODEL, TN	P: Group Ohio Valley S: none	36–36N	087–59W	6dB	881ft	stacked Yagi	010T
MORGANTOWN, WV	P: Group Ohio Valley S: none	39–37N	079–57W	9dB	1028ft	Yagi	005T
NASHVILLE, TN	P: Group Ohio Valley S: MSD Nashville	36–15N	086–54W	6dB	1005ft	collinear	180T
PARKERSBURG, WV	P: Group Ohio Valley S: none	39–21N	081–34W	10dB	1310ft	stacked dipole	215T
PITTSBURG, PA	P: Group Ohio Valley S: MSO Pittsburg	40–27N	079–57W	6dB	1340ft	stacked dipole	none

DISTRICT: 2 Group Ohio Valley (cont)

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
SIGNAL MT., TN	P: Group Ohio Valley S: CG Moorings, Chattanooga, TN	35–08N	085–19W	6dB	2308ft	stacked dipole	010T
WEIRTON, WV	P: Group Ohio Valley S: none	40–23N	080–36W	10dB	1410ft	Yagi	350T
WEST PORTSMOUTH, OH	P: Group Ohio Valley S: none	38–46N	083–04W	6dB	1796ft	stacked dipole	180T

DISTRICT: 2 Group Upper Mississippi River (UMR)

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
DUBUQUE, IA	P: Group UMR S: none	42–24N	090–34W	6dB	1465ft	stacked dipole	090T
GASCONADE, MS	P: Group UMR S: none	38–40N	091–32W	6dB	1083ft	stacked dipole	300T
HASTINGS, MN	P: Group UMR S: none	44–44N	092–50W	6dB	233ft	stacked dipole	none
KEOKUK, IA	P: Group UMR S: none	40–23N	091–23W	10dB	520ft	collinear	157T
LA CRESCENT, MN	P: Group UMR S: none	43–51N	091–19W	6dB	707ft	stacked dipole	none
MARSEILLES, IL	P: Group UMR S: none	41–20N	088–45W	6dB	932ft	stacked dipole	none
MARSHALL, MO	P: Group UMR S: none	39–08N	093–14W	10dB	1065ft	collinear	none
NOITA, IL	P: Group UMR S: none	40–36N	091–16W	6dB	909ft	stacked dipole	270T

DISTRICT: 2 Group Upper Mississippi River (UMR) (cont)

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
OMAHA, NE	P: Group UMR S: none	41-19N	095-59W	6dB	1485ft	stacked Yagi	180T
ORION, IL	P: Group UMR S: none	41-19N	090-23W	6dB	1105ft	stacked dipole	090T
PEORIA, IL	P: Group UMR S: none	40-39N	089-35W	6dB	1009ft	stacked dipole	000T
PERE MARQUETTE, IL	P: Group UMR S: none	39-00N	090-31W	6dB	1052ft	stacked dipole	010T
SAVERTON, MO	P: Group UMR S: none	39-38N	091-18W	6dB	1095ft	double corner reflector	333T 127T
ST. JOSEPH, MO	P: Group UMR S: none	39-44N	094-48W	5dB	1510ft	stacked dipole	none
ST. LOUIS, MO	P: Group UMR S: none	38-36N	090-12W	9dB	770ft	stacked dipole	none
BALD KNOB, IL	P: Group UMR S: none	37-33N	089-21W	5dB	1175ft	stacked dipole	255T

DISTRICT: 2 **Group Upper Mississippi River (UMR) (cont)**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO: GAIN	ANTENNA INFO: HEIGHT (above MSL)	ANTENNA INFO: TYPE	ANTENNA INFO: ORIENTATION
(proposed site, not operational at this time...)							
LA GRANGE (dtd 1989)	P: S:	39-56N	090-32W	3dB	654ft	folded dipole	

DISTRICT: 2 **Group Lower Mississippi River (LMR)**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
GREENVILLE, MS	P: Group LMR S: none	33–23N	091–05W	6dB	491ft	stacked dipole	none
HELENA, AR	P: Group LMR S: none	34–31N	090–36W	6dB	450ft	stacked dipole	227T
HORNBEAK, TN	P: Group LMR S: Group Ohio Valley	36–20N	089–17W	5dB	730ft	stacked dipole	270T
MEMPHIS, TN	P: Group LMR S: MSO Memphis	35–09N	090–03W	6dB	514ft	stacked dipole	none
MOUNT NEBO, AR	P: Group LMR S: none	35–13N	093–15W	9dB	1920ft	stacked Yagi	140T
POTEAU, OK	P: Group LMR S: none	35–04N	094–41W	6dB	2191ft	stacked dipole	none
VICK, LA	P: Group LMR S: none	31–12N	092–04W	6dB	365ft	collinear	none
VICKSBURG, MS	P: Group LMR S: none	32–23N	090–53W	6dB	263ft	stacked dipole	none

DISTRICT: 2 **Group Lower Mississippi River (LMR) (cont)**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
(proposed site, not operational at this time...)							
COLFAX (dtd 1990)	P: S:	31-32N	092-43W	6dB	447ft	folded dipole	none

DISTRICT: 5 Group Cape May

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
REHOBOTH BEACH	P: Group Cape May S: Sta. Indian River	38-58N	075-05W	6dB	117ft	collinear	none
FORTESQUE	P: Group Cape May S: SARDET Fortesque	39-15N	075-10W	6dB	80ft	stacked dipole	none
CAPE MAY	P: Group Cape May S: none	38-57N	074-54W	6dB	199ft	stacked dipole	none
ATLANTIC CITY	P: Group Cape May S: Sta. Atlantic City	39-23N	074-25W	9dB	205ft	stacked dipole	100T
BARNEGAT	P: Group Cape May S: Sta. Barnegat	39-45N	074-06W	9dB	185ft	stacked dipole	100T

DISTRICT: 5 **Group Philadelphia**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
BENSALEM	P: Group Phila. S: none	40-05N	074-55W	6dB	320ft	stacked dipole	055T
SALEM	P: Group Phila. S: none	39-28N	075-31W	8dB	255ft	collinear	none

DISTRICT: 5 **Group Baltimore**

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
OAK GROVE	P: Group Baltimore S: none	38–09N	076–54W	12dB	425ft	stacked dipole	105T
ALEXANDRIA	P: Group Baltimore S: none	38–45N	077–08W	12dB	335ft	stacked dipole	180T
ANNAPOLIS BAY BRIDGE	P: Group Baltimore S: Sta. Annapolis	39–00N	076–23W	9dB	380ft	stacked dipole	none
CATONSVILLE	P: Group Baltimore S: Sta. Curtis Bay	39–13N	076–58W	12dB	500ft	stacked dipole	070T
NORTHEAST	P: Group Baltimore S: Sta. Stillpond	39–34N	075–55W	9dB	430ft	stacked dipole	none

DISTRICT: 5 **Group Eastern Shore (ES)**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
CRISFIELD	P: Group ES S: Sta. Crisfield	37-58N	075-50W	12dB	252ft	stacked dipole	225T
PARRAMORE BEACH	P: Group ES S: Sta. Parramore Beach	37-34N	075-37W	12dB	105ft	stacked dipole	130T
CHINCOTEAGUE	P: Group ES S: Sta. Chincoteague	37-56N	075-23W	12dB	259ft	stacked dipole	130T
OCEAN CITY	P: Group ES S: Sta. Ocean City	38-19N	075-05W	12dB	205ft	stacked dipole	130T

DISTRICT: 5 Group Hampton Roads (HR)

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
CAPE HENRY	P: Group HR S: Sta. Little Creek	36–56N	076–00W	9dB	181ft	stacked dipole	none
PORTSMOUTH	P: Group HR S: MSO HR	36–50N	076–18W	6dB	105ft	stacked dipole	none
RICHMOND	P: Group HR S: Richmond Dept. of Emerg Serv.	37–30N	077–32W	9dB	592ft	stacked	none dipole
NEWPORT NEWS	P: Group HR S: none	37–13N	076–33W	12dB	325ft	stacked dipole	305T
COBBS CREEK	P: Group HR S: Sta. Milford Haven	37–31N	076–24W	9dB	280ft	stacked dipole	102T

DISTRICT: 5 Group Cape Hatteras (CH)

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
BUXTON	P: Group CH S: Sta. Hatteras Inlet S: Sta. Ocracoke	35–15N	075–32W	12dB	325ft dipole	stacked	090T
ENGLEHARD	P: Group CH S: none	35–37N	076–02W	12dB	266ft	stacked dipole	120T
OREGON INLET	P: Group CH S: Sta Oregon Inlet	35–46N	075–31W	12dB	205ft	stacked dipole	065T
MIDWAY	P: Group CH S: none	36–05N	076–46W	9dB	300ft	stacked dipole	180T
ELIZABETH CITY	P: Group CH S: Sta. Coinjock	36–18N	076–16W	12dB	287ft	stacked dipole	120T

DISTRICT: 5 **Group Fort Macon**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
CAROLINA BEACH	P: Group Fort Macon S: Sta. Oak Island S: Sta. Wrightsville Beach	34-03N	077-55W	12dB	504ft	stacked dipole	190T
HOLLY RIDGE	P: Group Fort Macon S: Sta Wrightsville Beach	34-31N	077-31W	12dB	240ft	stacked dipole	140T
CROATAN	P: Group Fort Macon S: Sta. Swansboro	34-48N	076-56W	12dB	305ft	stacked dipole	135T
CEDAR ISLAND	P: Group Fort Macon S: none	34-58N	076-17W	12dB	230ft	stacked dipole	152T
HOBUCKEN	P: Group Fort Macon S: Sta. Hobucken	35-15N	076-36W	12dB	200ft	stacked dipole	090T

DISTRICT: 7 **Group Charleston**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
MYRTLE BEACH	P: Group Charleston S: Sta. Georgetown	33–43N	078–53W	12dB	255ft	stacked dipole	090T
SOUTH ISLAND	P: Group Charleston S: none	33–09N	079–12W	3dB	325ft	whip	none
MT. PLEASANT	P: Group Charleston S: none	32–48N	079–51W	12dB	455ft	stacked dipole	090T
PARRIS ISLAND	P: Group Charleston S: Sta. Tybee	32–19N	080–42W	12dB	307ft	stacked dipole	090T
KELLER	P: Group Charleston S: Group Mayport S: Sta. St. Simons Island S: Sta. Tybee	31–48N	081–13W	9dB	258ft	collinear	none

DISTRICT: 7 Group Mayport

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
JEKYLL ISLAND	P: Group Mayport S: Sta. St. Simons Island	31–01N	081–26W	12dB	315ft dipole	stacked	090T
JACKONSVILLE BEACH	P: Group Mayport S: none	30–20N	081–25W	9dB	268ft	stacked dipole	none
FLAGLER BEACH	P: Group Mayport S: Sta. Ponce De Leon	29–28N	081–09W	9dB	251ft dipole	stacked	none
PORT CANAVERAL	P: Group Mayport S: Sta. Port Canaveral	28–30N	080–35W	6dB	409ft	collinear	090T
(called CAPE CANAVERAL in NTIA database)							
(proposed site... not in operation)							
ST. AUGUSTINE	P: Group Mayport S: none	29–52N	051–18W	12dB	337ft	folded dipole	none

DISTRICT: 7 Group Miami Beach (MB)

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
FORT PIERCE	P: Group MB S: Sta. Fort Pierce	27–33N	080–22W	12dB	430ft	stacked dipole	090T
JUPITER INLET	P: Group MB S: Sta. Lake Worth	26–56N	080–07W	6dB	310ft	stacked dipole	075T
(called just JUPITER in NTIA database)							
DELRAY BEACH	P: Group MB S: Sta. Lake Worth	26–26N	080–05W	12dB	303ft	stacked dipole	090T
SEA RANCH	P: Group MB S: Sta. FT. Lauderdale	26–10N	080–05W	6dB	225ft dipole	stacked	none
PERRINE	P: Group MB S: none	25–37N	080–23W	6dB	275ft	stacked dipole	090T

DISTRICT: 7 **Group Key West**

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
ISLAMORADA	P: Group Key West S: Sta. Islamorada	24–57N	080–34W	6dB	304ft	collinear	090T
MARATHON	P: Group Key West S: Sta. Marathon	24–43N	081–06W	6dB	208ft	stacked dipole	135T
SUGARLOAF KEY	P: Group Key West S: none	24–40N	081–32W	12dB	334ft	stacked dipole	270T

DISTRICT: 7 **Group St. Petersburg**

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
EVERGLADE CITY	P: Group St. Pete S: none	25–52N	080–24W	12dB	410ft	stacked dipole	260T
NAPLES	P: Group St. Pete S: Sta. Ft. Myers	26–03N	081–42W	12dB	420ft	stacked dipole	220T
PINE ISLAND	P: Group St. Pete S: Sta. Ft. Myers	26–37N	082–07W	3dB	200ft	whip	none
VENICE	P: Group St. Pete S: Sta. Cortez	27–66N	082–22W	12dB	300ft	stacked dipole	270T
ANCLOTE	P: Group St. Pete S: Sta. Clearwater	28–11N	082–46W	12dB	400ft	stacked dipole	270T
CRYSTAL RIVER	P: Group St. Pete S: Sta. Yankeetown	28–57N	082–42W	12dB	525ft	stacked dipole	270T
HINES	P: Group St. Pete S: Sta. Yankeetown	29–44N	083–14W	12dB	300ft	stacked dipole	none
SEMINOLE	P: Group St. Pete S: Sta. Clearwater	27–51N	082–46W	12dB	350ft	stacked dipole	none

DISTRICT: 7 Greater Antilles Section (GANTSEC)

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
MONTE DEL ESTADO	P: GANTSEC S: none	18-09N	067-00W	7dB	205ft	stacked dipole	085T
CERRO DE PUNTA	P: GANTSEC S: none	18-10N	066-35W	12dB	4490ft	stacked dipole	none
EL YUNQUE	P: GANTSEC S: none	18-18N	065-47W	12dB	3585ft	stacked dipole	none
CROWN MT. ST. THOMAS	P: GANTSEC S: none	18-21N	064-57W	6dB	1520ft	stacked dipole	none
(called "SIGNAL HILL" in NTIA database)							
BLUE MT. ST. CROIX	P: GANTSEC S: none	17-45N	064-48W	6dB	1120ft	collinear	none
SAN JUAN	P: GANTSEC S: none	18-27N	066-06W	7dB	205ft	stacked dipole	none

DISTRICT: 8 **Group New Orleans**

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
SOUTH BEND	P: Group New Orleans S: Sta. Grand Isle	29–37N	091–32W	9dB	400ft	stacked dipole	180T
LEEVILLE	P: Group New Orleans S: Sta. Grand Isle	29–13N	090–13W	9dB	560ft	stacked dipole	040T
CHALMETTE	P: Group New Orleans S: none	29–57N	089–57W	9dB	602ft	stacked dipole	060T
PLAQUEMINE PT.	P: Group New Orleans S: none	30–18N	091–12W	12dB	800ft	stacked dipole	130T
VENICE	P: Group New Orleans S: Sta. Venice	29–15N	089–22W	9dB	360ft	stacked dipole	090T
VAN CLEAVE	P: Group New Orleans S: Sta. Gulfport	30–29N	088–43W	12dB	701ft	stacked dipole	none

DISTRICT: 8 **Group Mobile**

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
PASCAGOULA	P: Group Mobile S: Sta. Pascagoula	30–22N	088–33W	6dB	170ft	collinear	none
SPANISH FORT	P: Group Mobile S: Sta. Pensacola	30–40N	087–54W	9dB	500ft	stacked dipole	180T
FORT WALTON	P: Group Mobile S: Sta. Destin	30–23N	086–48W	12dB	280ft	stacked dipole	190T
PANAMA CITY	P: Group Mobile S: Sta. Panama City	30–11N	085–47W	12dB	310ft	stacked dipole	225T
CAPE SAN BLAS	P: Group Mobile S: Sta. Panama City	29–41N	085–21W	12dB	226ft	stacked dipole	150T
ST. MARKS	P: Group Mobile S: Sta. Panama City	30–10N	084–12W	12dB	225ft	stacked dipole	220T

DISTRICT: 8 **Group Corpus Christi (CC)**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
PORT ISABEL	P: Group CC S: Sta. Port Isabel	26–04N	097–09W	12dB	150ft	stacked dipole	110T
PORT MANSFIELD	P: Group CC S: Sta. Port Isabel	26–32N	097–27W	12dB	280ft	stacked dipole	075T
ROBSTOWN	P: Group CC S: Sta. Port Aranas	27–39N	097–34W	12dB	500ft	stacked dipole	080T
PORT O'CONNOR	P: Group CC S: Sta. Port O'Connor	28–26N	096–28W	9dB	490ft dipole	stacked	330T

DISTRICT: 8 **Group Galveston**

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
GALVESTON	P: Group Galveston S: none	29–20N	094–47W 097–46W	12dB	221ft	stacked dipole	125T
FREEPORT	P: Group Galveston S: Sta. Freeport	28–59N	095–19W	12dB	390ft	stacked dipole	175T
MORGAN POINT	P: Group Galveston S: MSO Houston	29–41N	094–59W	6dB	176ft	stacked dipole	none
SABINE	P: Group Galveston S: Sta. Sabine	29–43N	093–52W	9dB	421ft	stacked dipole	180T
CAMERON	P: Group Galveston S: none	29–48N	093–18W	9dB	408ft	stacked dipole	180T
PECAN ISLAND	P: Group Galveston S: Sta. Sabine	29–41N	092–30W	9dB	406ft	stacked dipole	005T
HOUSTON	P: MSO HOUSTON S: none	29–44N	095–16W	9dB	unk	stacked dipole	unk

DISTRICT: 9 Group Buffalo

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO: GAIN	ANTENNA INFO: HEIGHT (above MSL)	ANTENNA INFO: TYPE	ANTENNA INFO: ORIENTATION
ASHTABULA, OH	P: Group Buffalo S: Sta. Ashtabula	41–54N	080–48W	9dB	720ft	stacked dipole	000T
DUNKIRK, NY	P: Group Buffalo S: none	42–25N	079–15W	9dB	1600ft	stacked dipole	000T
OSWEGO, NY	P: Group Buffalo S: Sta. Oswego	43–27N	076–32W	12dB	823ft	stacked dipole	000T
ROCHESTER, NY	P: Group Buffalo S: Sta. Rochester	43–17N	077–37W	9dB	435ft	stacked dipole	none
30 MILE POINT, NY	P: Group Buffalo S: none	43–20N	078–29W	12dB	760ft	stacked dipole	none
(not under Group Buffalo control)							
ALEXANDRIA BAY, NY	P: Station Alex Bay S: MSD Alex Bay	44–18N	075–59W	9dB	450ft	stacked dipole	none

DISTRICT: 9 **Group Detroit**

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
ALPENA, MI	P: Group Detroit S: Sta. Tawas	44-51N	083-25W	9dB	1121ft	stacked dipole	090T
PORT AUSTIN, MI	P: Group Detroit S: Sta. Saginaw	44-02N	083-00W	9dB	965ft	stacked dipole	000T
PORT HURON, MI	P: Group Detroit S: Sta. Port Huron S: Sta. Sanilac (rcv. only)	43-00N	082-25W	6dB	754ft	stacked dipole	180T
TOLEDO, OH	P: Group Detroit S: Sta. Toledo S: Sta. Marblehead	41-40N	083-22W	12dB	1140ft	stacked dipole	080T
BELLE ISLE, MI	P: Group Detroit S: Sta. Belle Isle	42-21N	082-59W	6dB	873ft	stacked dipole	none
CLEVELAND, OH	P: Group Detroit S: Sta. Cleveland Hbr.	41-30N	081-41W	6dB	1170ft	stacked dipole	none

DISTRICT: 9 **Group Sault St. Marie (SOO)**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
SAULT STE. MARIE, MI	P: Group SOO S: none	46–26N	084–24W	9dB	959ft	stacked dipole	290T
GOETZVILLE, MI	P: Group SOO S: none	46–04N	084–06W	12dB	1655ft	stacked dipole	134T
GRAND MARIAS, MI	P: Group SOO S: none	46–33N	086–02W	12dB	1330ft	stacked dipole	none
MARQUETTE, MI	P: Group SOO S: Sta. Marquette	46–35N	087–24W	6dB	1020ft	whip	none
BEAVER ISLAND MI	P: Group SOO S: Sta. Charlevoix	45–35N	085–34W	9dB	910ft	stacked dipole	225T
DULUTH, MN	P: Group SOO S: none	46–47N	092–07W	9dB	1330ft	stacked dipole	060T
PORTAGE, MI (CALUMET AFB) **(called CALUMET in NTIA database)**	P: Group SOO S: Sta. Portage	47–22N	088–10W	9dB	1610ft	stacked dipole	090T
HOUGHTON	P: Sta. Portage S: none	47–07N	088–34W	6dB	1060ft	collinear	none

DISTRICT: 9 Group Sault St. Marie (SOO) (cont)

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
BAYFIELD, WI	P: Group SOO S: Sta. Bayfield	46-50N	090-51W	12dB	1310ft	stacked dipole	045T
GRAND MARIAS, MN	P: Group SOO S: Sta. Grand Marias	47-46N	090-20W	12dB	2040ft	stacked dipole	122T

(called NORTH SUPERIOR in NTIA database)

DISTRICT: 9 Group Grand Haven

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
MUSKEGON, MI PORT SHELDON **(called HOLLAND in NTIA database)**	P: Group Grand Haven S: Sta. Holland	42–54N	086–12W	12dB	974ft	stacked dipole	270T
LUDINGTON, MI	P: Group Grand Haven S: Sta. Ludington	44–01N	086–30W	9dB	935ft	stacked dipole	none
FRANKFORT, MI	P: Group Grand Haven S: Sta. Frankfort	44–38N	086–14W	9dB	920ft	stacked dipole	none

DISTRICT: 9 Group Milwaukee

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
MILWAUKEE, WI	P: Group Milwaukee S: none	43-06N	087-53W	12dB	1123ft	stacked dipole	090T
CHICAGO, IL	P: Group Milwaukee S: Sta. Calumet Hrbr S: MSO/COTP Chicago	47-50N	088-10W	12dB	2049ft	stacked dipole	030T
TWO RIVERS, WI	P: Group Milwaukee S: Sta. Two Rivers	44-08N	087-33W	9dB	668ft	stacked dipole	090T
STURGEON BAY, WI	P: Group Milwaukee S: Sta. Sturgeon Bay	44-54N	087-22W	12dB	1316ft	stacked dipole	035T
ESCANABA, MI	P: Group Milwaukee S: Sta. Sturgeon Bay	45-45N	087-03W	6dB	1005ft	whip	none
(proposed site, not yet in operation...)							
KENOSHA, WI	P: S:	42-35N	087-49W	6dB	750ft	folded dipole	090T

DISTRICT: 11 Group San Diego

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
POINT LOMA	P: Group San Diego S: none	32–42N	117–14W	12dB	535ft	stacked dipole	180T
SAN CLEMENTE ISLAND	P: Group San Diego S: none	32–53N	118–27W	12dB	2165ft	stacked dipole	050T

DISTRICT: 11 Group Los Angeles/Long Beach (LA/LB)

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
LAGUNA PEAK	P: Group LA/LB S: Sta. Channel Is.	34–07N	119–04W	12dB	1520ft	stacked dipole	300T
SAN PEDRO HILL	P: Group LA/LB S: Sta. Long Beach	33–46N	118–20W	6dB	1593ft	collinear	none
TRANQUILLON MT.	P: Group LA/LB S: Sta. Channel Is.	34–35N	120–33W	12dB	2220ft	stacked dipole	150T

DISTRICT: 11 Group Monterey

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	ANTENNA INFO HEIGHT (above MSL)	ANTENNA INFO TYPE	ANTENNA INFO ORIENTATION
CAMBRIA	P: Group Monterey S: none	35–32N	121–15W	12dB	690ft	stacked dipole	none
MT. UMUNHUM	P: Group Monterey S: Group San Francisco	37–09N	121–54W	8dB	3450ft	stacked dipole	none
PIDGEON POINT	P: Group Monterey S: Group San Francisco	37–10N	122–20W	12dB	175ft	whip	none
PT. SUR LIGHT	P: Group Monterey S: none	36–19N	121–54W	12dB	370ft	stacked dipole	none

DISTRICT: 11 Group San Francisco (SF)

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
CARQUINEZ HEIGHTS	P: Group SF S: Sta. Rio Vista S: Sta. Mare Island	39-04N	122-14W	6dB	270ft	vertical dipole	none
(called VALLEJO in NTIA database)							
MT. DIABLO	P: Group SF S: Sta. Rio Vista S: MSO/MSD SF	37-55N	121-55W	6dB	3735ft	vertical dipole	none
MT. JENNER (SEAVIEW)	P: Group SF S: Sta.	38-29N	123-11W	12dB	1410ft	stacked dipole	none
(called just JENNER in NTIA database)							
CRYSTAL BAY NV	P: Sta. Tahoe City S: none	39-14N	120-00W	3dB	6555ft	vertical dipole	none

DISTRICT: 11 Group Humboldt Bay (HB)

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
CAHTO PEAK	P: Group HB S: none	39–41N	123–35W	6dB	4503ft	corner reflector	270T
POINT CABRILLO	P: Group HB S: Point Ledge Mrg.	39–25N	123–45W	6dB	50ft	whip	none
POINT ST. GEORGE	P: Group HB S: none	41–45N	124–15W	6dB	200ft	whip	none
TRINIDAD HEAD	P: Group HB S: none	41–05N	124–10W	12dB	408ft	stacked dipole	none

DISTRICT: 13 Group Astoria

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO: GAIN	ANTENNA INFO: HEIGHT (above MSL)	ANTENNA INFO: TYPE	ANTENNA INFO: ORIENTATION
PACIFIC BEACH	P: Group Astoria S: Sta. Gray's Harbor	47–13N	124–12W	9dB	310ft	stacked dipole	none
RAYMOND	P: Group Astoria S: Sta. Gray's Harbor	46–42N	123–46W	7dB	1200ft	collinear	none
NORTH HEAD (Also called NASELLE RIDGE) **(called CAPE DISAPPOINTMENT in NTIA database)**	P: Group Astoria S: Sta. Cape Disappointment	46–25N	123–08W	6dB	1955ft	collinear	none
CAPE MEARES	P: Group Astoria S: Sta. Tillamook Bay	45–29N	123–58W	6dB	232ft	collinear	none

DISTRICT: 13 Group Portland

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
RAINIER	P: Group Portland S: none	46–02N	122–55W	6dB	1160ft	collinear	none
SKYLINE	P: Group Portland S: none	45–34N	122–47W	6dB	1100ft	collinear	none
DALLES **(called LYLE in NTIA database)**	P: Group Portland S: none	45–43N	121–06W	6dB	3218ft	collinear	none
JUMP OFF JOE MOUNTAIN	P: Group Portland S: Sta. Kennewick	46–06N	119–08W	6dB	2045ft	collinear	none

DISTRICT: 13 Group North Bend

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
YAQUINA HEAD	P: Group North Bend S: Sta. Yaquina Bay	44–40N	124–03W	6dB	451ft	collinear	none
GOODWIN PEAK	P: Group North Bend S: Sta. Siuslaw River	43–55N	123–53W	3dB	1885ft	omni	none
SEVEN DEVILS	P: Group North Bend S: Sta. Coos Bay	43–17N	124–22W	6dB	754ft	collinear	none
CAPE BLANCO	P: Group North Bend S: none	42–50N	124–33W	6dB	186ft	vertical dipole	none
ROCKY PRARIE	P: Group North Bend S: Sta. Chetco River	42–12	124–20W	6dB	2040ft	vertical dipole	none

DISTRICT: 13 Group Port Angeles

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	ANTENNA INFO HEIGHT (above MSL)	ANTENNA INFO TYPE	ANTENNA INFO ORIENTATION
BAHOKUS PEAK	P: Group PA S: Sta. Neah Bay	48–21N	124–39W	6dB	1400ft	collinear	none
JAMES ISLAND	P: Group PA S: Sta. Quillayute River	47–54N	124–39W	9dB	150ft	stacked dipole	none

DISTRICT: 13 Group Seattle

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
GOLD MOUNTAIN	P: Group Seattle S: none	47–33N	122–47W	3dB	1745ft	vertical dipole	none
TACOMA	P: Group Seattle S: none	47–12N	122–30W	6dB	550ft	omni	none
KING–TV Tower **(called SEATTLE in NTIA database)**	P: Group Seattle S: none	47–38N	122–21W	6dB	975ft	collinear	none
MOUNT CONSTITUTION	P: Group Seattle S: none	48–41N	122–50W	3dB	2350ft	vertical dipole	none

DISTRICT: 14 Group Honolulu

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
KOKEE	P: Group Honolulu S: none	22–08N	159–39W	9dB	4060ft	stacked dipole	none
MOUNT KAALA	P: Group Honolulu S: none	21–30N	158–09W	9dB	4090ft	stacked dipole	none
MOUNT HALEAKALA	P: Group Honolulu S: none	20–43N	156–15W	9dB	10090ft	stacked dipole	none
KULANI	P: Group Honolulu S: none	19–31N	155–18W	9dB	5518ft	stacked dipole	none

DISTRICT: 17 Group Ketchikan

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
ZAREMBO ISLAND	P: Group Ketchikan S: none	56–21N	132–52W	6dB	2444ft	collinear	none
CAPE DECISION	P: Group Ketchikan S: none	56–00N	134–08W	6dB	152ft	collinear	none
GRAVINA ISLAND	P: Group Ketchikan S: none	55–22N	131–48W	6dB	2541ft	collinear	none
KETCHIKAN	P: Group Ketchikan S: none	55–20N	131–38W	6dB	93ft	vertical dipole	none
MARY ISLAND	P: Group Ketchikan S: none	55–06N	131–10W	6dB	60ft	collinear	none
SUKKWAN ISLAND	P: Group Ketchikan S: none	55–06N	132–46W	3dB	2200ft	coaxial	none

DISTRICT: 17 District COMMCEN

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
YAKUTAT	P: District COMMCEN S: none	59-33N	139-44W	9dB	130ft	collinear	230
JUNEAU	P: District COMMCEN S: none	58-18N	134-25W	6dB	232ft	dipole	none
ALTHORP PEAK	P: District COMMCEN S: none	58-06N	136-25W	6dB	2393ft	collinear	none
(called ALTHORP PARK in NTIA database)							
CAPE FANSHAW	P: District COMMCEN S: none	57-12N	133-28W	6dB	2256ft	dipole	none
MT. ROBERT BARRON	P: District COMMCEN S: none	58-14N	134-50W	6dB	3475ft	dipole	none
(called ADMIRALTY ISLAND in NTIA database)							

DISTRICT: 17 COMMSTA Kodiak

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
DIAMOND RIDGE	P: COMMSTA Kodiak S: none	59–42N	151–34W	10dB	1074ft	collinear	none
TUKLUNG MT	P: COMMSTA Kodiak S: none	58–51N	159–27W	6dB	1630ft	collinear	none
PILLAR MT	P: COMMSTA Kodiak S: none	57–47N	152–27W	6dB	1305ft	collinear	none
CAPE GULL	P: COMMSTA Kodiak S: none	58–13N	154–09W	6dB	556ft	collinear	none
BARREN ISLAND	P: COMMSTA Kodiak S: none	58–55N	152–16W	3dB	1545ft	coaxial	none
SITE SUMMIT	P: COMMSTA Kodiak S: none	61–15N	149–32W	6dB	3912ft	collinear	none
RUGGED ISLAND	P: COMMSTA Kodiak S: none	59–51N	149–23W	3dB	1436ft	coaxial	none
SITKINAK DOME	P: COMMSTA Kodiak S: none	56–33N	154–11W	3dB	1620ft	coaxial	none

DISTRICT: 17 AIRSTA Sitka

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
MUD BAY	P: AIRSTA Sitka S: none	57–09N	135–39W	6dB	1056ft	dipole	none
SITKA	P: AIRSTA Sitka S: none	57–03N	135–22W	6dB	50ft	collinear	one

APPENDIX C

VESSEL TRAFFIC SYSTEM TRANSCEIVER LOCATION INFORMATION
(listed by District and VTS)

DISTRICT: 1 **VTS New York**

				ANTENNA INFO			
COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
GOVERNORS ISLAND (BLDG 877)	P: VTS NY S: none	40-41N	074-01W	8dB	68ft	corner reflector	200T
NEW YORK CITY	P: VTS NY S: none	40-46N	073-58W	3dB	523ft	coaxial	270T
NEW YORK CITY	P: VTS NY S: none	40-47N	073-55W	3dB	248ft	corner reflector	280T
STATEN ISLAND	P: VTS NY S: none	40-35N	074-12W	3dB	217ft	coaxial	035T

DISTRICT: 8 **VTS Houston/Galveston (H/G)**

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
GALENA PARK	P: VTS H/G S: none	29–44N	095–15W	6dB	165ft	dipole	none
GALVESTON	P: VTS H/G S: none	29–20N	094–46W	12dB	221ft	stacked dipole	211T
HOUSTON	P: VTS H/G S: none	29–45N	095–22W	6dB	337ft	stacked dipole	none
MORGANS POINT	P: VTS H/G S: none	29–40N	094–58W	12dB	156ft	stacked dipole	none

DISTRICT: 11 VTS San Francisco (SF)

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
MOUNT TAMALPAIS	P: VTS SF S: none	37–48N	122–35W	6dB	2608ft	collinear	none
YERBABUENA ISLAND	P: VTS SF	37–48N	122–21W	6dB	200ft	collinear	none
POINT BONITA	P: VTS SF S: none	37–49N	122–32W	6dB	194ft	stacked dipole	none
TV HILL	P: VTS SF S: none	38–02N	122–00W	6dB	700ft	stacked dipole	none

DISTRICT: 13 VTS Puget Sound

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO GAIN	HEIGHT (above MSL)	TYPE	ORIENTATION
BAHOKUS PEAK	P: VTS Puget Sound S: none	48–21N	124–39W	6dB	1400ft	collinear	none
GOLD MOUNTAIN	P: VTS Puget Sound S: none	47–32N	122–47W	3dB	1776ft	vertical dipole	none
MOUNT CONSTITUTION	P: VTS Puget Sound S: none	48–40N	122–50W	3dB	2350ft	vertical dipole	none
PEARSON CREEK	P: VTS Puget Sound S: none	48–16N	124–14W	6dB	469ft	collinear	none
PORT ANGELES	P: VTS Puget Sound S: none	48–09N	123–24W	6dB	120ft	collinear	none
WEST POINT	P: VTS Puget Sound S: none	47–39N	122–26W	6dB	33ft	collinear	none

DISTRICT: 17 VTS Valdez

COMMON NAME	PRIMARY CONTROL/ SECONDARY CONTROL	LAT	LONG	ANTENNA INFO: GAIN	ANTENNA INFO: HEIGHT (above MSL)	ANTENNA INFO: TYPE	ANTENNA INFO: ORIENTATION
VALDEZ	P: VTS Valdez	61–08N	146–16W	0dB	125	whip	none
	S: none		146–21W	<-NTIA has->			75ft
POTATO POINT	P: VTS Valdez	61–03N	146–42W	9dB	165ft	array	210T
	S: none						
CAPE	P: VTS Valdez	60–15N	146–39W	9dB	235ft	array	140T
HINCHINBROOK	S: none			NTIA has -->		325ft	
NAKED ISLAND	P: VTS Valdez	60–39N	147–21W	0dB	1215ft	whip	none
	S: none				1235ft		
CORDOVA	P: VTS Valdez	60–33N	145–45W		60ft		
	S: none						
CORDOVA	P: VTS Valdez	60–29N	145–28W		60ft		
AV SUP FAC	S: none						
PT. PIGOT	P: VTS Valdez	60–49N	148–22W		1496ft		

S: none

APPENDIX D

List of VHF–FM Equipment Manufacturers

VHF–DF Equipment

STX – ST Systems Corporation 1577 Spring Hill Rd., Suite 500 Vienna, VA 22182	Phone: Fax: WATS:	(703) 827–6533 (703) 827–6724 (800) 423–6807
TechComm 5001 Hiatus Rd. Sunrise, FL 33351	Phone: Fax:	(305) 749–1776 (305) 741–1670
SIMRAD, Inc. 620 N.W. Bright St. Seattle, WA 98107	Phone: Fax: WATS:	(206) 789–6482 (206) 789–1766 (800) 426–5565
Doppler Systems, Inc. PO Box 31819 Phoenix, AZ 85046	Phone: Fax:	(602) 488–9755 (602) 488–1295
Southwest Research Institute 6220 Culebra Rd. San Antonio, TX 78228–0510	Phone: Fax:	(512) 684–5111 (512) 522–2709
Si–Tex Marine Electronics PO Box 6700 Clearwater, FL	Phone:	(813) 535–4681
Racal Communications 5 Research Place Rockville, MD 20850	Phone:	(301) 948–4420
Rockwell International/Collins 400 Collins Rd. NE Cedar Rapids, IA 52498	Phone: Fax:	(319) 395–5436 (319) 395–1642

Cubic Corporation 305 Airport Rd. Oceanside, CA 92054	Phone: (629) 757-7525

MF/HF DF Equipment

Furuno USA Inc. 271 Harbor Way South San Francisco, CA	Phone: (415) 873-9393

VHF-FM Remotable Transceivers

Motorola 1301 E. Algonquin Rd. Schamburg, IL 60196	Phone: (312) 397-1000 WATS: (800) 247-2346

Digital Selective Calling

Ross Engineering 12505 Starkey Rd. Largo, FL 34643	Phone: (813) 536-1226
RH Defense Systems 2703 Avenger Drive Virginia Beach, VA 23452	Phone: (804) 431-2975 Fax: (804) 431-3676

APPENDIX E

VHF–FM Frequency, Channel and Use Assignments

Marine Channel	Transmit MHz	Receive MHz	Intended Use
1	156.050	156.050	Commercial ship–ship, VTS
5A	156.250	156.250	Port operations, VTS
6	156.050	156.050	Ship–ship, VTS, on–scene SAR, safety
7	156.350	160.950	INTERNATIONAL USE
7A	156.350	156.350	Commercial ship–ship, ship–shore
8	156.400	156.400	Commercial ship–ship working channel
9	156.450	156.450	Commercial port services
10	156.500	156.500	Commercial ship–ship, ship–shore
11	156.550	156.550	Commercial ship–ship, ship–shore, VTS
12	156.600	156.600	Port operations, VTS
13	156.650	156.650	VTS, bridge–to–bridge communications
14	156.700	156.700	VTS, port operations
15		156.750	Class C EPIRB/safety – receive only
16	156.800	156.800	Internat'l distress, safety, calling
17	156.850	156.850	State/local gov't control
18	156.900	161.500	INTERNATIONAL USE
18A	156.900	156.900	Commercial ship–ship, ship–shore
19	156.950	161.550	INTERNATIONAL USE
19A	156.950	156.950	Commercial ship–ship, ship–shore
20	157.000	161.600	Port operations
21	157.050	156.050	INTERNATIONAL USE
21A	157.050	157.050	CG working frequency only
22	157.100	161.700	INTERNATIONAL USE
22A	157.100	157.100	CG–Public liaison and safety
23	157.150	161.750	INTERNATIONAL USE
23A	157.150	157.150	CG working frequency
24	157.200	161.800	Public correspondence
25	157.250	161.850	Public correspondence
26	157.300	161.900	Public correspondence
27	157.350	161.950	Public correspondence
28	157.400	162.000	Public correspondence

Marine Channel	Transmit MHz	Receive MHz	Intended Use
65	156.275	160.875	INTERNATIONAL USE
65A	156.275	156.275	Port operations, VTS
66	156.325	160.925	INTERNATIONAL USE
66A	156.325	156.325	Port operations, VTS
67	156.375	156.375	Commercial ship-ship, VTS
68	156.425	156.425	Non-commercial ship-ship, ship-shore
69	156.475	165.475	Non-commercial ship-ship, ship-shore
70	156.525	156.525	DIGITAL SELECTIVE CALLING
71	156.575	156.575	Non-commercial ship-ship, ship-shore
72	156.625	156.625	Non-commercial ship-ship
73	156.675	156.675	Port operations, VTS
74	156.725	156.725	Port operations, VTS
77	156.875	156.875	Ship-ship Pilot communications
78	156.925	161.525	INTERNATIONAL USE
78A	156.925	156.925	Non-commercial ship-ship, ship-shore
79	156.975	161.575	INTERNATIONAL USE
79A	156.975	156.975	Commercial ship-ship, ship-shore
80	157.025	161.625	INTERNATIONAL USE
80A	157.025	157.025	Commercial ship-ship, ship-shore
81	157.075	161.675	INTERNATIONAL USE
81A	157.075	157.075	CG working frequency
82	157.125	161.725	INTERNATIONAL USE
82A	157.125	157.125	CG working frequency
83	157.175	156.175	INTERNATIONAL USE
83A	157.175	157.175	CG working frequency
84	157.225	161.825	Public correspondence
85	157.275	161.875	Public correspondence
86	157.325	161.925	Public correspondence
87	157.375	161.975	Public correspondence
88	157.425	162.025	Public correspondence, LIMITED
88A	157.425	157.425	Commercial ship-ship fishing

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4.	COMMANDANT (G-TA) ATTN: LCDR Rex Buddenberg U. S. Coast Guard Washington, DC 20593	1
5.	COMMANDANT (G-NRS) U. S. Coast Guard Washington, DC 20593	1
6.	COMMANDANT (G-NSR) U. S. Coast Guard Washington, DC 20593	1
7.	Commander (Att) Attn: CDR Richard F. Carlson Atlantic Area, U. S. Coast Guard Governors Island New York, NY 10004-5000	1

8. Commander (Pt) 1
Pacific Area, U. S. Coast Guard
Coast Guard Island
Alameda, CA 94501-5100

9. Commander (MLCAt) 1
ATTN: CDR Terry Hurley
Maintenance & Logistics Command, Atlantic
Governors Island, Bldg. 400
New York, NY 10004-5098

10. Commander (MLCPt) 1
ATTN: LTJG Kevin Manalili
Maintenance & Logistics Command, Pacific
Coast Guard Island
Alameda, CA 94501-5100

11. Commanding Officer 1
U. S. Coast Guard
Information Systems Center
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