DEPARTMENT OF HOMELAND SECURITY

# UNITED STATES COAST GUARD

# STRATEGIC SPECTRUM PLAN

## DECEMBER 2007 EDITION

PREPARED PURSUANT
TO THE
PRESIDENT'S SPECTRUM POLICY INITIATIVE

PREVIOUS EDITION: NOVEMBER 2005

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*Note: While this Strategic Spectrum Plan illustrates both the current and projected use of the radio frequency spectrum by the Coast Guard, national priorities and mission requirements are subject to change. Therefore, while every effort has been made to provide accurate predictions for future spectrum requirements, these requirements are subject to change.*

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## EXECUTIVE SUMMARY

This Strategic Spectrum Plan was prepared in response to the President's 30 November 2004 Memorandum, "Improving Spectrum Management for the 21st Century." The Memorandum directed the Heads of Executive Departments and Agencies to identify spectrum requirements and develop spectrum needs plans that demonstrate effective and efficient use of federal government spectrum.

In the 21st Century and post 9/11 world, the US Coast Guard's missions of homeland security, and protecting the public, the environment, and U.S. economic interests in the nation's waterways, are increasingly dependent on state-of-the-art C4ISR (Command, Control, Communication, Computers, Intelligence, Surveillance and Reconnaissance) systems for operational effectiveness. In turn, these C4ISR systems are increasingly dependent on access to, and successful utilization of, critical spectrum resources. In order for the Coast Guard to accomplish its multiple missions, it must continue to have access to, and uninterrupted operation of, frequency spectrum for future deployment of mission-critical communications and advanced sensors.

This Strategic Spectrum Plan presents the current spectrum use by the Coast Guard and projects future (10 years) spectrum requirements necessary for the Coast Guard to carry out its missions. The Strategic Spectrum Plan reviews the Coast Guard's Operating Programs (including communications requirements for the safety and security of commercial and recreational vessels) and the major Acquisition Programs (Integrated Deepwater Systems (IDS), Rescue 21, and Nationwide AIS) in terms of C4ISR requirements and corresponding spectrum needs. The cumulative C4ISR future requirements of the major acquisition programs represent the majority of Coast Guard future spectrum needs. The successful implementation of these programs is critical to the national interest and is vitally dependent on access to spectrum for new, high-technology services. Without the future additional spectrum contained at Table 18 herein, the capability of the Coast Guard to respond to our Nation's needs will be compromised.

The Coast Guard is constantly seeking to provide more spectrum efficient operations, within budgetary constraints, to maximize the use of currently allocated spectrum necessary to carry out its missions. Existing commercial technology is continually evaluated for applicability and use in Coast Guard technology solutions. The use of non-spectrum dependent systems are also evaluated and considered to address C4ISR mission support. It is the goal of C4ISR systems to use the most reliable, proven, and spectrum efficient wireless solutions for economical and cost effective system implementation.

This plan represents a living document which will be updated biennially.

D. T. Glenn

Rear Admiral David T. Glenn
Assistant Commandant for C4 & IT

## FOREWORD

The 2007 Coast Guard Strategic Spectrum Plan is an update from the 2005 version of the plan. Below are the specifics modified, removed, or updated in each chapter.

- Removed Sensitive Security Information material
- Executive Summary: Removed reference to MDA as a separate major acquisition project
- 1.0 U.S. Coast Guard Missions:
  - Mission breakdown updated
  - Frequency usage graph updated
- 2.0 Current Spectrum Utilization
  - Spectrum usage updated for the new mission breakdown
  - Removed reference to GOTHAM
  - Updated sections on GMDSS, HF Fax, satellite communications, public safety, vessel traffic services and racons.
- 3.0 Emerging Spectrum Requirements
  - MDA program removed as an overarching acquisition program
  - Reference to AEROSTAT High Altitude Platforms removed (section 3.3.4 from 2005)
  - Reference to MDA Broadband data links removed (section 3.3.5 from 2005)
- 3.1 Integrated Deepwater Systems
  - Removed reference to Bell Eagle Eye
- 3.2 Rescue 21
  - Removed reference to Asset Tracking for this program
- 3.3 Nationwide AIS, 3.4 Unmanned Aerial Systems, 3.6 High Frequency Radar
  - Upgrade from subject under MDA in 2005
  - Several updates to AIS
- 3.5 Container Tracking and Security in U.S. Ports
  - New subject based on outcome of WRC-2007
- 3.7 Mobile Satellite Usage
  - New subject based on need for increased bandwidth to mobile assets
- Added new sections
  - 3.8 Blue Force tracking
  - 3.9 HF ALE Expansion
  - 3.10 Boat crew and boarding team communication
  - 3.11 Small cutter connectivity

    - 3.12 Enhanced Loran
    - 3.13 Long Range Identification and Tracking
- 4.0 Future Spectrum Needs
    - Table updated based on updated to Section 3.0
- Appendix A – Acronyms and Abbreviations
    - Updated per changes to the plan

# THE PRESIDENT'S SPECTRUM POLICY INITIATIVE

This United States Coast Guard Strategic Spectrum Plan has been prepared in accordance with the President's Spectrum Policy Initiative (SPI). The Administration recognized that frequency spectrum dependent services are the backbone of the nation's economic and national security, and therefore committed to develop and implement a SPI to foster economic growth and ensure national and homeland security.

> *"The existing legal and policy framework for spectrum management has not kept pace with the dramatic changes in technology and spectrum use."*
>
> President George W. Bush, Presidential Memorandum,
> May 29, 2003

In June 2003, the President directed the Secretary of Commerce to chair an initiative for a comprehensive review to develop, among other things, recommendations for improving federal spectrum management policies. In June 2004, the Commerce Department, through its National Telecommunications and Information Administration (NTIA), delivered its spectrum policy recommendations. [1] Based on these reports, President Bush issued a Memorandum on November 30, 2004 that directed all federal agencies and departments to identify spectrum requirements and develop spectrum needs plans that demonstrate effective and efficient use of federal government spectrum. Specifically, the ***Presidential Determination: Memorandum for the Heads of Execute Departments and Agencies*** provided the following tasking to agencies;

> *(a) Within 1 year of the date of this memorandum [30 November 2004], the heads of agencies selected by the Secretary of Commerce shall provide agency-specific strategic spectrum plans (agency plans) to the Secretary of Commerce that include: (1) spectrum requirements, including bandwidth and frequency location for future technologies or services; (2) the planned uses of new technologies or expanded services requiring spectrum over a period of time agreed to by the selected agencies; and (3) suggested spectrum efficient approaches to meeting identified spectrum requirements. The heads of agencies shall update their agency plans biennially. In addition, the heads of agencies will implement a formal process to evaluate their pro-posed needs for spectrum. Such process shall include an analysis and assessment of the options available to obtain the associated communications services that are most spectrum-efficient and the effective alternatives available to meet the agency mission requirements. Heads of agencies shall provide their analysis and assessment to the National Telecommunications and Information Administration (NTIA) for review when seeking spectrum certification from the NTIA.*

[1] In accordance with the Communications Act of 1934, as amended, the President is responsible for the use of the frequency spectrum by radio stations belonging to, and operated by, the United States. The President delegated this authority to the Secretary of Commerce, who in turn delegated the authority to the Assistant Secretary of Commerce for Communications and Information; this Assistant Secretary serves as the Administrator of the NTIA.

# 1.0 – U.S. COAST GUARD MISSIONS

The Coast Guard is a military, multi-missioned, maritime service charged with reducing America's risk throughout the maritime domain while maximizing safety and accessibility to the economic and recreational benefits of our Nation's waterways. As part of the Department of Homeland Security (DHS), the Coast Guard is the lead federal agency for maritime homeland security. The Coast Guard's Mission is to protect the public, the environment, and U.S. economic interests – in the nation's ports and waterways, along the coast, on international waters, or in any maritime region as required to support national security.

### RADIO COMMUNICATIONS ARE CRITICAL TO THE COAST GUARD'S MISSIONS

*"We are poised …to be a linkage between the maritime forces of this country and countries that are low tech or sometimes no tech, where it would be impossible to create a coalition and establish interoperability if it weren't for an intermediate platform that can go both ways. … We bridge asymmetries."*

Admiral Thad Alan
Commandant, United States Coast Guard
November 1, 2007

Radio frequency spectrum is necessary for wireless communications – an integral part of the Coast Guard's missions (Figure 1). Accordingly, the Coast Guard requires adequate and reliable communications capabilities in order to accomplish its missions, The Coast Guard's eleven missions fall into three broad Roles:

**MARITIME SAFETY**
Search & Rescue
Marine Safety

**MARITIME STEWARDSHIP**

Aids to Navigation and Waterways Management
Ice Operations
Marine and Environmental Protection
Living Marine Resources

**MARITIME SECURITY**
Drug Interdiction
Migrant Interdiction
Other Law Enforcement
Ports, Waterways and Coastal Security (PWCS)
Defense Readiness

**Figure 1: Coast Guard Missions**

## 1.1 MANAGING THE RADIO SPECTRUM

The radio spectrum is the radio frequency (RF) portion of the electromagnetic spectrum (Figure 2 and Table 1). In the United States, regulatory responsibility for the radio spectrum is divided between the National Telecommunications and Information Administration (NTIA) and the Federal Communications Commission (FCC). The NTIA administers spectrum for Federal government use, and the FCC, an independent regulatory agency, administers spectrum for non-Federal use (*i.e.*, state, local government, commercial, private internal business, and personal use). Because of the Coast Guard Missions, it must work with both agencies: with the NTIA on Federal government spectrum issues and with the FCC on non-government spectrum issues relating to the maritime public.

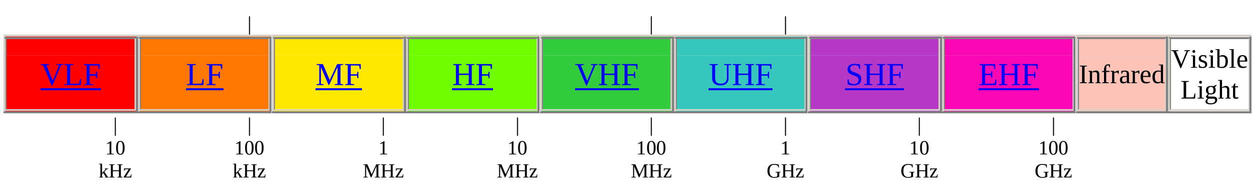

**Figure 2: Electromagnetic Spectrum**

**Table 1: Frequency Bands**

| | |
|---|---|
| Very Low Frequency (**VLF**) | 10 kHz to 30 kHz |
| Low Frequency (**LF**) | 30 kHz to 300 kHz |
| Medium Frequency (**MF**) | 300 kHz to 3 MHz |
| High Frequency (**HF**) | 3 MHz to 30 MHz |
| Very High Frequency (**VHF**) | 30 MHz to 300 MHz |
| Ultra High Frequency (**UHF**) | 300 MHz to 3 GHz |
| Super High Frequency (**SHF**) | 3 GHz to 30 GHz |
| Extremely High Frequency (**EHF**) | 30 GHz and Above |

Spectrum management involves all activities associated with regulating the use of the radio spectrum and it includes the structure and process for allocating, allotting, assigning and licensing the scarce resource as well as enforcing associated rules and regulations. Managing the frequency spectrum is a difficult task, and becomes much more important in the face of increasing demand. For example, the recent Commercial Spectrum Enhancement Act[2] provides that the Federal Government must vacate certain frequencies so that they can be used for commercial purposes.

At the end of FY 07, the Coast Guard held more than 16,000 frequency records (assignments) making it the seventh largest Federal user of frequency assignments (Figure 3).

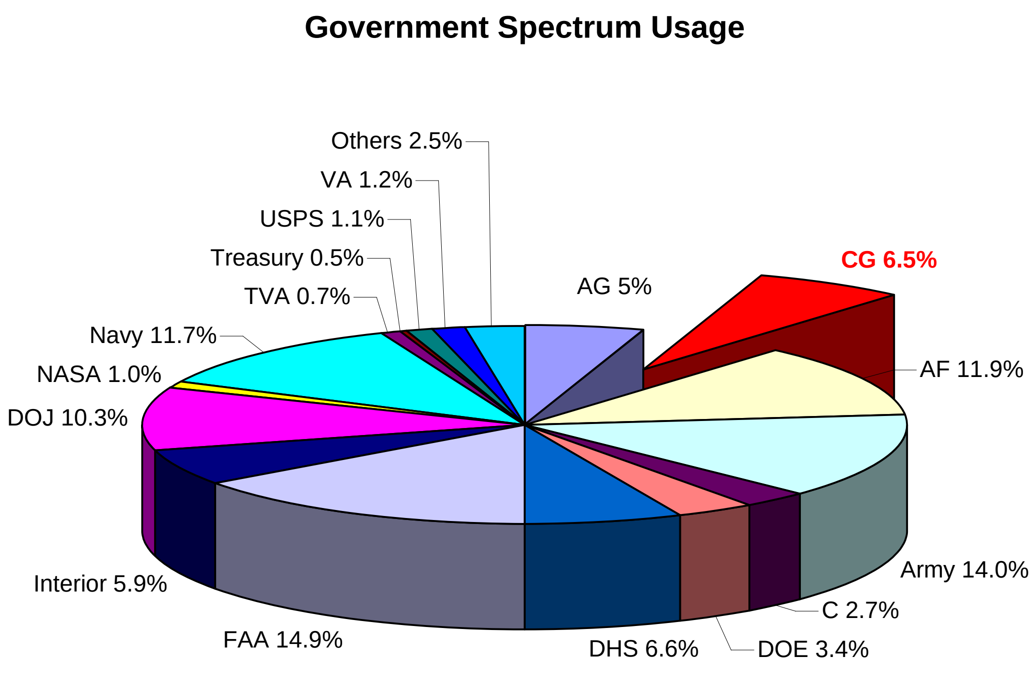


**Figure 3: Federal Frequency Assignments**

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2 Public Law No. 108-494, Title II, Dec. 23, 2004; 118 Stat 3986.

An authorization is required for each frequency at each transmitter site.[3] The Coast Guard requires a large number of radio frequency authorizations because of the unique Coast Guard maritime missions. Some activities, such as distress watchkeeping, require a disproportionate number of frequency authorizations. The Coast Guard has 651 frequency authorizations just for monitoring and operating over VHF distress Channel 16 alone. Similarly, the Coast Guard has an additional 630 frequency authorizations for maritime safety broadcasts and liaison on VHF Channel 22. Because new Coast Guard systems are increasingly technology-dependent and spectrum-dependent, the number of authorizations will only increase in the future.

Just as the Coast Guard takes a leadership role in the coordination and management of our nation's waterways and marine transportation system, it must take a leadership role in the protection, coordination and management of the frequency spectrum to assure that vital communications frequencies are available for military, commercial and recreational use of our nation's waterways, as well as to assure international interoperability. As a result, Coast Guard Spectrum Management is just as vitally concerned with public frequency allocations, regulated by the FCC, as it is with government frequency allocations within the province of NTIA. Coast Guard Spectrum Management attempts to assure that ample terrestrial and satellite radiocommunications channels are available for not only Coast Guard operations, but also for the commercial and recreational boaters communications needs on a national and international basis.

Typically, maritime frequency allocations are made on an international basis. Generally, there is input to the International Telecommunications Union (ITU) which makes the allocation after input from the International Maritime Organization (IMO) relating to requirements.

After the international allocation, the NTIA and the FCC decide what to do with the allocation domestically. For example, in the VHF (very high frequency) spectrum band, there is an international allocation for Maritime operations. Obviously some international allocation is necessary because ships travel all over the world and it is imperative that they be able to receive and transmit information, on standard frequencies, wherever they go. The international allocation for VHF Maritime frequencies is shown in Figure 4.

While this spectrum has been allocated internationally, because of reallocations of frequencies and auctions domestically (Figure 5), VHF frequencies allocated for Maritime operations in the U.S. are significantly less.

The diminishing VHF maritime allocation in the U.S. presents a good example of the need for the Coast Guard to be active with both the Federal and non-Federal frequency allocations. This specific frequency band provides the only remaining internationally interoperable VHF frequency spectrum available in the U.S. This band is used, among other things, for the Automatic Identification System (AIS). AIS is a unique maritime navigation safety communications system, providing collision avoidance functionality. Additionally, AIS can be used for vessel monitoring and tracking to enhanced maritime domain awareness.

[3] There is a fee payable to the NTIA for each authorization.

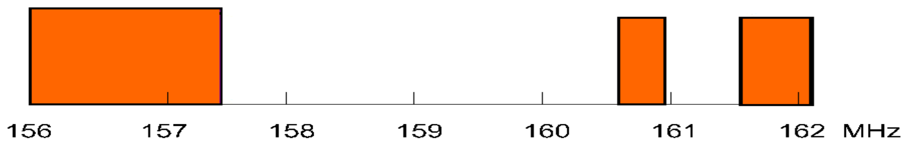



**Figure 4: International VHF Maritime Spectrum**

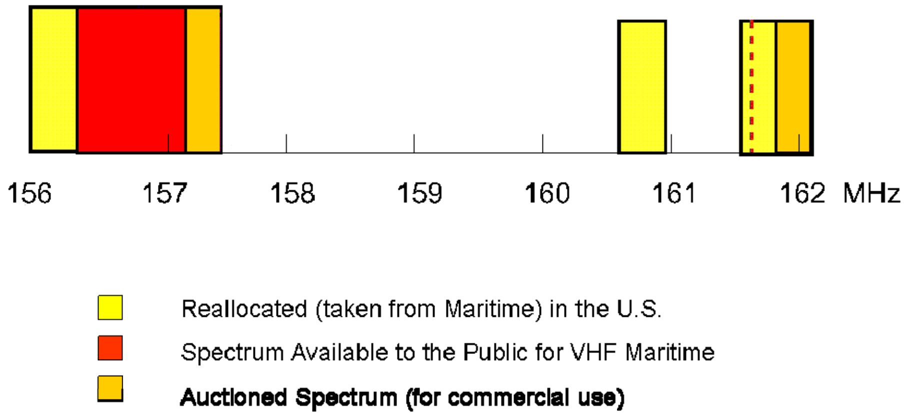



**Figure 5: VHF Maritime Spectrum in the U.S. after Reallocations and Auctions**

The United States is establishing a national capability to receive AIS from vessels in its own waterways and those in deep sea regions approaching its shores. Tracking vessels far at sea requires technology that is capable of providing very wide areas of view. AIS can only be received from wide areas if there are no other interfering signals on AIS transmitting frequencies. Therefore, to ensure AIS remains as accurate and persistent as possible, the frequencies used by AIS must be allocated exclusively for AIS both domestically and internationally. The Coast Guard has been engaged in a long battle, not yet concluded, to obtain frequencies for AIS. To support Blue Force Tracking (BFT) and satellite detection of AIS, two additional AIS channels will be required to protect the integrity of the VHF Data Link on AIS1 and AIS2. Based upon the international interoperability requirement, the frequency spectrum for new technology must come from the remaining U.S. VHF frequency allocation.

The following Sections will discuss, in detail, the current frequency spectrum utilization and future needs of the Coast Guard to accomplish its missions. One brief example relating to the events surrounding Hurricane Katrina illustrates the success of Coast Guard Spectrum Management and communications capabilities.

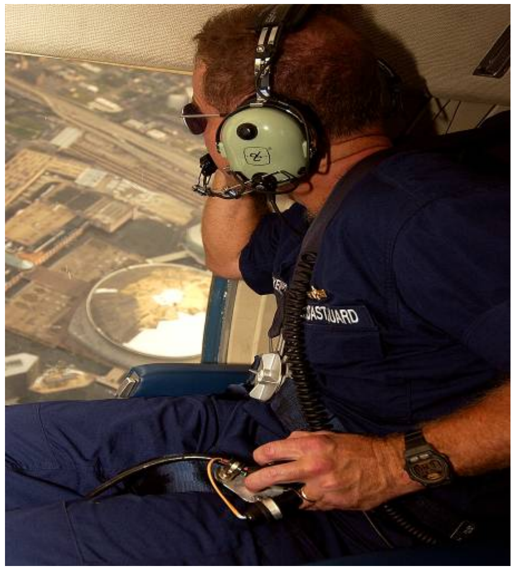


**Figure 6: Coast Guard in Action**

> *Coast Guard personnel saved more than 33,500 lives in the New Orleans area following Hurricane Katrina. In all, Coast Guard personnel saved more lives during Hurricane Katrina than they did nationally in the last eight years combined.*
>
> Military.com
> Nov. 2, 2005

During operations in response to Hurricane Katrina, the Coast Guard brought helicopters, fixed wing aircraft and various vessels from all over the country into the New Orleans area (Figure 6). Because the Coast Guard uses standardized frequencies, its personnel were able to communicate among and between vessels, shore stations and aircraft using existing radio frequency equipment. Thus, within the Coast Guard, "interoperability," the ability of Coast Guard personnel from all over the country to communicate seamlessly with each other using available radio facilities in the New Orleans area, was accomplished.

In order to assure the availability of adequate terrestrial and satellite radio frequencies for the Coast Guard missions, Coast Guard Spectrum Management faces the continuing challenge of safeguarding the integrity of existing mission critical services and making opportunities available for new spectrum requirements.

# 2.0 – CURRENT SPECTRUM UTILIZATION

The Coast Guard is the Seventh largest user of the Federal spectrum. Coast Guard missions are integrally dependent on spectrum access for command and control, search and rescue communications, radars, high accuracy navigational aids, and public safety communications. Coast Guard communications capabilities must be available on a worldwide basis because the Coast Guard operates worldwide. The following will highlight some of the specific frequency bands associated with missions of the Coast Guard.

## 2.1 MARITIME SAFETY

Maritime Safety includes search and rescue (SAR) operations and marine safety systems for safe navigation and collision avoidance. Coast Guard SAR involves multi-mission stations, cutters, aircraft and boats all linked by essential terrestrial and satellite communications networks using multiple radio frequencies.

### 2.1.1 OVER THE HORIZON TERRESTRIAL COMMUNICATIONS (3-30MHZ)

Coast Guard HF frequencies are used for long range (up to 3,000 miles and more) command and control of air, land and sea communications, including distress communication with commercial and recreational boaters. HF communications also support data traffic including operational message traffic. Due to limited circuit availability and high costs involved with satellite communications, HF has long been a primary means of communicating with long range, commonly referred to as over the horizon, mission assets. Additionally, the Federal spectrum allocations in the HF band allow the Coast Guard to manage its own system without relying on space-based commercial satellite systems. HF communications play a vital role in relief efforts related to natural disasters or other emergencies threatening the safety of life and property. In many cases the availability of HF communications has been the only link with remote areas affected in a disaster.

#### 2.1.1.1 HF VOICE (3-30MHZ)

The U. S. Coast Guard broadcasts National Weather Service high seas forecasts and storm warnings from six high seas communication stations. These broadcasts are prepared cooperatively by the Ocean Prediction Center, Tropical Prediction Center, Honolulu Forecast Office and others. Offshore and coastal forecasts are available in most locations, including Alaska. Transmission range is dependent upon operating frequency, time of day and atmospheric conditions and can vary from only short distances to several thousand miles. It is the variable propagation characteristics of HF that require access to multiple HF sub-bands between 3-30 MHz. For example, voice communications from the East Coast to the Pacific will need access to a frequency pool from various HF sub-bands.

#### 2.1.1.2 HF FAX (3-30MHZ)

The HF Fax, also known as the radiofax or WEFAX, for years has been the mainstay of weather and ice condition information for the mariner. During the tropical cyclone season, information on current tropical systems in text or graphical formats can be acquired via this method. Additionally, satellite imagery is made available throughout the year via this circuit. Transmitters located in Boston and New Orleans continuously transmit weather information for the Atlantic Basin, and transmitters located at Kodiak, AK and Pt. Reyes, CA cover the northeastern Pacific Ocean. A business case analyses conducted in 2007[4] confirmed the need to continue HF voice and fax broadcasts of maritime safety information.

[4] See http://www.navcen.uscg.gov/marcomms/high_frequency/HF-WX_notice.htm

#### 2.1.1.3 HF ALE (3-30MHZ)

The Coast Guard's current usage of HF Automatic Link Establishment is through the Customs Over-the-Horizon Enforcement Network (COTHEN). The Coast Guard uses the system to establish HF communications between aircraft and land stations. Operational experience with ALE shows that a large HF frequency pool is required to sustain reliable communication links.

### 2.1.2 NATIONAL DISTRESS AND RESPONSE SYSTEM (156-162 MHZ)

The National Distress and Response System provides emergency response capability through Maritime VHF channels to conduct search and rescue and protect the safety of life and property. The Coast Guard actively uses this spectrum in a joint capacity with the commercial and recreational maritime communities. Examples, of this use are VHF Channel 16, the international distress, safety, calling and watchkeeping frequency, Channel 22, used for liaison with commercial and recreational boaters and for Urgent Maritime Information Broadcasts (UMIBs) and Channel 13 used for ship bridge-to-bridge navigational voice communications. The Coast Guard receives and responds to approximately 10,000 distress calls per year over this system.

### 2.1.3 GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM (GMDSS) (MULTI BAND)

GMDSS is a worldwide communications and distress safety system. GMDSS utilizes numerous radio frequency bands for communications purposes. GMDSS is required by the International Maritime Organization (IMO) Safety of Life at Sea (SOLAS) Convention to provide a standardized method for automated distress calls throughout the world's waterways (Figure 7). GMDSS divides the world ocean areas into 4 segments A1, A2, A3 and A4. Sea Area A1 lies within the range of coastal VHF stations, usually about 20 miles from the coast. Sea Area A2 is defined as the area covered from shore by Medium Frequency (MF) installations usually 70-100 miles from shore. Sea Area A3 is that ocean area not covered by Sea Areas A1 and A2 within the reception area of the Inmarsat satellites (approximately 70 degrees north and south latitudes). Sea Area A4 covers that sea area not covered by A1, A2 and A3, generally the polar areas.

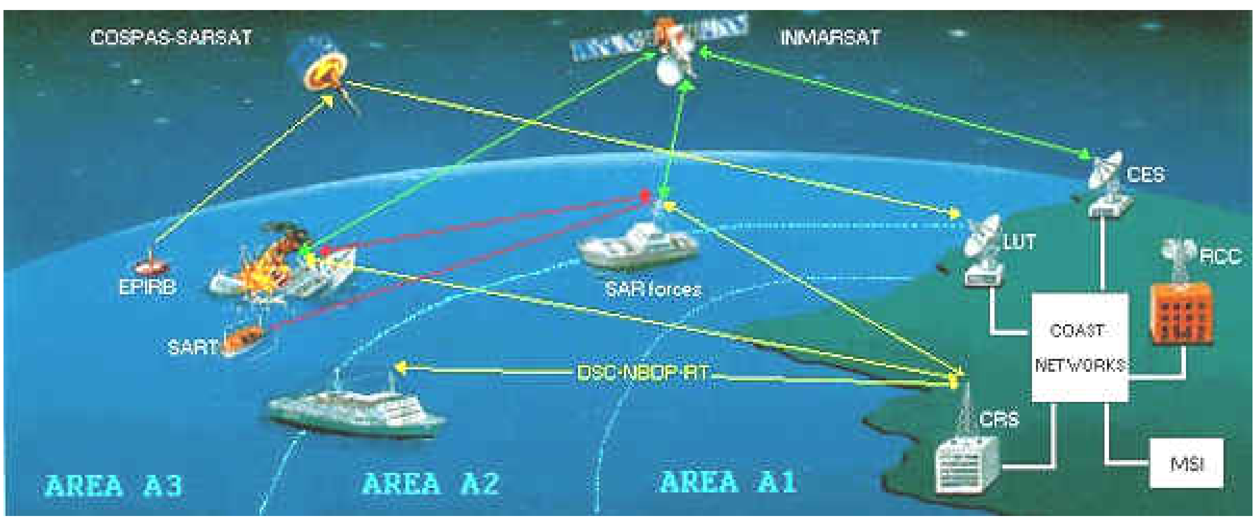



**Figure 7: Global Maritime Distress and Safety System**

#### 2.1.3.1 VHF DSC AND VOICE (156-162 MHZ)

VHF Digital Selective Calling (DSC) is used to meet the requirements for line of sight communications (approximately 20 miles). By using VHF DSC, countries satisfy the GMDSS requirements for Sea Area A1. DSC radio is the internationally standardized primary means for sending a distress alert to/from all vessels. It functions as a VHF radiotelephone and permits the selective reception of digital calls from other VHF DSC radios. This system allows a ship in distress to transmit a distress alert to any vessel in the area in addition to nearby Coast Guard search and rescue units.

#### 2.1.3.2 MF/HF DSC and Voice (2-30 MHz)

MF DSC is used to meet the requirements of sea area A2 (approximately 70-100 miles) from shore for maritime distress communications. HF DSC meets the requirements for Sea Areas A3 and A4, beyond approximately 100 miles from shore. These systems, normally combined aboard ship, function as a MF/HF radiotelephone and permit the selective reception of digital calls from other MF/HF radios.

#### 2.1.3.3 MF NAVTEX (518 kHz)

NAVTEX is a shore to ship broadcasting system that sends safety messages such as gale warnings, weather forecasts, navigational warnings and other safety information. All SOLAS vessels carry NAVTEX equipment under the GMDSS requirement.

#### 2.1.3.4 HF Narrow Band Direct Printing (NBDP or SITOR) (4-30 MHz)

SITOR (Simplex Teletype Over Radio) is used in two modes for different purposes.

**HF NAVTEX (broadcast mode)**: The Coast Guard broadcasts high seas meteorological information from the National Weather Service and navigational warnings (NAVAREA and HYDROLANT/PAC) provided by the National Geospatial-Intelligence Agency on 4210, 6314, 8416.5, 12579, 16806.5 and 16806.5 kHz.

**HF TELEX (ARQ mode)**: HF telex is used to receive AMVER ship position reports, meteorological information in cooperation with the National Weather Service, and urgency, medical and other safety information from ships.. The Coast Guard announced termination of this service from its stations on the east coast (CAMSLANT) and Kodiak AK effective 31 March 2008, and plans to terminate its remaining service at Pt Reyes CA, Honolulu HI and Guam on 30 September 2008. AMVER reports will be received instead through commercial stations. IMO is considering establishing HF data (e.g. email) in accordance with Recommendation ITU-R M.1769 as an equivalent for this service.

#### 2.1.3.5 EPIRB/COSPAS-SARSAT (406-406.1 MHz), Emergency Locating Transponders (121.5 MHz)

Emergency Position Indicator Radio Beacons (EPIRBs), authorized at 406 MHz, transmit a signal to a satellite in order to locate vessels and persons in distress. Aircraft typically carry a similar distress beacon on board called an Emergency Locator Transmitter (ELT). A 406 MHz personal locator beacon (PLB) is also available for use by persons on land in remote areas (eg hikers) or on small boats. A homing frequency of 121.5 MHz is used in conjunction with the 406 MHz satellite locating signal for localized position determination, although operational experience now shows that the transmitted emission level of this 121.5 MHz component is inadequate for this purpose. NOAA operates the U.S. component of this system, routing maritime alerts to responsible Coast Guard Rescue Coordination Centers.

#### 2.1.3.6 Inmarsat C SafetyNet (1.5-1.6 GHz)

Inmarsat C SafetyNet consists of a system of four (4) geostationary satellites providing worldwide coverage for most navigable waters and is owned and operated by Inmarsat, a commercial satellite service provider. This system provides a communications link to send or receive distress alerts, search-and-rescue coordination messages, Atlantic ice reports, weather warnings and forecasts, weather observation and ship position reports, and other safety traffic.

#### 2.1.3.7 Search and Rescue transponder (SART) (9 GHz and 162 MHz)

The Search and Rescue Transponder (SART) operating in the band 9200-9500 MHz is used within the GMDSS system to identify a target with a standard X-Band navigational radar during local search and rescue operations. Typically, a lifeboat will deploy a SART to allow rescue responders to locate the craft. The SART is a self-contained device that responds to an X-band radar pulse by transmitting a series of 12 pulses that display on the radar screen of the searching vessel. The International Maritime Organization has amended the SOLAS Convention to allow an automatic identification system (AIS) version of the SART, operating on the frequencies 161.975 and 162.025 MHz, to be used as an equivalent to an X-band radar SART. AIS-SART devices are expected to be available by early 2010, once the International Electrotechnical Commission (IEC) completes development of a certification standard for this device. See also 2.3.3.

#### 2.1.3.8 Satellite Communications

Chapter IV of the SOLAS Convention recognizes Inmarsat mobile satellite systems as the sole carrier for provision of satellite communications in the GMDSS. When Inmarsat was privatized, the intergovernmental organization International Mobile Satellite Organization (IMSO) was established, funded by Inmarsat, to maintain a public services agreement with Inmarsat to ensure IMO-mandated GMDSS provisions continued to be met. IMSO’s charter was expanded at IMO’s request to include oversight of other mobile satellite providers provision of GMDSS services, once IMO approves such provision. To date, no other mobile satellite providers have applied for GMDSS recognition. As of this date Inmarsat B, C and Fleet-77 terminals are approved for provision of GMDSS services. No other Inmarsat terminals provide GMDSS services.

### 2.1.4 Public Safety interoperability (VHF/UHF)

VHF and UHF bands are used to ensure Coast Guard interoperability with first responders and public safety partners in the mission areas of Maritime Safety, Maritime Security, and Maritime Stewardship. This communications includes use of non-federal frequency bands to ensure interoperability with state and local first responders and law enforcement as required by a particular location.

### 2.1.5 Vessel Traffic System (VTS) (156-162 MHz) (2900-3100 and 9300-9500 MHz)

The Vessel Traffic System (VTS) uses a variety of spectrum dependant systems to provide active monitoring and navigational control for vessels in particularly confined and busy waterways. Systems utilized by the VTS include coastal radar, VHF voice communication, and AIS data links. In the average year approximately 7 million VHF ship reports are taken through the various VTS offices around the Coast Guard. Figure 8 shows a typical VTS control room with various stations. The computer monitors display the radar and AIS data from around the area of operations. The individuals with headsets are using VHF radios to communicate with vessel traffic in the controlled areas.

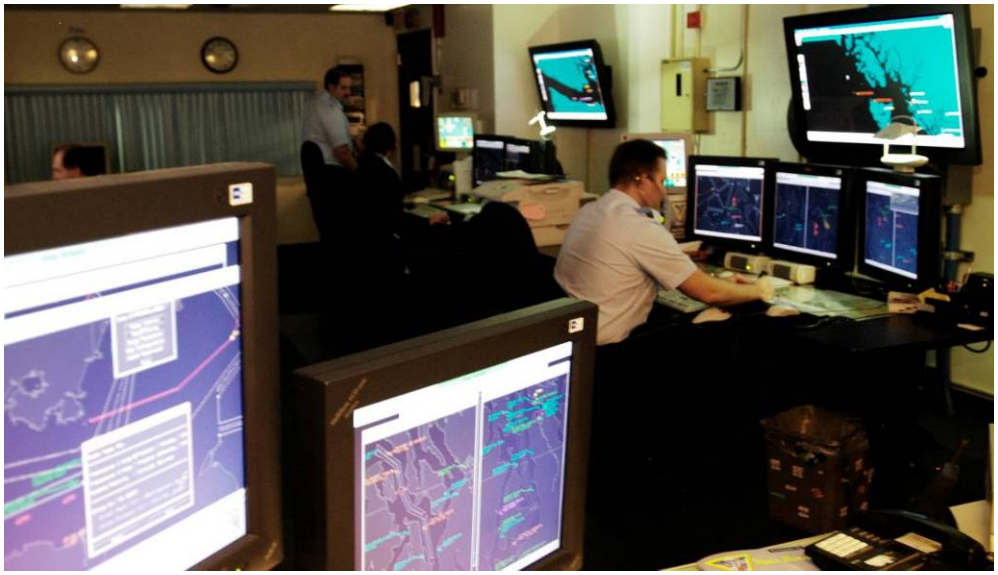


**Figure 8: Typical VTS Control Station**

#### 2.1.6 SEARCH AND RESCUE DATUM MARKER BUOY (225-400 MHZ)

The Datum Marker Buoys are dropped from Coast Guard aircraft to assess the movement of objects in the water. This system helps search and rescue personnel modify search areas to best use resources by factoring in the environmental factors.

#### 2.1.7 AIRBORNE AND SHIPBOARD IFF INTERROGATOR (1030 AND 1090 MHZ)

Used by both civilian and military aircraft, the Identification Friend or Foe (IFF) system is a surveillance system used to identify friendly or foe aircraft. Coast Guard has a requirement to operate IFF systems within the coastal areas of the United States.

#### 2.1.8 TACTICAL AIR NAVIGATION SYSTEM (960 MHZ -1210 MHZ)

The Tactical Air Navigation (TACAN) System is a line-of-sight, beacon-type, air navigation aid that provides slant range, bearing, and identification information to TACAN-equipped aircraft in determining the aircraft's position relative to own ship. This system is primarily used between an aircraft and a cutter to assist the aircraft in returning to the cutter.

#### 2.1.9 SPECTRUM AVAILABLE TO THE PUBLIC FOR VHF MARITIME

Figure 5 illustrates the VHF maritime frequency band in the U. S. Coast Guard vessel traffic systems; Coast Guard stations, cutters and boats; recreational boaters; foreign and US commercial vessels; port operations; pilots; marinas and shipyards; commercial marine shore facilities; distress and safety communications; maritime safety broadcasts and DSC all must use the limited amount of spectrum between 156.25 and 157.175 MHz in order to be internationally interoperable. This one small allocation is the most important VHF spectrum asset the US maritime community has available.

### 2.2 MARITIME SECURITY

Maritime Security covers the Coast Guard roles for National Defense and Law Enforcement. The Coast Guard is one of the five military services that provide essential capabilities to support our national security and national military strategies. Additionally, The Coast Guard is the lead federal agency for maritime drug interdiction and shares lead responsibility for air drug interdiction with the U.S. Customs Service. As the primary maritime law enforcement agency, the Coast Guard is tasked with enforcing immigration law at sea, and with enforcing laws pertaining to U.S. Exclusive Economic Zones, which extend up to 200 miles from U.S. shores. Finally, as the lead agency for Maritime Homeland Security, the Coast Guard is responsible for preventing and protecting against maritime security threats.

### 2.2.1 Coastal Surveillance Radars(2900-3100 and 9225-9500 MHz)

Coastal Radars are used by the Coast Guard for monitoring of the nation's ports and waterways for maritime domain awareness.

### 2.2.2 Intraship and Intership communications (UHF)

Law Enforcement Boarding parties and ship damage control parties utilize UHF radios for communications during operations and emergencies. This communication method helps provide situational awareness to all personnel involved in the operation.

### 2.2.3 Air-to-Ground Communications (HF, VHF, UHF, SATCOM)

Air to Ground communication is used during the course of Coast Guard airborne missions. It provides voice and data capability to coordinate with various USCG units from air to ground. The bands operate both in the clear and encrypted to ensure protection for mission critical data during aircraft operations. For example, it is critical that USCG Dauphin HH-65A helicopter communicates with USCG ships to report their position, call sign and status during search and rescue missions.

### 2.2.4 Ship-to-Shore Communications (HF, VHF, UHF, SATCOM)

Ship to Shore communication is used to provide critical and tactical information to accomplish various USCG missions. It provides a maritime communication services to support vessel tracking, Search and Rescue (SAR), navigation safety and law enforcements. Ship to Shore communications provides voice and data services such as severe weather warnings, navigational warnings, and distress calls from 20 miles to 3000 miles or more in range.

### 2.2.5 Point-to-Point Microwave (400 MHz – 14 GHz)

Point-to-point microwave links are used to provide data communications between locations where hardwire connections are not feasible. In particular, the Vessel Traffic Systems use microwave links to relay radar data from remote radar stations for monitoring the flow of traffic in port areas.

### 2.2.6 Command and Control (Between Air, Ship and Shore) (Multi band)

The Command and Control of Coast Guard units is accomplished through voice and data communications throughout multiple frequency bands.

### 2.2.7 Commercial Satellite Communications (1.5-1.6 GHz)

Commercial satellite is used to facilitate voice and data communication for command and control of underway units. Satellite links are vital connections for long range deepwater missions. Inmarsat is used for data and voice communication. Iridium is used for both day to day and contingency communications.

### 2.2.8 DoD Interoperability (Multiband)

These links provides vital interoperability spectrum for Coast Guard participation in Joint DoD operations.

## 2.3 Maritime Stewardship

Maritime Stewardship involves Radio Aids to Navigation (AtoN), waterways management, and protection of natural resources. The Radio AtoN assist government, commercial and recreational vessels with navigation and alert them to obstructions and hazards. Maritime Stewardship also includes ice operations, those ice breaking activities in the Great Lakes, the North East and Polar Regions. The Coast Guard is very active in protecting the marine environment from oil and chemical spills and in clean-up activities in the event there is a spill. The Coast Guard also protects the Nation's living marine resources, and protects U.S. Exclusive Economic Zones by enforcing fisheries laws. The command and control communications used for Maritime Safety are the same for Maritime Stewardship.

### 2.3.1 DIFFERENTIAL GPS (285-325 KHZ)

Differential Global Positioning System (DGPS) operates in the MF band and is used to assure the integrity of the GPS signal and increase the accuracy of standard GPS signals through use of differential corrections based on a known fixed reference stations. The system provides nationwide coverage for DGPS in the NDGPS program.

### 2.3.2 LORAN (90-110 KHZ)

Loran is a radionavigation aid that provides radionavigation service to the continental U.S., most of Alaska and the Bering Sea, for absolute accuracy within 0.25 nautical miles and relative accuracy within 50 meters.

### 2.3.3 AUTOMATIC IDENTIFICATION SYSTEM (161 - 162 MHZ)

Automatic Identification System (AIS) is a ship-to-ship, ship-to-shore, and shore-to-ship maritime navigation safety communication system used for collision avoidance and vessel monitoring and tracking. This digital maritime communications system utilizes internationally allocated VHF frequencies AIS 1 (161.975 MHz) and AIS 2 (162.025 MHz). AIS has been recognized as an important tool for Maritime Domain Awareness (MDA). In addition to the SOLAS requirement for the carriage of AIS equipment, the Maritime Transportation Security Act of 2002 (MTSA)[5] mandates expanded carriage of AIS equipment in U.S. waters.

### 2.3.4 RADAR BEACONS (2900-3100 AND 9300-9500 MHZ)

Radar Beacons (RACONS) are navigation aids to identify landmarks or buoys on shipboard marine radar in either the X or S-Band. USCG maintains about 80 RACONS in use throughout the waterways of the U.S. RACONS may eventually be replaced by AIS devices once compatible electronic navigation displays become commonly used by international shipping and US vessels (see 3.3).

### 2.3.5 SHIPBORNE RADAR (2900-3100 AND 9300-9500 MHZ)

This radar system is a navigational aid for collision avoidance, vessel tracking and general weather observations onboard ships. Additional radars onboard ships serve to control weapon tracking (fire control) and search for aircraft (air search).

### 2.3.6 AIRBORNE RADAR (5200-5900, 8500-10000 MHZ)

Airborne Radars are used for search and rescue, iceberg reconnaissance, surveillance, forecasting weather and navigational assistance onboard aircraft.

This mission relies upon the common command and control architecture of other CG missions and related radio frequency utilization.

[5] 46 U.S.C. §70114.

# 3.0 – EMERGING SPECTRUM REQUIREMENTS

This section addresses the major Coast Guard acquisition programs which require access to national and international spectrum resources. The Coast Guard's Integrated Deepwater Systems (DEEPWATER), RESCUE 21, and Nationwide AIS (NAIS) represent the major acquisitions which will shape the Coast Guard's command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) requirements in the future. Non-major acquisitions will have additional C4ISR requirements for communications, monitoring and interoperability nationally and internationally. The impact of the international spectrum allocation process is also examined with respect to global maritime interoperability. The roles of the International Maritime Organization (IMO) and International Telecommunication Union (ITU) are stated with respect to establishing global maritime standards and requirements, and globally interoperable maritime spectrum.

## 3.1 INTEGRATED DEEPWATER SYSTEM (DEEPWATER OR IDS)

To continue to meet America's 21st Century maritime threats and challenges, the Coast Guard initiated the Integrated Deepwater System (IDS) Program, the largest and most innovative acquisition in Coast Guard history. The IDS is not just "new ships and aircraft," but an integrated approach to upgrading existing assets while transitioning to newer, more capable platforms with improved systems for C4ISR and innovative logistics support (Figure 9). This new "system of systems" will significantly contribute to the Coast Guard's maritime domain awareness, as well as the improved ability to intercept, engage, and deter those activities that pose a direct challenge to U.S. sovereignty and security. Deepwater will provide the means to extend our layered maritime defenses from our ports and coastal areas to hundreds of miles at sea.

The IDS Program focuses on system-wide capabilities and not assets. The Coast Guard began the design process with the goal to acquire the performance capabilities required to perform the full range of Coast Guard deepwater missions. The Coast Guard is focusing on the overall required capabilities rather than the individual assets. This performance-based acquisition approach gave industry the flexibility to propose the optimal mix of assets necessary to meet the needs of the Coast Guard for Deepwater missions. Deepwater is a long-term acquisition program, but work to upgrade existing assets and acquire the first new aircraft and ships has already begun. According to the notional IDS implementation plan, the system will be completed in approximately 20 years.

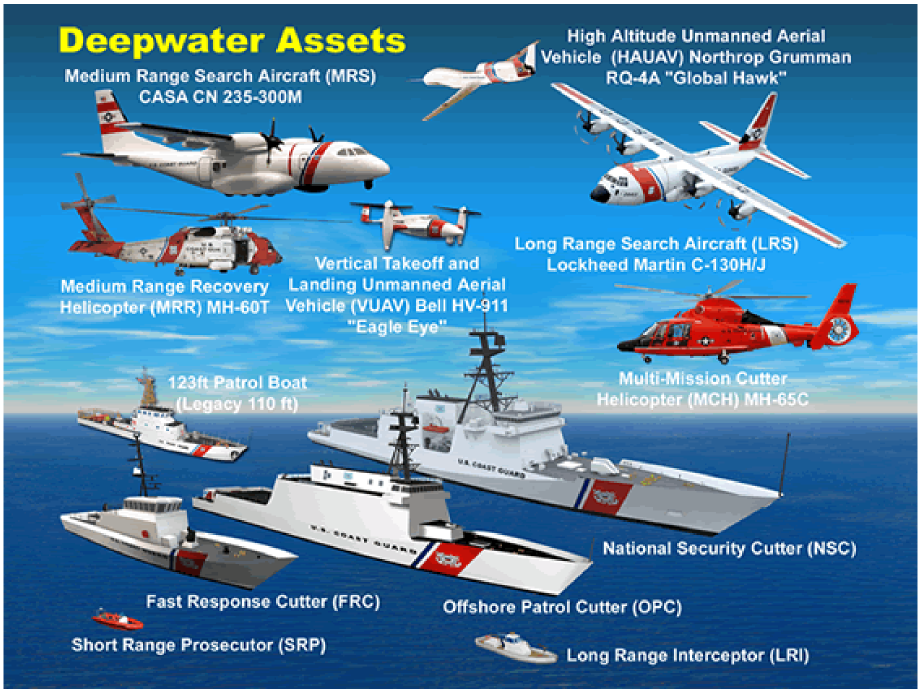



**Figure 9: DEEPWATER ASSETS**

### 3.1.1 Shorside/Pierside Communications

Operations information exchange is mainly performed at shore assets. This information exchange involves the planning and coordination effort for the mission. The shore assets, such as the Districts and Areas, plan mission strategies and tasking, coordinate with other shore assets, and disseminate the information to other shore assets. Communications among shore assets is through the Coast Guard Data Network (CGDN+).

Plans and tasking are also forwarded to air assets and to surface assets. The shore may need to send planning and tasking information to Line-of-Sight (LOS) assets using VHF or UHF to provide deployment instructions. If a surface asset is in port, the shore asset may then be able to use pierside connectivity. During the plan operations information exchange, shore assets may be required to communicate with on-scene surface assets beyond LOS communications. In this case, the assets would communicate using Over-the-Horizon (OTH) communications means, such as commercial SATCOM or HF. In addition, air and surface assets may be sending reports (SITREPS, Case Files) to update the shore assets of any updated conditions.

### 3.1.2 Commercial Satellite Communications (COMSATCOM)

IDS provides several communication pathways to support Over-the-Horizon (OTH) communications. Satellite communications are the main pathway for high-speed data and voice transmissions. Both commercial and military satellite communications are used. Commercial satellite phones provide additional voice capabilities.

IDS C4ISR communications systems will use commercial SATCOM capabilities which use existing and evolving Inmarsat terminals and services to handle the diverse OTH traffic demands of underway assets in an ocean region. Large cutters use Inmarsat-B leased services, which provide high-speed data connectivity on a leased 100 kbps circuit. Several leased circuits are available in each ocean region for the underway assets to share. Smaller cutters will use Inmarsat-F services, which provide packet-based services and/or integrated services digital network (ISDN) based dial on-demand circuit based services. The air assets will use the Aero-

High Speed Data (HSD) leased service. In general, all surface assets will have Inmarsat Mini-M service for non-secure and secure voice services.

Shore based communication station and Land Earth Stations (LES) architectures will be upgraded to accommodate Fleet asset support. Table 2 lists the commercial SATCOM services that are part of the IDS architecture.

**Table 2: Commercial SATCOM Services**

| Communication Identifier | Operational Need | Frequency Band (MHz) | Channel BW (kHz) | Data Rate (kbps) |
|---|---|---|---|---|
| Inmarsat-B HSD Leased Service | Commercial SATCOM for data communications between large surface assets and shore assets for extending CGDN+ and SIPRNET | Up 1626.5-1645.5, Dn 1525.0-1545.0 | 100 | 64 |
| Inmarsat-B HSD Leased Service (Include Upgrade) | Upgraded commercial SATCOM for data communications between large surface assets and shore assets for extending CGDN+ and SIPRNET | Up 1626.5-1645.5, Dn 1525.0-1545.0 | 50<br><br>100 | 64<br><br>128 |
| Inmarsat-F Service: MPDS | Commercial SATCOM for packet data communications between small surface, aviation and shore assets for extending CGDN+ and SIPRNET | Up 1626.5-1660.5 Dn 1525-1559 | 40 | Variable, throughput = 64 max |
| Inmarsat-F Service: Dial-up ISDN | Commercial SATCOM for dial-up data communications between small surface assets and shore assets for extending CGDN+ and SIPRNET | Up 1626.5-1660.5 Dn 1525-1559 | 40 | 64 |
| Inmarsat Mini-M | Commercial SATCOM for voice communications (Clear and Secure Digital Voice) between various assets | Up 1626.5-1660.5 Dn 1525-1559 | 5 | 2.4 |
| Inmarsat Aero-HSD | Commercial SATCOM for voice and data communications between aircrafts and shore assets | Up 1626.5-1660.5 Dn 1525-1559 | 40 | 128 |

### 3.1.3 Line Of Sight Communication (VHF/UHF)

The VHF/UHF communications support LOS operations between surface vessels, aircraft, and shore stations. Table 3 and Table 4 summarize VHF/UHF communication capabilities. VHF/UHF communications are used to support operational needs for law enforcement, military tactical, search and rescue, interoperability with other Federal agencies, interoperability with US DoD military and with NATO and coalition partners.

**Table 3: VHF Communication Capabilities**

| Communication Identifier | Operational Need | Band (MHz) | Channel BW (kHz) | Data Rate (kbps) |
|---|---|---|---|---|
| VHF Low Band Mobile | Law Enforcement (clear voice) | 30-50 | 25 | Analog only |
| VHF Military Tactical | Military Tactical (clear and Type 1 secure Voice) | 30-88 | 25 | 16 kbps |
| VHF Aviation | Commercial Aviation Services (clear voice) | 118-137 | 25/8.33 | Analog only |
| VHF High Band Mobile | Law Enforcement (clear voice) | 136-174 | 25 | Analog only |
| VHF High Band P-25 | CG Boarding Party & Law Enforcement P-25 (clear and Type III protected voice) | 136-174 | 12.5 | 9.6 |
| VHF Marine | Bridge-to-Bridge, Marine Operator, NOAA Weather, GMDSS monitoring maritime emergency channels (clear voice) | 156.05-162.55 | 25 | Analog only |
| VHF Marine DSC | Digital Selective Calling with MMSI. | 156.525 | 25 | DSC data |

**Table 4: UHF Communication Capabilities**

| Communication Identifier | Operational Need | Band (MHz) | Channel BW (kHz) | Data Rate (kbps) |
|---|---|---|---|---|
| UHF Military Tactical | Military Tactical, Ship-to-air, and Ship to Ship (clear and Type 1 secure voice) | 225-400 | 25 | 16 |
| UHF Link 11 | Military LOS Data Link, (TADIL-A) Type I secure data exchange for tactical situation, orders, status and C2 functions | 225-400 | 25 | 2.25 |
| UHF Low Band P-25 | Law Enforcement, P-25 (clear and Type III protected voice) | 406-420 | 12.5 | 9.6 |
| UHF High Band Mobile | Law Enforcement interoperability with state and local agencies (per non-federal agency usage) | 806-869 | 25 | Per non-federal usage |
| Cellular Phone | Commercial LOS Cellular telephone must be in range of commercial cellular towers (clear voice) | 824-849 Tx, 869-894 Rx, 1850-1910 Tx, 1930-1990 Rx | 30 - TDMA, AMPS; 1250 - CDMA | 9.6 |

### 3.1.4 OVER-THE-HORIZON COMMUNICATIONS (MILSATCOM/HF/SAT PHONE)

UHF Military SATCOM (MILSATCOM) is required for IDS assets to provide C4ISR and interoperability with DoD elements during defense missions and joint operations. Table 5 summarizes UHF MILSATCOM operational needs. Note this is subject to unavailability if there are DoD missions requiring full channel use.

**Table 5: UHF MILSATCOM Services**

| Communication Identifier | Operational Need | Frequency Band (MHz) | Channel BW (kHz) | Data Rate (kbps) |
|---|---|---|---|---|
| UHF MILSATCOM 1 | OTCIXS, data link for inter- and intra-surface group C2 Type I secure data exchange. | Up 291-318<br>Dn 243-270 | 25 | 2.4 -100 |
| UHF MILSATCOM 2 | Single Access "Dedicated" data link for inter- and intra-surface group C2 Type I secure voice and data exchange. | Up 291-318<br>Dn 243-270 | 5/25 | 2.4/16 up to 100 |
| UHF MILSATCOM 3 | 5 kHz DAMA, comm link for inter- and intra-surface group C2 Type I secure voice and data exchange. | Up 291-318<br>Dn 243-270 | 5 | 2.4 |
| UHF MILSATCOM 4 | 25 kHz DAMA, comm link for inter- and intra-surface group C2 Type I secure voice and data exchange. | Up 291-318<br>Dn 243-270 | 25 | 16-100 |
| UHF MILSATCOM 5 | Next generation MILSATCOM waveforms | Up 291-318<br>Dn 243-270 | Per DoD Usage | Per DoD Usage |

IDS uses HF/HF Automatic Link Establishment (ALE) for operational messages, voice, data, and e-mail messages as well as for backup to primary and secondary satellite systems. HF also provides interoperability to DoD, NATO forces, and Coalition partners during joint operations. Future evolutions in HF data modem technology will see a greater reliance on HF bands. Table 6 summarizes IDS HF future capabilities.

**Table 6: HF/HF ALE Capabilities**

| Communication Identifier | Operational Need | Band (MHz) | Channel BW (kHz) | Data Rate (kbps) |
|---|---|---|---|---|
| HF/HF ALE Data | HF/HF ALE, Commercial and Military, SSB-Data (clear and Type I secure data) | 2-30 | 3 | 9.6 |
| HF/HF ALE Voice | HF/HF ALE, Commercial and Military, SSB-Voice (clear, Type I secure & Type III protected voice) | 2-30 | 3 | N/A |
| HF Link 11 | Military Data Link, (TADIL-A) Type I secure data exchange for tactical situation, orders, status and C2 functions | 2-30 | 6 | 2.25 |

Iridium satellite phones will provide secure and non-secure voice and data communications as summarized in Table 7.

**Table 7: Iridium Satellite Phone Capabilities**

| Communication Identifier | Operational Need | Band (MHz) | Channel BW (MHz) | Data Rate (kbps) |
|---|---|---|---|---|
| Iridium Satellite Phone | Capability to provide clear and secure voice and data over commercial satellite | L-Band 1,616-1,626.5 | 10.5 | 2.4 |

### 3.1.5 Boarding Party Links

Communication capabilities vary widely across the assets, with the larger assets generally having a greater set of capabilities. However, all IDS assets have communications capabilities commensurate with the role of the asset in the IDS. For example, while a Short Range Prosecutor (SRP) would not normally carry OTH communication equipment, the cutter from which it launches does. Consequently, information from a Boarding Party on the SRP is passed to a cutter which can use its extensive communication abilities to put that information into a Common Operating Picture (COP), which can be reviewed by a shore-based commander in minutes. In the case where boarding operations are necessary, the IDS C4ISR provides the Boarding Party, deep within the vessel's interior, an ability to communicate with, and send data back to, the originating cutter. Table 8 characterizes a VHF Boarding Party Link.

**Table 8: VHF Communications**

| Communication Identifier | Operational Need | Band (MHz) | Channel BW (kHz) | Data Rate (kbps) | Comments |
|---|---|---|---|---|---|
| VHF High Band P-25 | CG Boarding Party & Law Enforcement P-25 (clear and Type III protected voice) | 136-174 | 12.5 | 9.6 | -Coast Guard operations<br>-Communication with Federal Agencies (JIATF, FBI, DEA, Customs) and State and Local Law Enforcement and Public Safety agencies. |

Figure 10 below depicts the communications links IDS assets use to exchange information. The combination of interconnected terrestrial T1 circuits, SATCOM, BLOS HF, LOS UHF and VHF, and TCDL allow IDS assets to interoperate as a system of systems, connects the shore and mobile assets, connects the surface and aviation assets, and extends voice communications and data networks from the highest echelon to the lowest.

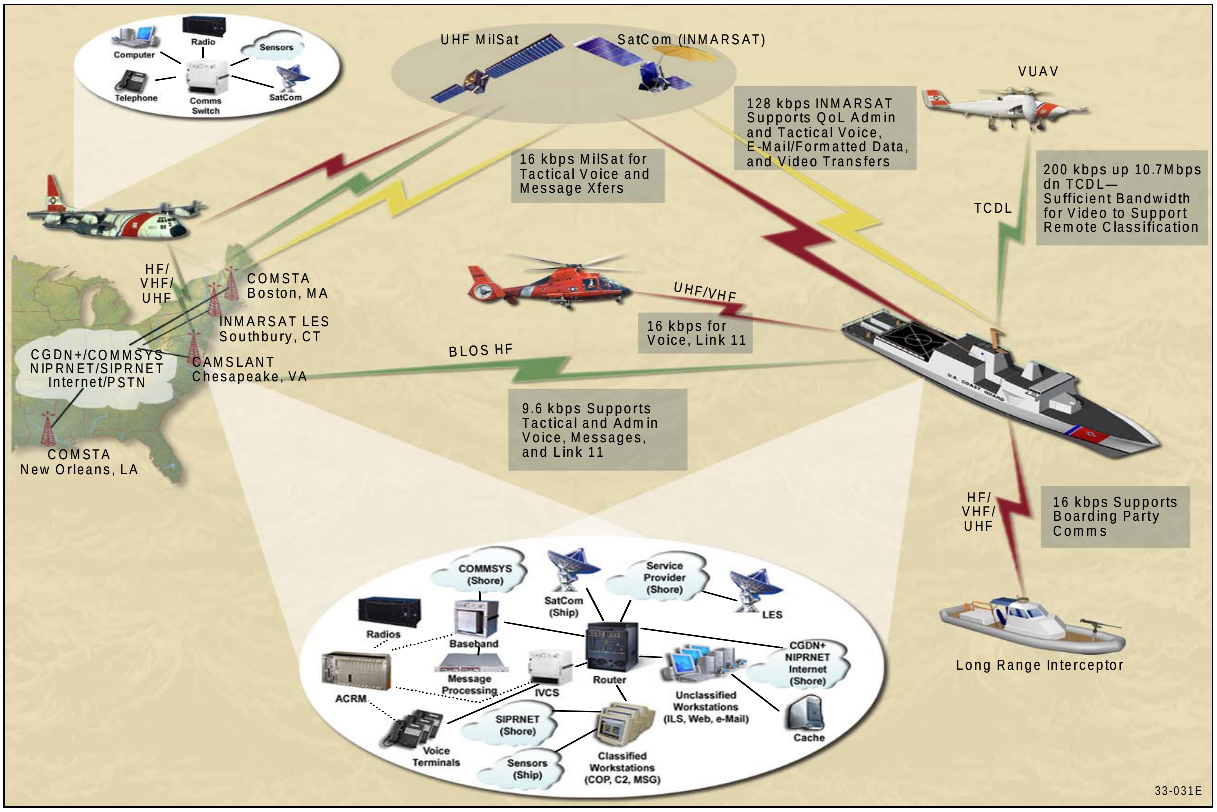



**Figure 10: High-Level DEEPWATER Asset Connectivity and Communication Links**

### 3.1.6 COASTAL AND SHIPBORNE 3D RADARS & MULTI MODE RADARS (MMR)

Coastal and Shipborne 3D radars are used to track multiple surface and air targets. This 3D radar operates C-Band (4-6 GHz) with the requirements summarized in Table 9.

**Table 9: C-Band 3D RADARs**

| Communication Identifier | Operational Need | Band (GHz) | Channel BW (MHz) | Data Rate (kbps) |
|---|---|---|---|---|
| Coastal and Shipborne 3D radars | C4ISR tracking of vessels & aircraft | 4-6 | 10 | N/A |

Multi-Mode Radar (MMR) provides detection, localization, classification and tracking capabilities under all weather conditions, during day or night. The MMR system provides 360° of azimuth coverage with the antenna mounted on the underside of the aircraft except in the VUAV. Due to the nature of the challenges of this radar mode, the radar uses combinations of high range resolution (wide bandwidth), a short revisit time, and incoherent post-detection processing to map sea clutter and distinguish sea clutter from difficult small targets such as small boats. The MMR can detect oil spills from the sea clutter map when there is at least a six (6) dB difference in sea clutter level between the non-polluted surface area and that from the oil polluted surface. The MMR also detects and tracks larger targets such as boats and ships, and icebergs. Synthetic and Inverse Synthetic Aperture Radar (SAR & ISAR) capability is useful in mapping fields of ice floes, ice caps, and beach lines. Beaches and icebergs stand out as focused areas in a SAR spot or strip map image because they focus over the dwell time of the SAR, while the surrounding ocean surface does not. High resolution SAR images have some limited utility in mapping unusually calm surface areas such as oil spills and kelp areas. ISAR, Inverse Synthetic Aperture Radar, is used to image targets detected in the Air to Sea mode. The result is a vertical view of the ship to a resolution of a meter or two in a few seconds, using the target's motion in the water to form an image. This image allows the operator to distinguish a ship from an iceberg (which will not come into focus because it does not move), and the general type of ship is apparent from the ISAR image. A small fishing boat is clearly distinguished from a pleasure boat of about the same size, and a container ship can be distinguished from a ship of similar size such as a cruise liner by the appearance of the deck, deckhouse, and superstructure. A loaded container ship can be distinguished from an empty container ship. A tug towing a barge can be identified, and the line between a tug and a towed barge is usually visible on the ISAR image. The importance of ISAR is that a target can be type-identified without breaking the Maritime Patrol Aircraft (MPA) or VUAV search pattern.

### 3.1.7 SENSORS

Two radars, S-Band Surface Search Radar (SSR-S) and X-Band Surface Search Radar (SSR-X), are used for vessel handling and navigation. They display coastlines, ships and buoys as required by International Maritime Organization (IMO) and International Electrotechnical Commission (IEC) standards. These radars are horizon scan radars that cover 360° in Azimuth. They can track and display up to 200 targets that are delivered to the Command & Control (C2) system.

The Identification Friend or Foe (IFF) sensor includes an interrogator for the National Security Cutter (NSC) and a transponder for all platforms. The interrogator antenna is mounted on the 3-D radar antenna. The IFF sensor interrogates and responds to interrogations in accordance with International Civil Aviation Organization (ICAO) Annex 10 SSR standards. It interrogates in modes 1, 2, 3/A, C and responds to interrogations 1, 2 and 3/A. It can respond in Mode 4 with support from additional encryption equipment and has the growth capability to Mode 5 via software and encryption upgrade. The sensor has a 360° Azimuth and from 0° to 45° Elevation Coverage. The IFF transponder is linked to the C2 system from where it gets platform identification and status data. The IFF interrogator supplies the C2 system with radar tracks that include any IFF information available and other data supported by the mode in use. The IFF transponder can supply the C2 system with data on interrogation signals that are recognized. On smaller platforms, the IFF will be operated as a standalone system not linked into a C2 system.

The Radio Direction Finding (RDF) sensor is used to search and provide bearing to Signals of Interest including distress frequencies. Signal of interests are defined as radar and radio emitters, shoreside, airborne, or shipborne. The sensor operates in a frequency range between 500 kHz and 2 GHz.

The Electronics Surveillance Measures (ESM) sensor is used to search and provide bearing to airborne and ship-borne radar and radio emitters. The sensor operates in a frequency range between 500 MHz and 18 GHz.

The Automatic Identification System (AIS) sensor, in accordance with International Maritime Organization AIS standard ITU-R M.1371-3, operates on 161.975 MHz and 162.025 MHz. The AIS receives contact information from AIS transmitters.

The Fire Control Radar (FCR) will provide detection, localization, classification, identification, and tracking capabilities under all weather conditions. The FCR provides 360 degrees of azimuth coverage, and can detect both air and surface targets. Track data from this radar is used to control guns through the C2 system. The FCR is a mast mounted X-band narrow beam rotating antenna with two back-to-back antenna faces. It can operate both air and surface channels with one transmitter for each face. Any face can be selected to be in either mode. The FCR uses the surface channel when operated as a fire control radar; its initial default configuration is for the NSC. Instrumented range for the surface channel is 20 nautical miles. Moving Target Indication (MTI) is used for clutter rejection. The system emits a one-degree beam that, at a range of approximately 10 nautical miles, is capable of detecting missiles at altitudes up to 500 feet. The FCR provides raw and clear plot (processed) surface video, processed radar air synthetic video, gate video, and beacon video synchronization signals

Penetrating radars are used by boarding parties for non-intrusive examination of ship cargo. Generally these radars operate below 960 MHz or between 3.1-10.6 GHz.

Table 10 provides a summary of the sensor band requirements.

**Table 10: Sensor Spectrum Requirements**

| Sensor | Operational Need | Band | Channel Bandwidth |
|---|---|---|---|
| S-Band Surface Search Radar | Used by vessels for ship positioning and safety of navigation | 2 – 4 GHz | 5 – 25 MHz |
| X-Band Surface Search Radar | Used by vessels for ship positioning and safety of navigation | 9 – 10 GHz | 5 – 75 MHz |
| IFF | Provide safety of aeronautical navigation | 1030 and 1090 MHz | |
| Radio Direction Finding | Find bearing to signals of interest | 500 kHz – 2 GHz | N/A |
| ESM | Search and provide bearing to radar and radio emitters | 500 MHz – 2 GHz | N/A |
| AIS | For the safety of navigation | 161 – 162 MHz | 25 kHz |
| FCR | Used to control the weapons while tracking targets of interest | 9 – 10 GHz | 5 – 25 MHz |
| Penetrating Radar | Conduct non-intrusive searches of vessels | Below 960 MHz and 3.1 -10.6 GHz | 5 – 25 MHz |

### 3.1.8 Joint Tactical Radio System (JTRS)

The Joint Tactical Radio System (JTRS) program supports acquisition and fielding of Software Defined Radios (SDR) that provide interoperable communications through an internationally endorsed open Software Communications Architecture (SCA). JTRS will replace older, hardware intensive radios with SDRs where software applications provide waveform generation and processing, encryption, signal processing and other major communications functions. The Joint Tactical Radio System is a family of radios that are modular, multi-band, multi-mode networked communication systems. Modular design of software and hardware will facilitate upgrades and replacement of functional components. JTRS capabilities will be developed and fielded in an evolutionary manner, to provide increasing capabilities as technology development and funding permits. The JTRS program implements software versions of legacy waveforms and will define new waveforms (such as the Wideband Networking Waveform or WNW) that meet emerging requirements for higher capacity, highly networked, secure communication. Waveform software applications will be common across all implementations, thereby ensuring interoperability between JTRS implementations. JTRS lays the foundation for achieving network connectivity across the radio frequency spectrum. JTRS provides the means for digital information exchanges, both vertically and horizontally, among joint warfighting elements, while enabling connectivity to civil and national authorities. JTRS supports joint operations by providing the capability to transmit, receive, bridge and gateway among similar and diverse waveforms and network protocols within the radio frequency spectrum-and across service boundaries.

JTRS is being developed in parts, referred to as clusters. The Army-led Cluster 1 is developing JTRS sets for Army and Marine Corps ground vehicular, Air Force Tactical Air Control Party ground vehicular, and Army rotary wing applications. The Special Operations Command-led Cluster 2 is upgrading an existing handheld radio, the Multiband Inter/Intra Team Radio, to SCA compliance. Clusters 3 and 4 have been combined to form a new program, Airborne Maritime Fixed-Station JTRS. The Army-led Cluster 5 program is developing handheld, manpack, and small form-fit sets suitable for embedding in the Army's Future Combat Systems and other platforms requiring a small radio. A cluster for space applications is also being considered.

DEEPWATER is evaluating the use of JTRS for future Coast Guard C4ISR and DoD/Non-DoD interoperability. The current plan uses JTRS to meet the MILSATCOM requirements as the new waveforms for UHF satellite communications are realized.

## 3.2 RESCUE 21 (R21)

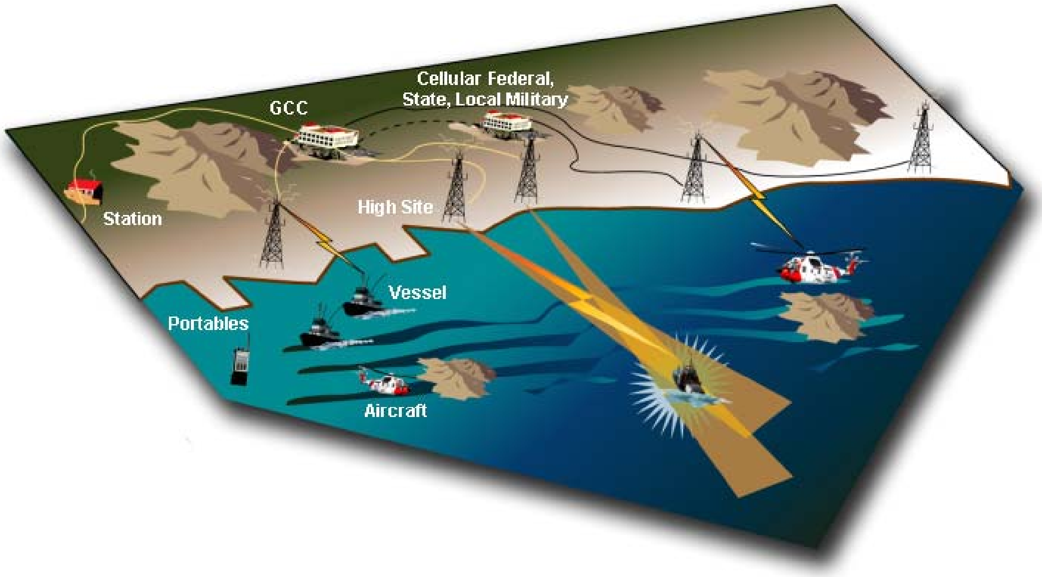
Rescue 21 is an advanced search and rescue (SAR) communications system that helps the Coast Guard more effectively locate and assist boaters in distress. The new system is replacing the Coast Guard's current communications system, the National Distress Response System (NDRS), built in the 1970s. Among other capabilities, Rescue 21 enhances line of sight coverage, increases position localization on a VHF-FM transmission, increases the number of voice and data channels available to the Coast Guard, and improves communications and information sharing between Coast Guard units and federal, state, and local partners. Rescue 21 will significantly increase life saving capabilities for the 21st Century.

Today the Coast Guard responds to approximately 60,000 emergency calls and saves nearly 5,000 lives in an average year. Coast Guard SAR response involves multi-mission stations, cutters, aircraft, and boats linked by communication networks. The National SAR Plan divides the U.S. area of responsibility into internationally recognized inland and maritime SAR regions, with the Coast Guard acting as the maritime SAR coordinator for vessel and aircraft distress incidents. To meet this responsibility, the Coast Guard maintains SAR facilities throughout the United States and its possessions and territories.

In addition to the traditional search and rescue mission, the events of 9/11, and disaster relief efforts, require the Coast Guard to integrate interoperable communications for Public Safety.

> *"Installation of Rescue 21 across the nation represents a quantum leap forward in command, control and communications. By closing coastal coverage gaps and capturing more accurate data from radio transmissions, the system offers an essential tool in maritime security, search and rescue and marine environmental protection."*
>
> — Admiral Thad W. Allen, Commandant, U.S. Coast Guard

**Figure 11: Rescue 21 Offshore Communications**




***Primary features of the Rescue 21 system:***

- Approximately 300 VHF/UHF Coastal Communication High Sites Nationwide, communication consoles in over 250 Coast Guard facilities, communication equipment on over 650 Coast Guard vessels, and over 3000 VHF/UHF portable radios (Figure 11).
- Enhanced VHF-FM and UHF (line-of-sight) coverage, for more certain reception of distress calls. VHF and UHF requirements are summarized in Table 11.
- Position localization — within 2 degrees — of VHF-FM transmissions, so rescue vessels have a dramatically smaller area to search.
- An increase in the number of voice and data channels, allowing watchstanders to conduct multiple operations. No longer will a single caller in distress — or worse, a hoax caller — prevent another caller from getting through.
- Protected communications for Coast Guard operations on designated channels.
- Digital voice recording with immediate, enhanced playback, improving the chances for unclear messages to be understood.
- Improved interoperability among the Coast Guard and federal, state, and local partners, so additional resources can be added to rescue operations as needed.
- Digital selective calling (DSC), an internationally standardized primary means for digital distress alters on VHF-FM channel 70.
- Disaster Recovery system using portable deployed towers and electronics to quickly deploy the channel capability described in Table 11 to the disaster location.

The requirement for asset tracking was removed from the Rescue 21 system requirements due to cost and spectrum inefficiency of the contractor's approach.  See section 3.8 for details on the current plans for Coast Guard asset tracking.

**Table 11: Rescue 21 VHF and UHF Communications**

| Communication Identifier | Operational Need | Band (MHz) | Channel BW (kHz) | Data Rate (kbps) | Comments |
|---|---|---|---|---|---|
| VHF Voice | Search & Rescue, Command and Control | 150.8-174 | 25/12.5 | | -Voice<br>-Communication with Federal Agencies (JIATF, FBI, DEA, Customs) and State and Local Law Enforcement and Public Safety agencies. |
| VHF Marine DSC | Search and Rescue Interface with GMDSS | 156.525 | 25 | 9600 | DSC Data |
| UHF Voice | Search & Rescue, Command and Control | 406.1-420 | 12.5 | | -Voice<br>-Communication with Federal Agencies (JIATF, FBI, DEA, Customs) and State and Local Law Enforcement and Public Safety agencies. |

## 3.3 Nationwide Automatic Identification System (NAIS)

Nationwide AIS is the keystone project to providing AIS functionality across all of the national waterways. The present allocations of the AIS VHF channels (AIS1 and AIS2) need to be expanded to ensure there is sufficient room for all vessels carrying AIS transponders. To facilitate long range tracking of vessels using AIS a dedicated satellite sensing channel will be required to reduce interference from terrestrial based AIS systems.

NAIS supports both national and international port safety and security operations, navigation safety and search and rescue. Within the United States, NAIS supports the requirements under the Maritime Transportation Security Act of 2002 by tracking vessels on approach to United States ports and in inland waterways. Internationally, NAIS lays the Coast Guard foundation for work with the ITU World Radio Conference (WRC) – 2011 Agenda Item (1.10) on Ship and Port safety and security. With the assistance of NAIS, Automatic Identification System received international recognition for satellite detection at WRC-2007 in a secondary status. The Coast Guard will work through agenda item 1.10 in WRC-2011 to upgrade this status and to receive internationally recognized protection standards for AIS in general.

The Coast Guard with support from NTIA and FCC is responsible for ensuring that the integrity of the AIS VHF data link (VDL) in US waters is monitored and maintained, and that additional uses of the primary AIS channels on 161.975 MHz and 162.025 MHz (e.g. by thousands of Class B devices, by blue force tracking units operating in an encrypted mode, and by stations providing aids to navigation information) does not cause saturation or degradation of security or navigation safety. Table 12 describes the requirements for additional AIS channels intended to ensure that congestion on the primary AIS channels does not occur.

AIS will also be used to provide Aids to Navigation information worldwide[6] to ships' electronic navigation displays, likely eventually replacing racon technology (section 2.3.4).

[6] IEC standard 62320-2, adopted in 2008.

**Table 12: Additional AIS Channels**

| Communication Identifier | Operational Need | Band (MHz) | Channel BW (kHz) | Data Rate (kbps) |
|---|---|---|---|---|
| Automatic Identification System (AIS)-Terrestrial | Vessel traffic tracking | 156-174 | 25 | 9.6 |
| Automatic Identification System (AIS)-Satellite | Long range maritime surveillance | 156-174 | 25 | 9.6 |

## 3.4 UNMANNED AERIAL SYSTEMS (UAS)

The Coast Guard is reviewing plans to utilize UASs in a variety of Coast Guard missions. Some options include: a high-altitude-long-endurance (HALE) UAV and a vertical takeoff-and-landing UAV (VUAV). The Coast Guard Research and Development Center (RDC), with sponsorship from the Headquarters Office of Aviation Forces (COMDT (CG-711)) and special funding from Congress, is exploring the use of medium-altitude long-endurance (MALE) UAVs and small UAVs to support a broad array of maritime surveillance applications.

The proposed Northrop Grumman RQ-4A Global Hawk High Altitude Long Endurance (HALE) UAV (Figure 12) will enhance MDA through long range and enhanced surveillance capabilities. With its 12,500-nautical mile range and 38-hour endurance combined with satellite and line-of-sight communication links to other air and surface platforms and operations centers ashore, the Global Hawk from a height of 65,000 feet can use its high-resolution sensors to conduct surveillance and monitoring operations in adverse weather conditions, day or night, over an area about the size of Illinois in 24 hours.

**Figure 12: Global Hawk High Altitude Long Endurance (HALE) UAV**

The HALE UAV will provide long-range surveillance over large areas for extended periods of time. These assets will provide a portion of the long-range surveillance capability that will be lost when HC-130s are retired at the end of their useful service life. HALE UAVs will possess the ability to transmit data and EO/IR imagery to shore-based Command and Control (C2) centers as part of the Common Operational Picture (COP).

It will be capable of simultaneously carrying electro-optical (EO), infrared (IR), and synthetic aperture radar (SAR) payloads. The system is capable of both direct line of sight communications with the ground station by a common data link or beyond line of sight through Ku-band SATCOM. The synthetic aperture radar and ground moving target indicator (GMTI) operates at X-band with a 600 MHz bandwidth, and 3.5 kW peak power. The system can obtain images with three foot resolution in its wide area search mode and one foot resolution in its spot mode.

The vertical takeoff-and-landing (VTOL) unmanned aerial vehicle (VUAV). VUAVs will be deployed aboard the new Offshore Patrol Cutters (OPC), the National Security Cutters (NSC) and the legacy Famous-class medium endurance cutters. Tactical Common Data Link control links (LOS) and a SAR sensor could be used on this vehicle.

The Small UAV project will evaluate craft with respect to both MDA and more traditional Coast Guard surveillance missions. A combination of field testing and simulation modeling will be used to evaluate performance, develop CONOPS, and perform a cost-benefit analysis. The sensor payload on small UAVs will be limited and therefore likely better suited to target identification and monitoring than to wide area detection and tracking. Thus, their potential benefit to the Homeland Security mission appears to lie in reducing the demand for more expensive response and interdiction assets, freeing them for critical intercepts that require manned response. Table 13 below summarizes UAV spectrum requirements.

**Table 13: UAV Communication & Sensor Capabilities**

| Communication Identifier | Operational Need | Band (GHz) | Channel BW (MHz) | Data Rate |
|---|---|---|---|---|
| TCDL – Imagery Data (LOS) | Capability to transfer imagery/video data to controlling surface vessel | 14.4 – 14.83<br>15.15 – 15.35 | 5.0 | 10.71 Mbps (CDL Compatible) |
| TCDL – Communication Relay (LOS) | Voice capability to extend LOS range by digitizing voice on the TCDL trunk and relaying through VHF/UHF radio in the UAV (clear and Type 1 secure) | 14.4 – 14.83<br>15.15 – 15.35 | 5.0 | 10.710 Mbps (CDL Compatible) |
| TCDL – Control and Status (LOS) | Provides the ability to control UAV and it's sensors | 14.4 – 14.83<br>15.15 – 15.35 | 5.0 | 200 kbps |
| TCDL-Secondary Command and Control TTC&D (LOS) | Provides Backup Command & Control Link | 1.76 – 1.85 | 2.620 | 25.65 kbps |
| $K_u$ Band SATCOM (BLOS) | Provides satellite data link | 12 – 18 | 5.0 | Various |
| Synthetic Aperture Radar (SAR) | Imaging & target identification | 9 – 18 | 80 – 620 | N/A |

## 3.5 CONTAINER TRACKING AND SECURITY IN US PORTS

One of the rapidly emerging requirements for ensuring United States port security is establish a means for inspecting cargo containers arriving into U.S. ports from abroad. For example, Sen. Dianne Feinstein, D-Calif. has stated "Much more needs to be done by the United States to help secure our seaports. Each year, approximately 13 million shipping containers enter United States ports, including 6 million from overseas. Despite this high volume of cargo, only 5 percent of the containers are inspected."7 Radio Frequency Identification (RFID) devices are being increasingly used to meet this need. "The trend toward RFID use for port security may be further fueled by the Port Security Act 0f 2006, signed into law on Oct. 13. This act provides regulatory incentives and clarifies best practices and adherence to international standards that enhance the security of containerized cargo shipments bound for the United States."[8]

The 2007 ITU World Radiocommunication Conference (WRC) agreed to establish a new agenda item for WRC2011 competent to address spectrum requirements for RFID used in ports necessary to enhance security[9]. The Coast Guard has begun working with International Standards Organization (ISO) Technical Committee 104 (Freight Containers) Sub-Committee 4 (Identification and Communication), which is responsible for international standards for RFID use on containers for purpose which include port security.

RFIDs on freight containers currently use the following frequencies: 433 MHz, 900 MHZ (868 worldwide and 902-928 in the US), and 2.45 GHz[10].

2.45 GHz is internationally interoperable but unprotected as an Industrial, Scientific and Medical (ISM) application under footnote 5.150 of the ITU Radio Regulations. It is desirable to use for location systems because it allows frequency hopping, providing the frequency diversity needed for Real Time Location Systems (RTLS). The 2.45 GHz band can be very crowded and RTLS systems can in some cases sweep the spectrum more rapidly that other uses of the band (wireless LAN's). This can have the effect of jamming the band from use by other legitimate purposes. 2.45 GHz systems can be very difficult to implement because of strict line of sight (LOS) and antenna alignment requirements. Human safety is a particular problem with 2.45 GHz systems because it is the same frequency at which water molecules vibrate, the principle behind microwave ovens, which radiate at 2.45 GHz. Safety stand off for a radio in this band may be 2 meters. Intrinsic safety in this band is also at issue because it takes 4 times as much power to go the same distance as you might with a frequency half that of 2.45 GHz. Safety stand off for Hazards of Electromagnetic Radiation on Ordnance (HERO) might be 3 meters around munitions. Radiated power may need to be kept low for licensing (or safety considerations) and range may be limited. Combined with the general critical requirements for LOS (no bending) and the tendency for the signal to bounce and vastly degrade if off plane, making it hard to implement, 2.45 GHz is not a very good choice for frequency in terms of performance.

915 MHz is a better choice because installation tolerances are not as critical as 2.45 GHz and frequency hopping is available. The down side is that it is not currently internationally recognized and thus can not be used world wide.

433 MHz is a better choice than the other two for performance. Antenna alignment is generally not required. Range is far greater with minuscule power levels. Safety stand offs for munitions are inches. The frequency will bend around corners and find its way to hidden tags. 433 MHz is generally an international frequency largely to the efforts of Savi Technology, trying to get their

[7] Reported in San Francisco Chronicle February 23, 2006.
[8] RFID Journal October 23 2006
[9] WRC2011 Agenda 1.10, ITU-R Radio Regulation Resolution 357, considering a) and resolves 1).
[10] Comments below are from Joe Burnam, Director RFID Operations of National RFID Center, and a member of ISO SC104 TC4.

systems accepted worldwide. Unfortunately there is no provision to allow frequency hopping in that band. There is no frequency diversity to allow location of the tags.

The emerging requirements for ports and freight containers in transit will likely include two general requirements beyond simple identification of the freight container. The first is localization or the ability to articulate the near exact position of a freight container in a large population of containers. The second is continuous monitoring of the container and its contents. Monitoring will mean a wide variety of sensors and the ability of the tag to call for help if it detects a problem. Both of these suggest solutions based on active tags, raising the discussion points above.

Mesh networking (802.15.4) tends to solve the problem of the requirement for LOS because there are theoretically enough tags in the field to expect a tag to always have LOS. This can be thought of as spatial diversity. Tags talking to tags theoretically solve the reader problems. Unfortunately it does not work that way in practice. There are severe limitations. Zigbee is the most popular of the 802.15.4 protocols and has the advantage of being offered by 90 companies, making it relatively easy to implement. These networks are best used for applications where sensors are being monitored on stationery assets. They can not tolerate a lot of movement of the assets. There is no alternate pathing and the numbers of containers in a busy port exceed the capabilities of the network protocol. They would not lend themselves to tracking freight containers in a busy port.

What is needed is a complete rework of the approach to at least one portion of the frequency spectrum, including the ability to use frequency hopping in the lower bands, like what is done in 915 MHz or 2.45 GHz, but at a lower frequency. Something in the 100 to 500 MHz would work well. It must, of course, be international, at least potentially. Until those kinds of rules are implemented, stakeholders will continue to pay too much for marginally performing systems and vendors will continue to be frustrated in not being able to apply available technology to solving problems. Table 14 contains the summary of emerging container tracking spectrum requirements.

**Table 14: Container Tracking**

| Communication Identifier | Operational Need | Band | Channel BW (kHz) | Data Rate (kbps) |
|---|---|---|---|---|
| RFID | Container Tracking and port security | 433 MHz | TBD | TBD |
| RFID | Container Tracking and port security | 900 MHz (868 MHz worldwide, 902-928 MHz in the US | 25 kHz | 12.8 |
| RFID | Container Tracking and port security | 2.45 GHz | TBD | TBD |

## 3.6 HIGH FREQUENCY RADAR

HF Surface Wave Radar and HF Sky Wave radar use the different properties of the High Frequency Band to either track vessels or study surface currents far out at sea. HF Surface Wave Radar has been accepted by the ITU for study for WRC-2011 as Agenda Item 1.15.

### 3.6.1 HF SURFACE WAVE RADAR ( LARGE APERTURE & COMPACT DISTRIBUTED APERTURE HFSWR)

HFSWR systems exploit the nature of low grazing angle electromagnetic propagation over seawater at frequencies between 3 and 30 MHz to provide coverage at ranges that can often extend well beyond the horizon of conventional microwave radars.

Large aperture HF surface-wave radar is a relatively mature technology for maritime wide area surveillance. Large aperture HFSWR systems have been extensively investigated and sometimes deployed for wide-area maritime/coastal surveillance in military, maritime security and law-enforcement applications.

Small compact aperture, possibly multistatic HFSWR systems are commonly deployed for remote sensing of ocean surface roughness and currents. In recent years a limited amount of research has been conducted to evaluate the potential of such systems to detect and track vessel targets. Compared to a large aperture, monostatic HFSWR at the same frequency, compact HFSWR systems offer the potential to require a smaller shoreline hardware footprint by employing superdirective receive arrays. Table 15 below provides the general bandwidth and frequency requirements for the HF Surface Wave Radar.

### 3.6.2 HF SKYWAVE OTH RADAR

HF sky wave OTH radar (OTHR) systems exploit the refractive nature of ionospheric propagation, as shown in Figure 13.

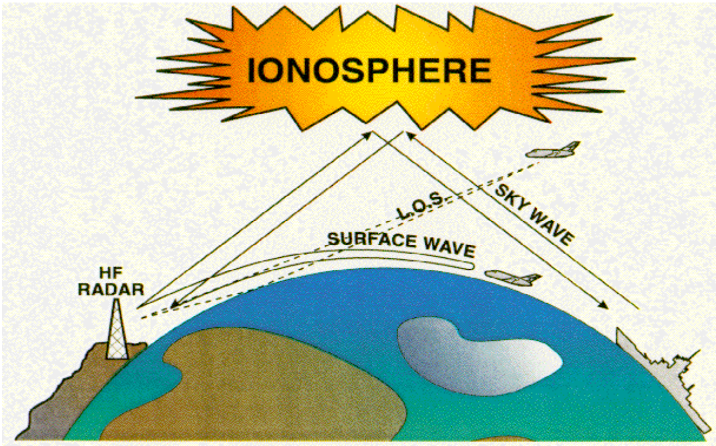



**Figure 13: Over-the-horizon propagation**

By exploiting ionospheric refraction, sky wave Over-the-Horizon radar offers long range (500-1500 nmi) persistent detection and tracking of aircraft as well as maritime surface targets. Due to the dependence on the ionosphere, performance varies with time of day, season, solar cycle, and target class. In particular, surface target tracking at night is difficult.

Table 15 below summarizes the bandwidth requirements HF Sky Wave Radars to accomplish long range tracking in the HF spectrum using ionospheric refraction.

**Table 15: HF Radar**

| Communication Identifier | Operational Need | Band (MHz) | Channel BW (kHz) | Data Rate (kbps) |
|---|---|---|---|---|
| HF Surface Wave Radar | Long range maritime surveillance | 2-30 | 6-40 | N/A |
| HF Skywave OTH Radar | Long range maritime surveillance | 5-30 | 6-100 | N/A |

## 3.7 MOBILE-SATELLITE USAGE

The Coast Guard cutter forces have a need for increased internet access while at sea. The current Inmarsat connections do not offer the bandwidth required to support all of the necessary applications. Studies are currently being conducted to test the feasibility of the use of commercial Satellite services with higher data rates then the currently used Inmarsat service. Potential frequency bands include the frequency band 11.7-12.2 GHz (Uplink) and 14-14.5 GHz downlink, the new Fleet broadband satellites being promoted by Inmarsat, and GlobalStar service in the 1.6-2.5 GHz range. The increased bandwidth in the 11-12/14 GHz Fixed Satellite Service bands will be filled with the increased use of the Earth Station on Vessels (ESVs) provision in the National Table of Frequency Allocations. Table 16 provides the summary of anticipated Mobile-Satellite usage over the next several years

**Table 16: Mobile-Satellite Usage**

| Communication Identifier | Operational Need | Band (GHz) | Total BW (MHz) | Data Rate (kbps) |
|---|---|---|---|---|
| Ku- Band COMSATCOM | Over the Horizon communication | 11.7-12.2 (up)<br>14-14.5 (down) | 30 | 400 |
| Fleet broadband | Over the Horizon communication | 1.525-1.559 (up)<br>1.6265-1.6605 (down) | 6 | 432 |
| GlobalStar | Over the Horizon communication | 1.610-1.6255 (up)<br>2.4835-2.5 (down) | TBD | 9.6 |

## 3.8 BLUE FORCE TRACKING AND SENSITIVE BUT UNCLASSIFIED TACTICAL EXCHANGE DISPLAY SYSTEM (STEDS)

Coast Guard operations is reviewing the need to have constant operational awareness of blue forces in all Coast Guard operational environments. This operational awareness, through tactical data exchange links, involves both Coast Guard units and other government agency units (i.e. DHS, Customs, FBI, State & Local Government). The Coast Guard has several systems that have SBU data exchange requirements. These include Rescue 21, Deepwater, Hawkeye Core C2, C130J and Aircraft Data Communications System. Current BFT efforts are investigating using the existing AIS data exchange system for a BFT capability. In order to avoid interference to navigational safety (primary AIS function on AIS 1 and AIS 2, 161.975 MHz and 162.025 MHz) when large numbers of units are connected, a separate dedicated channel common to all fixed station sites will likely be necessary for future BFT or Blue Force Tracking channels.

Table 17 provides the summary of anticipated need to meet the Coast Guard's blue force tracking requirements.

**Table 17: Blue Force Tracking**

| Communication Identifier | Operational Need | Band (MHz) | Channel BW (kHz) | Data Rate (kbps) |
|---|---|---|---|---|
| Blue Force Tracking | Asset Tracking | 156-174 | 12.5/25 | 9.6 |

## 3.9 HF ALE Expansion

Outside of Deepwater, the use of HF ALE will be expanding through the extension of the HF ALE shore infractructure to include the use of COTHEN for ship to shore and shore to ship command and control. This link will provide a vital communication mode for cutters outside the range of VHF coverage and without the satellite link on many of the larger Cutters.

## 3.10 Boat Crew and Boarding Team Communications

For Coast Guard boat crews and boarding teams to effectively communicate while underway, A standard boat crew communications system in the 2.4 GHz ISM band is being pursued. This system will allow the Coxswain, Boat Crew, Gunner and boarding team to communicate over the roar of the wind and the boat. The Boat Crew Comms system will also be tied into the boat's radios to allow the Coxswain or Crewman to answer the radio via the headset.

In addition to the VHF Boarding Party communications as described in section 3.1.5, the UHF frequency band is being tested as an alternate frequency range for communication with all boarding team members through the multiple decks and frames of large commercial ships. The frequency range being pursued for these communications are the 380-399.9 MHz and 406.1-420 MHz range.

## 3.11 Small Cutter IP Connectivity

In addition to the satellite connectivity described in section 3.7, the use of Cellular data solutions for Internet connectivity is being researched. A cutter, when within range of existing cellular phone coverage would have data capabilities commesurate with the standard commercial service being provided by the commercial company. The antenna and transceivers would be marinized, but otherwise would be the same as available off the shelf.

## 3.12 Enhanced LORAN[11]

Enhanced, or eLoran, is a Loran system that incorporates the latest receiver, antenna, and transmission system technology to enable Loran to serve as a backup and complement to global navigation satellite systems (GNSS) for navigation and timing. This new technology provides substantially enhanced performance beyond what was possible with Loran-C, eLoran's predecessor. With eLoran, it will be possible to obtain absolute accuracies of 8-20 meters positioning using eLoran for harbor entrance and approach. Similarly, eLoran can function as a highly accurate frequency source (on the order of $1x10^{-11}$) and as an independent source of coordinated universal time (UTC) (<50ns timing). The Department of Homeland Security began implementing eLoran as an independent national positioning, navigation and timing system that

[11] See http://www.navcen.uscg.gov/eloran/overview.htm

complements the Global Positioning System (GPS) in the event of an outage or disruption in service.[12]

## 3.13 LONG RANGE IDENTIFICATION AND TRACKING (LRIT)

The Maritime Transportation Security Act, authorized the Coast Guard under the Department of Homeland Security Delegation No. 0170.1, to implement the use of LRIT for U.S. and foreign flag ships off the U.S. coastlines that are equipped with GMDSS, i.e., Inmarsat-C, or equivalent satellite technology. The requirement of the carriage of this equipment for foreign flag vessels is contained in the SOLAS Convention, 1974, as amended, and in 47 CFR part 80 for U.S. flag vessels. When implemented, LRIT, as an amendment to SOLAS, will enhance overall maritime domain awareness by providing the United States, as a Contracting Government to SOLAS, with the identities and current location information of vessels that are within 1,000 nautical miles of the U.S., which includes vessels that may be in innocent passage or on the high seas. The Contracting Governments, including the U.S., meeting at the IMO set the distance at 1,000 nautical miles. As an ancillary benefit, LRIT may also assist the Coast Guard in the area of search and rescue by reducing the response time to the location of vessels in distress.

This rule will affect U.S. and foreign flag SOLAS vessels that transit internationally. LRIT will affect vessels engaged on international voyages and would include passenger vessels carrying more than 12 passengers including high-speed craft, cargo ships 300 gross tonnage or more including high-speed craft, and self-propelled mobile offshore drilling units.

LRIT will primarily be based upon commercial maritime satellite systems, particularly Inmarsat C recognized by GMDSS (see 2.1.3), including commercial maritime HF systems. Except possibly for satellite detection of AIS, federal spectrum is not expected to be required to meet this mandate.

## 3.14 INTERNATIONALLY INTEROPERABLE MARITIME SPECTRUM

The Coast Guard's role as a global maritime organization requires participation in international shipping and telecommunication organizations. The present systems of GMDSS and AIS are two prime examples based on IMO and ITU technical and spectrum standards. In order to continue to secure internationally interoperable spectrum to support future Coast Guard and commercial shipping, the United States must support domestic maritime allocations, which are internationally compatible. An example is the VHF frequency allocations for the maritime mobile service which are allocated internationally for marine voice and data. The domestic allocations within the United States must correspond to the international allocation to facilitate system compatibilities and interoperability. As port operations grow, new spectrum dependent technology, such as AIS, will also evolve and grow. This growth will require access to the limited spectrum resources indicated in Figure 5. Figure 5 spectrum is the last of the internationally-interoperable maritime spectrum above 30 MHz left in the United States. Unless a means is found to access additional spectrum indicated in Figure 4, this spectrum shortage and resultant congestion will cause severe problems to port and waterway operations, vessel traffic services, recreational boaters, commercial vessel operators, and safety communications serving those vessels.

### 3.14.1 INTERNATIONAL MARITIME ORGANIZATION (IMO)

The purposes of the Organization, as summarized by Article 1(a) of the Convention, are "to provide machinery for cooperation among Governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade; to encourage and facilitate the general adoption of the highest practicable standards in matters concerning maritime safety, efficiency of navigation and prevention and control of marine pollution from ships". The Organization is also empowered to deal with administrative

[12] DHS Press Release dated February 7, 2008.

and legal matters related to these purposes. The GMDSS is an example of an IMO required system which holds treaty status. The Coast Guard will continue to work through the IMO processes to promote safety of navigation, compatibility of communications systems, and national security. Current spectrum related initiatives at IMO include; AIS requirements, long range tracking and identification of vessels, GMDSS requirements, and maritime satellite and HF communication requirements.

#### 3.14.2 INTERNATIONAL TELECOMMUNICATION UNION (ITU)

ITU is an international organization within the United Nations where governments and the private sector coordinate global telecom networks and services. Established in 1865 to manage the first international telegraph networks, the Union has worked to ensure that the latest technological advances have been rapidly integrated into the telecommunication networks of countries all around the world. The Coast Guard participates in ITU-R Working Party (WP) 8B, which deals with maritime mobile service and GMDSS issues. WP 8B is responsible for studies related to the maritime mobile service, including the Global Maritime Distress and Safety System (GMDSS), aeronautical mobile service and radiodetermination service. The maritime mobile service, by the very nature of its remote operations, is critically dependent on the radio spectrum to provide general and distress communications.

#### 3.14.3 INTERNATIONAL ASSOCIATION OF MARITIME AIDS TO NAVIGATION AND LIGHTHOUSE AUTHORITIES (IALA)

IALA is a non-governmental organization having observer status at IMO and ITU. IALA maintains international configuration and management of maritime spectrum dependent systems such as AIS, LORAN and differential GPS.

# 4.0 – FUTURE SPECTRUM NEEDS

Current spectrum allocations, allotments, and assignments are vital for the Coast Guard to carry out its missions. In addition to sustaining present usage, Table 18 characterizes the Coast Guard's emerging and future strategic spectrum requirements. The ability of the Coast Guard to carry out its missions in the future is directly related to the availability of adequate spectrum resources for C4ISR systems. Coast Guard missions are nationwide and global in nature, which necessitate the use of a wide variety of bands to meet propagation requirements. For example the use of long distance satellite and High Frequency (HF) communication links are increasing due to the modernization of the C4ISR infrastructure. The increased priority on national defense and homeland security also requires the use of sophisticated sensing and data collection, relying on specialized radars and wireless high speed broadband systems. It is also critical that the Coast Guard constantly and consistently evaluate communication systems fielded by all Government and non-Government entities to understand the domestic interoperability picture. Internal Coast Guard interoperability and external interoperability of communications equipment will determine operational effectiveness in meeting mission objectives. Table 18 is a strategic 10-year look at emerging spectrum requirements, and will be influenced at any time by changing national priorities, and corresponding evolution of Coast Guard missions.

**Table 18: Summary of Future Additional Spectrum Requirements**

| Program | System | Band | Channel BW | Additional BW Requirements | Comments |
|---|---|---|---|---|---|
| General Infrastructure Improvement | DGPS | 285-325 kHz | 1.5 kHz | 60 kHz | Implementation of High Accuracy-DGPS |
| IDS & HF Radar | HF Voice, Data, & Radar | 3 – 30 MHz | 3-100 kHz | 1 MHz | Required to meet increased ALE frequency pools, expansion of HF data, and HF radar for long range tracking |
| IDS | VHF Aeronautical | 108-137 MHz | 25/8.33 kHz | 5% growth over current GMF frequency assignments | Anticipate increase as aircraft inventory grows |
| IDS & R21 | VHF Maritime Mobile | 156-162 MHz | 25/12.5 kHz | 10% growth over current GMF frequency assignments | Anticipate increase as vessel inventory grows and R21 coastal station growth over NDRS |
| NAIS | VHF AIS Satellite Sensing | 156-162 MHz | 25 kHz | 25 kHz | Long range vessel tracking |
| NAIS | VHF AIS Vessel Traffic | 156-162 MHz | 25 kHz | 25kHz | Additional AIS channel for vessel traffic |

| Program | System | Band | Channel BW | Additional BW Requirements | Comments |
|---|---|---|---|---|---|
| Communication | Blue Force Tracking (BFT) | 156-162 MHz<br>162-174 MHz | 25 kHz<br>12.5 kHz | 25 kHz<br>25 kHz | Dedicated VHF data channel for blue force tracking |
| IDS & R21 | VHF Mobile | 162-174 MHz | 12.5 kHz | 300% growth over current GMF frequency assignments | Asset growth & interoperability requirements-R21 VHF comms growth |
| Communication | VHF Data | 156-162 MHz<br>162-174 MHz | 25 kHz<br>12.5 kHz | 25 kHz<br>12.5 kH | Dedicated channel for VHF data other than BFT |
| IDS | UHF Fixed, Mobile, & MILSATCOM | 225-400 MHz | 25 kHz/5 kHz[13] | 50 kHz | Asset growth using MILSATCOM and DoD systems LMR |
| IDS, R21, Boarding Party | UHF Fixed and Mobile | 406-420 MHz | 12.5 kHz | 300% growth over current GMF frequency assignments | Asset growth & interoperability requirements-R21 UHF comms growth |
| RFID | Container Tracking and port security | 433 MHz | TBD | TBD | For Container Tracking |
| Public Safety and Interoperability | UHF Fixed and Mobile | 700-800 MHz | 10-50kHz | 30 MHz | To meet multi-agency interoperability requirements |
| RFID | Container Tracking and port security | 900 MHz (868 MHz worldwide, 902-928 MHz in the US | 25 kHz | TBD | For Container Tracking |
| IP Connectivity | Small Cutter IP Connectivity | 900 MHz or 1900 MHz | Per Commercial service | Per Commercial Service | For IP connectivity for mobile units not proposed for Satellite connectivity |
| IDS & Mobile Satellite | Commercial SATCOM | 1.5/1.6 GHz<br>1.6/2.5 GHz<br>11-12/14 GHz<br>Note 1 | variable by band | 680 MHz | Proliferation of high speed broadband connectivity to unit levels will require a 10 fold increase in BW |

[13] Coast Guard currently has six (6) 25 kHz MILSATCOM channels.

| Program | System | Band | Channel BW | Additional BW Requirements | Comments |
|---|---|---|---|---|---|
| RFID | Container Tracking and port security | 2.45 GHz | TBD | TBD | For Container Tracking |
| Boat Crew | Boat Crew Communication | 2.45 GHz ISM | TBD | TBD | For effective boat crew communication |
| IDS & UAS | Synthetic Aperture Radars | 9-18 GHz | 80-620 MHz | Note 2 | Imaging and target identification |
| UAS | Tactical Common Data Link (TCDL) | 12-18 GHz | 5 MHz | Note 3 | Anticipate significant growth of Ku-Band UAV links |
| MDA | Point-to-Point Microwave Data Links | 400 MHz- 100 GHz | 5-25 MHz | Note 4 | Broadband data transfer for Common Operational Picture |
| International Search and Rescue (SAR) | GMDSS Modernization | Multi-Band System (MF/HF/VHF/ UHF/ SATCOM) | Various | HF and SATCOM | SAR international interoperability |

Notes:

1. Increased use of the ESV provisions could meet this requirement for additional commercial satellite coverage for Coast Guard cutters.
2. Require access to currently allocated radiolocation bands. Potential increase in radiolocation allocated spectrum anticipated.
3. Continued access to Fixed and Mobile allocations in the 12 – 18 GHz range
4. Continued access to Fixed allocations in the 400 MHz – 100 GHz range

## 5.0 – Conclusion

In the 21ST Century and post 9/11 world, the US Coast Guard's missions are increasingly dependent on state-of-the-art C4ISR systems for operational effectiveness. In turn, these C4ISR systems are increasingly dependent on access to radio frequency spectrum resources. It is vital to national security and public safety that the Coast Guard continues to have access to critical frequency bands for future fielding of modern communications, and advanced sensors.

This Strategic Spectrum Plan presents the current spectrum usage and projected future (10 years) spectrum requirements for the Coast Guard to carry out its missions. The approach taken to develop this plan was a review and summary of the major Coast Guard operating and acquisition programs, in terms of C4ISR requirements and corresponding spectrum needs. The major acquisition programs reviewed include: Integrated Deepwater Systems, Rescue 21, and NAIS. The cumulative C4ISR future requirements of these major acquisition programs will represent the majority of Coast Guard future spectrum needs. The successful implementation of these programs is vitally dependent on access to high technology spectrum. Specifically, the Coast Guard requires spectrum access to implement technology solutions in the following areas:

- Satellite Communication Links for High Speed Data Connectivity (Military and Commercial)
- UAV High Speed Data Links (Line of Sight and Beyond Line of Sight)
- High Altitude Platforms For Sensing and Communication Relays
- HF Data and Voice Networks
- HF Long Range Surveillance Radar
- VHF Satellite Systems Detection (Satellite Automatic Identification System)
- High Speed Microwave Data Links
- Multi-Band International Search and Rescue System Modernization
- Advanced Aeronautical Imaging & Sensing Radars
- VHF and UHF Fixed, Mobile, Maritime and Aeronautical Frequency Growth
- High Accuracy GPS Augmentation
- Multi-Band Public Safety Interoperability
- Container Tracking and Port Security International Interoperability

The Coast Guard is constantly seeking spectrum efficient means and the use of currently allocated spectrum to carry out its mission. Existing commercial technology is continually evaluated for applicability and use in Coast Guard technology solutions. The use of non-spectrum dependent systems are also evaluated and considered to address C4ISR mission support. It is the goal of C4ISR systems to use the most reliable, proven, and efficient wireless solutions for economical and cost effective systems implementation.

This plan represents a living document which will be update biennially. While every effort was made to accurately predict future spectrum requirements, it must be noted that the Coast Guard missions and related spectrum requirements will evolve and may change in response to changing National priorities and emergencies.

## APPENDIX A – ACRONYMS AND ABBREVIATIONS

| ACRONYMS | LONG TITLE |
|---|---|
| AF | Air Force |
| AG | Department of Agriculture |
| AIS | Automatic Identification System |
| ALE | Automatic Link Establishment |
| AMVER | Automated Mutual Assistance Vessel Rescue System |
| ARQ | Automatic Repeat Request |
| AtoN | Aids to Navigation |
| BFT | Blue Force Tracking |
| BLOS | Beyond Line of Sight |
| C | Department of Commerce |
| C2 | Command and Control |
| C4ISR | Command, Control, Communication, Computers, Intelligence, Surveillance and Reconnaissance |
| C-Band | IEEE Designation for the band 4000-8000 MHz |
| CAMSLANT | Communications Area Master Station Atlantic |
| CG | Coast Guard |
| CGDN+ | Coast Guard Data Network Plus – CG Sensitive but Unclassified computer network |
| COMSATCOM | Commercial Satellite Communication |
| CONOPS | Concept of Operation |
| COP | Common Operational Picture |
| COSPAS – SARSAT | Cosmicheskaya Systyema Poiska Avariynich Sudov (Russian) - Search And Rescue Satellite Aided Tracking |
| COTHEN | Customs Over the Horizon Enforcement Network |
| DAMA | Demand Assigned Multiple Access |
| DEA | Drug Enforcement Agency |
| DEEPWATER | Coast Guard Major Acquisition to bring fleet into the 21st Century |
| DGPS | Differential Global Positioning System |
| DHS | Department of Homeland Security |
| DoD | Department of Defense |
| DoE | Department of Energy |
| DoJ | Department of Justice |
| DSC | Digital Selective Calling |
| EHF | Extremely High Frequency |
| EO/IR | Electro-Optical/Infrared |
| eLORAN | Enhanced Long-Range Aid to Navigation |

| | |
|---|---|
| ELT | Emergency Locator Transmitter |
| EPIRB | Emergency Position Indicating Radio Beacon |
| ESM | Electronics Surveillance Measures |
| ESV | Earth Station on Vessel |
| FAA | Federal Aviation Administration |
| FBI | Federal Bureau of Investigation |
| FCC | Federal Communications Commission |
| FCR | Fire Control Radar |
| FM | Frequency Modulated |
| FY | Fiscal Year |
| GHz | GigaHertz |
| GMDSS | Global Maritime Distress and Safety System |
| GMF | Government Master File |
| GMTI | Ground Moving Target Indicator |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| HALE | High Altitude Long Endurance |
| HERO | Hazards of Electromagnetic Radiation on Ordnance |
| HF | High Frequency |
| HFSWR | High Frequency Surface Wave Radar |
| HSD | High Speed Data |
| IALA | International Aids to Navigation and Lighthouse Authorities |
| ICAO | International Civil Aviation Organization |
| IDS | Integrated Deepwater System |
| IEC | International Electrotechnical Commission |
| IFF | Identification, Friend or Foe |
| IMO | International Maritime Organization |
| IMSO | International Mobile Satellite Organization |
| ISAR | Inverse Synthetic Aperture Radar |
| ISDN | Integrated Services Digital Network |
| ISM | Industrial, Scientific and Medical |
| ISO | International Standards Organization |
| ITU | International Telecommunications Union |
| ITU-R | International Telecommunications Union Sector for Radiocommunications |
| JIATF | Joint Inter-Agency Task Force |
| JTRS | Joint Tactical Radio System |
| kbps | Kilobits per second |
| kHz | kiloHertz |
| Ku-Band | IEEE Designation for the band 8-12 GHz |

| | |
|---|---|
| kW | Kilowatt |
| LAN | Local Area Network |
| L-Band | IEEE Designation for the band 1000-2000 MHz |
| LES | Land Earth Station |
| LF | Low Frequency |
| LMR | Land Mobile Radio |
| LORAN | Long-Range Aid to Navigation |
| LOS | Line of Sight |
| LRIT | Long Range Identification and Tracking |
| MALE | Medium Altitude Long Endurance |
| Mbps | Megabits per second |
| MDA | Maritime Domain Awareness |
| MF | Medium Frequency |
| MHz | MegaHertz |
| MILSATCOM | Military Satellite Communications |
| MMR | Multi-Mode Radar |
| MMSI | Maritime Mobile Service Identity number |
| MPA | Maritime Patrol Aircraft |
| MPDS | Multiple Packet Data Service |
| MTI | Moving Target Indicator |
| MTSA | Maritime Transportation Security Act |
| NAIS | Nationwide Automatic Identification System |
| NASA | National Aeronautics and Space Administration |
| NATO | North Atlantic Treaty Organization |
| NBDP | Narrow Band Direct Printing |
| NDGPS | National Differential Global Positioning System |
| NDRS | National Distress and Response System |
| NOAA | National Oceanographic and Atmospheric Administration |
| NSC | National Security Cutter |
| NTIA | National Telecommunication and Information Administration |
| OPC | Offshore Patrol Cutter |
| OTCIXS | Officer in Tactical Command Information Transmission System |
| OTH | Over the Horizon |
| OTHR | Over the Horizon Radar |
| PLB | Personal Locator Beacon |
| PWCS | Port, Waterways and Coastal Security |
| R21 | Rescue 21 |
| RACON | Radar Beacons |
| RDF | Radio Direction Finder |
| RF | Radio Frequency |

| | |
|---|---|
| RFID | Radio Frequency Identification |
| RTLS | Real Time Location Systems |
| SAR | Search and Rescue |
| SAR | Synthetic Aperture Radar |
| SART | Search and Rescue Transponder |
| SATCOM | Satellite Communication |
| S-Band | IEEE Designation for the band 2000-4000 MHz |
| SBU | Sensitive But Unclassified |
| SCA | Software Communications Architecture |
| SDR | Software Defined Radio |
| SHF | Super High Frequency |
| SIPRNET | Secret Internet Protocol Router Network |
| SITOR | Simplex Teletype Over Radio |
| SITREP | Situation Report |
| SOLAS | Safety of Life at Sea |
| SPI | Spectrum Policy Initiative |
| SRP | Short Range Prosecutor |
| SSB | Single Side Band |
| SSR – S | Surface Wave Radar, S-Band |
| SSR – X | Surface Wave Radar, X-Band |
| STEDS | Sensitive But Unclassified Tactical Exchange Display System |
| TACAN | Tactical Air Navigation |
| TADIL-A | Tactical Digital Information Link |
| TBD | To Be Determined |
| TCDL | Tactical Common Data Link |
| TTC&D | Telemetry, Tracking, Control and Data |
| TVA | Tennessee Valley Authority |
| UAS | Unmanned Aerial System |
| UAV | Unmanned Aerial Vehicle |
| UHF | Ultra High Frequency |
| UMIB | Urgent Marine Information Broadcast |
| USCG | United States Coast Guard |
| USPS | United Stations Postal Service |
| UTC | Coordinated Universal Time |
| VA | Veteran’s Administration |
| VDL | VHF Data Link |
| VHF | Very High Frequency |
| VLF | Very Low Frequency |
| VTOL | Vertical Take-Off and Landing |
| VTS | Vessel Traffic Service/System |

| | |
|---|---|
| VUAV | Vertical Unmanned/Uninhabited Aerial Vehicle |
| WEFAX | Weather Fax |
| WNW | Wideband Networking Waveform |
| WRC | World Radio Conference |
| X-Band | IEEE Designation for the band 8000-12000 MHz |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