WRITTEN TESTIMONY OF

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SUBCOMMITTEE ON COAST GUARD AND MARITIME TRANSPORTATION

HOW TO IMPROVE THE EFFICIENCY, SAFETY, AND SECURITY OF MARITIME TRANSPORTATION: BETTER USE AND INTEGRATION OF MARITIME DOMAIN AWARENESS DATA

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Chairman Hunter, Ranking Member Garamendi, and members of the Subcommittee, thank you for the opportunity to appear before you today. My name is Lisa Hazard, and I am the Operations Manager for the Coastal Observing Research and Development Center at UC San Diego's Scripps Institution of Oceanography (Scripps). At Scripps, I manage and supervise a team of technical staff in the operations and maintenance of distributed environmental sensor networks developed, deployed, and maintained by the Center. As a graduate of the U.S. Naval Academy, I had the opportunity to study at the U.S. Coast Guard (USCG) Academy as an exchange student. This experience gave me a better sense of USCG missions and the need for accurate and timely observations for mission critical applications.

My experience with near real-time observations includes managing data from the nation's network of high frequency (HF) radar designed to map coastal ocean surface currents, meteorological stations deployed in theater in support of U.S. Navy and Marine Corps operations and drifting oceanographic sensors designed to improve global ocean wave models. I have served as the Southern California Coastal Observing System (SCCOOS) Data Management and Communications (DMAC) representative to the U.S. Integrated Ocean Observing System (IOOS). I presently serve as the IOOS HF radar data management lead for IOOS and am a U.S. representative to the Global Group on Earth Observations (GEO) for topics pertaining HF radar. I will talk more about our emerging technologies and use of data management and visualization to provide pertinent information management to operational applications.

Because many Scripps scientists and students are involved in ocean observations for maritime domain awareness, I sought input for my testimony from USCG representatives and experts at Scripps. Aspects of my testimony on the specifics of technologies and data management are drawn from these sources and corroborated by my 14 years of experience working with ocean observations. I also had the opportunity to review the Government Accountability Office report on the Coast Guard implementation of the Common Operational Picture (COP) and will base the majority of my testimony addressing recommendations to concerns raised in the report.

Long-term Earth and Ocean Observation Programs at Scripps Provide a Foundation for Environmental Knowledge of Maritime Domain Awareness

Founded in 1903, Scripps Institution of Oceanography became a part of the University of California in 1912. Scripps has a long history of supporting national defense objectives and has provided recommendations and technologies to "improve the efficiency, safety and security of maritime transportation" with a focus on the "better use and integration of maritime domain awareness data."

During World War II, Scripps oceanographers worked closely with the Navy to create surf and swell forecasts for successful Allied landings in North Africa, the Pacific, and the beaches of Normandy. Scripps researchers also developed high frequency underwater sound systems to track submarines and detect mines, enabling secure Naval operations and improving maritime domain awareness. Research at Scripps currently encompasses physical, chemical, biological, geological, and geophysical studies of the oceans and Earth, with annual expenditures approaching $200 million and a fleet of four research vessels and Floating Instrument Platform (FLIP). Scripps has a long history of initiating and maintaining environmental observing programs in the oceans, atmosphere and on land at regional to global scales. These observations are core to scientific discovery across numerous disciplines, and inform our understanding of society's most pressing issues.

In 1975, Scripps researchers launched the Coastal Data Information Program (CDIP), a program that measures, models, forecasts and publicly disseminates real-time coastal wave information, and that now includes a network of over 50 wave buoys in 13 states and island territories. CDIP provides these updated and accurate wave data to the US Army Corps of Engineers (USACE), the National Oceanic and Atmospheric Administration (NOAA), and other federal agencies. The data are also critical for the operational maritime community to ensure safe and efficient navigation for military, commercial, and recreational maritime traffic, and are relied upon by dredging project managers for safe operations. CDIP buoys provide highly accurate wave height, period, and direction information, which are used as input to marine forecasts and incorporated into coastal inundation models. During Hurricane Sandy, the CDIP wave buoy network on the East Coast provided continuous, near real-time wave observations (reported every 30 minutes) without failure or interruption. In fact, over 99% of all data produced by CDIP buoys during the storm were successfully transmitted.

In 1998, Scripps led the development of the revolutionary array of ocean monitoring sensors known as the Argo network. Launched in 2000, the Argo program now deploys a global array of more than 3,600 free drifting profiling floats to gather subsurface ocean data. Combined with satellite observations, these data make it possible to operate global and regional ocean analysis models similar to those for weather forecasting in the atmosphere. They provide enormous amounts of new information on the ocean's changing state at weekly to seasonal to year-to-year timescales. These observations and model analyses provide the data on open ocean conditions needed for weather forecasting, safe shipping and effective fisheries management, as well as offshore data needed for coastal ocean analyses.

Improving the Use and Integration of Maritime Awareness Data: the Need for Technology Demonstrations and Modular, Problem Driven Applications

Need for demonstrations:
A significant investment of time, funds, and process documentation is required for a full scale analysis of developing technologies for USCG applications and implementation. Although costly, process studies are required to determine applicability and feasibility of new technologies. Scripps recommends developing partnerships with agencies such as the Office of Naval Research (ONR) for conducting small scale demonstrations to test concept of operations of new technologies and applications. These demonstrations have the ability to provide a low cost, flexible, and timely analysis of science and technology programs that are applicable to operational needs. Depending on the success of the demonstration, results can be scaled to larger processes and provide required analysis of risk, operational costs, manning requirements, and costs. Successful demonstrations can be scaled to support operations, while unsuccessful demonstrations provide valuable lessons learned and save significantly on a USCG wide full scale information technology guidance procedure.

An example of such a demonstration is the Persistent Littoral Surveillance (PLUS) Program for Naval Special Warfare (NSW) applications. NSW operations can be aided by accurate and timely meteorological and oceanographic (METOC) data and forecasts. Similar METOC environmental sensing requirements are shared by U.S. Marine Corps (USMC) marine expeditionary groups who have pressing technology gaps for sensing and predicting changing weather conditions in mountainous and desert terrains. Unfortunately, regions of interest can be data poor, introducing gaps of knowledge which can only be met through placement of environmental sensors and dependence on environmental models that have unknown accuracies when used in new coastal regions. In addition, environmental sensor data and environmental model outputs are perishable when used for operational decision making as the data is needed in near real-time. This places requirements on the need for tools to conduct timely synthesis of METOC information. The Marine Physical Laboratory at Scripps developed, tested, and evaluated new instrumentation and sensor operation procedures for improving tactical ocean and atmospheric environmental information collection. Efforts focused on developing techniques and procedures for best operational usage of powered unmanned underwater vehicles and optimal methods for exploiting and fusing underwater imagery, sidescan sonar, and oceanographic data collected by the platforms.

Need for problem driven, modular interfaces:

The use of mapping overlays for data visualization can be extremely useful for displaying observations that assist in USCG missions such as search and rescue operations, marine safety and security, marine environmental protections, and ice operations. There is a wealth of direct observations and derived products that can be integrated into these systems including, but not limited to:

1.) Automatic Identification System (AIS)
2.) Bathymetry
3.) Navigational Charts
4.) Waves
5.) Surface and subsurface currents
6.) Satellite imagery
7.) Ice distribution

Many of these observations are available in a common data format that can be self-describing, machine-independent and delivered through a web service. Examples of these observations are found within the Integration Ocean Observing System (IOOS) which, for many gridded products, utilize a Network Common Data Format (NetCDF) for file structure and are distributed via a Thematic Real-time Environmental Distributed Data Service (THREDDS). The Open Geospatial Consortium (OGC) provides recommendations and examples of data formats and services for data sharing and delivery. These technologies are developed and have proven examples for in-situ time series data (e.g. AIS, temperature, wind speed, salinity); gridded data and model output (e.g. HF radar derived service currents, waves, ice coverage); and imagery feeds (e.g. remotely sensed ocean color, pictures, charts). The data can also be displayed via open source – online platforms such as OpenLayers and Google Earth for unclassified interfaces or closed source, desktop applications for classified interfaces such as the Topside application from Naval Undersea Warfare Center (NUWC).

A USCG example is the Search and Rescue Optimal Planning System (SAROPS). This is an ArcGIS 9.3 (soon to migrate to 10.1) application designed specifically for search and rescue. SAROPS is directly supported by the Environmental Data Sever (EDS), which accesses environmental data and models, archives that data, and upon request from SAROPS, returns data cubes for the SAROPS trajectory predictions. The EDS gathers data from the HF Radar National Network (HFRNet) and short term prediction based upon HFR data. I will expand upon this system and its history in the section addressing HF radar. A separate, but compatible tool, could be designed for tracking submerged oil spills, monitoring fishing areas or maintaining vessel awareness. Throughout my experience in data management, I have found that "system of systems" or "one-stop shops" inevitably fail due to volume or complexity. Lightweight, problem/user driven applications are much more effective, easy to use, flexible, and can be rapidly developed if the user needs are well understood. Underlying data feeds, such as the EDS, that are common to all applications are easily reused and custom products for the specific problem can be developed and added. Modular, problem driven applications will be more cost effective, straight forward to use, and flexible.

Scripps recommends designing modular, problem driven applications that can be built upon the same technology, but are tailored to a specific application or problem area. This approach was taken when developing an online visualization for the pilots in Los Angeles/Long Beach harbor. They were primarily interested in overlays of charts, waves, surface currents, and wind predictions. An online, interactive application was built to match their needs.

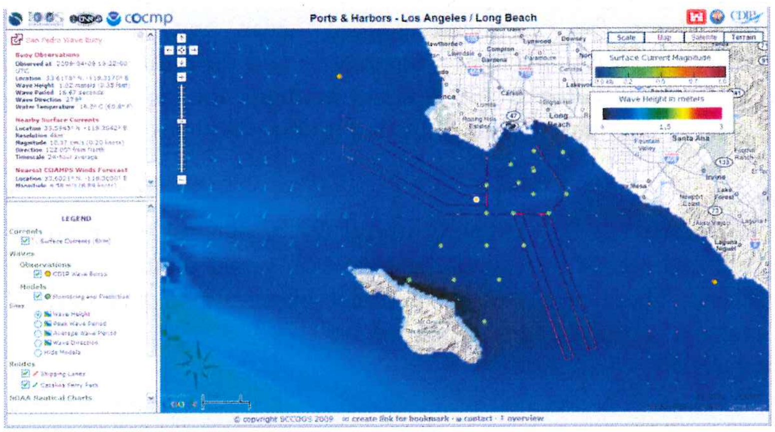

Figure 1. SCCOOS online ports/harbors custom interactive application

Improving the Use and Integration of Maritime Domain Awareness Data: the Use of Emerging Technologies

High Frequency Radar (HFR):

High-frequency radar (HF radar) systems measure reflecting radio waves off the surface of the ocean. Each HF radar land-based installation is sited near the coastline and includes two antennas: the first transmits a radio signal out across the ocean's surface, and the second listens for the reflected radio signal after it has bounced off the ocean's waves. By measuring and processing the change in frequency of the radio signal that returns, known as the Doppler shift, the system determines how fast the water is moving toward or away from the antenna. Data from neighboring antennas are processed and displayed to the user as surface currents maps in near real-time.

A national HF radar network (HFRNet) has been established to measure surface currents throughout the U.S., and is currently used in operational applications. Scripps developed and has operated data management for integration, distribution, and visualization of HFR surface currents for close to 10 years. The network includes approximately 31 participating organizations, 130 radars, and over 7 million files.

Beginning in 2000, the USCG Research and Development Center began a multi-year investigation into the utility of near real-time HF radar derived surface current measurements for search and rescue (SAR). This assessment showed a better comparison of radar-derived currents when compared against available NOAA tidal current predictions. Additionally a key element using the HF radar currents was the development of the Short Term Predictive System (STPS), a forecasting model that uses statistical information for surface current prediction. Following these evaluation studies, available in situ data were used to evaluate and define appropriate parameters for inclusions in the USCG search and planning tool as the inclusion of HF radar currents reduced the search area for USCG operators by two-thirds. Current velocities from HFRNet and the STPS forecasts are included in the USCG SAR Optimal Planning System. Data is made available in an easily digestible format through web services that were previously mentioned. This allows for integration in multiple applications and the data are used across an array of varying operational GIS based displays.

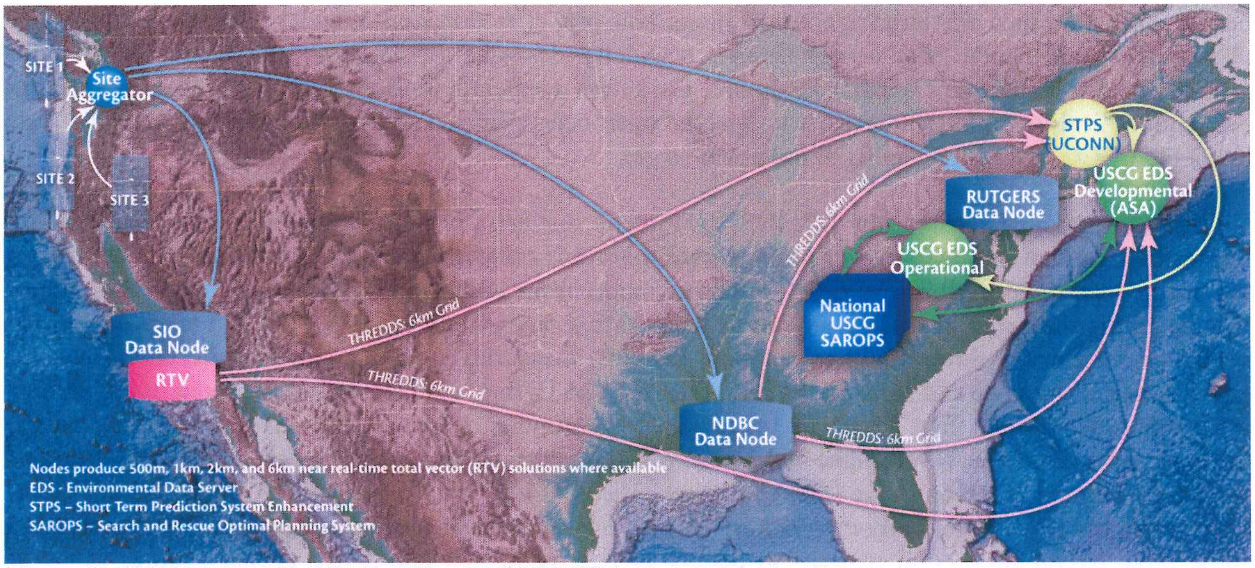

Figure 2. HFRNet data distribution for the SAROPS tool

Additional integrated operations applications include:

1. Oil Spill: Office of Response and Restoration (OR&R) Emergency Response Division (ERD) - Official NOAA forecasts for oil spill trajectories General NOAA Operational Modeling Environment (GNOME); National Preparedness Response Exercise Program (NPREP); CA Office of Spill Prevention and Response (OSPR)
2. Environmental Assessment: Office of Response and Restoration (OR&R) Assessment and Restoration Division (ARD) - Environmental Response Management Application (ERMA)

HF radar technology is being developed for over-the-horizon ship tracking applications and is an emerging technology for maritime domain awareness. In 2008 the Department of Homeland Security established the National Center for Secure and Resilient Maritime Commerce (CSR) and the Center for Island, Maritime, and Extreme Environmental Security (CIMES) – DHS Science & Technology (S&T) sister Centers of Excellence (CoE). Their mission includes basic research and education that develops and transitions new technologies supporting Maritime Domain Awareness (MDA) at three scales – the global scale observed via satellite, the approach scale observed by beyond-the-horizon HF radar, and the local scale observed via line-of-site microwave radars, cameras and underwater acoustics. The HF radar research focused on development of a dual-use surface current mapping and vessel-tracking capability. This capability is designed to bridge a surveillance gap between the low update rates provided by global satellite coverage and the high update rates of local line-of-sight microwave radars and underwater acoustic sensors in ports and harbors. CSR established the first two multi-static dual-use HF radar sites that began reporting real-time surface-current mapping and vessel-detection results to an aggregation center in 2011. Two independent DHS studies indicate that: (a) a network of inexpensive compact HF radars is more effective and robust to countermeasures than large single radars; and (b) the demonstrated dual-use vessel-tracking capability indicates that a multi-static HF Radar network is a viable approach for establishing a national MDA capability. This technology will enable a long range (~200km) view of vessels and can provide valuable information for situational awareness.

Unmanned Underwater Vehicles:
Unmanned Underwater Vehicles (UUVs) continue to develop as the frontier technology for subsurface exploration and sensing advances. Examples include buoyancy driven gliders, such as the SPRAY system developed by Scripps for large scale operations and propeller powered vehicles such as the REMUS (Remote Environmental Monitoring UnitS), originally designed by Hydroid Inc. and Woods Hole Oceanographic Institution (WHOI) for higher resolution applications. Both vehicles utilize an array of acoustic, optical, and physical sensors to analyze open ocean, littoral and benthic environments and can assist the USCG in detecting spills of unknown origin.

Unlike ship mounted sensors, the REMUS UUV has a distinct advantage to navigate a grid or terrains with consistent and thorough geo-positioned tracks. Scripps currently has been operating REMUS UUVs for over 6 years and performs a variety of experiments from outfall plume tracking outside San Diego Bay to discovering ship and plane wrecks in Palau. Most recently, in March of 2013, a team of Scripps researchers dedicated three weeks to mapping habitats, measuring unique hydrodynamic environments, and locating lost planes and ships in the Republic of Palau. Using a built-in side-scan sonar, two vehicles were able to survey and map 7.3 square miles with 10 centimeter resolution in 21 days. From the surveys, the team discovered one WWII plane and 3 new WWII Daihatsu landing craft wrecks. Despite 70 years of decay, underwater video and dive sonars allowed experts to identify the plane as an E15K Shiun (Violet Cloud) that the allies historically reported as "Norm." Mosaics of the entire seafloor have the capability to show large overarching coral patterns to details as fine as sunken buoys and anchor scours. Onboard sensors such as fluorometers can measure the presence of oil. Aggregation of imagery and sensor information can assist the USCG mission in determining oil leaks from submerged wrecks.

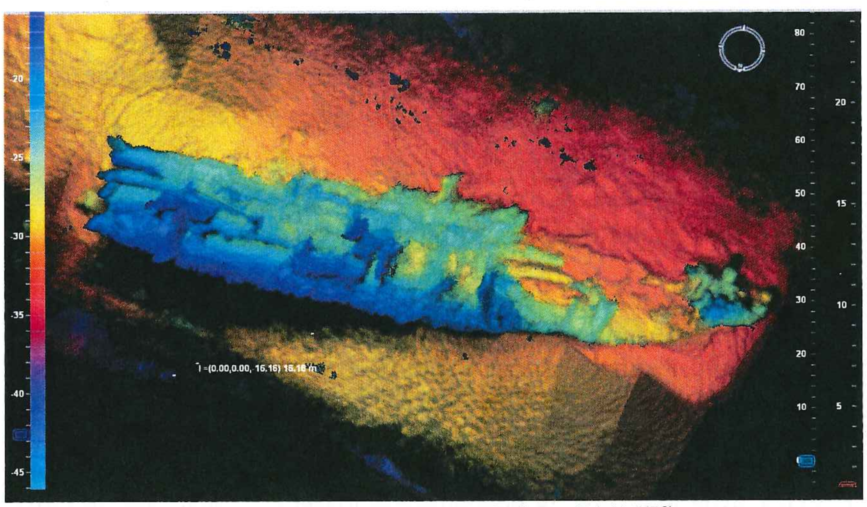

Figure 3. Mosaic image of submerged wreck from REMUS sonar

Additionally, gliders were used in the 2010 Deepwater Horizon explosion for analyzing water column properties and detecting the presence of oil. Gliders narrowed the search zone for subsurface oil and provided valuable information to help answer key questions about potential movement of oil. Through IOOS, the glider community is establishing a common data format for glider near real-time data feeds. This will significantly improve the ease of ingestion and display of glider data retrieved from varying platform vendors.

Research Vessels and Education/Training:
Scripps can provide an educational role to USCG through MS and PhD programs, especially through the Applied Ocean Sciences (AOS) program. A recent USCG masters graduate of the program went on teach at the USCG Academy and is now at Office of Science and Technology Policy, Executive Office of the President. Additionally, grants provide partnerships for education and training. Through the National Science Foundation's (NSF) program Ship-based Science Technical Support in the Arctic (STARC), Scripps provides marine science and technical services to NSF-supported research cruises aboard the U.S. Coast Guard cutters HEALY and POLAR SEA. This program is a collaborative between the Shipboard Technical Support (STS) department at Scripps and the Marine Technician Group (MTG) at Oregon State University (OSU) that provides the highest level of shipboard technical support possible. The program uses a model for arctic shipboard technical support that follows best practices of the University-National Oceanographic Laboratory System (UNOLS) fleet.

An Arctic Mission Coordinator at Scripps is responsible for creating and overseeing the scientific planning process, using existing methods, modified to suit the needs of scientists sailing on the USCG cutters in the Arctic.

Education and training of students, new technicians and USCG personnel in use of technology and techniques at sea are among the broader impacts of this proposal, thus growing the technical knowledge base that supports U.S. oceanographic research. Scripps supports the acquisition and appropriate handling of underway shipboard data in concert with national data centers such as the NSF-supported Rolling Deck to Repository (R2R) program, making data available to the academic community and the public at large. Scripps and OSU will coordinate with NSF, USCG and the Arctic Icebreaker Coordinating Committee to define priorities for maintenance and upgrades to science equipment onboard.

Thank you again for the opportunity to testify on improving efficiency, safety and security of maritime transportation and maritime domain awareness. Scripps' scientists are leaders in research and operational use of maritime technologies and have a long history with national defense. Scripps recommends developing partnerships with other agencies (e.g. ONR) to provide low cost demonstrations of emerging technologies that can then be applied to full-scale operations, providing valuable feedback and business case requirements such as risk, cost, and manning requirements. Designing problem driven, modular applications for USCG missions will improve data reliability and performance as well as reduce complexity for watch standers. The use of data products from high frequency radar (e.g. surface currents and vessel tracking), unmanned underwater vehicles, and research vessels will significantly improve all aspects of USCG missions.