**WRITTEN TESTIMONY OF**
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**SUBCOMMITTEE ON COAST GUARD AND MARITIME TRANSPORTATION**
**COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE**
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## Introduction

Good morning Chairman Hunter, Ranking Member Garamendi, and Members of the Subcommittee. My name is Gerd Glang, and I am the Director of the Office of Coast Survey at the National Oceanic and Atmospheric Administration (NOAA), within the Department of Commerce. Thank you for inviting NOAA to testify before you today on the suite of data, products, services, and expertise that NOAA provides in support of marine navigation.

For over two hundred years, NOAA and its predecessor organizations have provided foundational data, products, and services to support safe, efficient maritime commerce, which contributes to our Nation's economy. Today, NOAA is using state-of-the-art technology and innovative partnerships to deliver nautical charting products, real-time ocean and coastal observations, highly-precise positioning services, weather forecasts, oil spill response support, and other information and expertise to the maritime industry and navigation community. As we look to the future of navigation in the U.S., NOAA is at the cutting-edge of technological development, working to understand and address stakeholder needs and finding ways to further improve the accuracy and usefulness of data and products, as well as the efficiency with which NOAA fulfills its missions.

As the use of U.S. ports has increased, and larger ships with more advanced sensing technology push the limits of available draft and bridge clearance, the demand for NOAA's navigation services has never been greater. NOAA is one of several Federal agencies that contribute to the physical and informational infrastructure that support the movement of goods through our coastal ports and on the inland waterways. The focus of NOAA's role is on informational infrastructure in the form of nautical charts, ocean and coastal observations, positioning services, weather products and services, emergency response support, and integrated ocean and coastal mapping.

## Nautical Charting

NOAA is the Nation's authoritative provider of nautical charts for the 3.4 million square nautical miles comprising the U.S. Exclusive Economic Zone. NOAA's surveying and charting responsibilities have existed since 1807, and NOAA has specific authorities under the Coast and Geodetic Survey Act of 1947 (33 U.S.C. 883a et seq.) and the Hydrographic Services

Improvement Act (33 U.S.C. 892 et seq.).

Through its nautical charting program, NOAA maintains a suite of over 1,000 raster and electronic nautical charts to support safe navigation for commercial shipping, commercial and recreational fishing, recreational boaters, as well as State and local government uses. However, the data used to compile NOAA nautical charts are not collected by NOAA alone. NOAA cartographers compile data from over 50 different sources for display on nautical charts, including U.S. Coast Guard (USCG) aids to navigation, U.S. Army Corps of Engineers (USACE)-maintained navigation channels, and locations of key port infrastructure provided by the Nation's many port authorities.

Building and updating a nautical chart requires more than just bathymetric data. NOAA also delineates and maps the national shoreline, which provides a critical baseline on nautical charts, helps define U.S. territorial limits, and supports coastal resource management. Shoreline data is acquired using various remote sensing technologies, including tide-coordinated aerial imagery, commercial satellite imagery, and Light Detection and Ranging (LiDAR). Accurate vertical water level control is also critical when conducting hydrographic and shoreline mapping survey operations to ensure that charts are accurate. Water level data collected from NOAA's National Water Level Observation Network and subordinate water level stations form the basis of the national tidal datum network, which establishes the vertical datum for NOAA nautical charts.

NOAA's personnel, ships, and aircraft also play a critical role in mapping the Nation's oceans and coasts. NOAA civilians and the NOAA Commissioned Officer Corps operate, manage, and maintain NOAA's active fleet of 16 research and survey ships and nine specialized aircraft. The NOAA fleet, which ranges from large ocean-going ships to smaller near-shore vessels, supports a wide range of marine activities including fisheries surveys, ocean and climate studies, and nautical surveys. NOAA's ships operate in all regions of the U.S. and around the world, meeting mission needs despite challenges posed by weather, fuel costs, changing mission mandates, and other variables.

The technology with which NOAA acquires data for nautical charting and other purposes has advanced significantly in recent years. For example, in FY 2013 NOAA enhanced its imagery collection abilities to include technology that enables the assessment of damage to vertical structures that would not normally be visible through traditional imagery. Other data collection improvements include aerial topographic-bathymetric (topo-bathy) LiDAR, which will provide improved elevation data, both above and below the shoreline. In addition to supporting nautical charting, topo-bathy LiDAR data will benefit a multitude of uses, including coastal inundation modeling, floodplain mapping, coastal zone management, marine debris removal, recreational boating, and emergency response. NOAA is transitioning traditional water level gauges to microwave technology for more efficient data collection in lower wave energy environments and working toward the implementation of sea floor-mounted water level gauges for long-term deployments in Arctic environments. NOAA has also developed a tool, VDatum, that enables users to convert data from different horizontal and vertical references to a common system, making it possible to more easily integrate diverse datasets. NOAA is working toward the use of GPS tide buoys to help verify the accuracy of VDatum in offshore areas where traditional tide gauges cannot be installed. Eventually, VDatum will be used in place of a discrete water level

gauge in certain locations for tide coordination of survey operations.

To fulfill its navigation-related missions and advance mapping technology, NOAA leverages the expertise of the Joint Hydrographic Center at the University of New Hampshire. As world leaders in developing hydrographic and ocean mapping technologies, NOAA and University scientists at the Center are working to expand the scope and effectiveness of hydrographic services through the development of innovative technologies and research collaboration with the private sector, other universities, and other government agencies. Among the research projects underway are new tools to capture habitat and nautical charting data from fisheries sonars, improved sonar and LiDAR data processing technologies, new concepts in electronic charting, and enhanced visualization of hydrographic and oceanographic data.

U.S. charting has also continued to push the cutting-edge of technology and innovation. NOAA is moving away from paper charts while strengthening its electronic charting products to best serve mariners. Starting in April, NOAA's paper charts will only be available through private "print-on-demand" partners. This shift to a digital focus will allow NOAA to update charts with new information between new editions and will improve content, as electronic charts can contain more information than can fit on paper. NOAA is also focusing on new ways to apply functional technological advances to further reduce risk to the mariner, particularly in busy ports where under-keel clearance is minimal. Format and limitations of traditional chart products dodo not support tight maneuvering in ports. This "risk reduction tool" would incorporate forecast models of wind and waves, real-time weather observations, and high-resolution chart overlays into a ship's vessel dynamics, providing mariners with highly-localized means to visualize their entry and exit into port. Similarly, NOAA is also working toward producing tide-aware electronic navigation charts that integrate water level data from NOAA's observing systems with chart depth soundings, thus providing the mariner with tide-adjusted water depths right on their electronic nautical chart display. These and other charting improvements all fall within the scope of advancing e-Navigation in the U.S. NOAA has worked with USCG, USACE, and other Federal agencies on the Committee on the Marine Transportation System to develop an e-Navigation Strategic Action Plan, with the goal of providing an integrated information environment to improve the safety of navigation on our Nation's channels and waterways.

NOAA's ultimate goal is to provide the best charts − in the most appropriate, effective format − to all of our users, including commercial mariners, pilots, military and recreational customers, as well as non-navigation users. To this end, recent changes NOAA made to its charting products include free chart PDFs, higher resolution raster charts, and seamless online viewing of electronic navigation charts. Over the next few years, NOAA will be working closely with the National Geospatial-Intelligence Agency and USACE to further integrate and improve the dissemination of navigational charts.

**Coastal and Ocean Observations**

NOAA is responsible for providing tide and tidal current predictions, real-time oceanographic and meteorological data, and other navigation products to promote safe and efficient navigation within U.S. waters. NOAA's suite of observational data and products to support navigation includes tide tables and tidal current tables that provide predictions at over 3,000 locations; real-

time oceanographic and meteorological data via NOAA's Physical Oceanographic Real-Time System (PORTS®) in 22 seaports and harbors nationwide; the 210 long-term water level gauges that comprise the National Water Level Observation Network; and the ability to forecast these environmental data 48 hours into the future via hydrodynamic models in 13 major estuaries. NOAA monitors all of its real-time coastal and ocean observations 24 hours a day, 365 days a year to ensure that only accurate information is used to support navigation.

NOAA's coastal and ocean observations, when combined with up-to-date nautical charts and precise positioning information, provide mariners with a clearer picture of potential dangers that may threaten navigation safety. Studies have found that the use of real-time observations from PORTS has helped to reduce groundings by 50 percent and deliver $38 million in economic efficiency benefits annually in just three locations where PORTS is available.

NOAA continually works to improve the reliability and cost effectiveness of its coastal and ocean observing systems. Recent technological improvements include a new microwave water level sensor and a new bridge air gap sensor. The microwave water level sensor is easier to maintain than NOAA's traditional gauges because the system is not submerged, which helps reduce maintenance costs and improves sensor longevity. NOAA has also started deploying a new bridge air gap sensor that is just as accurate, but more cost-effective, than existing sensors. NOAA plans to integrate these new technologies nationwide over time. In addition, NOAA works to be responsive to specific user needs. In response to requests for visibility information from the maritime community NOAA worked with the Federal Aviation Administration to identify a visibility (fog) sensor that would work well in harsh marine environments. Several PORTS locations now include visibility sensors.

NOAA is also looking for ways to improve its observational data delivery and increase its data holdings by accepting water level data from Federal and State agencies, universities, and other entities. As the Nation's water level data clearinghouse, NOAA can apply its scientific expertise to provide a much larger offering of quality water level data. For example, NOAA has partnered with the Texas Coastal Ocean Observation Network to incorporate and display water level data and products from their network.

In addition to operating its own suite of coastal and ocean observation platforms to support safe navigation, NOAA is also the lead Federal agency for the U.S. Integrated Ocean Observing System (IOOS), which is a comprehensive effort both to observe the ocean and provide valued ocean services to the Nation, as authorized by the Integrated Coastal and Ocean Observation System Act of 2009. U.S. IOOS makes available to mariners a range of ocean and coastal data, including surface and subsurface current speed and direction; wave height, period, and direction; tidal height; wind speed and direction; and water temperature and salinity. NOAA has been working with U.S. IOOS partners to incorporate such data into NOAA's products to better serve the maritime community. For example, NOAA partnered with Stevens Institute of Technology to integrate their current data into the New York/New Jersey PORTS display.

One U.S. IOOS asset of particular significance is high frequency (HF) radar systems. The U.S. HF radar network is comprised of 128 radars that measure the speed and direction of ocean surface currents in support of navigation, pollutant tracking, search and rescue operations,

harmful algal bloom monitoring, and ecosystem assessment. For example, HF radar has been incorporated into USCG's operational search and rescue system and is used to inform life-saving decisions when rescuing disabled vessels and people stranded in the water. Tests have shown that ingesting HF radar data into the USCG search and rescue system decreased the search area by 66% over 96 hours, thereby helping USCG focus their efforts and save more lives. NOAA and its U.S. IOOS partners are collaborating on a new HF radar web product that provides broad spatial coverage, in near real-time, of surface currents and tidal current predictions in estuarine and coastal locations that are vital for marine navigation. The product will be deployed on NOAA's Tides and Currents website in late March 2014 and will initially include lower Chesapeake Bay and San Francisco Bay PORTS locations.

Waves are a common challenge for vessels entering and leaving port, but can be particularly dangerous in certain locations. The USACE-funded Coastal Data Information Program (CDIP) measures, analyzes, archives, and disseminates data on coastal wave height, direction, and period. NOAA, its U.S. IOOS partners, U.S. Navy, and Scripps Institution of Oceanography also play key roles in this partnership. For example, NOAA uses and makes available CDIP wave buoy data at the following five PORTS locations: the mouth of Chesapeake Bay, off the Port of Los Angeles/Long Beach, and near the entrances to the Lower Columbia River, San Francisco Bay, and Humboldt Bay (California). In addition, two U.S. IOOS regional entities − the Southern California Coastal and Ocean Observing System and the Central and Northern California Coastal and Ocean Observing System – have developed interactive online products to provide real-time and predicted wave conditions, as well as other valuable data, to inform navigation and planning decisions in these busy port regions. The value of wave data is underscored by the risk that longer period swell can pose to supertankers and deep draft vessels, which informs decisions on whether to hold a vessel offshore until conditions improve.

**Positioning Services**

NOAA provides precise positioning infrastructure, products, and services that support all spatial activities in the U.S., including navigation. The NOAA-managed and maintained National Spatial Reference System (NSRS) provides a consistent geodetic framework for latitude, longitude, and height information, and forms a spatial foundation for transportation, mapping and charting, and a multitude of scientific and engineering applications. The NSRS provides over $2.4 billion in estimated annual benefits to the U.S. economy. Within the NSRS, NOAA manages and maintains a network of over 1900 Continuously Operating Reference Stations (CORS), which are GPS base stations operated by over 200 Federal, State, and local partners. Through CORS, NOAA provides a positioning service that improves the accuracy of latitude and longitude determination from over 5 meters without CORS to a centimeter with the system. The CORS network alone provides an estimated $758 million per year in economic benefits.[1]

With respect to vertical positioning, NOAA's Gravity for the Redefinition of the American Vertical Datum (GRAV-D) is an initiative to re-define the vertical datum of the U.S. by 2022.

[1] Leveson, Irving. *Socio-Economic Benefits Study: Scoping the Value of CORS and GRAV-D*. Washington, D.C.: National Oceanic and Atmospheric Administration, 2009.
http://www.ngs.noaa.gov/PUBS_LIB/Socio-EconomicBenefitsofCORSandGRAV-D.pdf

The current vertical reference frame has a mismatch with global sea level that is anywhere from 16 inches to 6 feet. When GRAV-D is completed, elevation errors will be reduced to just under an inch across the Nation, and users will be able to access the new datum and determine elevations more accurately than ever via their GPS receiver. Implementation of the new vertical reference system, once GRAV-D is completed, will generate an additional $522 million in annual economic benefits, nearly half of which will be derived from improved floodplain management alone.

Another type of positioning reference, tidal datums are used to measure local water levels and are also tied to fixed geodetic references known as bench marks. Tidal datums are also used to delineate maritime boundaries, high seas boundaries, privately owned land, and State-owned land. NOAA works closely with USACE, the U.S. Geological Survey (USGS), the National Park Service, and State entities to ensure that all water level data is collected to NOAA standards for determining tidal datums for applications in navigation and engineering projects as well as sea level and climate studies. After Hurricane Katrina, USACE and NOAA worked together to reference USACE projects to a NOAA tidal datum, which ensured that levees were repaired and reconstructed with an accurate understanding of inundation risks. To advance this partnership, NOAA and USACE signed a Memorandum of Agreement in 2013 for NOAA to provide tidal datum computations for USACE projects.

**Weather Products and Services That Support Marine Navigation**

NOAA is responsible for issuing marine weather forecasts and warnings for U.S. coastal waters and Great Lakes; the Pacific and Atlantic Oceans (and connected bodies of water); and a portion of the Arctic Ocean (north of Alaska). The top priorities are providing information that protects life and property in the marine domain, and enhancing the national economy. NOAA forecasts and warnings assist mariners to avoid areas of dangerous weather and optimize routes for safety and efficiency. These products are disseminated to mariners via radio, internet, and other means.

Over this vast environment, NOAA collects data primarily from satellites, buoys, ships, and land/island-based sites in coastal and ocean areas and the Great Lakes. These data are used to provide marine users and others with weather and wave conditions (as near to real-time as possible) and directly support timely and accurate marine forecasts and warnings. This information is used by the marine community to plan for a wide variety of activities, ranging from recreational boating to the safe and efficient movement of commercial shipping across the world's oceans. These responsibilities drive our agency to improve the quality, accuracy, and timeliness of the information and services we deliver to meet the needs of mariners and other users of marine weather services and information.

In the future, technological advances in computer modeling and observation networks will enable improved and more detailed forecasts and warnings for the maritime community. NOAA is also working to improve our dissemination capabilities to ensure users can receive the critical information they need through a wide variety of communication devices and systems.

**Emergency Preparedness and Response**

Maritime infrastructure is vulnerable to a number of coastal hazards. NOAA provides information to help ports and coastal communities prepare and respond to these hazards, such as tsunami warnings, storm surge forecasts, real-time water level monitoring, hydrographic surveys, aerial surveys, and scientific support for oil spill response. For example, NOAA is improving the accuracy, resolution, and communication of storm surge forecasts by integrating better tide information, higher resolution ocean circulation models, and social science on how stakeholders interpret and use information from inundation forecasts. In addition, NOAA's Storm QuickLook tool provides a synopsis of near real-time oceanographic and meteorological data at locations affected by a tropical cyclone, to help inform emergency managers, weather forecasters, the media, and the public on water level and meteorological conditions in the path of a storm.

Natural disasters and other events can create hazards to navigation that result in vessel draft restrictions, port closures, and significant economic impacts. Large items such as lost shipping containers or derelict vessels can become hazards to navigation, especially when submerged below the water surface. NOAA's Navigation Response Teams (NRTs) are highly mobile, versatile, and particularly well-suited to respond to such emergencies. USCG Captains of the Port rely on hydrographic surveys conducted by the NRTs to determine when it is safe to remove draft restrictions or re-open a port after a disaster. As members of regional "Port Recovery Teams", NOAA's NRTs and regional Navigation Managers work very closely with USCG, port authorities, pilots associations, USACE, and local governments charged with restoring maritime commerce following a storm or incident. Recent demonstrations of the NRTs' rapid response capabilities include a small plane crash in a shipping channel into Port Everglades and a sunken fishing vessel near Belle Pass, LA, both of which led to short-term port closures. The teams also provided invaluable services to augment NOAA's response to the damage caused by Post-Tropical Cyclone Sandy in the Ports of New York/New Jersey, Delaware Bay, and Hampton Roads. During Sandy, NOAA also deployed three of its larger ships, the *Ferdinand Hassler*, *Thomas Jefferson*, and *Bay Hydro II*, which were routed away from their regular survey locations in order to assist with the response.

NOAA also flies aerial survey missions to assess damage and aid recovery following both natural and man-made disasters. These datasets and images, which NOAA makes freely available online, help emergency and coastal managers develop recovery strategies, facilitate search and rescue efforts, identify hazards to navigation and hazardous materials spills, locate errant vessels or other marine debris, and provide documentation necessary for damage assessment through the comparison of before-and-after imagery. NOAA's aerial imagery assisted with response and recovery efforts along coastlines impacted by numerous major hurricanes, dating back to Hurricane Isabel in 2003 and including Hurricane Katrina in 2005 and Hurricane Isaac and Sandy in 2012. In the wake of Sandy, NOAA collected more than 12,000 aerial images of the hardest hit areas in New Jersey and New York and is currently in the process of acquiring topo-bathy LiDAR from Long Island to the northern part of South Carolina using funding provided by the Disaster Relief Appropriations Act of 2013. In addition to responding to natural disasters, NOAA has provided aerial imagery support in the wake of man-made disasters, such as the Deepwater Horizon oil spill in 2010. Looking forward, and to the extent resources allow, NOAA intends to deploy new imagery technology that will provide enhanced support for emergency response efforts, in addition to helping assess and address other coastal hazards and resiliency issues.

Every year NOAA supports response to more than a hundred oil and chemical spills in U.S. waters, which threaten life, property, and public natural resources. Spills into our coastal waters, whether accidental or intentional, can harm people and the environment and substantially disrupt marine transportation with potential widespread economic impacts. NOAA's expertise spans oceanography, biology, chemistry, and geology, allowing the response team to estimate oil and chemical trajectories, analyze chemical hazards, and assess risks to coastal animals, habitats, and important areas to humans. NOAA's regional Scientific Support Coordinators provide scientific support to USCG for spills in coastal waters.

As transportation demand grows in the Arctic, including cargo and tanker vessel traffic through Bering Strait and Unimak passes, existing commercial fishing traffic, and increased cruise and recreational vessels, the potential for incidents will also grow. Accurate charts and other aids to navigation are essential for safe navigation, and for response to spills and other marine hazards. Accurate charts and aids to navigation are key spill prevention tools and critical to selecting places of refuge for a stricken vessel, as well as staging of marine assets for any large response or salvage efforts.

**Integrated Ocean and Coastal Mapping**

Ocean and coastal mapping uses a variety of technologies to acquire, process, and manage data on physical, biological, chemical, and archaeological characteristics and boundaries of marine environments and resources. NOAA's Integrated Ocean and Coastal Mapping program plans, acquires, documents, manages, integrates, and disseminates such data and derivative products in a manner that facilitates access to and use by the greatest range of users. NOAA embodies these practices throughout its mapping programs with the philosophy of "map once, use many times."

This cross-cutting NOAA program includes at least three primary tasks: 1) coordination and collaboration between mapping organizations within NOAA and with other agencies to avoid duplication of effort and maximize survey resources; 2) end-to-end data management to provide an efficient system to ensure that all data collected is consistently processed and provided to the national archive centers; and 3) maximum use and re-use of the total archive of mapping data to consistently generate the products that were originally intended, as well as the innovative re-use of data to generate additional products that serve national needs. At present, the program is focused on streamlining operations, reducing redundancies, improving efficiencies, developing common standards, and stimulating innovation and technological development.

The Sandy response and recovery efforts provide a useful example of the application and benefits of integrated ocean and coastal mapping. Following Sandy, NOAA took an integrated ocean and coastal mapping approach toward deciding where and how to focus its recovery and resilience-building efforts. Using a web-based mapping GIS tool, NOAA, USGS, USCG, USACE, and other Federal agencies collected mapping needs from Federal, State, and regional stakeholders and developed preliminary plans to survey those areas. The agencies then coordinated plans to determine what overlaps and gaps existed, and shifted their plans to optimize resource allocation and avoid duplication of effort. NOAA, with its Federal partners, has also worked to use mapping data collected following Sandy for multiple purposes. For

example, hydrographic data collected in waters off New York and New Jersey will be used to update nautical charts as well as for marine debris identification and removal. NOAA is also examining other agencies' shoreline data to develop environmental sensitivity index maps, which help States determine the extent of current and potential damage from disasters, and for elevation models that provide the foundation for inundation mapping.

Integrated ocean and coastal mapping does not just represent an efficient way of doing business, it also embodies the future of mapping. As new mapping technologies are developed, such as the topo-bathy LiDAR discussed above, agencies are collaborating to ensure that mapping data meets the greatest breadth of user needs possible. A few examples of work planned for 2014 include the establishment of a water column sonar data archive to improve access to and use of sonar data, and agency-wide efforts to update the U.S. Interagency Elevation Inventory in coordination with USGS. Working closely with USACE and USGS, NOAA is near completion of a National Coastal Mapping Strategy that will provide comprehensive and accurate coastal elevation that supports numerous Federal missions and stakeholder needs.

**Conclusion**

NOAA plays a unique and important role in providing critical informational infrastructure to support safe, reliable, and efficient navigation and maritime commerce. Thank you for the opportunity to discuss some of those efforts with you. We would welcome the opportunity to provide the Committee with greater detail on any of NOAA's navigation- and infrastructure-related services.