Precision Marine Navigation

Virtual Stakeholder Workshop Report

October 2020

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Prepared October 22, 2020 By:

LYNNE CARBONE & ASSOCIATES, INC.

Executive Summary

Overview

On September 30 and October 1, 2020, NOAA hosted its second annual Precision Marine Navigation (PMN) Workshop which was attended by 247 participants from a wide range of user groups. The purpose of this workshop was to update NOAA's partners and stakeholders on the progress that the PMN team has made in the past year, get feedback from these groups, and establish long term mechanisms for continued engagement.

Engagement and Highlights

Hosting this year's workshop virtually allowed for much broader stakeholder engagement. With this in mind, the workshop consisted of five sessions. The opening and closing session included presentations on the program development, the data providers, and future directions which were attended by everyone. Then NOAA hosted discussion sessions designed to collect focused feedback from three major stakeholder groups: Software Developers and Distributors, End Users, and Federal Partners. Some key highlights from those sessions include:

- An important component of success for PMN is continuing to develop clear implementation guidance. Workshop attendees also emphasized the need for robust training materials and engagement with Maritime Academies.
- Participants also discussed the need for different service levels for different user groups as the data will be used in a multitude of ways from recreational mariners to SOLAS shipping to autonomous shipping, and NOAA data needs to be able to fit all of these needs.
- NOAA is working to develop a one-stop-shop for NOAA marine navigation data and would like to one day bring in all marine navigation data across the federal government. Federal agencies discussed which data sets would be most valuable to include links to in the meantime. Vessel Traffic Services, marine navigation and weather warnings, real time observations, high resolution bathymetry and training materials were the most common suggestions.

Closing

Julia Powell, Program Manager, and Admiral Shep Smith, Director of Coast Survey, closed out the workshop by thanking everyone for joining. They pointed out that time scales are being driven down from years to hours and even minutes with the S-100 as the framework and catalyst. They acknowledged that partners and stakeholders at the international, federal, developer and distributor, and end user levels all have critical roles in successful implementation of this change and look forward to continuing to build these relationships.

Visit the workshop web page for links to recordings of each of the speakers and their slide decks.

NOAA's Precision Marine Navigation Overview and Updates

Context

Rear Admiral Shep Smith, NOAA Office of Coast Survey Director, welcomed participants to the workshop and expressed his appreciation for everyone's attendance and engagement. The Admiral then provided context for the PMN Program and the workshop:

- The next generation of navigation services, enabled by technology advances in recent decades, will dramatically increase the speed at which updates are made to charts and enable new services and levels of customization.
- International standards will provide uniformity and create new opportunities for the development and implementation of these new next generation services.
- Continued collaboration among international, federal, software system providers and distributors, and end users is critical to these developments.

Overview and Updates on NOAA's Precision Marine Navigation

Vision and Expectations of the Program

Julia Powell, NOAA Office of Coast Survey Program Manager, presented an overview of the vision and expectations for the PMN Program:

- Definition: PMN is the ability of a vessel to safely and efficiently navigate within the U.S. EEZ and operate in close proximity to the seafloor, bridges, narrow channels, or other marine hazards.
- The PMN Program will consolidate all navigational data into a single easily accessible dissemination system that is machine-to-machine readable.
- S-100 standards will ensure greater international uniformity and enable the selection of data layers as specified by the user.

The Dissemination System

John Kelley, NOAA Office of Coast Survey Project Manager, and Jason Greenlaw, Lead Architect presented an overview and update on the PMN processing and dissemination system currently under development and demonstrated the gateway viewer:

- The prototype processing and dissemination system is being developed in an agile and flexible DevOps environment, leveraging cloud computing technology and services, and open source software to maximize innovation and efficiency.
- Data is consolidated in a single cloud location, automatically updated with the latest information, processed to meet S-100 data standards and formats, and available for developers and users to ingest.
- The prototype surface current data is publicly available for developers and users to begin to experiment and provide feedback. Models are running every six hours and will automatically update with the latest available data; file sizes will remain small for easy transmission in low bandwidth environments.
- Continued stakeholder engagement and feedback is critical to success.

NOAA Data Provider Overviews

Laura Rear McLaughlin, NOAA Center for Operational Oceanographic Products and Services (CO-OPS) Mapping and Charting Program Manager, provided an overview of CO-OPS' role and contributions to PMN; Darren Wright, NOAA NWS National Marine Program Leader, provided an overview of NWS' role and contributions to PMN:

- The Center for Operational Oceanographic Products and Services (CO-OPS) PORTS® Program is providing valuable real-time data, and the CO-OPS is also providing many of the foundational observations for navigation.
- The National Weather Service (NWS) is developing new products and services for mariners – including probability of visibility – and is working on increasing vessel-based observations at sea, as well as providing foundational weather observations and forecasts.

Canadian Hydrographic Service: Next Generation of Dynamic Geospatial Navigation Services

Louis Maltais, Canadian Hydrographic Service; Karen Hart, Teledyne Technologies; Hans Christoffer Lauritzen, PRIMAR; Mike Montesano, OneOcean; Mark Hayden, SEAiq; and Pascal Rheaume, St. Lawrence River Pilots, provided a presentation on the Canadian Hydrographic Service complete value chain efforts towards next generation dynamic geospatial navigation:

- The Canadian Hydrographic Service is building an on-demand streaming capability for navigational data and is in the process of developing and implementing the S-100 product suite.
- Effective partners are critical to the value chain and are assisting from cloud services, data packaging, data distribution, application development, all the way to end users who provide feedback on the user experience.
- Interpolation carries risks and data transparency should be a priority to allow users to understand the underlying sources to support decision-making and new innovations in development.

S-100 Under Keel Clearance System (GeoNavigation Technologies)

Ed Weaver, GeoNavigation Technologies Director, provided an introduction to the software systems and distributors breakout group and the S-100 under keel clearance system:

- NOAA's registry and catalog are well organized and allow for data and metadata to be easily retrieved/streamed in user-specified formats. There are still some adjustments to be made, including a higher-level catalog, and these changes are already underway.
- The platform being used is AWS which is accepted from a cybersecurity standpoint; this will be further supported by authenticated digital signatures and encryption.
- PPUs and other commercial users are ready to transition to S-100 products as there are already methods available to integrate S-57 and S-101 at the same time. There are significant benefits to initiating this transition, and it is still possible to continue supporting legacy products. The transition should be complete by 2030.

High-Level Takeaways

The brainstorming and discussion sessions are summarized under each of the following category questions:

How Do You Hope or Expect to Use S-100?

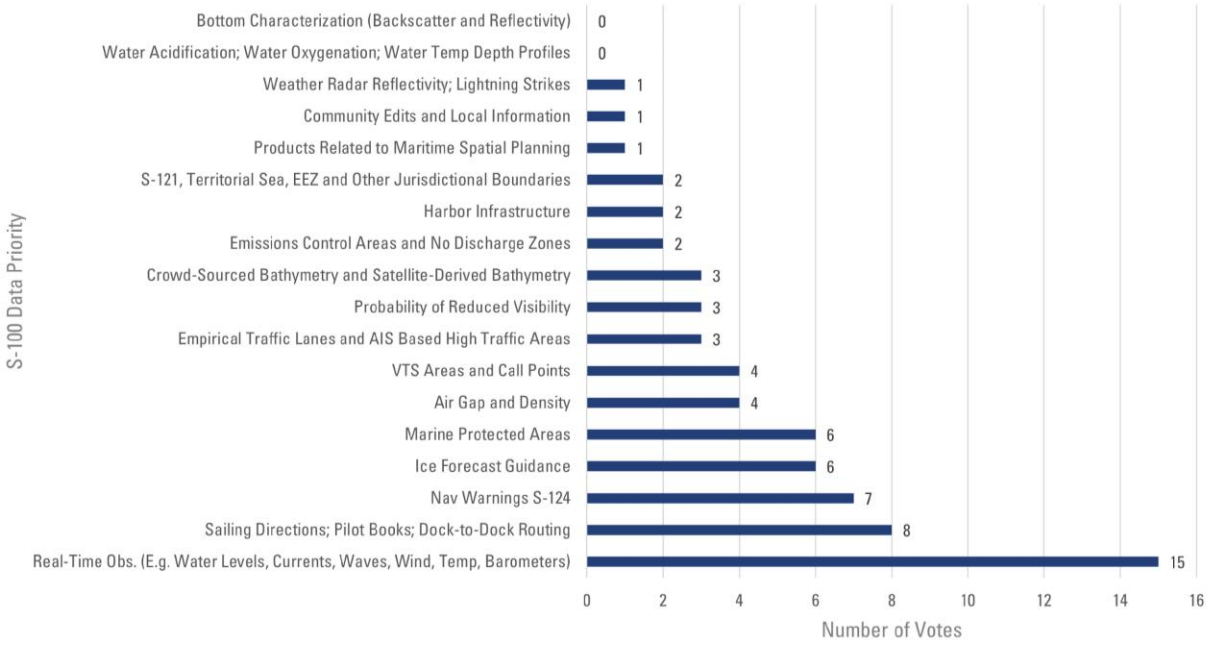
- Software System and Distributors expect to develop tools, applications, infrastructure, and software to support the interoperable S-100 framework and add value to the next generation of navigational products.
- S-100 will also enable greater quality assurance, verification, troubleshooting and distribution.
- Route planning for sailing is another value expected use of S-100.
- Interoperability and eliminating stovepipes will dramatically streamline processes and allow for instantaneous updates.
- Commercial partners are ready to begin this transition to the S-100 framework and can begin to do so while still supporting legacy systems, and in parallel/advance of IMO regulatory support.

Beyond the Current Six Product Specs (Surface Currents, Water Levels, Bathymetry, ENCs, Weather Overlay, and Ice), What Would You Like to See Incorporated into the Program and Are We Missing Anything? What Should Be Our S-100 Data Priorities?

- In addition to the six S-100 product specs currently scheduled for release in the next five years, boundaries including Marine Protected Areas and harbor infrastructure, and real-time observations (including wind, air gap, wave height, water levels, temperature and more) were the most common requests.
    - Other suggestions included pilot books and local information, visibility, training support, Vessel Traffic Service (VTS) areas, lightning strikes, endangered species, bottom characterization, routing, emission control areas, and navigational warnings.
- Data is going to be Open Geospatial Consortium (OGC) compliant to aid in the ease of transition and integration of the S-100 product suite and more accessible to companies supporting the recreational boating community.
- A high-level "catalog of catalogs" is important to aid in discoverability and automatic update of data sets.

Software Systems and Distributors Feedback Session

The brainstorming results were consolidated and voted on by stakeholders resulting in the following priorities:



What Are Your Barriers to Implementation of S-111/S-100? What Can We Provide to Make Implementation Seamless?

- Conversion to S-100 should be automated and open source libraries can greatly improve the transition process.
- The supply of data must be sufficient, and easily accessible and discoverable on a global scale.
- The ISO 8211 format is complex, and other formats seem to require their own specific implementation steps.
- Standards still in development present a moving target for implementation, and standards must be normalized across national boundaries.
- Thorough guidance and documentation are needed to support implementation.
- Products and S-100 product adoption should remain flexible and segmented for the more nimble recreational market.
- Companies must make challenging decisions about when to invest in S-100 given the evolving nature of the product suite and regulations.

What Forecast Horizon (e.g. 48hrs, 3 Days, 5 Days, Etc.) for S-100 Weather Forecasts and Ocean Model Forecast Products Do You Need to Support Your Customers?

- Customers' desired forecast horizon for S-100 weather and ocean-model forecast products is very dependent on the specific navigational use.
- Most responses indicate that customers would like forecast from one to three days. In some instances the forecast for short voyages (less than 24-hours) is desirable, and for other planning purposes out to 14-days is requested.

Software Systems and Distributors Feedback Session

What Are the Spatial Data Resolutions (Structured vs Unstructured Grids) That You Need to Capitalize on PMN for Your Customers' Trip Planning Support?

- Near unanimous consensus calls for scalable resolution settings that will allow for higher-resolution in user-selected areas – including specific points of interest and zooming capabilities. Resolution always needs to be balanced against file size.
- Some users such as Mississippi River pilots would like to see high-resolution down to 3 cm of accuracy for deep draft ships and terminal docking, and racing sailors request the highest degree of resolution available.
- Stakeholders are encouraged to look through the structured and unstructured grids available through the AWS NOAA Big Data Bucket and provide feedback to the PMN Program at any time.

Where Do You Most Want to See High Resolution Surface Currents?

- The most frequently requested areas for high resolution surface currents were ports and harbors, as well as shipping channels.
- Areas of heightened navigational risk such as constrained waterways or high current areas were also requested, as well as nearshore to support rescue efforts.

Where Do You Most Want to See High Resolution Bathymetry?

- Shipping channels, ports and approaches, anchorages, and nearshore are all important locations for greater high-resolution bathymetry; fishing grounds and eventually all places as technology evolves were also noted.
- Wherever available the highest resolution bathymetry will be made available so that the user can zoom in/out to their level of need. There are still some issues relating to Hydrographic Office liability to be worked out, but the National Bathymetric Source Database (NBS) will make all high-resolution bathymetry available.

For S-104 Water Level Forecast Guidance from the Forecast Models Do You Need the Water Level Referred to MLLW or Some Other Datum?

- The water level should be referred to whatever the underlying chart datum corresponds to, whether that is defined against vertical datums, tidal datums, or others.
- MLLW are used and vertical datums may be used separately for other purposes and local transformations.
- The issue of international compatibility needs to be addressed, including the difference between the U.S. and Canada as well as other neighboring countries.
- The switching of reference planes in some waters such as Mississippi suggests there is value in having a range of reference options.

Software Systems and Distributors Feedback Session

What Level of Data Uncertainty Are You Comfortable with and How Should That Uncertainty Be Communicated?

- Uncertainty and level of comfort are situationally dependent, and it may be useful to have multiple levels of uncertainty for the user to choose from (e.g. conservative, best estimate, or optimistic).
- The graphical representation of predicted vs actual observed state is highly valuable.
- There is a preference for spatially and time resolved uncertainties at the individual feature level to convey reliability.
- Uncertainty should be tied to the data to enable the data integrator to choose how to best present the uncertainties.
- Graphical representation and easily understandable visuals are key, for example heat map portrayals, limited “clutter”, and vessel-specific presentation.
- Consistency and standards internationally are needed.

What Are Your Expectations of NOAA Support When Problems Occur With S-100 Products and Their Delivery?

- Issues require rapid communication and resolution especially where warnings and urgent information is concerned. Some client service level agreements require a response time within 30 minutes and resolution within two hours.
- Ultimately the PMN Program will need to establish 24/7 support for the S-100 product suite. This real-time support will need to be responsive, evolve with the product suite, and should include regional contacts for support.
- Data consistency and availability is critical – even if there are problems or outages, “old” data can be used if the uncertainty is properly communicated.
- The NWS may serve as a good model for both scheduled releases and intermediate updates and messages as needed.

S-100 and NOAA's Precision Marine Navigation Services Overview

Julia Powell, International Hydrographic Organization (IHO) S-100 Working Group Chair, provided an overview of S-100 and NOAA's Precision Marine Navigation Services:

- The IHO and the S-100 framework will provide international standards to ensure global consistency and interoperability for marine navigation.
- While IHO is establishing the framework, a network of intergovernmental organizations will be responsible for specific components of the S-100 product suite.
- End-users will be able to "plug and play" - selecting desired layers from any data set to seamlessly ingest and display navigational information from machine readable formats.
- The Geospatial Information Registry defines specific terms which are consistent across the full S-100 product suite eliminating possible conflicts and enabling interoperability.
- Catalog Builders collect data to meet the desired product specification and ensure consistency across all the pieces, while Feature Catalogs bind the requested product specifications together, and Portrayal Catalogs provide multiple mechanisms.
- Discovery metadata allows a navigational system to determine which data sets are required based on the parameters of the route plan and provide only those data sets that are needed, when and where they are needed, thereby minimizing bandwidth use.

High-Level Takeaways

The brainstorming and discussion sessions are summarized under each of the following category questions:

What Sort of Data Do You Need to Capitalize on Precision Marine Navigation for Trip Planning? How Will You Use This Data to Improve Trip Planning and Route Optimization?

- Essentially the complete S-100 product suite is needed to improve trip planning and route optimization, including wind, waves, tides, currents, weather, visibility, and under keel clearance.
- Using this data will allow for improved trip planning to open up sailing windows, delay traffic, optimize commerce, expand the usable channel, increase space between ships, and create new passing zones.
- There will always be a place for fixed station observations and tide tables when it comes to long term planning, however, as planning enters the 72 hours or less timeframe, the models can be an excellent tool and both can be used in parallel.
- Bandwidth remains a real concern and weighed into the cost-benefit equation for pilots.

How Important Is Water Level Trend to Your Operations?

- End users consider water level trends to be "very important" (61%) or "important" (39%) to operations and encoding this into S-104 HDF5 files will be an important component for navigation.

End Users Feedback Session

How Should We Calculate the Water Level Trend of the Model Forecast Guidance for Inclusion in the Future S-104/HDF5 Files?

- Most end users support following the PORTS® approach to water level trends which references the last 30-minutes of observations against six corresponding data points to make determinations.
- Comparing observations against forecasted levels will assist in this calculation and application.

What Level of Data Uncertainty Are You Comfortable with and How Should That Uncertainty Be Communicated/Visualized?

- Uncertainty increases over time and depends on the type of data; the user needs to know what factors to take into account, how these vary by hour, and how uncertainty degrades.
- Consistency is key to understanding and visualizing uncertainty, and Zone Of Confidence (ZOC) may be a good example.
- Visualization must be simple and clear to aid the mariner, and a dynamic mouse-over window or basic traffic light methodology are two potential approaches.

How Important Is the Robustness of Reliability in Data and Delivery Method?

- Many end users consider the robustness of reliability in data and delivery to be critically important, with 99% reliability considered the right goal particularly for real-time data (e.g. bathymetry is considered less critical).
- The level of reliability and delivery needed depends on the type of data and the accuracy of the forecast.
- Consistency over time and data on-demand are important to the future of navigation.
- Forecast models will provide near real-time updates to pilots for certain parameters on a 24/7 basis, but reliability erodes with time and mariners can revert to current practices (e.g. the traffic light methodology) if they are not comfortable with a data set.

What Is Your Expectation of Support for S-100 Operational Products From NOAA?

- End users expect to have access to training, information, and education relating to the S-100 product suite, including lectures, online videos, explanations and guidance, demonstrations, and lectures.
- Authoritative versus non-authoritative data will still be clearly indicated, and NOAA will provide digital signature to its data marking it as authoritative.
- NOAA may pursue a tiered approach with, for example, 24/7 operational support for navigational vendors, and a different tailored level of service to the recreational market, but this service model is still in development.
- NOAA will be developing toolkits, “read me” files, guidance, and opportunity for “geek to geek” detailed exchanges to educate and inform end users and other stakeholders on developments and implementation.

U.S. Committee on the Marine Transportation System (CMTS) and S-100

Heather Gilbert, U.S. Committee on the Marine Transportation System (CMTS) Deputy Director, provided an overview of CMTS and its role in S-100:

- The U.S. Committee on Marine Transportation System (CMTS) represents more than 30 federal agencies and offices and is uniquely positioned to promote federal integration and coordination across the Marine Transportation System (MTS) and advance the implementation and realization of e-Navigation.
- Key areas of focus for the CMTS include interagency coordination and engagement, waterway harmonization, river information services, e-Navigation data interoperability, raster sunsetting, PMN updates, and an update to the e-Navigation Strategic Plan among other challenges and priorities that will be addressed.
- The CMTS inter-agency roundtable is an excellent model for continued collaboration to address difficult, complex, and technical challenges stemming from the implementation of S-100.

U.S. Army Corps of Engineers (USACE) S-100 Development

Denise LaDue, U.S. Army Corps of Engineers (USACE) Inland Electronic Navigation Charts (IENC) Program Manager, provided an overview of USACE's IENCs and the agency's contributions to S-100 development:

- USACE provides data and Inland Electronic Navigation Charts (IENCs) to a vast network of inland waterways that are home to unique navigational challenges and obstacles. USACE will be making the transition to the S-100 product suite.
- The Inland ENC Harmonization Group (IEHG) is an international working group developing IENC specifications that will help facilitate safe and efficient inland navigation and transition to S-100.
- USACE works closely with NOAA and provides data and support to NOAA's ENCs through a recently streamlined process by which all USACE coastal and inland districts provide survey data directly to an Enterprise-level website for ingest; and as well as improving the data confidence to increase Category Zone of Confidence (CATZOC) ratings from B to A2 in critical areas.
- USACE data and IENCs are available in multiple formats including XML catalog through its website iencloud.us for single or combined download, however, the ultimate goal is to combine this data with all other federal navigation data in a single one-stop-shop dissemination site.
- There are real opportunities for collaboration between IENC and ENC producers as both migrate to the S-100 product suite.

High-Level Takeaways

What Is Integral for Your Navigation Customers That We Need to Include Links to From Our Marine Navigation Website?

Integral to inclusion in a future one-stop-shop marine navigation website for all federal navigation information is real-time observations (e.g. tides, water levels, currents, weather, air gap); high resolution bathymetry; training, information, and tools for users; marine zones (e.g. safety and security, whale speed reduction); warnings, statements, and discussion information; and Vessel Traffic Services.

How Should We Stay Engaged and Coordinate Across Agencies (Outside of the CMTS)?

The brainstorming and discussion sessions are summarized under each of the following category questions:

- Suggestions to stay engaged and coordinated across federal agencies (in addition to continued CMTS involvement) focused on engaging maritime academies and their students who will be future pilots; Local Harbor Safety Committees are another good source of information and potential solutions, and continued IHO support will be necessary.
- There is also a real opportunity for federal agencies to engage with industry stakeholders in provide high resolution bathymetry and digital simulations during the early planning and development stages of potential new facility developments.
- CMTS may still have additional communication opportunities that are less known which can be applied to federal agency coordination, such as regular emails, webinars, and contacts and guidance for maritime academy engagement.
- The level of resolution being used in Aids to Navigation (AtoN) and their interface with PMN should be considered, including how they will AtoNs will then be used by pilots.

Potential Gaps

After reviewing discussion highlights from all three breakout groups, the following topics emerged as potential gaps which would need to also be considered in the development of PMN:

- The future of autonomous and high-automation shipping will likely begin to enter waterways during the lifecycle of this new product suite, and these user types will need be considered and able to be integrated.
- Training simulators for testing and evaluation of NOAA navigation data product interface capabilities will be beneficial and may assist with the evolving autonomous navigation products from vendors.
- In addition to considerations of education and training for the new S-100 product suite, licensing and the mandating of carriage requirements for services also need to be addressed – all three of these components need to move together to be successful.

Continued Stakeholder Engagement

High-level takeaways from the brainstorming and discussion included:

- There are a number of recommended targets for increased PMN stakeholder engagement, including manufacturers, other international Hydrography Offices such as those in the Caribbean, commercial fishing, small businesses, Harbor Safety Committees, maritime academies, Control Centers, and marine terminal operators.
- Continued communication through NOAA OCS Navigation Managers, LinkedIn, advertisements and the website are good channels to increase awareness and engagement.
- Informational packages, guidance, and other educational materials will aid in further educating stakeholders; ride alongs may prove useful as well.
- The Annual PMN Stakeholder Workshop will continue in 2021.

Visions for the Future

The Future of S-41X Marine Weather Overlays

LTJG Hillary Fort, NOAA NWS Ocean Prediction Center Technical Operations Officer, and Joe Sienkiewicz, NOAA NWS Ocean Prediction Center Branch Chief, provided an overview of the future of S-41X and marine weather overlays:

- NWS' S-41X overlays will convey marine weather hazards, conditions, observations, and ice in a graphical format that is more user friendly and intuitive, and more dynamic to account for the complexities and rapid changes of events and aid safe navigation and route planning.
- The process of transitioning to S-41X presents an opportunity to evolve and integrate meteorological and ocean information, streamline and standardize outputs internationally, and integrate information and authoritative source data across ECS and other applications (currently still in the prototype development phase, not yet testing).
- Meteorological and product boundaries are fixed, but navigation is not – mariners need continuous seamless progression across these lines and the products that serve them need to be able to evolve to meet changing weather conditions.
- Forecasting fog capabilities will have an immense positive economic impact through greater efficiencies and route planning.

Report Out and Next Steps

The Future of Real-Time Data and Products

Christopher DiVeglio, NOAA Center for Operational Oceanographic Products and Services (CO-OPS), provided an overview of CO-OPS' contributions to the future of real-time data and products:

- CO-OPS' Physical Oceanographic Real Time System (PORTS®) provide real-time observations to 35 operational systems across the nation, serving 40% of all seaports, ~83% of all cargo value and weight; the systems reduce groundings by ~60% and property damage by ~37%.
- PORTS® continues to grow in numbers, and additional upgrades and expansions are being built every year.
- A longtime goal of PORTS® is to get its data to AIS standards for broader use and dissemination.
- CO-OPS also provides the National Operational Coastal Modeling Program (NOCMP) which provides Operational Forecasts Systems as part of the larger Coastal Ocean Modeling Suite, and the National Current Observation Program (NCOP) which updates NOAA tidal current predictions.

Closing Remarks

Julia Powell, NOAA Office of Coast Survey Program Manager, thanked the participants for their time and efforts, and reflected on some key takeaways, which included:

- Time scales are being driven down from years to hours and even minutes with S-100 as the framework and catalyst.
- All partners and stakeholders at the international, federal, developer and distributor, and end user levels have critical roles to the successful implementation of this change.
- Continue to push S-100 as part of larger IMO agenda and broaden the engagement of end users and stakeholders.
- Recognize the need to develop catalogue of catalogues for better discovery of product lines.
- There is a more clear idea of what is required from data request, real time observations, and dissemination.

Rear Admiral Shep Smith, NOAA Office of Coast Survey Director, expressed his appreciation for everyone's participation and engagement in contributing feedback to what will be building blocks in the PMN Program roadmap over the next several years. Building this coalition and these relationships will be foundational to the Program's success and to aligning with stakeholder needs.