NOAA Input to the Secretary General's Report
UN ICP 23rd Meeting
Theme: New maritime technologies: challenges and opportunities

To accelerate NOAA's next-generation ocean science capabilities, NOAA has identified six Focus Areas in emerging science and technology. The six Focus Areas will produce transformative advancements in the quality and timeliness of NOAA's maritime products and services across our mission areas. These Focus Areas are:

1. Artificial Intelligence (AI)
2. Uncrewed Systems (UxS)
3. 'Omics
4. Cloud
5. Data
6. Citizen Science

These six key science and technology focus areas guide transformative advancements in the quality and timeliness of NOAA's maritime products and services. They also help us more efficiently and effectively adopt the breakthrough science and technology applications to deliver accurate oceanographic models and to grow the American Blue Economy. These Focus Areas incorporate numerous maritime technologies that dramatically enhance our ability to explore and observe the ocean; however, to achieve these ambitious goals, it will be necessary to overcome the engineering challenges associated with developing novel technology and to enhance existing infrastructure to meet the analytical demands of emerging technologies.

1. Artificial Intelligence (AI)
The NOAA AI Strategy will dramatically expand the application of artificial intelligence (AI) in every NOAA mission area by improving the efficiency, effectiveness, and coordination of AI development and usage across the agency. As data exploitation capabilities continue to increase exponentially with improved satellite systems and architecture, unmanned systems and commercial data sources, AI methods will provide transformative advancements in the quality and timeliness of NOAA science, products, and services. Despite the progress made thus far, the true potential for AI to advance NOAA's mission has not been realized

AI examples include:

- aerial and underwater surveys from ships and autonomous platforms to assess the abundance of marine mammal and fish populations
- robotics for deep-sea exploration
- quality control of weather observations
- improving physical parameterization for weather, ocean, ice modeling, and improving the computational performance of numerical models
- aiding weather warning generation

- operation of unmanned systems for bathymetric mapping, habitat characterization, hydrologic, oceanographic, atmospheric, fishery, ecosystem, and geographic surveys
- supporting partners in wildfire detection and movement
- using machine learning (ML) for reliable and efficient processing, interpretation, and utilization of earth observations.

2. Uncrewed Systems (UxS)

NOAA Uncrewed Systems Strategy; Maximizing Value for Science-based Mission Support. The purpose of the National Oceanic and Atmospheric Administration (NOAA) Uncrewed Systems Strategy is to dramatically expand the collection and utilization of critical, high accuracy, and time-sensitive data by increasing the application and use of uncrewed aircraft and marine systems (together, "uncrewed systems" or "UxS") in every NOAA mission area to improve the quality and timeliness of NOAA science, products, and services. This will be accomplished by strengthening and centralizing key support functions, expanding UxS applications across NOAA's mission portfolio, sustaining research and accelerating transition of research to operations, expanding partnerships, and increasing workforce proficiency in UxS use and operations. UxS platforms, sensors, and architecture will expand future data-leveraging opportunities through the integration of Artificial intelligence (AI), other computing tools, and new commercial data sources.

Other documents and reports:

- **Use of Unmanned Maritime Systems** Report to Congress. Unmanned Maritime Systems (UMS) are becoming increasingly important for collecting data to support NOAA's diverse mission requirements, including fishery and hydrographic surveys, oceanographic and atmospheric observations, and information critical for marine ecosystem characterization and assessment. Additionally, UMS have become an important tool for augmenting traditional methods using manned ships and aircraft. They have proven to be particularly adept at facilitating missions in remote, data-sparse locations, hostile environments, and for sampling efforts of long duration. As a force multiplier, UMS are increasing NOAA's presence in and on the ocean, and their use will continue to grow. NOAA's use of UMS spans multiple Line Offices (LO) and includes a wide variety of maritime mission uses.

- The **NOAA-UNH Joint Hydrographic Center** develops tools and approaches that support safe navigation, increase the efficiency of surveying, offer a range of value-added ocean mapping products, and ensure that new generations of hydrographers and ocean mappers receive state-of-the-art training. The Center has found ways to process the massive amounts of data generated by multibeam and sidescan sonar systems at rates commensurate with data collection and uses advanced technology to map U.S. waters, advances technology for digital navigation services, and advances marine geospatial and soundscape expertise. This is achieved through the use of a variety of marine technologies including acoustic and lidar systems, unmanned systems for hydrographic and other ocean mapping, innovative approaches for electronic navigation charts, and developing new approaches for the application of spatial data technology and cartography.

- **Guidelines for Bathymetric Mapping and Orthoimage Generation using sUAS and SfM**, An Approach for Conducting Nearshore Coastal Mapping - NOAA and its partners published guidelines for using aerial drones to map the nearshore coastal seafloor. Several organizations need imagery and elevation and depth data to effectively manage our nation's coastlines. However, many nearshore areas are expensive, challenging, and even dangerous to map with conventional technologies, resulting in information gaps along the coastline. Drones outfitted with cameras and coupled with advanced photogrammetry techniques, such as Structure from Motion (SfM), can provide a portable, efficient, and cost-effective method to fill some of these nearshore data gaps. The new report provides the results and analyses from over 100 sUAS bathymetric mapping flights, evaluating the influence of airframes, sensors, environmental conditions, and processing procedures.

Examples of UxS:

- **Saildrones to observe hurricanes in real time**: Saildrones are uncrewed surface vehicles powered by wind and solar energy and remotely piloted. The saildrones are able to transmit data back in real time to agencies that will use it to predict hurricane paths and intensities. For this project, several specially constructed saildrones have been fitted with short wings best suited for handling hurricane-force conditions. The 2022 Saildrone Hurricane Observations Mission report summarizes the accomplishments and lessons learned from the seven saildrones that were deployed in 2022.

- **Autonomous surface vehicles (ASVs) for hydrographic surveying**: ASVs include self-driving cars to camera-equipped drones and have been used to support hydrographic survey operations since 2004. The goal is to explore how autonomy provides more efficient and effective acquisition of environmental data to support NOAA's navigation products and services.

- **CO-OPS' Real-Time, Shallow Water CURrents BuoY (CURBY):** These programs provide tide and current predictions, as well as real-time current and meteorological information. Outdated current predictions, navigational support requirements, and incident response scenarios (e.g., oil spills, vessel accidents) have highlighted CO-OPS' need for a rapidly deployable system that provides near-surface current and meteorological observations. To address this, CO-OPS designed, developed, and tested a real-time system based on a surface buoy platform, hereinafter referred as CURrents BuoY (CURBY). This paper provides an overview of the system design, field test results, operational applications, and future plans.

- **Finding and Tracking a Phytoplankton Patch by a Long-Range Autonomous Underwater Vehicle** - The dynamic nature of the ocean, including its many chemical and biological processes, makes it challenging to monitor microscopic, marine algae in real time, but NCCOS-funded scientists have shown it can be done. A new, NCCOS-funded publication describes how a group from the Monterey Bay Aquarium Research Institute (MBARI) designed an underwater glider that can independently find and follow patches of phytoplankton. The researchers developed a kind of olfactory-based search mechanism that allows a self-propelled, long-range autonomous underwater vehicle (LRAUV) to detect the phytoplankton's chlorophyll and steer toward rising concentrations associated with algal blooms.

- **Buoy equipped with wave sensor and acoustic Doppler current profiler** (ADCP): can be a useful system design option for many different coastal ocean measurement applications

- **Passive Acoustic Monitoring of marine mammals using gliders**: 2014 report, 2015 report, 2016 report, 2021 report and numerous published papers (examples for beaked whales, for fin whales, and using autonomous hydrophones)

3. 'Omics

The NOAA 'Omics Strategy: Advances in 'omics methodologies can improve the ability to monitor and understand the biological communities of the oceans. 'Omics approaches can be faster, cheaper, less invasive, and can provide more information than traditional methods, and thus result in improved delivery of NOAA products and services. As such, techniques such as high-throughput DNA sequencing and subsequent bioinformatics analyses can aid national priorities including: fisheries management, aquaculture development, food and water safety, species and habitat conservation, seafood consumer protection, and natural products discovery.

Examples of 'Omics:

- Indicate ecological status, with monitoring used to inform and track the efficacy of management actions by measuring biodiversity, population distributions, food web function, and organism abundance.
- The analysis of "environmental DNA" **(eDNA)** can be used to characterize life forms that range from microbes to mammals, using a single sample of seawater or sediment without the need for slow sorting and counting methods. NOAA uses eDNA to measure biodiversity and identify the presence of invasive species.

4. Cloud

The NOAA Cloud Strategy defines a strategy to guide NOAA's adoption and utilization of cloud services. The strategy establishes a default architectural end-state for NOAA's cloud services, provides a unified approach to migrating to the cloud, promotes a smart transition based on requirements, business cases and best practices, and enables broad sharing of solutions. The strategy recognizes the inherent risks of the adoption and utilization of cloud services, including the risk of unintended consequences. For example, the risk profile for operational prediction models and computers differs from that of research and other applications, which the supporting IT infrastructure needs to account for. To mitigate this and similar risks, the strategy calls for strong cloud governance to establish and manage change to the technical baseline, and a smart migration that includes a thorough and objective evaluation of viable architectural alternatives from a cost, schedule and performance perspective. Additionally, careful and deliberate consideration of other factors that could introduce unintended consequences is critical.

Examples of Cloud computing:

- The **Open Access GTS project**, or Open-GTS, increases the exchange of near real-time data with operational and forecast services. The Open Access to GTS (Open-GTS) project aims to ease the sharing of this marine data via the WIS/GTS and, by doing so, increase the amount of marine data available for real-time forecasts. This WMO data conference poster demonstrates the methods and benefits of the Open-GTS workflow. Through the support of the GOOS Observations Coordination Group (OCG), a successful pilot project showcased the Open-GTS workflow, demonstrating that the framework eased the process for globally distributing the data. The Open-GTS is now moving to an operational phase, with the workflow being used to distribute Saildrone data, and is currently being integrated into the operational processes of the US Integrated Ocean Observing System (IOOS).

5. Data

The purpose of the NOAA Data Strategy is to dramatically accelerate the use of data across the agency and with other key partners, maximize openness and transparency, deliver on mission, and steward resources while protecting quality, integrity, security, privacy, and confidentiality. The overall strategy is designed to serve as a framework for consistency that builds upon existing laws and regulations related to how NOAA uses and manages data, while being flexible and adaptable to external influences such as new policies, Executive Orders, stakeholder input, and new technologies that drive innovation within the agency

Examples of data repositories:

- Saildrone data

6. Citizen Science

The NOAA Citizen Science Strategy outlines a path for the agency to engage the public in support of key mission areas. Citizen science as well as crowdsourcing, and challenge competitions all provide opportunities for the agency to engage the American public, address societal needs and accelerate science, technology, and innovation. New and emerging technologies, a growing field of practice and a better connected public are rapidly enhancing citizen science as a powerful tool for research and monitoring. NOAA is well positioned to leverage and contribute to this growth and harness the power of the crowd.

Other examples of maritime technologies:

The **NOAA Office of Exploration website** lists a number of marine exploration tools that NOAA employs to research the oceans. Today's technologies allow us to explore the ocean in increasingly systematic, scientific, and noninvasive ways. With continuing scientific and technological advances, our ability to observe the ocean environment and its resident creatures is beginning to catch up with our imaginations, expanding our understanding and appreciation of this still largely unexplored realm. Technologies include platforms such as vessels and submersibles, observing systems and sensors, communication technologies, and diving technologies that transport us across ocean waters and into the depths and allow us to scientifically examine, record, and analyze the mysteries of the ocean.

NOAA Draft Research Strategy on Carbon Dioxide Removal (CDR): This document focuses on NOAA's potential role in CDR and how its mission and capabilities map to specific CDR needs. CDR is currently in its infancy, as are NOAA's efforts to support it. NOAA has a suite of capabilities that can be applied to understand and assess CDR and understand its impacts on ecosystems and society. In this report, we outline some key 15 established techniques for carbon dioxide removal in land, marine, and coastal settings; discuss how these techniques intersect with NOAA's existing research mandates; and, finally, discuss what a mature CDR research and assessment strategy might look like at the agency. What becomes readily clear is that NOAA's climate and carbon cycle research are already foundational, respected, and world class. We now need to put these assets to work to address carbon dioxide removal as a key component of climate crisis adaptation and mitigation.

Other themes related to maritime technologies:

Transitioning emerging marine observing technologies to operations: The IOOS Ocean Technology Transition program sponsors the transition of emerging marine observing technologies, for which there is an existing operational requirement and a demonstrated commitment to integration and use by the ocean observing community, to operational mode. Transitioning marine observing technology to operations will result in improved ocean, coastal, and Great Lakes observing capabilities that are critical for helping us understand our ocean, coastal, and marine environments and improve environmental intelligence for decision making.

Using engineering for education: If it weren't for our satellites, buoys, planes, and ships, NOAA wouldn't have nearly the amount of data it does today. That's why technology and innovation are key ingredients for cutting-edge science. This education resource includes a collection of lessons, mobile apps, videos, data, and more, you can learn how NOAA uses technology and engineering to get the job done.

Spatial modeling to identify offshore wind energy locations: NOAA NCCOS, in partnership with the Bureau of Ocean Energy Management (BOEM), built a spatial model to identify optimum locations for offshore wind energy in the Gulf of Mexico. The coastal ocean is busy, and finding the right spot for new industries is challenging. With hundreds of data layers on natural resources, existing industries, areas important for national security and conservation, spatial analyses provide powerful insights about the past, present, and future ocean. The NCCOS spatial model provided BOEM with new analytical capabilities, increased transparency, reduced impacts to fisheries and endangered species, and resulted in stronger stakeholder support for wind energy in the Gulf of Mexico.