

NOAA Uncrewed Systems Strategy

Maximizing Value for Science-based Mission Support



National Oceanic and Atmospheric Administration
U.S. Department of Commerce



NOAA Science & Technology Focus Areas:

Uncrewed Systems ■ Artificial Intelligence ■ 'Omics ■ Cloud ■ Citizen Science ■ Data **Revised September 2020**



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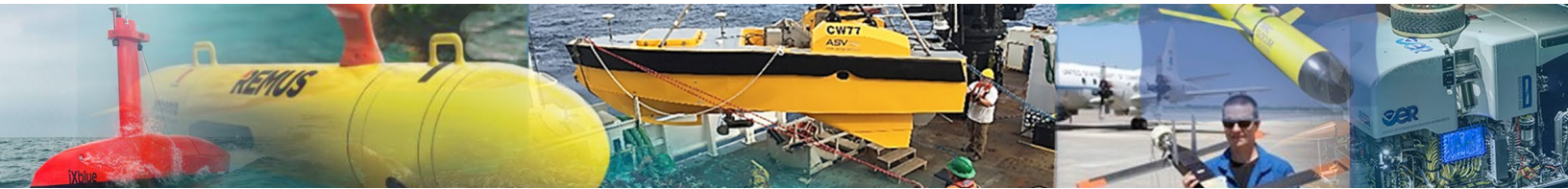
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The purpose of the National Oceanic and Atmospheric Administration (NOAA) Uncrewed Systems Strategy is to dramatically expand the collection and utilization of critical, high accuracy, and time-sensitive data by increasing the application and use of 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.



Background

The use of UxS is not new to NOAA. Our scientists and engineers have been experimenting with vehicles, robotics, portable and miniaturized sensors, power sources, and communications—and delivering operationally capable systems—for decades. In fact, NOAA’s ability to meet its mission relies on a continuous process of testing and evaluation of new technologies that routinely deliver new applications into operational and sometimes commercial use. The recent rapid expansion in availability of UxS, fueled in part by NOAA scientists and discoveries, has brought a corresponding increase in their innovative use as a force multiplier for many NOAA programs—augmenting data collection often at lower cost, increased safety, and reduced risk, especially in remote or extreme environments. Examples include hydrographic and habitat mapping, ocean exploration, marine mammal and fishery stock assessments, emergency response, and at-sea observations that improve forecasting of extreme events, such as harmful algal blooms and hypoxia.

The NOAA UxS Strategy aligns with FY 2020 President’s Budget (PB) funding for a centralized NOAA UxS Operations Program, and the bipartisan Commercial Engagement Through Ocean Technology Act of 2018 (CENOTE, P.L. 115-394) that requires NOAA to coordinate research, assess, and acquire uncrewed maritime systems with the U.S. Navy, other federal agencies, industry, and academia. The strategy will complement and support existing priority NOAA initiatives such as the NOAA Ecological Forecasting Roadmap. The strategy also supports provisions of the Weather Research and Forecasting Innovation Act of 2017 (P.L. 115-25) and its 2019

reauthorization (P.L. 115-423) which provide for weather research and forecasting improvements—including the use of uncrewed systems. This strategy also supports the November 19, 2019, presidential memorandum “Memorandum on Ocean Mapping of the United States Exclusive Economic Zone and the Shoreline and Nearshore of Alaska.” Lastly, this strategy supports the Department of Commerce Strategic Plan for 2018-2022, and will accelerate NOAA’s top two priorities to (1) regain world leadership in global weather modeling through establishment of the Earth Prediction Innovation Center, and (2) sustainably grow the American Blue Economy.

Vision

NOAA is the national and global leader in UxS operations that support science, public safety, and security.

Goals and Objectives

These goals and supporting objectives are intended to directly improve the understanding, coordination, awareness, and application of UxS at NOAA. This includes a strong supporting environment for investigations on experimental and innovative UxS uses and designs that advance NOAA’s research and operational applied science missions. The result will be transformational advances in every mission area.



NOAA Ship *Ferdinand R. Hassler* crew recover the Office of Coast Survey's Hydroid REMUS 600 UUV after completion of a bathymetric mapping mission. This vehicle can operate for 20+ hours at depths up to 450 meters while maintaining acoustic communications with the host ship. Photo credit: NOAA/OCS.

What Are Uncrewed Systems?

Uncrewed systems are vehicles—airial, terrestrial, or marine—and associated elements, such as sensors and communications software, that can execute data-collection missions without a human presence aboard.

They are typically controllable or programmable, self-powered, untethered, and operate on a continuum from attended to fully autonomous. This strategy also includes Remotely Operated Vehicles which are typically deployed from ships and receive power and operator instructions from a tether.

GOAL 1. Coordinate and Support UxS Operations at an Enterprise Level.

Improving overall coordination of UxS while, in parallel, prioritizing these systems in budget formulation, strategic communications, and Information Technology (IT) investments, such as cloud computing applications, will rapidly increase UxS use and value across NOAA.

Objective 1.1. Establish an Effective and Adaptive Organizational Structure.

New capacity is needed to support the rapidly expanding use of UxS across NOAA in order to raise safety standards, increase efficiency, and promote the economical operation of UxS across the agency. To effect this, NOAA will establish a new uncrewed systems operations program within the Office of Marine and Aviation Operations to provide centralized support, and to improve coordination of UxS activities across the agency in alignment with the existing NOAA UxS Executive Oversight Board. Recent NOAA advances in the governance and resourcing of uncrewed aircraft systems (UAS) activities and the current NOAA small boat program provide useful examples. The purpose of the program will be to provide higher quality, cost-effective services at faster cycle times that result in higher operational performance and safety than any individual NOAA office or program can provide for itself.

Objective 1.2. Identify and Deliver Priority Core Services Including Cybersecurity, Training, and Acquisition.

As the pace and scope of UxS activities expands, so does the need for a centrally organized core set of expert support services to ensure safe, cost-effective and compliant operations. Cybersecurity is perhaps the most pervasive and complex example for UxS operators and their IT support staff to navigate, requiring significant time and expertise. Other examples are certification training, standard acquisition protocols for platforms and related services, such as data buys or leasing, access to pre-approved vendors, use of standards, and proven techniques to increase system interoperability and security, and maintenance, such as sensor calibrations, to keep platforms in top condition.

Objective 1.3. Implement an Innovative, Robust, and Encompassing UxS Data Enterprise.

A functional and adequately resourced data enterprise that accommodates moving large volumes of quality-controlled UxS-generated data to shoreside processing and storage centers—and that significantly increases the quantity, quality, and throughput of these data—is essential to the success of NOAA's UxS Strategy. This will require fully leveraging NOAA's Cloud Strategy working in close partnership with data users, NOAA's Environmental Data

Management Committee, and Big Data Project on cloud storage and computing and use of AI, and overall compliance with existing NOAA data management directives on governance, stewardship, access, and use. These protocols are essential for the effective and timely execution of NOAA's mission priorities.¹

NOAA Uncrewed Systems Strategy

Goal 1: **Coordinate and Support UxS Operations at an Enterprise Level.**

Goal 2: **Expand UxS Applications Across NOAA's Mission Portfolio.**

Goal 3: **Accelerate Transition of UxS Research to Applications.**

Goal 4: **Strengthen and Expand UxS Partnerships.**

Goal 5: **Promote Workforce Proficiency in UxS Use and Operations.**



NOAA research biologists, Katie Sweeney and Dr. Brian Fadely, deploy a hexacopter to monitor depleted northern fur seal populations with minimal disturbance. UxS can be ideal for marine mammal monitoring in difficult-to-traverse environments, such as the remote Aleutian Islands, at reduced cost and risk to scientists. Photo credit: NOAA Fisheries, Alaska Fisheries Science Center.

¹ The NOAA Uncrewed Systems, Artificial Intelligence, 'Omics, and Draft Cloud Strategies are available at <https://nrc.noaa.gov/NOAA-Science-Technology-Focus-Areas>.



GOAL 2. Expand UxS Applications Across NOAA's Mission Portfolio.

The overarching intent of this goal is to significantly increase the quantity and quality of UxS use within NOAA operations and with our partners.

Objective 2.1. Establish A Requirements-Based Process to Prioritize UxS Operational Applications and Use.

Concentrating on mission-driven research and operational applied science requirements that can benefit from UxS, particularly for meeting observational gaps and new capabilities, will be useful to identify and prioritize new and potentially valuable applications. While increased efficiency, reduced costs, and improved safety are also important factors, transformational change via UxS will continue to be largely driven by NOAA scientists investigating new capabilities to meet science needs and, where feasible, transitioning those discoveries to operations. Sharing the list of priority applications with government, academic, and industry partners will facilitate recommendations for leveraging access to commercial and other assets to support NOAA science priorities.

Objective 2.2. Establish a Thriving UxS Community of Practice at NOAA.

Promoting the expanded and innovative use of UxS across the full scope of NOAA's earth science missions will expand the community of practice where UxS operators and data users connect across the agency on common ways to develop, acquire, test, configure, manage, and utilize new systems. This could include developing and implementing the requisite companion policies, procedures, and regulations to support field operations, and possibly requiring funded partners to track progress in the use and applications of UxS performed or supported annually. In addition, NOAA will work with regulators to propose and coordinate on streamlined procedures for the use of UxS, especially during emergencies where rapid deployment of personnel and assets is required.

Objective 2.3. Institutionalize Operational Applications Through Formal Concepts of Operations.

Formal concepts of operations (CONOPS) describing UxS operational applications to NOAA mission priorities will ensure efficient and reproducible operational methods, including flexibility to adapt and align to potentially radically different approaches like working beyond line-of-sight or operating swarms of platforms. CONOPS may also describe allocation pools to share UxS assets similar to provisioning of NOAA ships and aircraft to help ensure the greatest number and highest priority of mission requirements are satisfied. Integrating these diverse operational modes into an overall NOAA UxS CONOPS will improve consistency of operations, and provide a template for partner organizations. The CONOPS will include language that states NOAA will operate UxS assets in a safe and secure manner in compliance with all relevant environmental laws, ensuring that operations do not interfere with individual privacy rights or adversely



NOAA's U.S. Integrated Ocean Observing System Program partnered with the U.S. Navy and Shell Oil Co. to share data from over 20 gliders deployed in the Gulf of Mexico in 2018. Salinity and temperature data from gliders can improve hurricane intensity forecasts. Photo credit: DVIDS/Jennifer Ervin.

impact protected species or sensitive environments, such as wildlife preserves, national parks and monuments, and historic and cultural sites.

GOAL 3. Accelerate Transition of UxS Research to Applications.

The intent of this goal is to rapidly accelerate transition of new and emerging UxS to NOAA operations (R2O) and private-sector commercialization (R2C – together R2X).² This will include matching capabilities to requirements. This will also include support to expand the public-private-academic research partnerships to investigate tailoring commercial technologies to our missions in a manner consistent with NOAA policies for identifying, transitioning, and coordinating research and development output to operations, applications, commercialization, and other uses.

Objective 3.1. Identify and Prioritize Candidate UxS Platforms for NOAA Use.

NOAA's research community has been engaged in pursuing this objective, and this strategy will enhance the efforts and support the innovation to build on past success. Matching NOAA's priority applications of UxS (Obj. 2.1.) to a preliminary "best fit" of available and emerging commercial platform specifications is an important step towards operational use. Examining how platform choices were made for current NOAA UxS activities will be a useful starting point. Support for extending the research and development efforts to identify, test, evaluate, and incorporate NOAA mission-dependent sensors is necessary. External recommendations in response to published NOAA priority applications will also be helpful. Products with the most tightly integrated payloads may be most desirable for many uses until flexible, and easily configured payloads for multiple missions are possible. Encouraging trials of standardized modular open UxS system architectures and implementations will help accelerate the emergence of these type of systems. Participation in

² The UxS Strategy is inclusive of "R2X" considerations, i.e., Research to Operations, to Applications, and to Commercialization, as well as the feedback to Research. As such, the UxS Strategy is meant to consider the full R2X2R feedback of activities.

annual technology demonstrations such as the US Navy's Advanced Naval Technology Exercise (ANTX) will also help NOAA identify new technologies for meeting mission requirements.

Objective 3.2. Develop Transition Plans With Operational Partners.

For this strategy, accelerating transition is aimed primarily at existing and emerging commercial platforms with significant potential for operational use in support of NOAA missions. Transition plans for candidate platforms should be consistent with NOAA administrative policies. Transitions to operations shall be reflective of a broad-based community outreach, and include Line Office Transition Managers, NOAA field researchers and engineers, and partners from industry, academia, and other government organizations. Plans should outline steps for technology transfer, and identify the varying sponsorship of resources throughout the evolution of technology from inception to acceptance for operations. Combining technologies may speed transitions. For example, the integration of AI with airborne or maritime platforms may significantly improve autonomous navigation, collision avoidance, target recognition or other on-board decision-making, dramatically increasing mission efficiencies.

Objective 3.3. Conduct Systematic Testing and Evaluation to Ensure High Performance.

Performance testing and evaluation is a proven and essential process in NOAA that necessarily precedes operational use in order to clarify and validate design specifications, as well as to develop and test operating concepts. This includes calibration of key instruments or sensors, evaluating alternative configurations and payloads, and field trials to monitor overall vehicle-plus-sensor system performance. This process may include simultaneous testing of two or more platforms in combination with traditional data collection methodologies such as ships, to compare results, and could potentially be conducted in partnership with other government or academic stakeholders and at designated test "ranges" operated by the U.S. Navy or other organizations as suggested in CENOTE. These and other practices have proven valuable for NOAA and shall be sustained or expanded.

GOAL 4. Strengthen and Expand UxS Partnerships.

Cooperative and extramural partnerships, including federal-state collaborations, various owner-operator models, and conventional cooperative research and development agreements or CRADAs—or perhaps even some new innovative technology development alliances—all serve as force multipliers to optimize resources and effort. The resulting scientific and technological exchange keeps NOAA current in the rapidly evolving field of UxS. Current collaborations on UxS applications, such as the U.S. Integrated Ocean Observing System network of partners, have already created a community of practice at NOAA that is sparking innovation and has the opportunity to accelerate tremendous advances in our observing capabilities. Building the operational capability and organization is the root of this strategy, but

research and development will remain important. Partnerships are the vital accelerator.

Objective 4.1. Increasingly Leverage Interagency Integration.

Expanding partnerships with agencies, nationally and internationally, through formal MOUs or other vehicles, particularly those with shared mission objectives and operating environments, will strengthen best practices in areas such as UxS testing and evaluation, training, and operations. The U.S. Navy will be an increasingly important collaborator in this enterprise as directed by CENOTE. Other key Federal partners include the U.S. Coast Guard, National Aeronautics and Space Administration (NASA), and the Departments of the Interior and Energy.

Objective 4.2. Reinforce Cooperation With Academia.

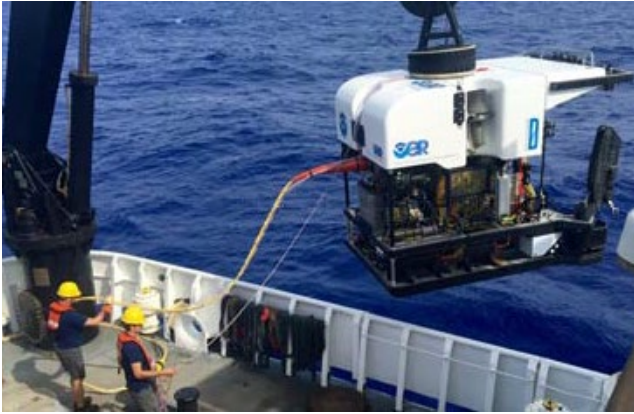
Strengthening UxS collaboration with academic institutions will include working with NOAA's Cooperative Institutes, and further utilizing the National Oceanographic Partnership Program (NOPP), which enables federal agencies to leverage resources for investment in priorities that fall between agency missions or that are too large for any single agency to support. As described in CENOTE, NOAA may also elect to co-locate operations or research activities with academic partners to share best practices, conduct joint training, or facilitate commercialization of technologies.

Objective 4.3. Dramatically Grow Partnerships With the Private Sector.

Partnerships with industry to research and develop the design and use of UxS is a key provision in CENOTE and can be expanded through multiple mechanisms. These include CRADAs, increased use of NOPP, Small Business Innovation Research grants, contracts, cross-agency agreements, and other vehicles as appropriate to increase and accelerate collaborations, support commercialization, assist with assessments of commercially available UxS, and participate in cooperative investigations. Iterative demonstrations and field trials of industry technologies, and evaluation of acquisition alternatives, e.g. government owned/operated, industry owned/operated, leasing, and data or product buys have proven successful and important. Through these collaborations, NOAA will also grow advocacy and awareness of UxS mission priorities.



NOAA's Office of Coast Survey and the University of New Hampshire's Center for Coastal and Ocean Mapping/Joint Hydrographic Center are working with iXblue to evaluate the "DriX" USV as a force multiplier by working in tandem with research ships to increase rates of ocean-bottom mapping. Photo credit: iXBlue.



Deploying the ROV Deep Discoverer from the NOAA Ship *Okeanos Explorer* for a NOAA Office of Ocean Exploration and Research project to map and characterize deepwater areas in and around the Marianas Trench Marine National Monument in 2016. Photo credit: NOAA OER/Diva Amon.

GOAL 5. Promote Workforce Proficiency in UxS Use and Operations.

Increasing UxS proficiency will equip our workforce to fully leverage the rapidly evolving field of UxS. This can only be achieved by providing continuous, current, creative, and tailored training and learning opportunities. NOAA's existing development programs are well-suited to be adapted for these, and we will look to partners for new options to develop skill, understanding, and expertise.

Objective 5.1. Expand Recruiting Efforts to Showcase NOAA UxS Activities.

Current NOAA employees and experienced academic and industry candidates are the best source of new recruits, including pilots, mariners, engineers, materials scientists, IT and policy specialists, oceanographers, meteorologists, and marine biologists. Assignments through the NOAA Rotational Assignment, student internships, and the Leadership Competencies Development Program will enlist cross-office experience and raise overall skills. External recruiting can include targeting NOAA Sea Grant and Presidential Management Fellows, Interagency Personnel Assignments, cross-agency/institution exchanges or details, Interservice Transfers to the NOAA Corps, and other similar post-graduate and mid-career opportunities.

Objective 5.2. Establish Formal Training and Certification.

Course work and hands-on practicums developed and taught by academia, industry, and government ensures up-to-date knowledge, supports safe operations, and builds career paths. This includes plain-language guidance for support staff and technical curricula for mission specialists, such as pilots and engineers on operations, safety, maintenance, cybersecurity, privacy, and legal/regulatory compliance. Working with established training programs will expedite integration. This knowledge and experience should be shared and collaboratively editable across NOAA line and staff offices for general practices that apply to UxS equipment or platforms that are used in varied missions. Temporary assignments with UxS

developers and users outside NOAA will sharpen skills and build partnerships. Involving graduate and undergraduate students with developing applicable technologies will also build a stronger pipeline of skilled UxS engineers, scientists, and managers and help ensure the long-term sustainability of NOAA's technological proficiency and the science workforce as a whole.

Objective 5.3. Include NOAA UxS Assignments as a Retention Tool.

Training and hands-on opportunities to operate and/or support UxS activities with NOAA and our partners exist across NOAA's mission portfolio to all corners of the nation and across the globe. For example, the University of Southern Mississippi's School of Ocean Science and Engineering offers an Unmanned Maritime Systems Certificate Program to train undergraduates in vehicle operations and basic oceanography. Skilled NOAA personnel will have opportunities in routine mission support—and discovering UxS methods and applications we have not yet imagined. Establishing UxS career paths—from entry-level technicians to senior scientists, managers, and mission specialists for civilians and uniformed officers of the NOAA Corps—is also essential for retaining skilled personnel.

Conclusions

To ensure the NOAA Uncrewed Systems Strategy realizes transformational advances in performance, skill, and efficiency, NOAA is developing a companion UxS Strategic Implementation Plan or "Roadmap" that will define detailed action items, deadlines, and responsibilities scaled to potential available funding levels. Meanwhile, NOAA's use of uncrewed systems is already significantly improving performance in our lifesaving and economically impactful missions, and setting the course to strengthen our renowned environmental science and technology leadership for the coming decades. Together with our advances in NOAA's other science and technology focus areas—AI, 'Omics, and Cloud Computing—NOAA will achieve our top agency priorities to regain global leadership in numerical weather prediction and sustainably expand the American Blue Economy.



The L3 Latitude is a hybrid quadrotor UAS that combines vertical takeoff and landing with the speed and range of a fixed-wing aircraft. NOAA is testing it for launching from a ship for climate and air quality studies, fishery and mammal surveys, weather observations, oil spill detection, and post severe weather damage assessments. Photo credit: NOAA PMEL/Trish Quinn.



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Acknowledgements

The NOAA UxS Strategy is led by Timothy Gallaudet, Ph.D., Rear Admiral, U.S. Navy (Ret.), Assistant Secretary of Commerce for Oceans and Atmosphere / Deputy NOAA Administrator. Charles Alexander, on detail from the NOAA Office of Marine and Aviation Operations, is coordinating the overall process in collaboration with the NOAA UxS Strategy Team (below) and the NOAA UxS Executive Oversight Board. NOAA is also grateful for the many generous and thoughtful comments received during the Public Comment period. This strategy includes revisions based, in part, on comments received.

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