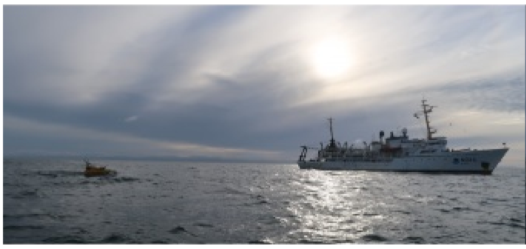
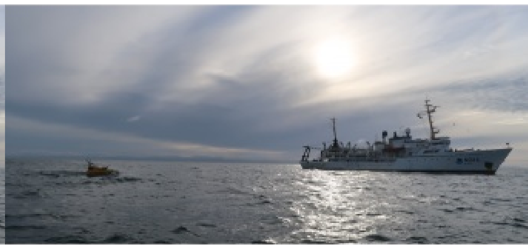
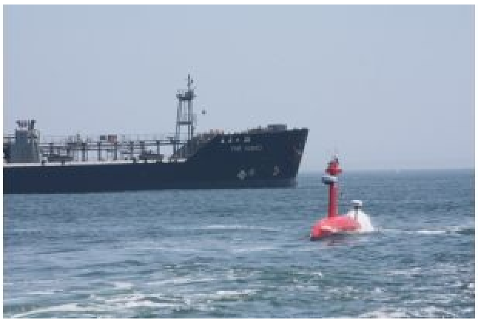
CRITICAL COMPONENTS OF HYDROGRAPHIC EFFORTS

The case for hydrographic survey vessels in uncrewed vessel operations





The state of the art in autonomous surface vehicles has evolved tremendously, and these technologies will revolutionize the field of hydrography. However, our experience shows that developing these systems to their full capabilities while fulfilling NOAA’s hydrographic needs will continue to require the support of capable hydrographic ships.



Since 2015, the Center for Coastal and Ocean Mapping (CCOM) at the University of New Hampshire has deployed autonomous surface vehicles (ASVs) from NOAA Ship *Fairweather* (2018), Exploration Vessel *Nautilus* (2017, 2018, 2021, 2022 x 3), NOAA Research Vessel *Shearwater* (2017) and NOAA Ship *Thomas Jefferson* (2019 and 2022). The Center has also deployed ASVs from shore in NOAA’s Thunder Bay National Marine Sanctuary (2019 and 2021) and in countless day deployments from its own vessel and from shore off the New Hampshire coast. CCOM owns two ocean-capable, diesel-powered ASVs, works closely with manufacturers of sail-powered ASVs and is at the forefront of active research and engineering focusing on the practical application of ASVs in marine science and hydrography. CCOM is also proud to maintain close collaborations with many corporate partners, working to solve the challenges of creating practical robotic hydrographic survey platforms. Few are more excited about the revolution that these technologies will bring to the field of hydrography than the engineers and scientists now routinely conducting these operations.

Best practices

In a 2020 technical paper published in the *International Hydrographic Review* (IHR), CCOM presented best practices for ASV operations in hydrographic surveys (see *Hydrographic Survey with Autonomous Surface Vehicles: A Best Practices Guide,* IHR, 2020). This paper built on a 2015 workshop hosted by the National Oceanic and Atmospheric Administration’s (NOAA) Hydrographic Systems and Technologies Branch (HSTB) to explore and evaluate the state of the art of autonomous systems.

At this workshop, attendees defined a set of *practical* autonomy levels to provide a common understanding in discussions, and mapped these to real-world operating conditions. It became clear that any given mission, operating environment, vehicle level of autonomy and level of supervision determines a level of risk, which is broadly defined as risk to property and personnel as well as risk of failing to achieve the mission. No operation is risk-free, and therefore the IHR paper sought to make recommendations to mitigate the risks involved in operating uncrewed systems.

Figure 1: The Center for Coastal and Ocean Mappingâ€™s C-Worker 4 ASV, BEN, deployed from NOAA Ship Fairweather in the vicinity of Point Hope, Alaska.

The paper described the great variability in operating environments at sea, the ability of autonomous systems to perceive and safely navigate that operating environment and the need for operators to continuously adjust their level of supervision accordingly. Participants in the workshop noted that caution is warranted in uncrewed operations when the mission is complex, the operating environment harsh and the level of autonomy low. As the paper described:

“Even fully *Attended* operation [over a telemetry link] may not be a high enough level of supervision, particularly if the ASV’s sensors and operator interfaces do not provide good situational awareness. In this case, additional monitoring can be provided by limiting operations to within visual line of sight or with other ancillary systems. In some cases, any ASV operation may be deemed too risky altogether.”

The considerable increase in recent years in the capability of uncrewed systems to perceive and react to hazards will continue. However, only by marrying uncrewed systems with local shipboard or shore-based operators and support personnel can supervision of these systems be adjusted to ensure safe operation over the range of environments required to make them useful or, if necessary, recover the uncrewed systems altogether. Therefore, maintenance of a hydrographic fleet of ships capable of collecting high-quality data, and husbanding these uncrewed vessels through the development of more advanced capabilities, is critical.

Level of reliability

At this inchoate point in industry development, the chance that a failure will require human intervention is relatively high compared to traditional vessels. Experience shows that uncrewed systems can struggle to accurately perceive the operating environment, can suffer from system failures in both hardware and algorithms more frequently than crewed vehicles, and contain sensors not necessarily designed for robotic systems or robotic sensors not designed for operation at sea. The loss of a single cable connection, trivially resolved by a human operator, can render an autonomous system wholly unable to complete a mission. In the worst case, when human operators are not available to intervene, simple failures can lead to navigational or environmental disasters. For systems intended to operate for long periods of time, deployed far from human operators, the level of reliability must greatly exceed that of the crewed vessels to be effective. The rapid pace of new and untested systems and the relatively low volume of production of robotic vessels, combined with the expense of testing these systems in a variety of conditions at sea, have not yet afforded the industry the opportunity to fully engineer and demonstrate solutions for high reliability.

Figure 2: DriX-8, operated by the Center for Coastal and Ocean Mapping, during dead-vehicle recovery training with the crew of the E/V Nautilus.

There is a subset of uncrewed systems that scavenge power from the wind, waves or sun, operate at slow speeds and offer high endurance. Systems of this kind, operating in remote areas without on-site crewed vessel support can, however, also have operational drawbacks. The limited power available to these systems can translate to limited navigation authority in the presence of ocean currents and limited payload operational times, negatively impacting the survey objectives. In addition, the power constraints often support relatively limited telemetry, limiting the ability of operators to maintain full situational awareness and quickly assess hazards, which requires limiting operations to maintain adequate safety. The long deployment times required of these systems increase the chance a failure will occur. When it does, any savings accrued by not deploying shipboard assets locally can be lost in the response to a few faltering uncrewed systems in distant locations. For this reason, the real costs of operating these systems for long periods of time in remote areas are yet to be fully understood.

Conclusion

While the goal of fully autonomous survey systems operating efficiently for long periods of time is one we aspire to, the realistic vision for uncrewed systems is, at present, one that extends the capability of crewed systems to more nimbly and more cost effectively meet the Nation’s survey needs. Crewed ships remain, for the foreseeable future, critical components of the Nation’s hydrographic efforts to ensure safe and responsible operation in all conditions. While the marine robotics industry has made great strides in these endeavours, it is not in the Nation’s interest to forsake the shipboard resources that put operators and support teams in the local operating area of uncrewed systems and ensure the ability to meet the Nation’s hydrographic needs as we build towards a future of truly autonomous operations.

Figure 3: DriX-12, owned and operated by NOAA, during sea acceptance testing at University of New Hampshire facilities in the summer of 2022.