ROBOT 🤖 REVOLUTION

Autonomous Survey Platforms are Accelerating Global Seafloor Mapping and Increasing Hydrospatial Awareness

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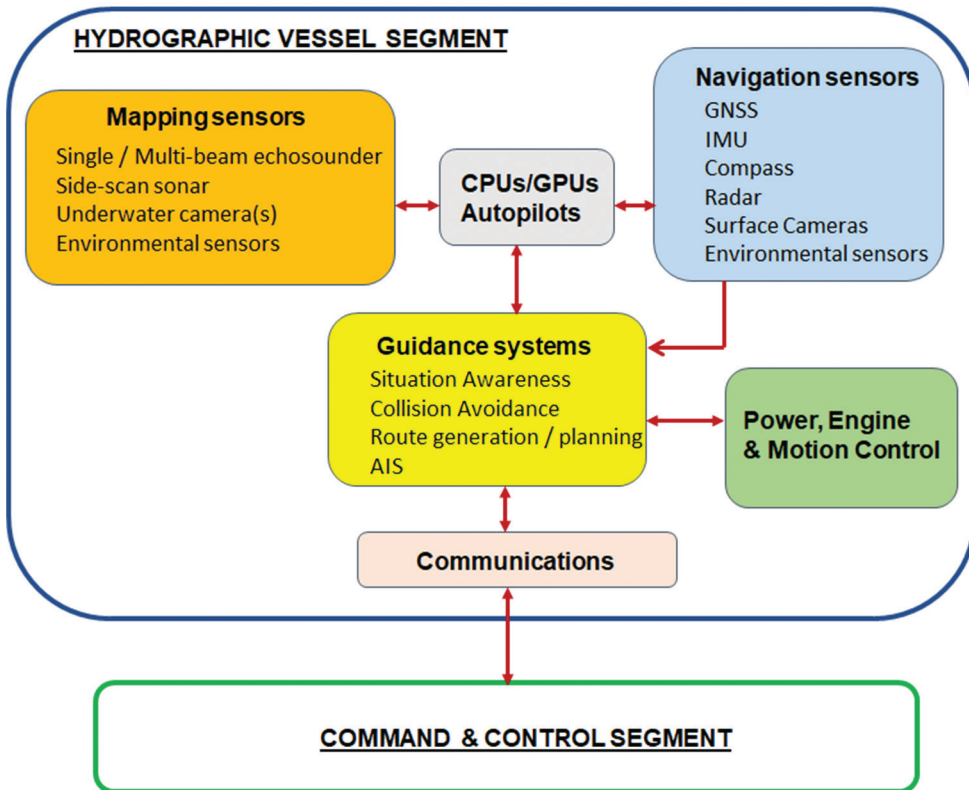
Force Multipliers

Today, innovative new technologies are being leveraged to collect ocean mapping, hydrospatial, and ocean observing data at lower costs through increased speed and decreased human resources per unit area surveyed. Some modern sensor payloads have a sufficiently small size and low power consumption to allow their use in uncrewed operations by satellite instruments, uncrewed aerial vehicles (drones), autonomous surface vehicles (ASVs), autonomous underwater vehicles (AUVs), and other machines. The conceptual configuration of an uncrewed marine vessel (UMV) for hydrographic surveys is shown in Figure 1.

ASVs and AUVs can be less efficient at mapping large areas than a ship due to their reduced operating speeds and the range limitations imposed by their onboard power supply. Therefore, the best near-term application of these autonomous vehicles is as "force multipliers" with multiple robots working in tandem, occasionally returning to a crewed "mothership" for maintenance and recharge. The Nippon-GEBCO Seabed 2030 Project – which seeks to coordinate the "complete" bathymetric mapping of the global ocean at a 100-metre resolution by 2030 – is contemplating a variety of ways to accelerate surveying. Force multipliers under consideration include fleets of long-duration uncrewed surface barges and sailing vessels; energy efficient sonars on gliders; and thousands of ARGO free-drifting profiling floats.

Multibeam sonar bathymetry and geophysical seabed data can be collected at higher resolution than ship-based systems using AUVs and remotely operated vehicles (ROVs) because such platforms are not constrained to the sea surface. The most capable of these vehicles can approach depths of 11 kilometres. The inertial navigation system in modern AUVs can enable the accurate positioning of hazards and other underwater features. Deep-water rated AUVs can be used for petroleum field developments, site clearances, pipeline and cable route planning and inspection, regional mapping, and even archaeological surveys of shipwrecks. AUVs optimized for shallow water can be used for port and harbour surveys, coastal engineering projects, offshore wind-farm developments, and the hunt for unexploded mines.

Remote operations are being enabled by improved digital high-speed communication and data transfer through orbital satellite networks and maritime broadband radio. We can anticipate that remote capabilities will accelerate as outfits like SpaceX's Starlink construct satellite constellations to provide faster, affordable, and reliable broadband Internet globally. Advances in remote digital communications will allow rapid delivery of data to hydrographic agencies, research institutes, survey companies, and secure data repositories. In situations where data transmission remains too costly or temporarily unfeasible, data can be automatically processed on board an

HYDROGRAPHIC VESSEL SEGMENT

Mapping sensors
Single / Multi-beam echosounder
Side-scan sonar
Underwater camera(s)
Environmental sensors

CPUs/GPUs Autopilots

Navigation sensors
GNSS
IMU
Compass
Radar
Surface Cameras
Environmental sensors

Guidance systems
Situation Awareness
Collision Avoidance
Route generation / planning
AIS

Power, Engine & Motion Control

Communications

COMMAND & CONTROL SEGMENT

COSTAS ARMENAKIS

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Uncrewed Marine Vessels (UMV) can be characterized by their operational mode.	
Remotely controlled	• Operated by a pilot controlling the UMV remotely. • The vessel may be uncrewed, the system is not. • Operate within Visual Line-of-Sight (VLOS).
Automatic	• Execute pre-defined processes that require UMV pilot initiation and/or intervention. • Examples: way-point navigation, auto-pilots, pre-programmed manoeuvres. • Can operate within VLOS (mostly) but also Beyond Visual Line-of-Sight (BVLOS).
Autonomous	• UMV can execute processes or missions using onboard decision-making capabilities. • The UMV system is not designed to permit crew member intervention. • Operate reliably in BVLOS mode.

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Figure 1: (A) Schematic diagram of an uncrewed marine vessel (UMV) for hydrographic surveys. (B) Characteristics of an UMV.

autonomous vessel and then periodically transmitted as products with reduced sizes to satellite or surface receiver networks.

Safer Marine Operations
Another advantage of autonomous hydrospatial data acquisition is the reduced health, safety, security, and environment exposure to operators. Uncrewed survey vessels can work in perilous conditions without risking human life. Autonomous surveys are also appealing in the context of the ongoing pandemic. It is apparent that physical distancing measures prompted by COVID-19 are accelerating, perhaps by years, the adoption of autonomous marine surveying technologies and remote workforce operations – as evidenced by the teleworking arrangements recently established by government hydrographic agencies.

Industry was already moving in this direction before the pandemic. By the end of 2020, Fugro anticipates being the first company providing offshore subsea inspections via uncrewed surface vehicles (USVs) and ROVs operated from onshore remote operations centres (ROCs). The company has built seven of these "mission control" centres worldwide. An example of the advanced technology that will be coordinated from these ROCs are USVs being developed by SEA-KIT and partners that will be able to deploy both ROVs and AUVs for marine asset inspections, science, or military applications.

Of Robots and Humans
Should we be concerned that ocean mapping robots will take our jobs? No. The argument that autonomous and intelligent platforms will remove the need for human interaction is unfounded. The search for return on investment by increasing the level of automation decreases the number of menial tasks that lend themselves to automation. Those tasks happen to be the ones with the least humanity in them, usually involving mindless repetition or blind application of operation sequences and algorithms. As such, automation can shift the focus from technocentric work to anthropocentric work involving the human elements that define us such as creativity, intuition, wisdom, and altruism. Ocean mapping teams should strive to successfully leverage advanced technology to not only work more efficiently, but also to ask different questions and solve new types of problems.

The key will be to view robots and artificial intelligence, and their capacity to augment a human's work, through a collaborative lens. For instance, it is likely that many hydrographers will develop into hydrospatial analysts and data scientists who serve as integral members of multidisciplinary ocean science, engineering, and operations teams. We are also a long way off from robots maintaining themselves – as the global economy recovers, competition to hire trained autonomous marine vehicle hardware technicians will intensify. Working together, an ocean of hydrospatial data will be assembled from a greater variety of sources through continuous in-situ monitoring and autonomous repetitive surveys – facilitating change detection, trend analysis, modelling, prediction, and, ultimately, process-based understanding of the subaqueous natural and built world.

Dr. Sean Mullan is a geospatial and geological oceanographer. In fall 2020, he is helping launch two new applied graduate programs in ocean mapping at Memorial University of Newfoundland's Marine Institute. Along with the other authors, he is a member of the Canadian Ocean Mapping Research and Education Network (COMREN). Denis Hains has assumed many executive roles in his 35-year career in the Public Service of Canada; retiring as Hydrographer General of Canada in 2018. Currently, he is the Founder, President, and CEO of H2i (www.h2i.ca). He is internationally active as a "hydrospatial ambassador," with many professional affiliations, including Senior Special Advisor to COMREN. Dr. Costas Armenakis is a Professor of Geomatics Engineering, Lassonde School of Engineering, York University. His research interests are in the areas of photogrammetric engineering and remote sensing mapping focusing on small unmanned mobile mapping systems, 3D high definition mapping products, rapid computational methods, and synergistic approaches between mobile mapping platforms. Guillaume Morissette is the R&D Director for CIDCO, a research and development centre in coastal and ocean mapping. He has over 15 years' experience developing and managing operations research software solutions. His research interests include artificial intelligence, machine learning, embedded systems, and cybersecurity.