How Innovations in Mapping Will Help Support the Ocean Decade

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A wholly mapped ocean is one of the foundational goals of the United Nations Decade of Ocean Science for Sustainable Development. This multifaceted initiative aims to reverse the cycle of decline in ocean health and facilitate improved conditions for sustainable ocean development worldwide. Meeting this goal will require significant innovations in marine geodesy and survey. The following commentary details how innovations in satellite positioning, satellite imaging technology, remote operations, autonomous vehicles and robotics, and analytics and cloud automation are helping to provide safer, more efficient, cost-effective and sustainable marine survey and mapping solutions in support of the Ocean Decade. Real-world innovation examples from Geo-data specialist company Fugro are provided.

The calculus of innovation is really quite simple: Knowledge drives innovation, innovation drives productivity, productivity drives economic growth.” This quote by American scientist William Brody succinctly captures the importance of innovation to the recently launched United Nations Decade of Ocean Science for Sustainable Development. A multifaceted initiative to develop a common, global framework for ocean science, the Ocean Decade aims to reverse the cycle of decline in ocean health and facilitate improved conditions for sustainable ocean development across the globe. Innovation will play a key role in the Ocean Decade, helping to deliver the massive knowledge gains needed to achieve “the science we need for the ocean we want”.

While the Ocean Decade is broad, covering many aspects of ocean science, one of its foundational goals is a wholly mapped ocean. As such, innovation in marine geodesy and survey are considered critical and will include both technologies (systems) and techniques (solutions). As a leading Geo-data specialist, with research, development, and innovation at the core of our strategy, Fugro is helping to support the Ocean Decade with marine geodesy and survey technologies and techniques.

A Framework for Innovation
In developing the Implementation Plan for the Ocean Decade, the Intergovernmental Oceanographic Commission of UNESCO (IOC) created the Decade Action Framework, as presented in Figure 1, to guide the design and implementation of initiatives that will support the Ocean Decade (IOC, 2020). The highest level of this framework is a set of ten Ocean Decade Challenges, which represent the initiative’s most immediate and pressing priorities. The need for ocean mapping is detailed in Ocean Decade Challenge 8, which states:

Through multi-stakeholder collaboration, develop a comprehensive digital representation of the ocean, including a dynamic ocean map, which provides free and open access for exploring, discovering, and visualizing past, current and future ocean conditions in a manner relevant to diverse stakeholders.

The second level of the Decade Action Framework comprises three Ocean Decade Objectives, which guide the multi-step, iterative and cyclical process required to fulfill the Ocean Decade Challenges and ultimately contribute to fulfillment of the Ocean Decade Outcomes, or “the ocean we want”. The three Ocean Decade Objectives include:
1. The identification of ocean knowledge that is required for sustainable development.
2. The generation of the data, information, and knowledge for the development of a comprehensive understanding of the ocean, its components, and its interactions.
3. The use of the generated knowledge and understanding of the ocean to deploy solutions for sustainable development.
The application of these three objectives to Ocean Decade Challenge 8 connects knowledge, innovation, productivity, and sustainable development, while also articulating the importance of innovation in marine geodesy and survey.

Marine Geodesy
Innovation to Support the Decade

Approximately 30 years ago, the availability of Global Positioning System (GPS) technology helped revolutionize the field of marine geodesy and survey. By providing a global and continuously available positioning system on a single geodetic reference frame, GPS transformed the way marine navigation, positioning and survey are performed. Instead of local or regional shore-based radio positioning systems operating on separate datums, global satellite-based positioning systems provided a single global datum 24 h a day. This transformation started with survey and mapping applications but has since broadened to cover virtually any marine application and almost every marine platform in the world. From the largest cruise ships to stand-up paddle boards (via the smart watch on the wrist of the paddle boarder), platforms are now positioned in real-time by GPS and/or other Global Navigation Satellite Systems (GNSS) that have since been introduced.

While this technology revolution originally occurred in the early 1990s, a series of subsequent innovations have increased the availability, accuracy, and reliability of GNSS, while decreasing its costs. These improvements were made available through the addition of other satellite navigation systems, augmentation systems and techniques, and miniaturization. As a result, International Maritime Organization Safety of Life at Sea (SOLAS) requires that virtually every ocean-going vessel be equipped with GNSS systems to support marine navigation and positioning (NAVSREGS, 2017). This requirement, combined with SOLAS mandates for echosounders and communications systems for measuring water depth and reporting position and emergencies, makes it possible for all ocean-going vessels to help build a digital representation of the ocean, through a strategy called crowdsourced bathymetry. The International Hydrographic Organization defines crowdsourced bathymetry as depth measurements from vessels, collected using standard navigation instruments, while engaged in routine maritime operations; this approach has the power to significantly improve the global coverage of ocean bathymetry.

Additional GNSS technologies and techniques continue to be introduced that will support marine navigation, positioning, and survey in support of the Ocean Decade. For example, in addition to GPS, there are now three other global GNSS systems
(GLONASS, Beidou, and Galileo) in various stages of maturity. By combining positioning from multiple constellations, Fugro has developed a set of GNSS augmentation services, which significantly improve the accuracy, availability, and reliability of standalone GNSS solutions. Most significant and relevant to the Ocean Decade may be the high-performance positioning solutions now available in high latitudes (the Arctic and Antarctic), where traditional GPS-only solutions struggle.

Furthermore, as outlined above, GNSS has become an essential element of the worldwide information infrastructure. Marine navigation and survey are increasingly dependent on quality satellite positioning services, the integrity of which can be compromised through exposure to cyberattacks. Security is not a built-in feature of GNSS open services, and low-received power as well as unencrypted civil signals are vulnerable to jamming and spoofing attacks. To mitigate these risks, Fugro has introduced a service that offers GNSS navigation message authentication to cross-check the satellite navigation message in our global reference network, providing a digital signature to the user’s GNSS receiver and clearly indicating any potential threat. This capability is extremely important on autonomous vehicles, which are becoming increasingly relevant to marine survey and mapping applications.

**Marine Survey Innovation to Support the Decade**

While marine geodesy experienced its innovation revolution approximately 30 years ago, the marine survey innovation revolution is happening now. Survey and mapping systems and solutions are now advancing at an unprecedented pace, driven primarily by innovations in core technologies, such as remote operations, autonomous vehicles and robotics, and analytics and cloud automation. The pace, breadth, and sophistication of these innovations is now very high and will ultimately provide safer and more efficient, cost-effective, and sustainable marine surveying and mapping solutions in support of the Ocean Decade.

Another exciting area of innovation is related to satellite imaging. The growing availability and reduced cost of satellite remote-sensing data, combined with improved algorithms and analytics, mean that satellite solutions are becoming an increasingly important tool for marine survey in shallow coastal waters with reasonable water clarity. While satellite-derived bathymetry (SDB) solutions have been available for approximately 25 years, the technology has matured appreciably over the past decade, and improvements will only increase further with the advent of cube satellites, which significantly increase persistence and reduce costs of satellite imagery.

Capitalizing on these advancements, Fugro has developed a satellite-based solution for coastal monitoring. While it does not provide absolute depths, it does provide a very efficient and cost-effective approach to detecting the location and scale of coastal change. This information can then be used to determine if additional survey is required using more precise techniques (via SDB, lidar, or multibeam) at very discrete and specific locations, thereby eliminating the need to resurvey large areas of seabed where change is not occurring.

Despite using remote technologies in offshore operations for some time, the relevance and value of these innovations were highlighted to Fugro anew during the recent Covid-19 outbreak and associated lockdowns. Advances in communications, telemetry, and data compression have all contributed to the development of remote command and control technology that allows qualified staff to increasingly conduct their work from shore-based office environments instead of onboard vessels.

Fugro first introduced remote operations in 2013 and, since then, the scope and scale of these remote services has grown significantly. From eight remote operations centers located around the globe, Fugro personnel are performing a wide range of offshore activities onshore, including positioning and navigation services, the collection of multibeam and other marine sensor data, the processing and dissemination of acquired data, and even the piloting of remotely operated vehicles (ROVs). With more staff now executing these offshore projects from onshore, Fugro can acquire and deliver data faster, with improved operational safety, increased business continuity, and a significantly reduced carbon footprint.

Advancements in remote operations have also contributed to innovations in autonomous and uncrewed platforms. Innovations are occurring in the water with autonomous underwater vehicles (AUVs), on the water with uncrewed surface vehicles (USVs), and in the air with uncrewed aerial vehicles (UAVs). While each platform supports different aspects of marine survey and mapping, they all share similar technology goals and challenges, including sensor miniaturization,
sustained power, operational endurance, and collision avoidance. Of the three technology platforms, AUVs are the most mature, having operated without human intervention for years. These systems tend to be used in deeper water near the seafloor, meaning they do not have the same traffic management, collision avoidance and regulatory requirements as UAVs and USVs. Ultimately, the goal for USVs and UAVs is to reach the same level of autonomy as AUVs but, until the collision avoidance technology matures and a regulatory regime is established, uncrewed operations will still require some level of supervision.

Fugro has been offering AUV-based high-resolution survey and mapping solutions for nearly two decades. Even though this technology tends to be relatively mature compared to its USV and UAV counterparts, it continues to benefit from significant advancements in terms of power, endurance, and sensor payload. With respect to aerial mapping and remote sensing, Fugro now offers a bathymetric lidar capability for shallow water coastal mapping that can be offered from UAVs. Known as RAMMS (Rapid Airborne Multibeam Mapping System), the technology has to date been operating from fixed-wing UAVs and will soon also be operated from rotary wing UAVs. More recently, Fugro’s Blue Shadow class of USVs has been designed for coastal hydrography and is currently used as a cost-effective force multiplier to increase productivity. Through a partnership with SEA-KIT, Fugro has most recently developed a larger oceangoing class of USVs known as Blue Essence, capable of deepwater mapping, while hosting an eROV or AUV for remote and uncrewed high-resolution mapping, exploration, and characterization applications. Fugro’s Blue Essence USV is shown in Figure 2, while Fugro’s Blue Volta eROV is presented in Figure 3.

Marine survey data acquisition and processing have also improved as a result of advances in artificial intelligence (AI) and cloud processing.
AI, for instance, has proven essential to the safe operation of autonomous and uncrewed survey platforms, providing route optimization, dynamic line planning, and collision avoidance. It also enables data to be pulled from crewed or uncrewed acquisition platforms, so that it can be accessed in near real time by shore-based clients, processors, analysts, and consultants. Finally, AI and cloud processing are now being used in cleaning, processing, and running analytics on integrated survey, and mapping datasets that are increasingly being combined in a digital twin framework.

Conclusions

Within the Decade Action Framework, Decade Actions will fulfill Decade Objectives and achieve Decade Challenges. Decade Challenges will in turn contribute to one or more Decade Outcomes, which ultimately will support the United Nations 2030 Agenda for Sustainable Development and related regional and global policy frameworks (IOC, 2020). Innovation is a common theme throughout the framework, being directly referenced in multiple Ocean Decade Challenges and one Ocean Decade Outcome, while being implied by extension via knowledge references in the Decade Action and Decade Objectives. Given this, the fact that one of the Ocean Decade Challenges involves the development of a comprehensive digital representation of the ocean, including a dynamic ocean map, there is no doubt that the exciting innovation that is currently occurring in marine geodesy and survey, including within Fugro, as depicted in Figure 4, will be accelerated by and contribute to the Ocean Decade.

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References
