20V PLANET

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EDITOR-IN-CHIEF
Richie Enzmann

COPY EDITOR
Will Grant

SALES DIRECTOR
Nick Search

DESIGN & LAYOUT
Milan Farkas

CONTRIBUTORS
Richie Enzmann, Brian Allen, Rod Larson, Duane Fotheringham, Sean Beckwith, Dr. Henry Robinson, Gregg Stewart, Michal Latacz, Lee Wilson, Luke Wissmann, Lauren Forgie

SPECIAL THANKS TO
Åge Holsbrekken, Alex Bahr, Allan Nygård Bertelsen, Alma Alling, Audrey Leon, Bill Mallin, Cameron Whyte, Christa Ravensbergen, Erica Kierstead, Freddy Christensen, Gary McConnell, Gautier Dreyfus, Gillian Montanaro, Graham McAvoy, Helen Carpenter, Hugo Mitchell-Heggs, Igor Martin, James Colebourn, Johan Stam, John Benson, Jostein Jansen, Julian Lalanne, Katie Marshall, Marion Seyve, Matt Bates, Neil Manning, Paloma Robinson, Paul Fletcher, Rachel McAlpine, Simon Machin, Steve Gibb, Steve Phelps, Thomas Jonsson, Trond Crantz, Victor Sepulveda, Willard Balthazar

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EVENTS CALENDAR

For more information about all events visit WWW.ROVPLANET.COM

AUGUST 2021

OFFSHORE TECHNOLOGY CONFERENCE (OTC)
Houston, TX, USA (16–19 August 2021)

DEEP SEA MINING SUMMIT
London, UK (25-26 August 2021)

SEPTEMBER 2021

SPE OFFSHORE EUROPE
Aberdeen, UK (7–10 September 2021)

DSEI
London, UK (14-17 September 2021)

FLOATING OFFSHORE WIND
Aberdeen, UK (15-16 September 2021)

MTS/IEEE OCEANS'21 SAN DIEGO – PORTO
San Diego, CA, USA (20–23 September 2021)

GLOBAL OFFSHORE WIND
London, UK (29-30 September 2021)

OCTOBER 2021

OCEAN BUSINESS
Southampton, UK (12–14 October 2021)

OFFSHORE ENERGY EXHIBITION & CONFERENCE
Amsterdam, The Netherlands (26–27 October 2021)

NOVEMBER 2021

WINDEUROPE – ELECTRIC CITY
Copenhagen, Denmark (23-25 November 2021)

DECEMBER 2022

UNDERSEA DEFENCE TECHNOLOGY (UDT)
Rostock, Germany (14-16 December 2021)

FEBRUARY 2022

SUBSEA EXPO
Aberdeen, Scotland, UK (22–24 February 2022)

My name is Richie Enzmann, and allow me to welcome you all to the latest issue of ROV Planet!

WELCOME TO ROVPLANET!

Dear Reader,

There is an ongoing robotics megatrend in the oceanographic space, no doubt about it. We're seeing the technology evolve at an ever-increasing pace. When we started our magazine 7 years ago it was named ROV Planet, but now we're seeing the development of autonomy, unmanned systems, and remote operations, perhaps the term ROV to describe "Remotely Operated Vehicles" is no longer adequate. Maybe it should be redefined and become broader to cover all robotics solutions in the marine and underwater space. We will see.

In line with this robotic theme, we chat with Brian Allen, CEO of Rovco, to find out more about their new start up Vaarst. We're told that Vaarst was always hidden inside Rovco as part of their unique technology group. Now however, they're spinning it off to offer "robotics as a service" to all ROV operators that want to take advantage of their unique technology. This could bolster those operators' vehicles ahead of a future where autonomy will take a significant role in underwater surveys.

Another transition lies ahead: not just in unmanned technology, but also in electrification and a carbonless, net-zero future. Rod Larson, CEO of Oceaneering, shares his views about this energy transition, what it means for the offshore industry, and how his company has prepared for this new challenge.

Sean Beckwith gives us with a breakdown of deep-sea mining. He's talked with several experts from a range of backgrounds that are involved in deep sea mining to learn about the industry's targeted technologies, and the fate of the Earth's seafloors. We also look at two technologies offered by companies Pliant Energy Systems and Honuworx in more detail, and how they could provide more environmentally friendly solutions for this industry.

Last but not least we talk with Duane Fotheringham about the future of AUVs, UUVs, and unmanned systems in the defence space. As you can see, we have a lot in store, and as always, we hope you enjoy our latest offerings!

Best regards,
Richie Enzmann

vaarst

CLOUD ROBOTICS COMPANY WITH VAST OPPORTUNITIES

Vaarst, the new technology spin-off company from Rovco launched March 2021, with the stated mission to enable data to drive the future of marine robotics. Their vision being to give all offshore robotics enhanced capabilities, through artificial intelligence, machine learning and autonomy. The key to this is that they are enabling the integration of their technology into all robotic vehicles, both new and as a retrofit solution to existing ROVs.

ROV Planet spoke to CEO Brian Allen to get the inside track on the launch, the company's future direction, and the considerable benefits that Vaarst's innovative technology is bringing to the offshore industry today.

Given that Vaarst grew from its parent company Rovco, can you explain the relationship between the two?
Rovco is a service provider to the offshore sector, supplying survey and asset integrity services across the offshore infrastructure lifecycle. Vaarst provides the technology that is behind Rovco's innovation-led services. What is significant now, is that with the launch of Vaarst we are making that technology available to all offshore robotic players.

Although Vaarst only formally launched recently, it already existed as a stealth business within Rovco, right from its initiation in 2016. By operating as an offshore services business, Rovco was functioning as the test bed for Vaarst, enabling its technology to be refined and proven in a real-world environment. In the marine sector, where clients write task plans and work orders that specify the tools and equipment to be used, it is often difficult to introduce new innovations. Therefore, as a service provider, Rovco was able to test the practical application and demonstrate the value of Vaarst technology, while building a secure trust of the technology within the customer base.

Where did the ideas behind Vaarst technology come from?
Vaarst technology was born to enable the modernisation of offshore data collection in survey and O&M work, where methods have not changed significantly for many years. This work requires the deployment of large vessels, that create surprisingly high levels of environmental pollution and cost.

Each vessel can produce up to 275K tonnes of CO2 over its lifetime, depending on the job. They can require up to 60 people to work in hazardous conditions and cost £1-10m a month to operate. We started Vaarst because we believe there is a better way, and that the solution to this industry problem is through technological innovation.

From the beginning, we looked at how to do things differently. Starting our research journey, with universities across the US and Europe, to explore new methods of data collection in aerial drone technologies to see what could be applied to the offshore industry. This led us to focus on the ExoMars Rover and the technologies employed to assess landscapes. There was a clear synergy, between the problem of sending data from Mars back to Earth, and the problem of sending data from deep underwater back to shore. We knew that there were hurdles with sending video back over this distance, so this took us down the route of SLAM and using 3D data reconstruction as a compression tool. That is where it all began.

Can you tell us more about the benefits of SLAM and 3D data reconstruction?
Our SLAM product, SubSLAM X2, is an AI-driven intelligent data collection system that delivers live underwater 3D point clouds, enabling users to get highly accurate reconstructions in real-time. The model actually builds in front of your eyes as the ROV is navigating around the structure. And because the team are still on the boat while the data is being gathered, it's possible to ensure that all the data needed has been captured during the dive. So, there's no need for any costly rework.

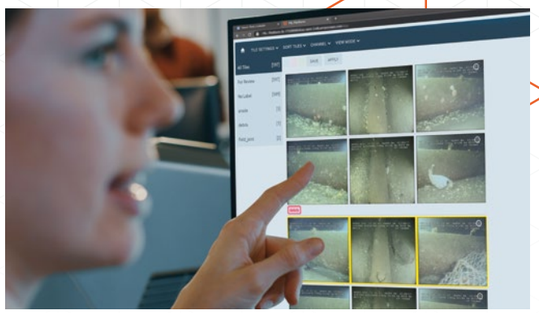
Using relative positioning technology, SubSLAM ensures the vehicle always knows where it is, removing the need for any additional positioning equipment or scale bars. Although, we can also switch on the IMU for those infrequent scenarios where the visibility isn't good.

As well as collecting 3D data, the system also captures 4K video, which can be post-processed for high-resolution photogrammetry. So, the client gets live 3D data on all their assets while on the job, and is then able to focus their attention when post-processing on creating high detail photogrammetry models for areas of greater interest.

One of the advantages of SubSLAM is live streaming. How does that work?

The compressed 3D point cloud data – captured by SubSLAM – is sufficiently small in file size (150-200 kbits/s) that it can be live-streamed back to any device in the world over a low bandwidth data link, being easily transmittable through a ship's VSAT system. This gives remote teams access to survey and construction data in real-time, so they can make informed decisions and recommendations while the work is still taking place. While we offer this to clients today on a bespoke basis, in 3 to 6 months, this will be part of our harmonised product set, and available to all clients.

The live-streamed data will also be automatically updated to our geo-referenced data platform. This will store a historical archive of all the customer's assets. So, employees will be able to collaborate in a smarter, safer and more efficient way. The geo-referenced data platform is also scheduled for release later this year.



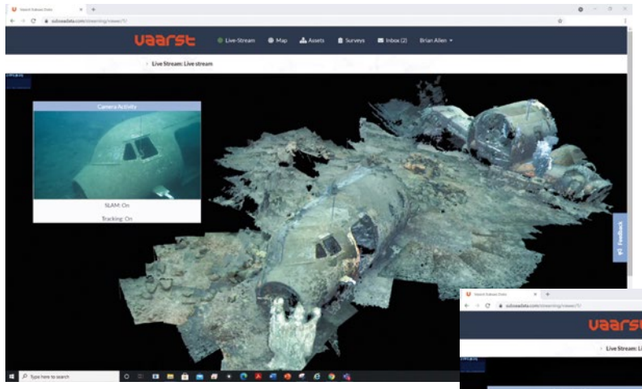
Can you tell us more about the capabilities your machine learning platform?

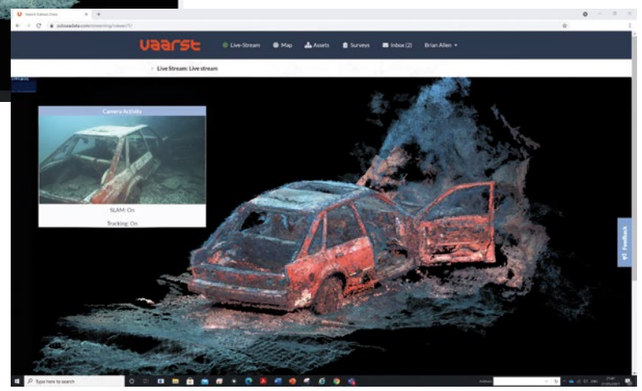
The Vaarst ML platform takes visual data and enables it to be analysed really quickly. Put simply, ML is about multiplying the human effort of a single person, so they can do much more work.

For example, to undertake a routine check-up on a subsea pipeline, an ROV needs to travel along the pipeline to capture video footage. An operator, or more specifically – a team of operators, then analyses images manually, checking for issues and potential threats that will require action, such as free span, corrosion, debris and large rocks. One example data set we've worked with was approximately 120 hours in length.

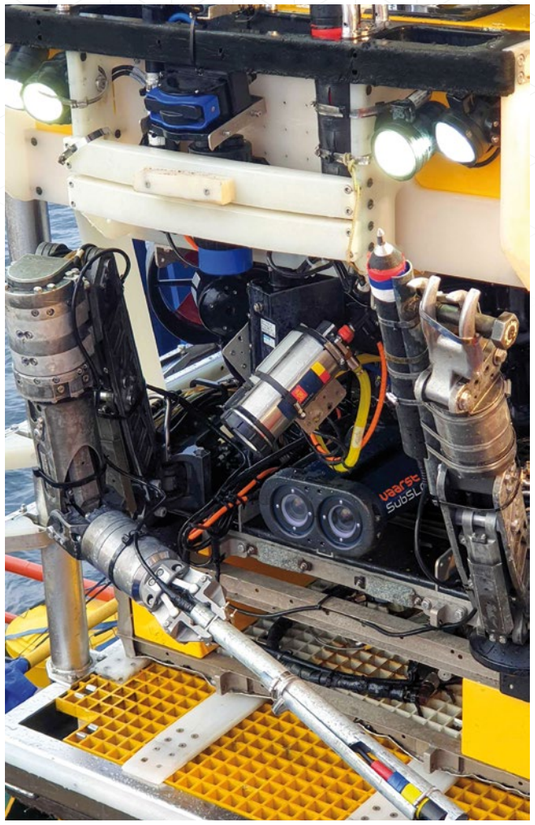
With our ML solution, that data could be analysed in just 7 hours, enabling a 15 x of human effort. That ML system has now just finished trials with an oil supermajor, and they are currently looking to roll it out to their supply chain.

While right now our ML is delivering analysis in post-processing, our machine learning capabilities are now being integrated into SubSLAM at the edge, where the data collection is taking place. These technologies have not been combined before and create a unique and innovative much-needed solution for the offshore energy sector. In fact, there will be no need to send visual data back to shore, instead we'll just need to transmit the answers.



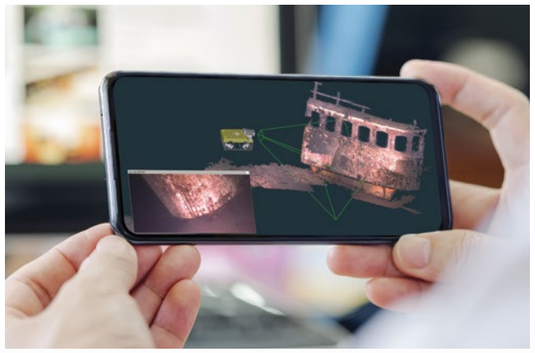


Enabling data to drive the future of offshore robotics



What's the future vision for Vaarst? And what makes you different from others?

The overall challenge that Vaarst is solving is how to remove large vessels from our waters. But at the same time, we want to ensure that the replacement solution is efficient and intelligent, and not reliant on a remote operations centre to drive the robots. So, we are building a cloud robotics with true autonomy capabilities, where the purposes of the operations centre is only to monitor and supervise, and the vehicles drive themselves through their own data-driven intelligence. That is what makes us so different from other companies out there who are starting to offer remote centres.



We are enabling robotic vehicles to answer key questions: where am I now? what's around me? And where shall I go next? With the system constantly localising, learning and deciding, so that it can accurately position the vehicle in its own surroundings, predict the next move and operate without assistance.

And, as I mentioned previously, we are also integrating live machine learning at the edge. This means we will deliver rapid, on-the-fly, feature detection and analysis, all while navigating autonomously at close range around complex underwater structures.

Our next step is to then take things up to yet another level, enabling multiple robots to work together as a coordinated fleet. Pair all of that with an autonomous vessel, and it enables a vast scale-up of operations through connected robotics. And ultimately the removal of many large vessels from our seas.

So, what's the endgame?

What we have here with the individual technology components are the constituent parts of a powerful cloud robotics solution. SubSLAM sits at the edge and collects the data, machine learning analyses the data on the fly, the analysis is sent back to the shore in real-time and the data is stored on the Vaarst platform for collaborative analysis and historical comparison.

Once this is all glued together, that's a true cloud robotics company. The separate technology modules are available, and clients coming on board now, are well placed to capitalise on what is coming very soon.

It would be absolutely true to say data is enabling the future of marine robotics.

How can customers access Vaarst technology?

Vaarst's SubSLAM X2 is available today for retrofit to any suitable ROV, and the system has already been interfaced with several widely used vehicles. To increase accessibility, we've recently made SubSLAM available to license, for £36K per annum over a fixed 3-year term, or on day-rates for short-term projects.

More information Vaarst is available at www.vaarst.com or I'd welcome anyone to get directly in touch with me, Brian Allen, or Mike Gallo in my team (mike.gallo@vaarst.com).

To find out more visit www.vaarst.com

vaarst

WHAT'S NEXT AND WHAT'S NEEDED IN OFFSHORE OIL AND GAS

THE INDUSTRY'S ROLE IN THE ENERGY TRANSITION

Rod Larson, President and CEO, Oceaneering

Rod Larson, President and CEO, Oceaneering (Courtesy of Oceaneering)

The rumors of our industry's death have been greatly exaggerated. While many believe that oil and gas is going away, history tells us otherwise.

We often hear the refrain, "we've found all the oil out there, and we will soon run out." While in the past this has led to an energy crisis and higher costs, the industry continues to find more oil, in deepwater and in oil sands. When the industry was struggling with the high cost of per barrel break-evens, the industry found a way to adapt and bring down the price per barrel with new fit-for-purpose technology and techniques.

The question now is can we be "clean"? More precisely, can we be clean enough to get a public mandate to continue what we do to provide the energy the world needs? Personally, I think we can. There are plenty of opportunities for us to participate in the energy transition, but we need to approach it differently.

MOVING OCEANEERING FORWARD

Currently, the major oil and gas operators are making significant commitments to reducing carbon emissions. However, at least 70% or more of that reduction will come from vendors in the industry.

How do service companies like ours achieve this? We will need to implement newer technologies like automation and machine learning. Resident subsea vehicles, like our Liberty™ E-ROV and the Freedom™ Subsea Autonomous Vehicle, will have an important role in reducing carbon footprints offshore. Instead of having a tender vessel on location for weeks, we can drop off our Liberty™ E-ROV to do the work (surveys, inspections, and interventions), and then have the vessel return to pick it up when it's most practical. In integrity management, we can also make some changes. We can make sure that the industry infrastructure doesn't have fugitive methane. We also want to avoid oil spills – due to equipment

Oceaneering's Liberty E-ROV system being deployed from a vessel of opportunity offshore Norway. (Courtesy of Oceaneering)

The Isurus™ ROV, designed specifically for the harsh currents faced by offshore wind installations, underwent testing offshore the UK in 2020. (Courtesy of Oceaneering)

wear from damage or failure – which puts our customers on their heels when we talk about our right to participate.

Oceaneering can provide a lot of those services. When I break our corporate strategy down, there are three main components. First, we need to be the best, most efficient and innovative version of ourselves to compete in a very challenging environment. Secondly, we need to be prepared to take the oilfield into the next generation; an era that will be cleaner, safer, and more cost effective. And third, we need to prepare for growth industries. For example, there will be an uptick in the work we do with the aerospace industry and with the government, as well as less conventional examples like theme parks and entertainment business. Those are natural offshoots of what the company has always done with its marine expertise. There will also be potential for people movers and Automated Guided Vehicles (AGVs) for factory floors, etc. These are all things that allow us to leverage what we do well, even if oil and gas over the decades does experience a gradual decline.

We've done a lot of work throughout 2020 to be a more efficient company and to be more competitive in this energy transition. That means rapid innovation, rapid development, flawless execution in harsh environments, all while being highly efficient. We've used the sense of urgency from Covid-19 to deliver that. Furthermore, we leveraged our core experience; we have a global mobility group which assigns crews and understands who is available to go where, who is closest, etc. That knowledge was a competitive advantage. As with many companies, we became much better at remote work.

All of this makes us better able, especially when we get into new businesses like AGVs and people movers. We're going to be up against the best companies in the world. We can't just be "oilfield good." We must be world-class if we are to compete with Siemens, Amazon, and Tesla.

REPURPOSING THE OFFSHORE INDUSTRY

So much of the expertise of the offshore oil industry – like building offshore structures – translates perfectly to offshore floating and fixed wind projects. And if offshore platforms are repurposed to produce blue hydrogen, we can inspect for life extension and aid in the modification of the subsea infrastructure.

Harnessing wave energy is also huge as well as subsea mining. This plays a large role, especially if we become heavily dependent on batteries. Currently, we don't have access to the rare earth minerals that we need to make a wholesale transition to on-demand electricity created by renewables, especially when wind and sun are not on demand. We need to think about all these things so that we can leverage the right people to help innovate our way around energy.

The Isurus™ ROV is based on Oceaneering's field-proven Magnum™ Work Class ROV system, combining optimized hydraulic propulsion packages and a hydrodynamic design for challenging offshore environments. (Courtesy of Oceaneering)

How do we get to the next step? Better integrity of the infrastructure: using embedded sensors and drones to inspect, more analytics around machine learning, artificial intelligence, and leveraging big data so we can predict when and where problems arise. For example, we can embed the sensors and do the inspections onsite, without having to fly people on helicopters for installations and have the carbon footprint associated with human intervention. All these things are very doable to reduce our carbon footprint while transitioning to a greater portion of renewables.

However, it's essential to create a stable environment before making an investment into transitioning. A lot of these things are coming from our customers who make commitments to investing in offshore wind and other large-scale renewables, and we're happy to continue working with them. We've always shifted alongside our customers, whether it be location or technology. If we can find ways to help them continue their oil and gas business with a lower carbon footprint – or to better understand the things that they're good at and target that towards renewables – then that's a short put, because of that existing relationship.

AN ETHICAL ENERGY TRANSITION

For the oil and gas industry at large, we need a rational, stable, and international approach to the energy transition. We need to level the expectations and the facts. We need stable supply, stable pricing, and a stable regulatory environment. A science-based, market-driven approach is very important where energy is concerned. If we don't have that approach, then the poorest people in the world are going to suffer.

The people that already have energy are already going to have options other than natural gas, etc. They'll pay a little more and be okay. But we're going to leave a lot of people in energy poverty that are already there today, and none of us should be "okay" with that.

If we take out some of the dramatic cycles that are driven by regulatory pressure or bad behavior in business, then we can invest in this stable, rational progression to reduce carbon emissions and our dependence on hydrocarbons at large. We can move to a greater percentage of energy that comes from renewables without leaving people behind. At the end of the day, we need oil and gas, and we need a rational approach to do it cleanly so that we can make a decent transition to a greater percentage of renewables. This will ensure that the poorest people in the world, those that need our help the most, are not left behind.

Rod Larson is President and CEO of Oceaneering International, Inc. He holds a Master of Business Administration from Rice University and a Bachelor of Science in Electrical and Electronic Engineering from North Dakota State University. He joined Oceaneering in 2012 after 22 years with Baker Hughes where he had most recently served as President for Latin America. Rod currently serves on the boards of Oceaneering and Newpark Resources. He also serves on the board of the National Ocean Industries Association and the Energy Workforce and Technology Council (Formerly the Petroleum Equipment and Services Association).

Photo: Dugornay Olivier (2019). HROV Ariane and Antea vessel. (Courtesy of IFREMER)

MIMOSA

THE MISSION PLANNING AND MONITORING SOFTWARE WITH THE RIGHT MIX OF INGREDIENTS

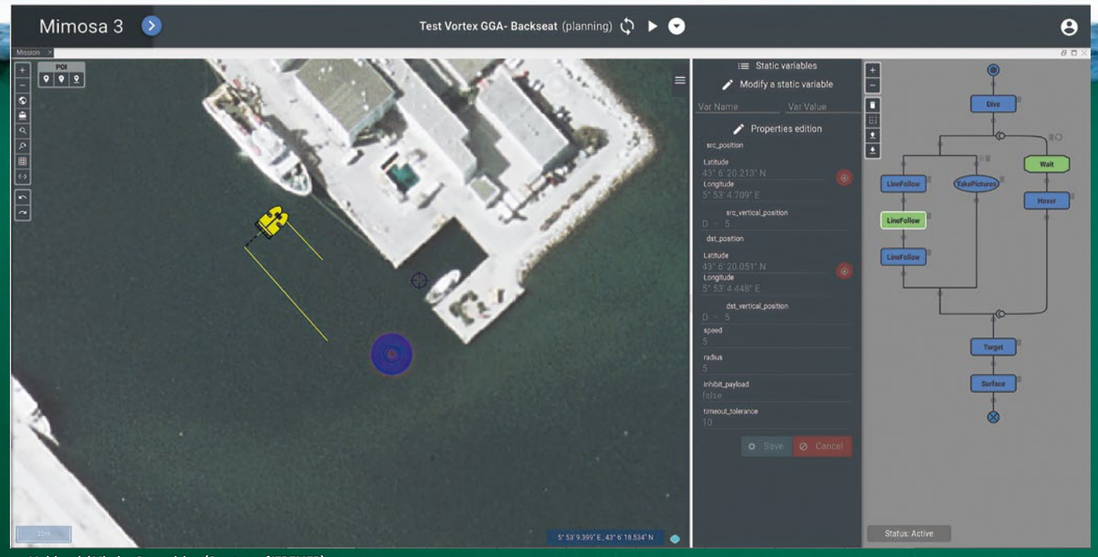
iXblue's Robotics and AI division, Robopec, have been working with the French National Institute for Ocean Science IFREMER since 2017 on the development of Mimosa3. Mimosa3 is the new generation of mission planning and monitoring software, dedicated to the underwater vehicles in the French Oceanographic Fleet[1]. Based on web technologies, the surface mission management software Mimosa3 will also be used in IFREMER's new 6000 AUV, Ulyˣ. It's specifically designed to program autonomous diving missions for AUVs and introduces a new concept for implementing intelligent autonomous exploration strategies.

Mission management software are key tools for operators and scientists alike to conduct subsea exploration. Located within the support vessel's subsea vehicles control room, they include the vehicle's mission planning and real-time monitoring of navigation data, as well as storage of scientific data, provision of support charts, and analysis of technical data.

A SOFTWARE SUITE DEDICATED TO SUBSEA OPERATIONS MANAGEMENT

To that end and to respond to increased needs for autonomous and remotely operated missions for the Institute's fleet of underwater vehicles, Robopec has partnered with IFREMER in the development of the 3rd generation Mimosa software suite.

1: a national research infrastructure managed by Ifremer



Multimodal Mission Supervision. (Courtesy of IFREMER)

Mimosa3 and its DataPortal extension cover all functionalities of mission management for operator-piloted systems, such as the human-operated vehicle Nautile, the ROV Victor 6000, or the hybrid vehicle Ariane. For these systems nautical-chart-based navigation, 3D displays, sensor feedback, auto-pilot modes, data management, etc., are the core functions that allow for efficiently operated scientific dives.

For IFREMER's AUVs (two 3,000m vehicles asterˣ and idefˣ, and the newly developed 6,000m system Ulyˣ), the mission management cycle includes programming of the dive plan. This is evolving in Mimosa3 from former generations of linear, pre-programmed track towards a construct of high-level tasks: implementing reactive dive strategies and ruling embedded autonomous decision-making by the AUV. Mimosa3 provides a unique editor dedicated to complex mission planning, making the most of the advanced embedded execution engine. IFREMER's syntax allows flowchart-like mission description, taking into account events, conditions, loops, and more.

Although AUVs are not permanently supervised by human operators, the feedback of vehicle information allows for precise monitoring of the robots' actions within Mimosa3, in dive phases where acoustic communication with the deploying mothership is available.

MULTI-SYSTEM OPERATION

Ocean science subsea operations tend increasingly towards multi-system deployment, with possible interactions such as communication rendezvous between AUV, ROV, and USV (used e.g., for acoustic positioning when the research vessel follows other tasks). Such multi-system operations require new functionalities for mission programming through the creation of a new Graphical User Interface (GUI) capable of representing the information as clearly as possible to ease the operators work.

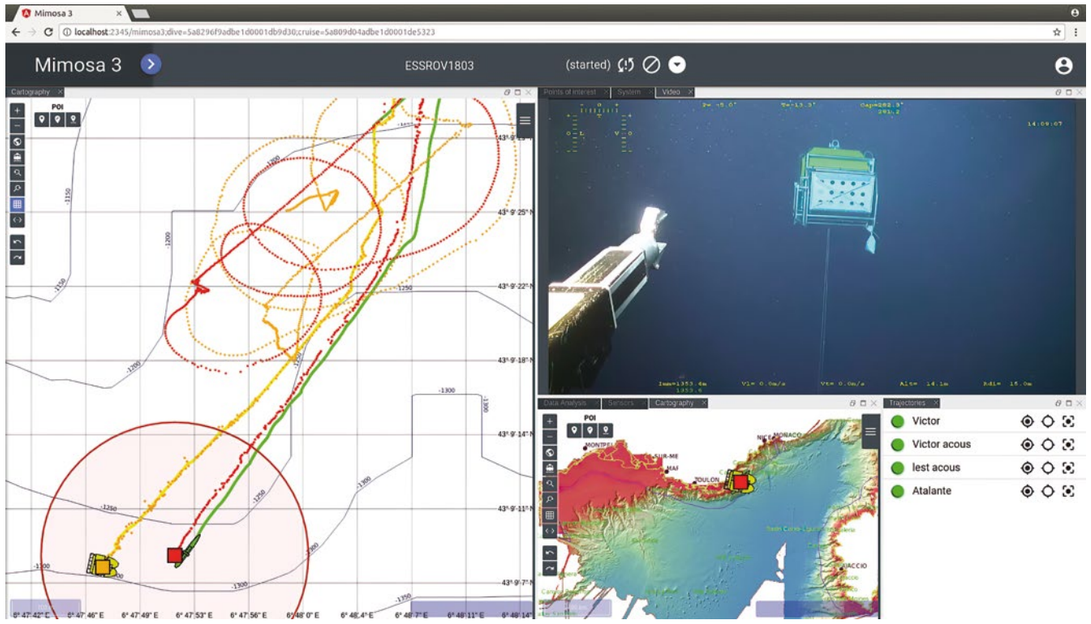
Remote access from any location on the research vessel – and eventually from land-based telepresence sites – is a core requirement for state-of-the-art operations at sea. This is enabled through Mimosa3 being entirely designed in web-technologies, providing access within defined user profiles.

A SINGLE MISSION MANAGEMENT TOOL FOR A WIDE RANGE OF UNDERWATER VEHICLES

One of the challenges to the development of Mimosa3 was to meet all requirements of different types of subsea vehicles within the French Oceanographic Fleet.This includes manned, remotely operated, and autonomous vehicles, all in a single software package.

Christophe Rousset, Managing Director of iXblue Robotics and AI division explains, "Supervision and planning software are often specific to a vehicle. There is no standard for controlling underwater vehicles that would allow us to create a universal tool. He goes on to say, "Some tools are able to interface with different equipment, but not necessarily those of IFREMER, which are often specific gears.

Photo: Ambre Bodenes, Ifremer (2020). Ulyx AUV, La Seyne-sur-Mer. (Courtesy of IFREMER)



Augmented reality bettering ROV operator's experience. (Courtesy of IFREMER)

"The requirement that IFREMER had here, was to be able to plan a mission expressed in the form of a DSL (Domain Specific Language) created by them. There are computer tools for creating code generators from DSLs. However, these tools are text-edition based, and the operators – not being computer scientists – would have many difficulties understanding this way of describing the mission.

Rousset continues, "Therefore, it was decided to create our own "graphic" and user-friendly mission description language.

"IFREMER has developed a language for describing the capabilities of a machine. This language allows [us] to describe what a machine can do in terms of locomotion, measurements, and actions. The description includes the map view display. iXblue then developed a GUI that can interpret this language, and that only offers operators mission blocks that can be carried out by the specific vehicle which mission is being planned."

In order to make deployment easier, the software was also developed using a Web User Interface with Google's latest framework Angular. That can be used collaboratively by the vehicle operators in the control station, and by scientists conducting or observing the dive on board the vessel or on shore.

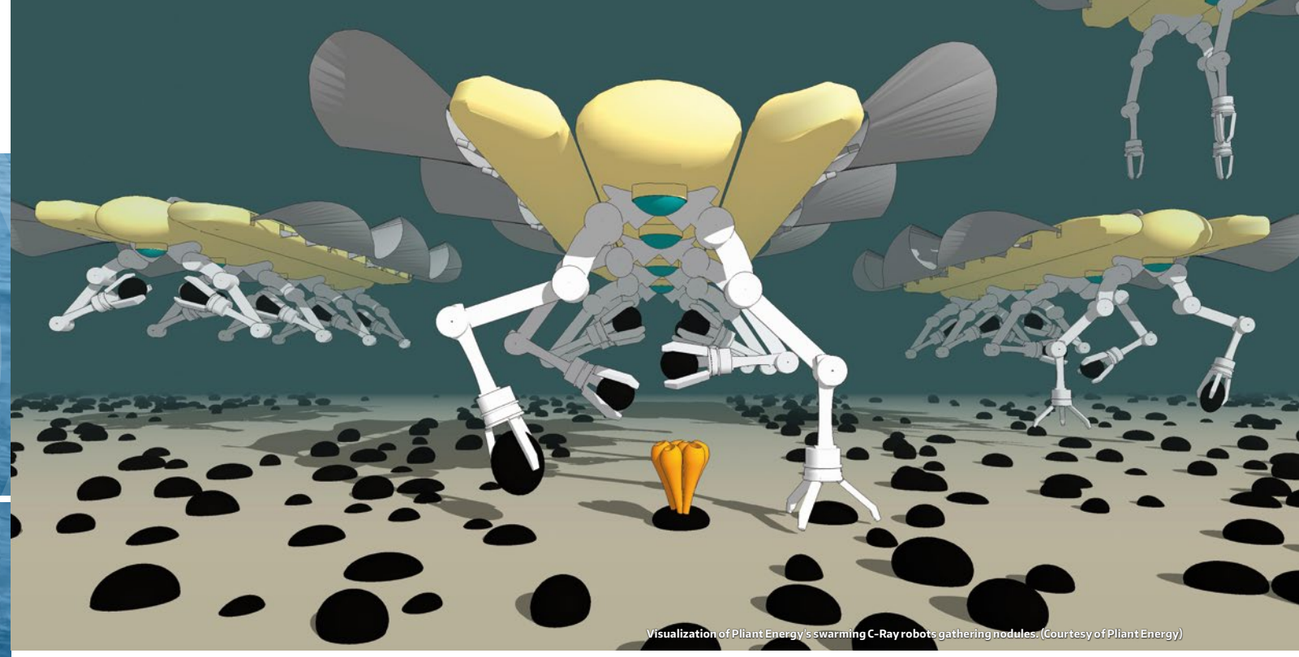
NEW FEATURES AND CAPABILITIES FOR MISSION SUPERVISION

The second challenge was the transmission of data via a satellite link: very expensive when one needs to transfer a large amount of data. IFREMER's fleet of support vessels are equipped with an IP satellite link with a "variable" bandwidth (between 50 kbps and 2Mbps), so the main obstacle was the transmission of video streams. In the absence of a compatible off-the-shelf solution for the transmission installed on IFREMER's vessels, the development of a dedicated transport layer was carried out and tested successfully.

Following tests and RETEX from several missions using the Mimosa3 software, several new features were subsequently investigated. These included audio and text "chat", the ability to broadcast the stream to several clients simultaneously, a real-time 3D view, adaptation to touch tables and screens, and an augmented reality functionality on the videos broadcasted by the underwater vehicles.

Uly^{X}, IFREMER's latest generation of deep-sea AUV, will also benefit from the Mimosa3 software. iXblue Robotics and AI division has thus adapted the planning tools to the specifics of the AUV, taking into account particular mobility capacities (fast diving, ballasting, lateral displacement, etc.), and specific payloads (long range SAS, etc.). Already onboard Uly^{X} with several sensors (Phins Inertial Navigation System, Sams Synthetic Aperture Sonar, Echoes Sub Bottom Profiler), iXblue is now adding a new software brick to IFREMER's most advanced deep-sea AUV.

A long-standing partner of the French National Institute for Ocean Science IFREMER, iXblue is also a key partner for system integrators and vehicle manufacturers wishing to equip their drones with modern drone management systems or planning to develop new capabilities. iXblue Robotics and AI division is also continuing to develop its own range of products in the fields of perception (multi-sensor data fusion, detection, and tracking of tracks at sea), as well as autonomous land and naval navigation (SLAM, dynamic trajectory planning, obstacle avoidance, COLREGs).



Visualization of Pliant Energy's swarming C-Ray robots gathering nodules. (Courtesy of Pliant Energy)

INTELLIGENT ROBOTS COULD BE THE BEST CHOICE TO MINE THE DEEP SEAFLOOR

THE PLANET WILL LIKELY AGREE

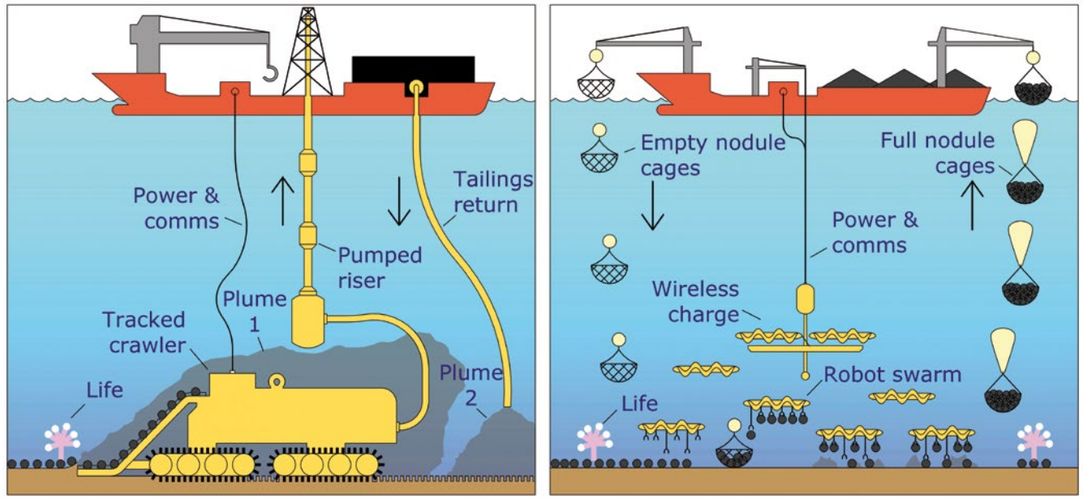
By Sean Beckwith

As a Ph.D. student at the University of South Florida College of Marine Science studying autonomous underwater glider deployment, recovery, and data analysis, I became interested in the deep-sea mining industry. I've asked experts from a range of backgrounds to learn more about the industry's targeted technologies and the fate of the Earth's seafloors.

At a lab facility in the Brooklyn Navy Yard Industrial Park in New York City, a team is building robots to help achieve one of humankind's greatest undertakings to date: mining polymetallic nodules from the seafloor.

The timing is right for Benjamin Pietro Filardo and his team at Pliant Energy Systems, and for the robotic industry as a whole. AI for navigation and mobility is advancing rapidly. The pursuit of self-driving cars, and uses for autonomous robotic devices abound, as science and industry explore ever-greater extremes of our planet.

The stars seem to be aligning for deep-sea miners and investors, as well. Technology to mine the deep seabed was shown to work in the 1970's, yet high entry costs and a lack of regulation have continually prevented the industry from gaining any traction. How soon mining of our deep seas will commence is still an open question, but the prevailing sentiment in the industry is that it will happen within this decade. A near doubling of the atmospheric carbon dioxide concentration in the geological blink of an eye has convinced many that the world needs these resources lying on the floor of the deep sea now. And – according to exponential growth projections for electric vehicle (EV) sales and energy storage demands – the need will likely grow stronger over the next decade and beyond.



Left - Conventional "crawl and pump" method. Right - Proposed "swarm and raise" method. (Courtesy of Pliant Energy)

Currently, the three best known nodule fields – and therefore the logical places to start the seabed mining industry – are the Clarion-Clipperton Zone (CCZ), the Central Indian Ocean Basin, and the Cook Islands Exclusive Economic Zone. In the CCZ where most of the attention is focused, the grade (content of metals) is similar throughout the zone, but the abundance (kilograms per square meter) changes significantly throughout the CCZ. This necessitates detailed exploration to identify first-generation mine sites. That's according to Dr. James Hein, Senior Scientist at the USGS and 45-year veteran in the field of deep-ocean marine minerals.

Industry frontrunner, DeepGreen Metals Inc., is conducting water column and benthic observations as part of their assessment of the Environmental, Social, and Governance (ESG) factors, while trying to determine which technology can deliver raw materials for the clean energy transition on the required timeline with the lowest ESG footprint.

THE ENVIRONMENTAL PRICE

The green conundrum, as it has been called, is that while deep-seabed mining (DSM) is arguably much friendlier to the planet and its inhabitants (child labor violations are among the more egregious offenses associated with terrestrial mining practices), there is still an environmental price to pay and no one can say with certainty how high exactly that will be. Filardo proposes that technology developed for nodule mining should be as focused on minimising impact as it is on maximising profit. "The future of the industry, with all its potential to be a net positive for the environment, may come down to demonstrating just how minimal its impact on deep sea ecosystems can be."

According to a recent white paper by DeepGreen (see link at the bottom of the article), a lifecycle analysis of metal production from nodules based on already proven technology found an opportunity for dramatic reduction of the impacts compared to ores mined from land.

The aforementioned conundrum, as DeepGreen's Head of Strategy & Business Development, Erika Ilves, points out, is strongly tied to the specific resource. "What we should be focusing on is comparing the ESG footprints across different sources of metals and choosing the ones that can help us minimise the damage to planet and people.", she said.

Seafloor resources contain different metals and are found in vastly different environments, from abyssal plains to seamounts to hydrothermal vents. Harvesting seafloor massive sulfide deposits or cobalt crusts requires cutting hard rock, and the preferred method now focuses on the removal of unattached polymetallic nodules from the seafloor. To harvest the nodules, the trawler/riser combination (see diagram) is the most developed so far, and is poised for use by early movers, such as DeepGreen and Global Sea Resources, the deep-sea exploratory division of the DEME Group.

MINING REGULATIONS AND CHALLENGES

Commercial extraction of resources outside of territorial waters and their 200 nautical mile "economic exclusion zones" fall under the jurisdiction of the International Seabed Authority (ISA), an organisation mandated under the UN Convention on the Law of the Sea, and comprised of 167 member states and the EU, as of March 2020. The ISA "Assembly" is tasked with creating the "Mining Code" to govern all aspects of seabed mining in international waters. Finalisation of the Mining Code was expected in 2020, but Covid-19 and other factors have caused delays. Commercial mining cannot start without it, but completion appears to be in sight within a few years. This would be very fitting, seeing as how the United Nations has declared 2021–2030 the "Decade of Ocean Science for Sustainable Development." DeepGreen expects adoption of the Code no later than 2023, according to a presentation published for investors. Further delays cannot be ruled out, however, nor can a complete halt, as public sentiment toward any sort of damage to ocean habitats is increasingly negative.

What the ocean mining world needs is a Plan B, as Filardo puts it, if at least to avoid a potential shut down. Sir David Attenborough, narrator of the BBC's Blue Planet, recently called for a moratorium on DSM. Filardo suggests that the seabed mining industry has a PR problem. Fundamentally, he agrees that seafloor mining is far less traumatic for the planet by comparison to terrestrial mining, but he fears that the industry might never get off the ground—or under the sea, to phrase it more appropriately—if they cannot present a better image to the public, and to the governing members of the ISA. Part of that effort, Filardo believes, is demonstrating an exhaustive effort to identify the most environmentally benign methods within the bounds of economic feasibility.

MULTI-TALENTED SWIMMING ROBOTIC TECHNOLOGY

With support from the Office of Naval Research (ONR), and other federal and state funding streams, Pliant has the go-ahead to develop the next generation of their Velox robot platform, an agile swimming robot called C-Ray that can transition from water to land, and travel over sand, snow, and ice. The undulating fins running along each side of the robot's core are the key to its low-energy propulsion and very high maneuverability, according to Filardo. Pliant has a string of patents on the core technology underlying the company's additional product concepts, which include hydroelectric power generation in streams and rivers as well as water filtration in underdeveloped countries, ongoing work for which Pliant is currently being funded by the US Department of Energy.

Modified for deep-seabed mineral extraction, the C-Ray robots will look something like the Cambrian Era apex predator, Anomalocaris, with nodule-grasping claws. This wholly different mining concept will employ large fleets of robots that make minimal contact with the sediment to pluck the polymetallic nodules and place them in containers that are raised to the surface with lift bags or vessels (see illustration). This method eliminates both the tracked crawler and the pumped riser whose potential affects alarm some environmentalists due to megafauna kills, sediment compaction, and sediment plume creation. Filardo points out that the crawler and riser also pose significant economic risks since both are single-point failure vulnerabilities that may cause an entire mining operation to shut down until repaired. He describes his alternate methodology, outlined on the NACROM website (see below), as a distributed system versus a centralised one. Plans include the possibility of replacing the metallic nodules one-by-one with low value rocks that double as ballast to aid descent of the collection baskets.

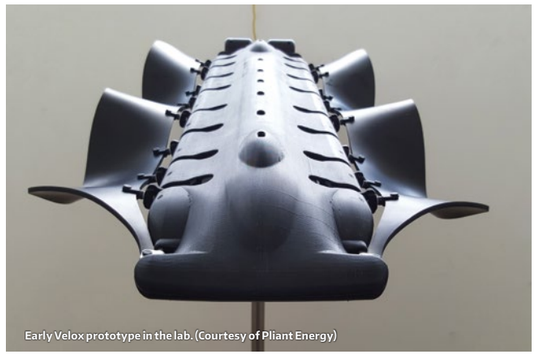
A push for advances in artificial intelligence (AI) has been a contributing factor in securing government grants, and Pliant's partnership researchers at MIT's Marine Robotics Group bring some of the world's best talent to the task. The MIT group will also help develop the swarm technology. The ocean seafloor presents all new challenges, though, as it is difficult to send signals at depth and in a 3-D environment.

As currently envisioned, the robot swarm will be under constant supervision by an optical fiber cable extending from the surface ship down to a robot base station. At the base station, optical modems will send signals through the water for robots to coordinate with each other and send signals back to the surface ship via the fiber cable. These optical modems are developing fast and will be taking advantage of the fact that the water is very clear in the abyssal plains, which Filardo maintains should remain clear during nodule extraction thanks to the slow-moving action of Pliant's robot fins. The robots will even be able to utilise underwater wireless charging at the base station while working, precluding any need to go to the surface or to plug in.

THE AMALGAMATION OF ROBOTS AND DEEP-SEA MINING

Lee Wilson is co-founder and CEO of HonuWorx, a startup developing new models for the autonomous deployment and operation of subsea robots. He believes robotics is key to the restoration of our seas and the sustainable scaling of emerging blue economy markets. "Technologies being developed by companies such as Pliant Energy and HonuWorx enable entirely new operating models for frontier marine markets, and that might be what's needed to make them viable," says Wilson.

Industry frontrunners like DeepGreen and DEME are likely to continue their technology development focusing on tracked vehicles to meet the demand for the highly sought-after metals needed for EVs and renewable energy components. But why not wait to see what the robotic platforms can offer? Given the urgency to reduce global greenhouse


Early Velox prototype in the lab. (Courtesy of Pliant Energy)


Early Velox prototype in the lab. (Courtesy of Pliant Energy)

emissions, and the apparent advantages to DSM over terrestrial mining, it seems unlikely at this point that the ISA will hold off approval of methods using the machines already in advanced stages of development to allow time for developing and testing alternatives. Filardo says he sees this reality and is working towards what he sees as the next generation of seabed mining machinery and methods.

Dr. Sebastian Volkmann, Marine Mining Advisor for Blue Mining Consulting, sees the current seabed mining methods as essential to kick-start DSM, but hopes it will find its way to a museum sooner than later, as second-generation technologies become competitive and push their way into adoption by the mining community. "It took us quite a while to go from 'dirty' gas and diesel engines to the mass production of high-range EV cars that can be quick-charged using green energy; however, I think the combustion engine was and still is a great invention that helped us reach this stage of civilisation and collective wealth. We need to learn and improve amazingly fast considering the vast area consumption and potential impacts of first-gen (tracked) technologies," says Volkmann.

For polymetallic nodules, we would need to mine about 100 soccer fields per day (1.5 megatons/year) to meet market demand, and some contractors are targeting even higher production rates, peaking near 11 Mt/yr (See below for DeepGreen's investors presentation).

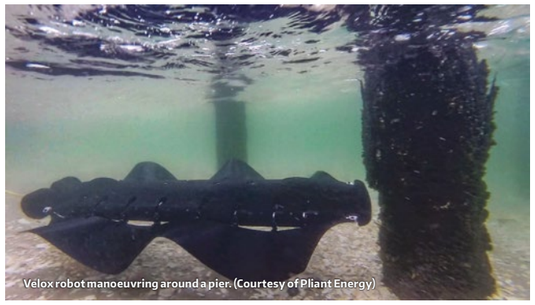
"The aim should be to, first of all, limit impacts through setting production limits and environmental threshold values, strive to minimise the impacts, and to ultimately restore habitat or improve the area," shares Volkmann.

THE WAY FORWARD

In order for the technology to become affordable, it requires someone to invest the time and effort. Ocean mining may provide the demand required to cheaply mass produce robots for the job. Mass production for DSM is not a starting point, though. Cross-training in other arenas – such as military reconnaissance and support, oil and gas interventions and checkups, offshore renewable energy service and monitoring, and aquaculture – might be the path forward until the robotic method becomes more appealing for mining. Simultaneously mining operations, like DeepGreen's for example, would need a lot of subsea platforms with sensor payloads to monitor future operations and track impacts in real time.

"Operations the scale of deep-sea mining consume a lot of energy and interact with a variety of habitats. If alternative technologies can shave away even a small percentage of those impacts, I believe they're worth adopting, but until regulations require them, financial models will drive their adoptions," says Geoff Douglass, CEO at Mythos AI, a maritime startup co-founded with senior developers from the Silicon Valley self-driving car industry.

"Deep sea mining meets the dull, dirty, and dangerous criteria of all great robotics applications, but technologies must be at a high maturity level to aid operations rather than impede them," he said. "This has prevented the subsea community from adopting autonomy and forced them to work with remote and man in-the-loop systems. The tech simply has not been reliable enough, but we are at the precipice of a new generation of marine robotics enabled by AI and deep learning. In the near future, vertically integrated AI will lead to a level of capability, efficiency, and reliability the subsea industry has not known."


Vélox robot manoeuvring around a pier. (Courtesy of Pliant Energy)

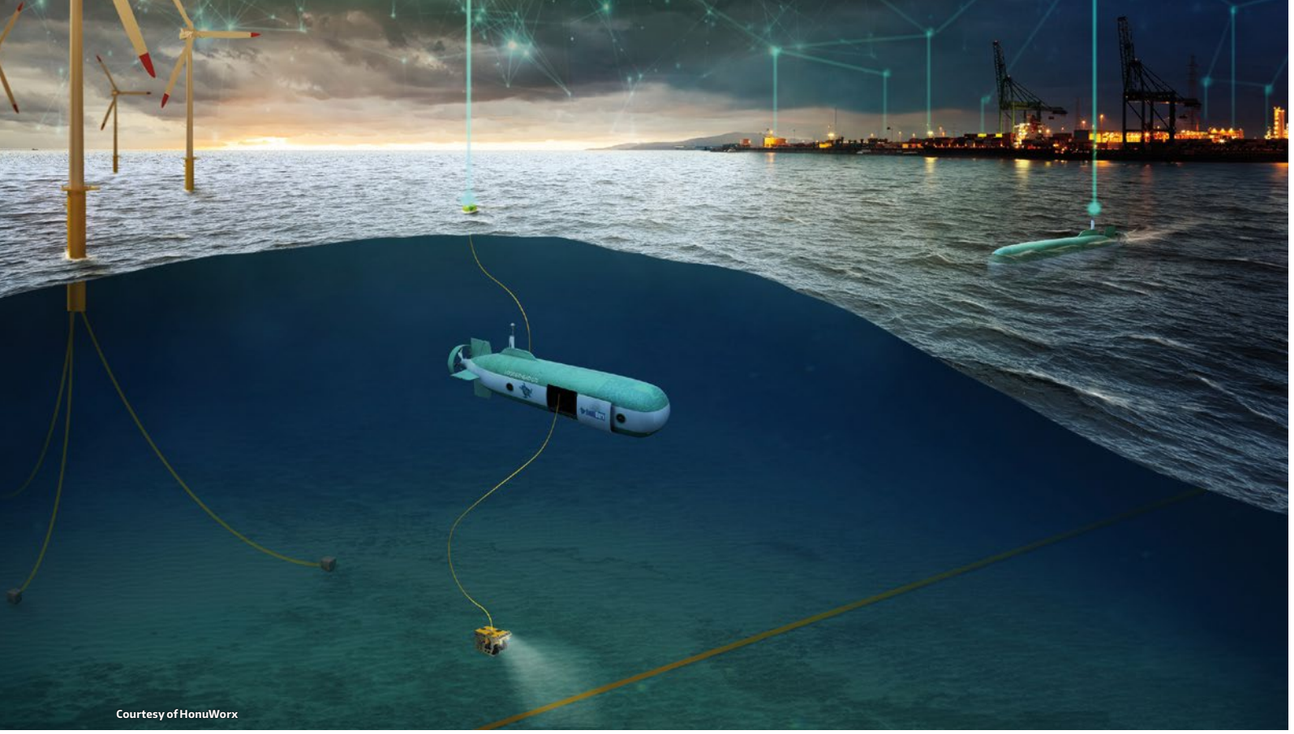
Nations and governing bodies are likely interested in alternative technology as, although deep-sea mineral extraction supports de-carbonisation, it is still, at-scale, an unproven risk to biodiversity.

Ian Denton, a self-employed marine engineer operating ENOTIV Consulting, feels that as the present-day focus on a net-zero carbon economy becomes standard practice in the future, the focus will shift to loss of biodiversity. Subsequently, companies using existing DSM technology will become very interested in next-generation, environmentally benign technology.

"The ocean holds valuable mineral resources that are key to building a green energy future but is also home to bizarre and beautiful creatures; most are still unknown to us humans. We need to understand the needs and health of the ocean and its ecosystems for large areas and time scales to the most remote and difficult places: before, during, and after our marine business," said Volkmann.

Once a robotics company scales up to mass production levels, the robots can be modified for other purposes. Some noteworthy mentions that Filardo has in mind for his robots are harvesting scallops without today's destructive trawl methods, and for seagrass planting and coral reef restoration. As with the seabed mining, all of these projects are designed around the fundamental job of robots: to perform operations that humans cannot, to perform them at the scale needed, and to work in environments and perform tasks that are too dangerous for humans.

As deep-seabed mining regulations make their way to finalisation, we will have yet another opportunity to become a global people that will do the right thing for the environment based on the best available research or let "business as usual" rule the day. With brilliant minds – and robots – presenting a case for alternative extraction of deep-seabed resources, the emerging DSM industry will have some great options to work with in the near future.



COST-EFFECTIVE SUBSEA OPERATIONS WITH HONUWORX

Lee Wilson and Lucas Wissmann, HonuWorx Co-Founders, www.honu-x.com

HonuWorx is pioneering robotics technology for restoring, exploring and commercialising the ocean's resources. The company's visionary Loggerhead concept will make sustainable subsea operations at scale a reality for many sectors in the blue economy.

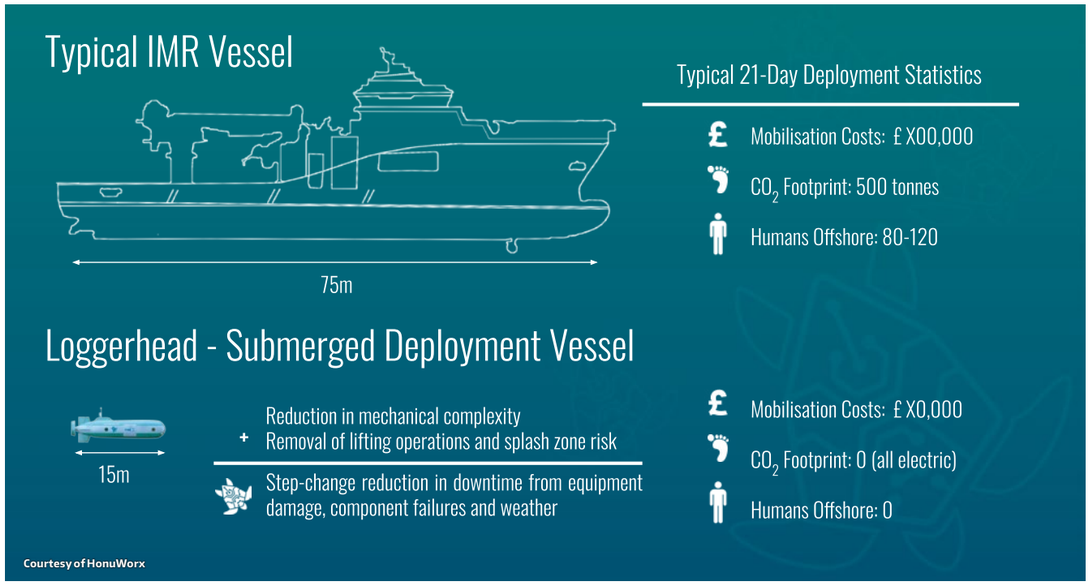
A BOLD APPROACH

The world needs to work subsea—for the sustainable development of energy, to advance understanding of our planet, to restore and monitor the oceans and for the responsible harvesting of their resources. Subsea robots are critical to the continued growth of many ocean economy sectors. However, the cost and environmental footprint of traditional deployment methods is no longer sustainable with their reliance on large, crewed, diesel-powered vessels.

Despite growing demand, the global intervention-class ROV fleet of over 1,000 vehicles rarely achieves annual utilisation beyond 50%, largely because of steep costs in transport and deployment. A 21-day subsea inspection campaign can run at least £1.5m and emit more than 500 tonnes of carbon dioxide. Fully configured vessels can cost upwards of £100k per day, with the ROV and crew making up a fraction of the overall price tag. Because of the cost domination of the vessel, work is generally priced on a day rate, regardless of the complexity of the subsea task.

HonuWorx's Loggerhead concept (patent pending) is a game-changing development that utilises an uncrewed submersible robotic vessel as a mobile power and communication hub for ROVs and AUVs. Emerging uncrewed vessel concepts may face difficulties deploying in heavy weather, whereas Loggerhead deploys the robots subsea to avoid splash-zone risks. With impact risks associated with launching robots through the splash-zone eliminated, ROV and AUV designs can be simplified and optimised for the task at hand.

Loggerhead's major innovations are three-fold: (1) the integration of a long endurance submersible delivery craft with remotely operated or autonomous "worker vehicles", (2) flexible, Distributed Control Centers (DCCs) to support human supervision and control by onshore operators, support teams and observers that could be distributed geographically and (3) advanced software to mitigate teleoperation issues with robots, and make the best use of the communications modes, whether satellite and 4G/5G (or a mix of both).



Loggerhead promises to disrupt the commercial model of how work is performed subsea, which makes it appealing to several of the emerging blue economy sectors. Since geographically distributed teams can be digitally connected through the DCCs, onshore crews can manage multiple projects with smaller teams. And because Loggerhead promises a significant reduction in mobilisation and operational costs, subsea robotic services can also be more lean and agile—and priced the way they should be, based on value.

THREE PILLARS

HonuWorx integrates technology in three key areas to progressively automate remote, subsea robotic operations. The first pillar of our work is submersible deployment vessels, which keep the robotic systems subsea and eliminate risky crane drops through the splash-zone. These vessels serve as control and communications hubs, allowing humans to supervise and control the offshore robotic operation from the safety and comfort of onshore facilities.

Deploying vehicles from surface vessels is a tricky balancing act at best and an archaic dance at worst. The vessel size will determine its stability in the waves, and the vehicle's ability to absorb load depends on its strength. Other deployment factors in the splash-zone include: the vehicle shape; the extra weight a tether management system typically adds; how well the armoured umbilical and launch systems can manage dynamic loads. Each element of deployment is unique to the given use case, and a cyclic dependency exists between each element. Submerged launch bypasses the complexities. Vehicles, tooling suites and sensors reach a site in a low-stress manner.

The second pillar of our work is connecting geographically distributed team members to remote robotic operations. By enabling distributed supervision and control, stakeholders can keep human staff on shore and out of harm's way. Keeping employees onshore not only allows business leaders to connect team members across the organisation more rapidly, but it also creates an opportunity to build a more inclusive work environment, as roles that once required physical mobility can now be executed onshore by any trained staff members.

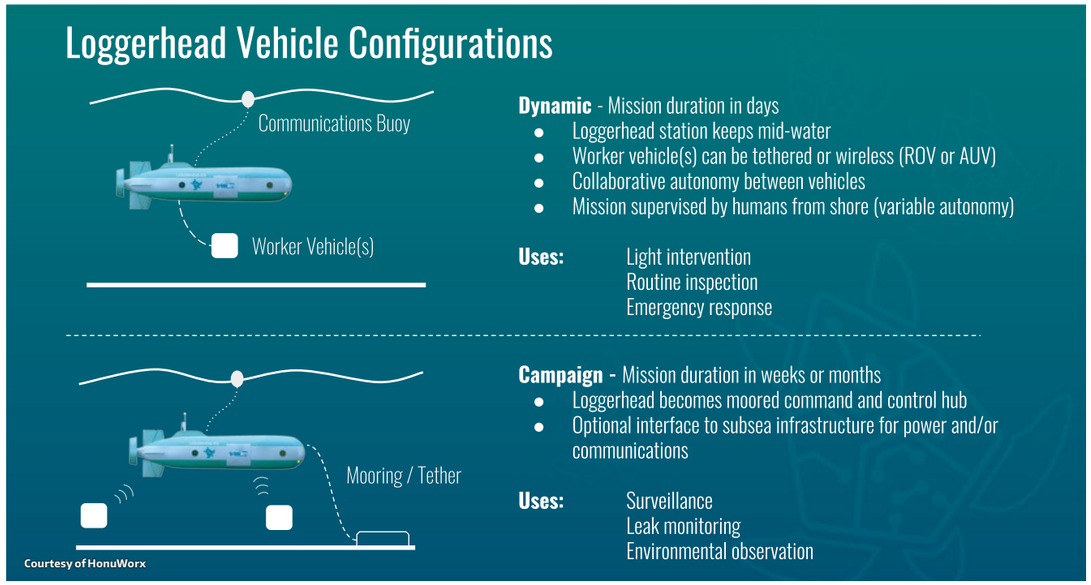
The offshore industry is already embracing the potential for remote operations to reduce risk and increase productivity, with several cutting-edge remote operations centers already in use for supporting ROV operations. By keeping human robotic pilots in the loop via the DCC, while making sure employees retain the autonomy to handle arising situations, offshore businesses can leverage human skills as they verify the system's capability.

The HonuWorx Distributed Control Center evolves legacy peer-to-peer remote operations systems toward digital "control towers." Control and mission planning modules are moved to the cloud, along with administration and data management tasks. Removing the need for physical data centers and IT infrastructure allows participants to access the operation securely, and in real-time, from wherever they are located.

Lastly, HonuWorks creates software, our third pillar of work, to expedite automation and coordinate multiple robotic platforms to perform tasks. Autonomous behaviors are a productivity booster, and in time they will become the preferred way of operating. Coupling proven software and communications technologies with standardised interfaces, HonuWorx can deliver remote operations capability for ROV or AUVs from a wide range of manufacturers.

CROSS-SECTOR ENABLER

The Loggerhead solution is inherently cross-sector. Affordable subsea robotics are the bedrock of smart growth



in vital sectors like offshore renewable energy and aquaculture, where a lack of subsidy and dynamic margins can already challenge profitability. Loggerhead enables cost-effective, sustainable subsea work for a wide range of commercial applications, from offshore floating wind to offshore aquaculture. The technological capabilities of Loggerhead also facilitate scientific and environmental restoration, including the removal of ghost gear and UXOs, and the recovery of coral reefs and kelp forests.

With a new model for working subsea across a range of sectors, the demand for subsea robots will only grow. This expansion benefits existing robot owners by improving utilisation while seeding new sales and product development opportunities for manufacturers. For vehicle and accessory companies looking to get offshore, submerged launch offers a route, since it removes the barriers of surviving launch and the financial burden of investing in surface vessels and bespoke launch systems.

EXPERIENCE & VISION

The HonuWorx team is a seasoned, multidisciplinary group of entrepreneurs and engineers with a groundbreaking approach to subsea robotic operations. In long careers building subsea robotics systems, we've learned from working alongside many true industry pioneers, and we led the development of one of the world's most advanced commercial AUV developments, the Subsea 7 AIV.

Our expertise spans ROV and AUV design, subsea intervention and repair, underwater and surface autonomy, remote operations and manipulator automation. As proven innovators in marine robotics, we bring a depth of experience in cutting-edge autonomous systems and subsea infrastructure. HonuWorx's new model for underwater work grew out of many time-tested observations, along with technical and commercial battle scars. We're eager to accelerate the uptake in advanced subsea robotics, for the entire industry's advantage.

The blue economy is here. As noted in the European Commission's Blue Economy 2020 report, optimising marine and maritime economic sectors plays a vital role in society's resilience. Existing approaches for working subsea are not scalable in terms of carbon footprint, not to mention cost. Plus, there is a capabilities gap related to working subsea that extends across multiple sectors.

HonuWorx has the technological edge needed to deliver sustainable subsea operations for the blue economy. As a team, we've operated in companies both large and small, with a wide range of mature and bleeding-edge technologies. Industry leaders want a new way of working, one that restores ocean resources while creating value. We believe Loggerhead offers that new model, and HonuWorx can deploy robots sustainably at scale.

Loggerhead was initially inspired by our deep experience with offshore energy use cases, but we're exploring other sectors too. Potential sponsor organisations interested in championing our approach range from defense and marine science to subsea mining. Although HonuWorx has aligned with several prospective partners, we're constantly learning about emerging technologies that can help us accelerate our product roadmap.

The subsea industry can generate commercial success and lead the way on safeguarding ocean health. That requires an honest look at legacy systems as well as legacy business culture: neither are equipped to usher in a resilient future. Innovative practices and revolutionary technology pave the way forward for organisations seeking to restore, explore and sustainably commercialise ocean resources.

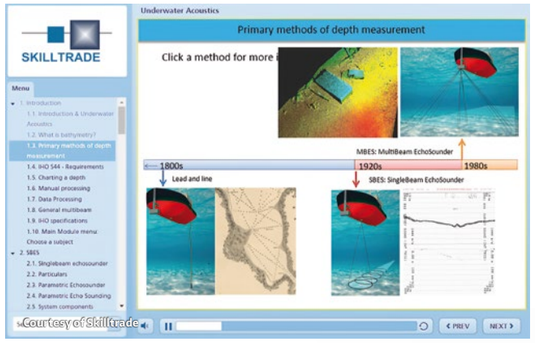
SKILLTRADE HYDROGRAPHIC SURVEY COURSE REVIEW

E-LEARNING MODULES (BATHYMETRY, GNSS, GEODESY)

Richie Enzmann, ROV Planet

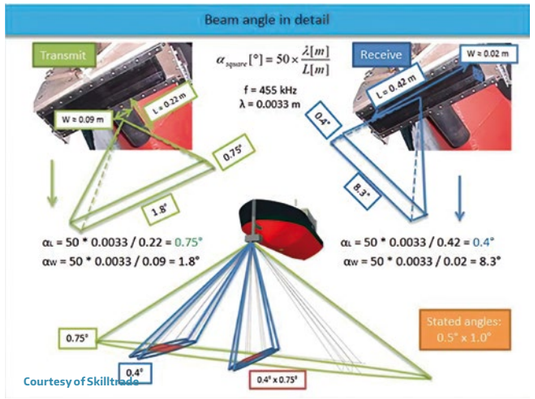
I took the opportunity to start the Hydrographic Survey Category B training with Dutch company Skilltrade B.V. They are now providing some of their courses partly online, followed by practical training in the Netherlands. Besides the training, I can recommend their three volume Handbook of Offshore Surveying, which I also bought. It's an excellent reference point if someone wants to know about topics related to offshore surveying, including acoustics, active sonars, geodesy, underwater positioning, and satellite navigation systems. With the UN Seabed 2020 initiative to map the seabed by 2030, the hydrographic skills – including remote hydrography using AUVs and USVs – are more relevant and in higher demand than ever.

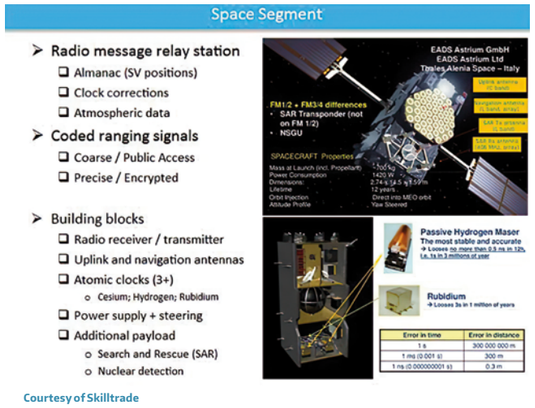
In order to actually start the course, Skilltrade want to make sure that all their students are up to standard in Maths and Physics to a level that is required for the understanding of hydrographic principles, and to be able to actually perform the job of a hydrographic surveyor. So, the whole process starts with those modules that you must complete in your own time prior to commencing with the course.



E-LEARNING MODULES

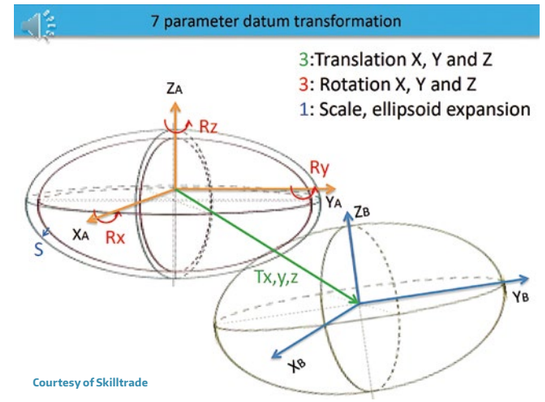
Once the basics are out of the way then you can work through the Course's E-learning modules. Skilltrade recommend students complete these within around 12 weeks. I like learning new things, especially things related to underwater robotics, engineering, and science, so these E-learning modules were a real treat for me. However, I did find that you need to put in a considerable amount of time if you want to thoroughly understand the topics, and I do recommend that future students spend time on them regularly on a daily basis.





BATHYMETRY

It's a comprehensive course module comprised of both Underwater Acoustics as well as an in-depth approach to both Singlebeam and Multibeam echosounders. For these systems both their principles, installation, calibration, and operation are described. Other bathymetric systems are described on a more general level, including their basic measurement principles. Here you will also learn about the sonar equation, acoustics and sound velocity parameters, transducers, and different sonars.



I found this module to be very practical in terms of its focus on the needs of a hydrographic surveyor. The exam questions also address problems from real life scenarios that need to be solved.

GNSS OPERATIONS

It's a comprehensive course module teaching both the operational principle of Global Navigation Satellite Systems, as well as the electronic basis on which they operate. All four major GNSS are described (GPS, Glonass, Beidou, and Galileo) as well as their application to (hydrographic) surveying. A short introduction to relevant geodetic and statistic concepts are given. More advanced topics such as the Least Squares Adjustment computations and satellite position computations are found in the modules 'Positioning' and 'Geodetic Coordinate Reference Systems'.

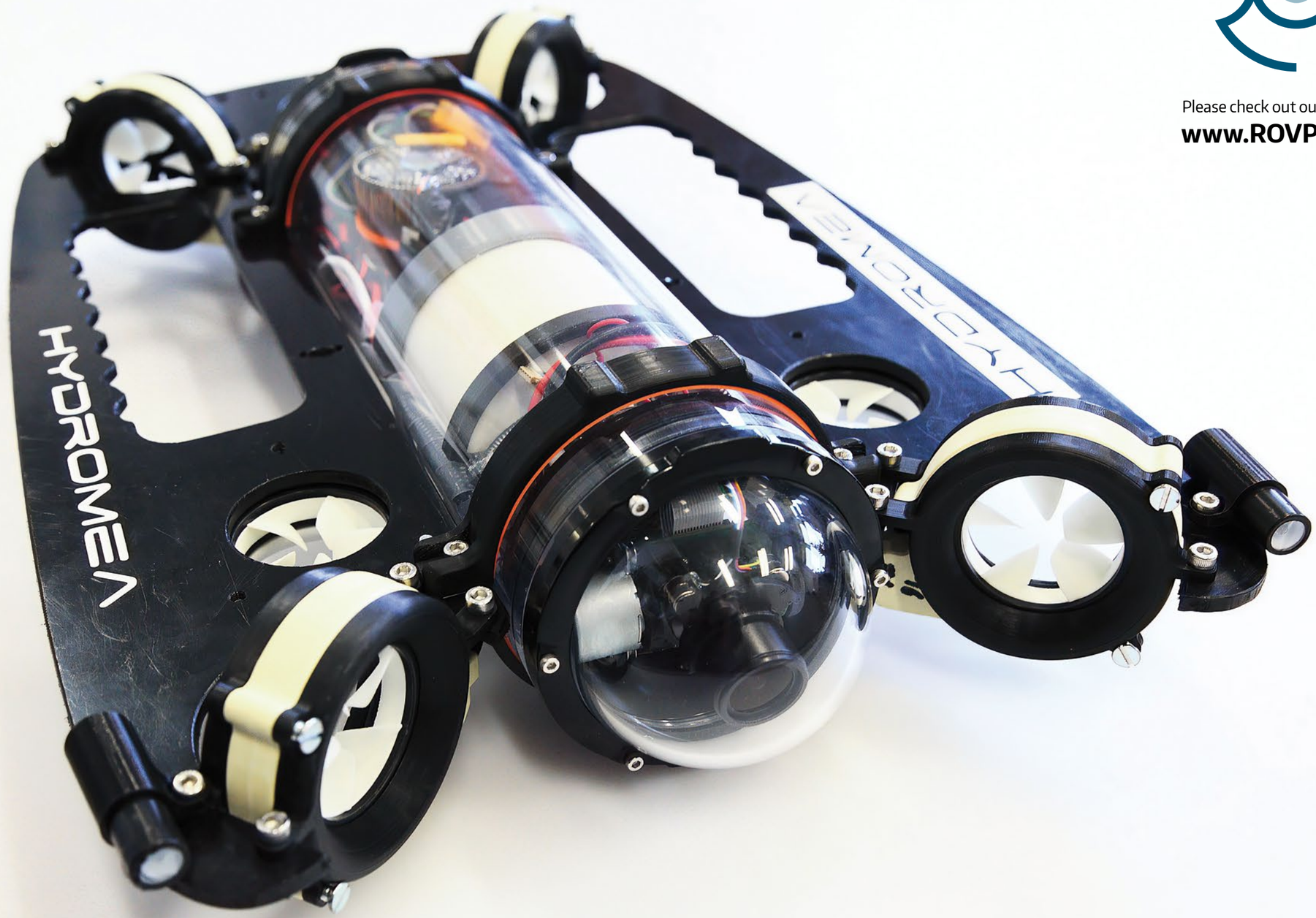
GEODESY

A comprehensive course module giving all the necessary information to understand and apply geodetic principles to surveying in general, and hydrographic surveying in particular. Topics include horizontal datums, the geoid, datum transformation, map projections in general, UTM and vessel reference systems. The course module teaches both a general understanding as well as the main formulae and their application to geodetic software.

FREE "TASTER" COURSE MODULE

Are you interested but still not 100% committed to booking? Then the Hydrography Introduction might be the way for you to go to get a taste of the course. The Hydrography starter course module is based on the introduction chapters of the Handbooks of Offshore Surveying. Those chapters are part of the course and all are available for free (after registration as a user). This training can be done free of charge.

Overall, I wholeheartedly recommend this course to everybody that wants to get into hydrography and/or is interested in the workings of underwater equipment and their capabilities. I'd argue that this could be of interest even for development engineers/scientist (already with engineering qualifications and experience) working on novel underwater technologies, who want to get grips with the practical requirements, needs, and limitations of the underwater world.



ExRay: Wireless Portable Underwater Drone (Courtesy of Hydromea)


Courtesy of HMS Oardacious

HMS OARDACIOUS

The Submariners are back! HMS Oardacious is ready to GO AGAIN! With sights set on the Talisker Atlantic Challenge in December 2022, 2023, 2024 and beyond!

In January 2020, four serving Royal Navy Submariners became both the first ever Royal Navy team, and fastest serving military team in history to row an ocean, spending 37 days 6 hours and 40 minutes battling across the North Atlantic.

'HMS Oardacious' has grown from a mad concept into a successful submariner wellbeing initiative that has reached millions around the world. The rowers and wider team collaborated with fantastic organisations that add value to a unique defence community; they have helped inspire the next generation of sailors and adventurers in partnership with the Sea Cadets; they have championed Mental Health and Resilience through the pandemic and successfully fundraised over £110,000 in support of Mental Health and Wellbeing charity initiatives.

Submariner culture truly harmonises with the extreme environment of "the World's Toughest Row", whether it's being experts of their environment and equipment, looking after crew mates, managing watch systems whilst battling sleep deprivation and coping with the emotions of leaving loved ones. Fortunately, the greatest strength of the Submariner is being able to maintain a sense of humour in some of the very worst conditions. Humour is a cornerstone to Submariner ethos, when the vessel you choose to call home for upwards of 3 months at a time is designed to sink, remaining positive and being able to laugh is essential. HMS Oardacious is back to showcase the professionalism and adaptability of Submariners; the teams' bodies and minds will be tempered by the sheer vastness of the Ocean Surface; Neptune will again throw his fury upon the small Oardacious craft... and he will be met by Royal Navy Submariners, laughing back at him!


Courtesy of HMS Oardacious

Courtesy of HMS Oardacious

Courtesy of HMS Oardacious

CHARITY

HMS Oardacious continues to collaborate with the Royal Navy & Royal Marines Charity in support of some fantastic initiatives; The Submarine Family, a new project with a focus on mental health and wellbeing support to both serving and retired submariners and their families and the Submariner Memorial Appeal which was set up to create a fitting tribute at the National Arboretum to submariners who have lost their lives, creating a place for personal reflection, repair and renewal in the face of tragedy.

GETTING INVOLVED

The campaign is only just starting and there are many opportunities to get involved including sponsorship and charity support. To find out more about the team, the challenge, the charities or how to sponsor, please visit www.hmsoardacious.com, follow the campaign on social media @hmsoardacious or you can contact admin@hmsoardacious.com

REMUS 300 UUV (Courtesy of HII)

THE FUTURE OF THE AUTONOMOUS UNDERWATER VEHICLE INDUSTRY

Richie Enzmann chats with Duane Fotheringham, president of the Unmanned Systems business group at Huntington Ingalls Industries (HII), Technical Solutions division, about his perspective on what the future holds for AUVs.

HII's USV solution include sensor fusion, perception, and multi-agent command and control. (Courtesy of HII)

RICHIE ENZMANN: With the new acquisition of Hydroid by Huntington Ingalls Industries (HII), would the technology – or the focus of the technology – change?

DUANE FOTHERINGHAM: The reason HII acquired Hydroid was for our deep domain experience and expertise in autonomous unmanned underwater vehicles. Overall, we see the increasing importance of unmanned systems in the future of maritime operations, on both the military and the commercial side.

HII is a U.S. defense contractor and a shipbuilder and has been very involved on the military side of things. Hydroid also had a strong history in commercial and international markets, so all these things are coming together. It's been over a year since Hydroid became part of HII and we are fully integrated with the unmanned systems that HII already had in their portfolio: primarily the large underwater vehicles that were part of a previous acquisition from the Columbia Group, but also the partnership with Boeing on the fabrication of the Orca XLUUV.

And we have been increasing our capabilities throughout the year, so it's been a busy 12 months for us. During the summer we made an equity investment in Sea Machines which is a provider of USV technology, so we are really increasing our unmanned systems portfolio from underwater to the surface.

We announced another large investment in the fall with the development of the Unmanned Systems Center of Excellence, which is a high-tech manufacturing operation in Virginia. We see this facility as complimentary to all of our manufacturing that we are currently doing.

Right at the end of the year, we acquired the autonomy business of Spatial Integrated Systems (SIS). Their primary work is with unmanned surface vessels, and they have some significant positions there, but they also have some positions in ground and aerial vehicle autonomy. We are really expanding the scope of what we are doing and how we define unmanned systems. We now have the full portfolio: under the water, on the surface, and in limited cases in the ground and air.

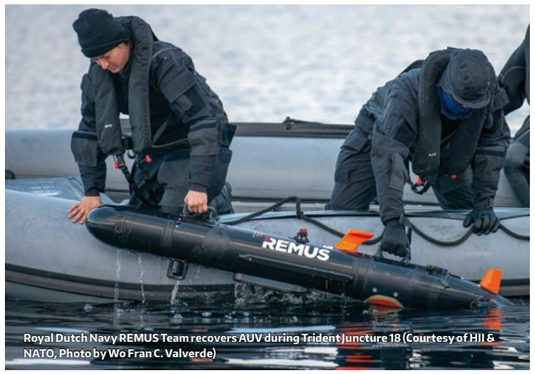
A HII REMUS 100 UUV was launched from a Malloy T150 UAV as part of a proof-of-concept demonstration during the Advanced Autonomy Force (AAF) 2 exercise. (Courtesy of HII)

RE: Are you trying to integrate the different domains into one complete system then?

DF: That's right. We see all these things as key for an unmanned portfolio. What we have been really working on is the integration of the autonomy. Taking the capabilities that existed within HII, Hydroid, and SIS, and forming them together into one autonomy architecture. There are a lot of overlaps in the different domains. A lot of development of the future capability of unmanned systems is in increasing the capabilities of the autonomy.

RE: Do you think that the human operator will ever be taken out of the loop? Could these systems be truly autonomous one day when the decisions are made by the machine itself?

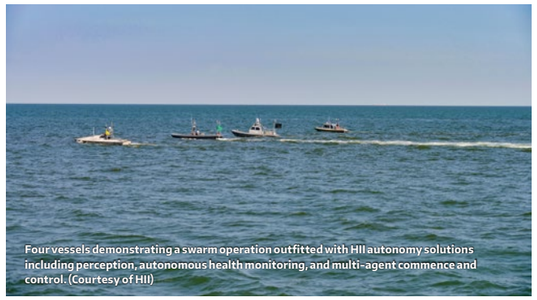
DF: I guess it all depends on how you define that. One of the unique things about underwater vehicles is that they have a very limited communication span over relatively short ranges compared to other domains. We have been building AUVs for 20+ years and most of those are fully autonomous.



Royal Dutch Navy REMUS Team recovers AUV during Trident Juncture 18 (Courtesy of HII & NATO, Photo by Wo Fran C. Valverde)

The new REMUS 300 UUV combines advanced modularity and flexibility in a two-man portable platform. (Courtesy of HII)


Rendering of HII's new Unmanned Systems Center of Excellence, due to open in Q4 of 2021. (Courtesy of HII)


Four vessels demonstrating a swarm operation outfitted with HII autonomy solutions including perception, autonomous health monitoring, and multi-agent commence and control. (Courtesy of HII)

We put vehicles in the water, they go out and do the mission, and that mission can last from 8 hours for a small vehicle all the way up to 30+ day missions with very little communications or man in the loop. The man in the loop in those cases is usually limited to receiving information and small redirects – in essence, they can operate that whole time without a man in the loop. Our Seaglider UUVs are out there typically for 90+ days. They certainly communicate, but it's not required to do that to run the mission and is not required to have any operator intervention. So that way, we are a man out of the loop. What we are able to do with the increasing autonomy is really increase the capability of the vehicles. We are moving from a much more deterministic type of autonomy, where the vehicle goes essentially down the decision tree of choices, to a more artificial intelligence/machine learning autonomy, where the vehicle can actually make a decision on its own based on the information it is gathering during the mission. That is where we see the capability increasing.

RE: When you say "deterministic", you mean that, for example, in Mine Counter Measures the vehicle would include the detection of mines and how to disable them, right?

DF: Most of our work right now is with the detection of mines. The vehicles we put in the water run a mission and that mission may be able to be adapted in situ by the vehicle depending on what the environmental conditions are. When it returns, we would download and analyze the data and visually identify the mines and take the next steps. We are now operating systems that the Navy calls single sortie detect to engage. This means that the vehicles can go out, the software can automatically identify mines, and the vehicles can change the missions to go back and reengage the mines with either a high-resolution sonar or with optical sensors. The vehicles can ultimately relay that information back to other vehicles or people, that then act against the mine to destroy it. But it is typically two separate types of vehicles that detect and then do the mine disposal.

RE: So there is some cooperation between the vehicles then, right?

DF: Absolutely. They can have cooperative autonomy, meaning that one vehicle can communicate with the other and pass information back and forth between them depending on the mission defined. One example of that would be that one vehicle detects the mine and cues the second vehicle to either come in with a better resolution sonar or perhaps even to dispose of the mine.

RE: When people talk about swarming, are you far off from that, or does that imply a higher number of vehicles and a more coordinated approach?

DF: That is one of the significant capabilities that we brought in with the autonomy business from SIS: multi-vehicle autonomy, which is another word for swarming. This is a significant capability for multiple vehicles working together cooperatively on the surface and can also be applied to our subsurface vehicles.

RE: Do you think that some other areas of underwater warfare could also use these kinds of technology? With mine countermeasures you have a static target. But would the


1000-meter rated Seaglider operated by NOAA. (Courtesy of HII)


REMUS 6000 being launched from the quayside. (Courtesy of HII)

same apply for dynamic targets in the battlefield for anti-submarine warfare?

DF: That is certainly an application area for our unmanned surface vessels and unmanned underwater vehicles. Our REMUS UUVs can be integrated with submarines and the Navy has programs out for unmanned surface vessels for anti-submarine warfare missions. There are lots of different military and non-military missions that these vehicles can do besides mine countermeasures. Some of the missions particularly well suited to unmanned systems are ISR (intelligence, surveillance and reconnaissance) missions, going into places where you would not want to put a manned platform to gathering information about an environment. There are many sensors that can be put onto the vehicles to gather information.

RE: And I guess the vehicles can also be used for survey, research, etc when going into the commercial/civilian side of things.

DF: Yes, absolutely. A big application area for both unmanned surface and underwater vehicles is seabed survey including side scan survey and hydrographic survey. Our vehicles have been used by the U.S. Navy, the Naval Oceanographic Office, for gathering hydrographic quality data capable of building charts. That says a lot about both the performance of the sensors as well as the positioning systems of the vehicles to be able to collect data with enough accuracy to go onto nautical charts. This has always been an application area for surface vessels in general, but again, autonomy removes the man off these platforms to be much more efficient than a manned platform.

RE: Do you think that humans would be removed from military submarines as well?

DF: The simple answer is probably not. What we see is cooperation: the ability for manned and unmanned platforms to be interoperable and work together to perform missions that otherwise they wouldn't be able to do themselves. Unmanned systems are certainly a force multiplier for manned submarines. And there are missions that are well-suited for unmanned systems where we want to operate for long periods of time to gather information, gather intelligence, and put sensors on targets. But also missions that are best suited for manned missions where you have a significant number of people making decisions and performing those complex missions that may be outside of the capability of an unmanned vessel. However, the unmanned platforms can give them capabilities that they would otherwise not have.

RE: That makes sense. What's going to be the next product or capability for Hydroid/HII? Is there anything in the pipeline that you are planning to launch in the future?

DF: Right now, the newest thing that we have on the market is the REMUS 300: the next iteration of the small class UUV. It is two-man portable, 300m rated, open architecture and completely modular. In this case, one single vehicle is suitable for doing anything from small man-portable missions all the way to long 30 hours of endurance. Customers can increase endurance further with field-exchangeable energy modules. In the software, we are continuing to add new capability to these vehicles and our open architecture platform makes them very upgradeable, so they are in essence future proof. Our customers and third parties can add to that open architecture and modularity with capabilities and payloads now or in the future.

One of the new capabilities with the autonomy that we are working on is the ability of the vehicle to detect a degradation of the system or one of its sensors. It would then replan the mission to either accomplish the whole mission or significant portions of the mission even though there might be some degradation of the vehicle. In the future, there will be capabilities to predict the failures before they happen using artificial intelligence and machine learning.

RE: And all these features will be available for the REMUS 6000 too?

DF: As we move forward and refresh all our products with the new generation of the REMUS Technology Platform, all these capabilities will be available across the product line. As we are looking into 2021, we are looking at how we integrate all these systems across our complete product portfolio, and we continue to increase the international presence that we already have with Hydroid as well as our core market in the U.S. for the U.S Navy.

ARGEO ORDERS TWO SEARAPTOR AUVS FOR ULTRA-DEEPWATER SURVEYS

Courtesy of Argeo

Argeo has placed an order for two new-build SeaRaptor 6000 Autonomous Underwater Vehicles from Teledyne Gavia, with first delivery taking place early Q4 2021 and next delivery taking place Q1 of 2022. The delivery includes several ancillary system components, software, and crew training. In parallel with acquiring the AUVs, Argeo has secured a deep-water survey in the Pacific region for an un-named scheduled in several projects over a three-year campaign, and potential for further extension.

If we're looking for deep sea minerals on the Norwegian continental shelf – near the mid-Atlantic ridge – then in two years' time as an example, a long range AUV could be launched from Tromso, north of the Polar Circle to go out, acquire data for 8 days, and come back again. Or it could be sent from Stavanger to the UK for a survey and come back again. With long distance AUVs there is now a tremendous scope for technology, and it is endurance that's really paving the way for these solutions.

Argeo – established in 2017 with offices in Asker and Tromsø, Norway – is on a mission to transform the survey and inspection industry in this way. That is their game plan. They think that the future of offshore survey will look completely different in 5 years' time.

Initially, the company started becoming experts on the data side before moving into the robotics game to make sure that they could handle the complete the workflow from survey, and the acquisition of data to the digital export. They also have a new project launched last year; a digital twin of the ocean space. From a survey campaign they can present their customers with a digital representation of segments that they're working on, from inception to decommissioning. This gives a completely different view of the data when it comes to decision making.

Although they're working closely with Teledyne and other vendors on the AUVs, they also design and develop their own USV surface robotics solutions with another Norwegian company, Maritime Robotics. They've created a brand-new,


Courtesy of Argeo

long-endurance surface robot, scheduled to come to the market this September. It features 30 days endurance, complete onshore mission controls, and all the high-spec sensors available to be able to survey the shallower type of offshore wind farms. It will also be able to link up with their existing Hugin AUV system, and the new SeaRaptor AUVs that they've just bought from Teledyne.

TELEDYNE GAVIA SEARAPTOR 6000

The design, specification, and procurement of the AUV have been successfully carried out in close cooperation with Teledyne Gavia of Teledyne Marine. The detailed work conducted ensures that Argeo will receive a state-of-the-art, high spec AUV. The AUV is modular and very mobile (air transportable), with supporting systems which can be strategically placed in their geomarkets for rapid deployment between regions. All data collected will be processed onboard (the AUV) using postprocessing and mosaicing software to allow quick turnaround during missions, and improved decision making for the customer.


Courtesy of Argeo

The SeaRaptor AUV systems will be the company's third and fourth vehicle contributing to their growing robotics fleet. It will enable deep-sea surveys to the benefit of marine industries, including installations and infrastructure, offshore wind, oil and gas, and deep-sea minerals.

SEARAPTOR 6000 SENSORS AND PAY-LOAD SPECIFICATION

The AUV will be equipped with the latest Kraken MinSAS 120 Synthetic Aperture Sonar (from Kraken Robotics, Canada), providing large swath area coverage, high-resolution imagery, and bathymetry data collection. The vehicle will also be fitted with a Teledyne Reason T50-S Multi-Beam dual frequency 200/400 kHz Echo Sounder, a Teledyne Benthos Chirp III Sub Bottom Profiler, an iXblue PHINS 6000 INS coupled to a Teledyne RDI Tasman DVL, and a CathX Hunter Camera System.

Courtesy of Argeo


Courtesy of Argeo

The AUV is also fitted with a large variety of scientific sensors which will take conductivity, temperature, pressure, turbidity, pH, dissolved oxygen, redox, CH4, and magnetic measurements to provide valuable water column data. These will contribute to better ocean basin characterisations.

The SeaRaptor 6000 AUV will be supplied in a 40-foot container hosting its Launch and Recovery System, all deck support and handling equipment, as well as a spare set to offer the highest redundancy and availability of the system. The vehicle is designed to be air transportable, including its lithium-ion batteries, which feature capacity for long endurance missions.

DEEP SEA MINERALS (DSM) CONTRACT

The AUV is scheduled to start work on a deep-sea mineral and environmental impact study campaign in the Pacific region immediately after completing Factory Acceptance Testing (FAT). The campaign contract value over that three-year period is estimated to be between NOK 30 to 40 million. The company intend to further upscale project activity in the region with the system already present, thus reducing mobilisation cost for our customers who need high-quality deep-sea data.

The holistic approach of how Argeo approach robotics and data – including bringing the digital twin to the deep-sea market segment – will have a major impact on the environmentally neutral activities of how data could reduce cost, and aid decision making in our all-electric future.

To find out more visit www.argeo.no


Courtesy of Argeo

Courtesy of Argeo

SEA SENTINEL

BIONIC UNMANNED UNDERWATER VEHICLES FROM NOA MARINE


Courtesy of NOA Marine

Michał Latacz – Chief Engineer & CEO, NOA MARINE

NOA Marine implements the use of renewable energy to power unmanned bionic underwater vehicles. The Sea Sentinel vehicles come both in tethered and untethered configuration, collecting chemical, acoustic, and visual data, and conducting uninterrupted observation with high resolution measurements for 300 days a year.

INSPIRED BY NATURE

The future of ocean exploration and infrastructure maintenance belongs to autonomous vehicles; hence the goal was to build efficient units capable of safe and long periods of unsupervised service, powered purely by a renewable source of energy. Applied biomimetics was one of the passions shared by the NOA Marine team, and we as engineers were driven by mechanical and physical solutions that Mother Nature has developed over millions of years. Clearly those remain well ahead of contemporary human technology. Inspired by the beautiful and elegant way cephalopods swim, we noticed that the propulsion system of those animals is completely different from that used by man-made structures. The struggle for survival forces evolution to adopt the best possible optimisation; a creature that would be ineffective couldn't survive. This inspired us to study the wave drive propulsion aiming to find a more efficient manner of movement. In addition, the wave drive propulsion – aside from being highly efficient, gives amazing manoeuvring possibilities that cannot be offered by traditional solutions.

In 2016 we founded NOA to develop and bring technologies to the marine market. Initially we aimed to become a UUV manufacturer, but along the way we found that there was vast potential for becoming a robotics-as-a-service provider: servicing clients purely with data they need, instead of offering them tools to collect said data. Today we build UUV solutions that include hulls, power systems, battery management, propulsion, control software, and integrate third party solutions for navigation, positioning, and mission-specific sensorics.

The Sea Sentinel vehicles are part of a much larger and scalable system. While testing and working at sea with our vehicles, we are also engaged in developing a fully autonomous platform for the collection of oceanographic data; one that's able to work for up to 6 months without human intervention on-site. It would allow automatic docking of unmanned Sea Sentinel vehicles, wireless data transfer, and recharging of green energy generated in the station from solar, wind, and wave energy. Our, industrial grade, biomimetic, underwater propulsion system constitutes a new class of underwater robots and provides exceptional capabilities, such as high static thrust, long range, unmatched energy efficiency, and up to 100kg sensor payload capacity per vehicle, with silent work so the systems do not stress aquatic animals.

RENEWABLE ENERGY POWERED DRIVE

One of the key challenges was to develop and introduce a vehicle that is energy efficient to a level that allows recharging purely with renewable energy generated on-site. Also, our goal was to make a wave drive that was robust, failsafe, and resistant to damage, making it applicable in demanding multi-day missions. That is how we came up with the biomimetic NOA Drive that is propelling our UUVs.


Courtesy of NOA Marine


Courtesy of NOA Marine

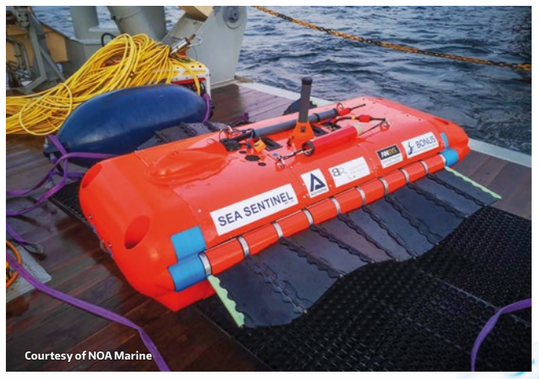
The Sea Sentinel's NOA Drive ensures high efficiency, power, and maneuverability, with up to one week between charging events. Vehicle weight in air oscillates around 350kg (depending on configuration). Its length is 2.2m and has a payload capacity up to 100kg. This is the largest payload as per vehicle length possible, which allows for more sensors, extra power, payload, and devices. The crafts are very efficient in maneuvering with significant payloads while keeping noise levels at a minimum. The propulsion system of the ROV/AUV is also harmless to fragile marine life, as it has no rotating elements. This also makes the vehicles less vulnerable to entanglement in plants or other aquatic obstacles. Its energy efficient drive enables it to utilise a pure, green energy power source mounted on a floater, which results in zero emission and a very low carbon operational footprint. High maneuverability with heavy cargo provides installation of multiple sensors on a single mission.

Thanks to NOA Drive's high thrust capabilities and efficient design, the vehicle's inertia is reduced to a minimum. It can reach a full stop from 3kn to zero in less than 1 m, even with the maximum payload of up to 100kg installed. With this feature overall mission safety is vastly increased. Glider capability with innovative Ballast Vectoring Protocol (BVP) ensures an extra-long range even with heavy cargo.

DOCKING PROCEDURES MADE SIMPLE

NOA's Sinaps docking stations – along with all their subcomponents – are designed towards ease of deployment and maintenance, so no seabed infrastructure is required. With a single mooring point (from 30 to 3,000m depth) all hardware is designed to be installed under a floater. This approach makes the procedure for installing and servicing the system very similar to placing an ordinary buoy, which can be done by almost any vessel equipped with a simple A-frame with a 6-10 tones lift capacity. NOA Sinaps' low cost, simple, and reliable docking procedure technology aims to provide auto dock functionality


Courtesy of NOA Marine



Courtesy of NOA Marine

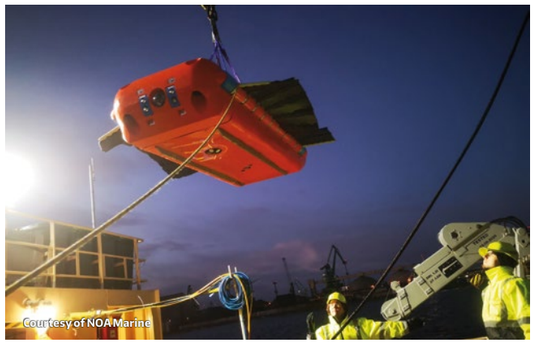

Courtesy of NOA Marine

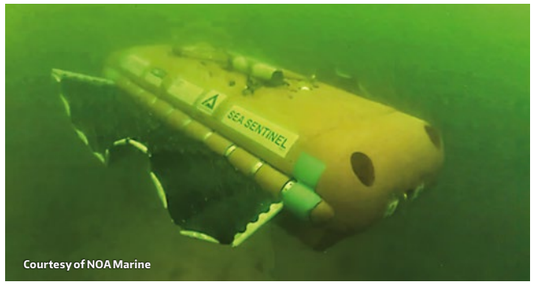
at sea state 6, so the vehicle is dynamically moored without requiring sophisticated aiming and precise positioning which makes docking procedure simple and effective. We aim for the docking procedure to accept very large approach angle deviations and other inaccuracies, resulting from a dynamic nature of docking process. After the vehicle is docked, it will obtain inductive access to energy and a data link. The aim for each individual floater to provide 3 to 5 Sea Sentinel vehicles CO2 free hybrid renewable power: wave, wind, and solar. No infrastructure or additional training will be required on the client's side.

The vehicles come in both tethered and untethered configuration to collect chemical, acoustic, and visual data, and to conduct uninterrupted observations with high resolution measurements. It is beneficial to use the tethered configuration in some activities, for example in the offshore wind sector. Full implementation of the Sea Sentinel service involves two main components. We have completed our work on Sea Sentinel vehicles to enable them to handle unmanned missions, and to carry first market pilots in the Baltic Sea environment, both in ROV (tethered) and AUV (untethered) configurations. Simultaneously, we are working on introducing our floating docking stations, NOA Sinaps, so that our innovative vehicles will be able to work autonomously in the sea without any human intervention for up to 6 months. Right after the vehicle is automatically moored to the docking station, it will send the collected data directly to the client's desk, at the same time filling its batteries with renewable energy generated from wave, solar, and wind power.

TESTING THE WATERS

In the future the company is looking towards taking part in the digital transformation of the Baltic and North Seas. Our vision is to bring new tools for the exploration of our "Sister Seas" and beyond by using a complete digital twin interconnecting and monitoring the ecosystem's physical and chemical parameters, marine life, and pollutions levels. At present we have demonstrated our Sea Sentinel's reliability and capabilities for working in real sea conditions. Our docking stations will be exposed to rough sea conditions in 2023. That will provide our company with the opportunity to offer our vessel-free


Courtesy of NOA Marine



Courtesy of NOA Marine

data collection service to vendors on a subscription-based agreement. It will outline the type of data to be collected and a period of installation, where a given number of vehicles will be fully mobilised on a designated site 24/7, 300 days/year.

In the meantime, our company has secured its first job for a reputable global energy producer with our Sea Sentinel machines. It will be handled in 2021 for monitoring purposes and documentation of designated marine habitats in upcoming offshore wind energy sector investments. We are also in preparations for a Seed funding round in Q3 of 2021. This will allow us to handle survey subcontracts coming from the Baltic and North Sea wind energy market in 2022 and introduce market pilots to our fully autonomous platform for the collection of oceanographic data. We very much look forward to the outcome.

Skilltrade Hydrographic **Survey Training**

Since 2001 Skilltrade has been sharing hydrographic knowledge and experience. We started with a two-day Introduction to Hydrography course and evolved into specific courses like Multibeam echosounder, DGPS, RTK, Side Scan Sonar, Sub-bottom Profiler and Tides. Hundreds of people have been trained on these short courses to date.

Since 2008 we also offer a **full Hydrographic Survey Category B curriculum** as defined by the FIG/IHO/ICA International Advisory Board on Standards of Competence for Hydrographic Surveyors (IBSC). Our Cat B training is normally an intense 30 week course (a 13 weeks e-learning programme, 1 week safety training, 12 weeks training in The Netherlands, followed by a 4 weeks Field Training Project).

However, as the development of the COVID-19 pandemic is still unpredictable, we saw no realistic possibility to deliver traditional on-site teaching this year. With approval of the IBSC all lessons that can be delivered on-line will therefore be taught using digital formats for the upcoming 26th class. Workshops, practical assignments and exams will be held in The Netherlands, in line with IBSC regulations, in April 2022.

We can offer you this modified program at a substantial lower rate than our regular on-site program. With both the health and safety of the students and staff and the IBSC regulations in mind, we trust this is an appropriate way to be become a Category B Hydrographic Surveyor during this pandemic.

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SKILLTRADE

Dynautics Phantom AUV (Courtesy of Dynautics Ltd)

MODELLING, TESTING, AND SEA TRIALS ALL WITHOUT LEAVING THE LAB

Dr Henry Robinson, CEO, Dynautics Limited

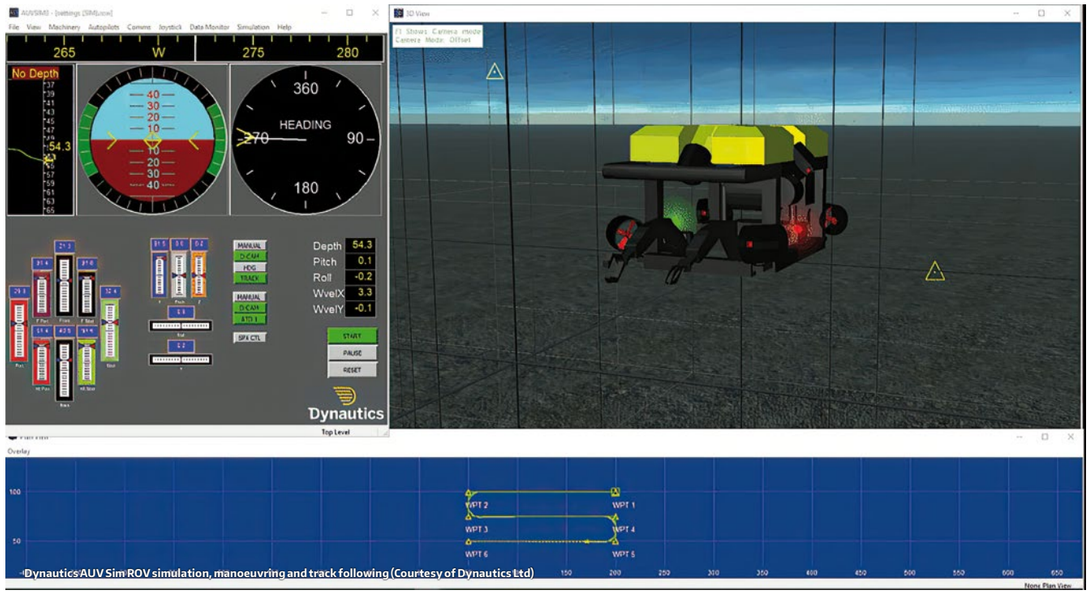
Developers of Autonomous or Uncrewed Underwater Vehicles (AUVs or UUVs) and Uncrewed Surface Vessels (USVs) benefit greatly from effective simulation tools that support the complex design process of these technologies. When design iterations can be modelled, tested, and modified without the safety risk and expense of scale or full-size models and test tanks, the development cycle is shortened. The road to achieving a commercially viable and successful solution then becomes safer, faster, and more cost-effective.

Marine simulators are powerful tools, enabling developmental and pre-commissioning sea trails to take place in the safety of the lab, before committing to the rigours and cost of a real sea trial.

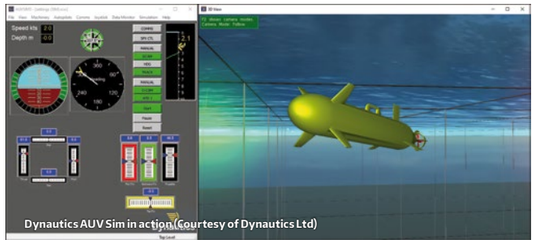
Dynautics designed AUV Sim to enhance the development and testing process for underwater control systems. AUV Sim is a proven simulation suite that enables designers to overcome power management challenges, maximise endurance, and make the right propulsion decisions. It also ensures efficient payload transportation for their AUV/UUV and USV designs.

HOW MARINE SIMULATION WORKS

AUV Sim was developed based on Dynautics' Ship Sim, a proven vessel simulator for surface craft. Ship Sim has been used not only for surface vehicle design but also for training, with systems installed for the Royal Navy that support helmsman and navigation training. As with Ship Sim, AUV Sim comprises a physical simulation of the vehicle, as well as variable testing environments and a comprehensive suite of navigation sensors.



Dynautics AUV Sim ROV simulation, manoeuvring and track following (Courtesy of Dynautics Ltd)


Dynautics AUV Sim in action (Courtesy of Dynautics Ltd)


Wayamba ROV controlled by Dynautics SPECTRE (Courtesy of DSTO)

The AUV/UUV is built by assembling standard modules, such as static bodies, fins, hydroplanes, and thrusters. Size, position, orientation, drag coefficients, displacement and mass, can all be configured, alongside parameters such as actuation speed. There is also an Added Mass module that allows for non-linear hydrodynamic forces. AUV Sim's comprehensive vehicle build toolkit enables users to assemble anything from a work-class Remotely Operated Vehicle (ROV) to a torpedo or even a sea glider propelled by a gravity engine.

The assembled vehicle is visible as either a wire frame model or 3D render, for a more realistic display. The operator connects controls to each actuator, driven manually by sliders, by the built-in autopilot or by external control signals. External control signals are simple to implement in a variety of formats, one of the easiest being serial data sentences in the well-known NMEA0183 format. These can be used to set machinery channel demands. The software can be configured to transmit navigation sensor data from a wide range of onboard sensors, including INS, DVL, gyro and magnetic compass, USBL, etc. Data rates and noise characteristics can be adjusted allowing the external autopilot system to be comprehensively put through its paces.

A PORTABLE AND COMPREHENSIVE SIMULATION TOOLKIT

Dynautics' AUV Simbox enhances the functionality of the software only AUV Sim solution by including hardware elements. This kit – conveniently packed into a portable, robust Peli Case – gives the AUV developer everything they need to take a project from inception through to sea trials, by creating both a virtual and hardware environment. AUV Simbox, contains the simulator software, a SPECTRE autopilot module, and RCW front end Remote-Control Workstation (RCW) software. It also has a GENIE analogue and digital interface, as well as power supplies and cables. This saves time by enabling the testing of the MicroSPECTRE firmware before it's installed in a real prototype.

The SPECTRE autopilot can control a wide range of vehicles and the Dynautics team frequently implement new features. They recently accommodated the need for a small, fast vehicle to corkscrew through the water without losing control, a demanding requirement necessary in the early phase of the mission, where there was insufficient speed for the fins to effectively keep the vehicle upright against the propeller torque reaction.

AUV SIMBOX DELIVERS FOR THE US NAVY

In late 2019, AUV Sim was used to deliver several AUVs to the US Navy in record time: just 100 days from order to on-water testing. AUV Simbox enabled the project team to develop the Phantom AUV, simulate it, and manufacture parts, then execute the build and get the vehicle out for real sea trials within that time. The sea trials – which took place in Plymouth in the UK – verified the controllability and performance of the vehicle, confirming the predictions made during simulation. Production vehicles were delivered soon after and commissioned in Florida, USA.

The success of this project, with its aggressive delivery timeline, clearly demonstrated how AUV Sim reduces timescales, risk, and cost. Rapid prototype development enabled the US Navy to quickly test ideas, and thereby broaden the scope of their unmanned vehicles innovation drive.

Other projects that have benefited from the use of AUV Sim before sea trials include a work-class ROV project in the Gulf of Mexico, where the SPECTRE system was successful in achieving positional stability around 15mm rms: precise enough to engage a hot-stab using the SPECTRE DP system. In a separate initiative, SPECTRE was fitted to DSTO's Wayamba ROV in Melbourne with immediate success. DP trials showed stability down to the resolution of the INS position reporting (c. 10mm).

In China, AUV Simbox has helped AUV/UUV developers to achieve a dramatic reduction in development time, a key element of mission success. Access to water tanks or lakes is expensive, so testing the design and adapting it via simulation prior to on-water trials represents a significant saving.

SIMULATION FOR THE NEXT GENERATION

The Dynautics management team worked closely with the Society of Maritime Industries' (SMI) earlier this year to develop a robust roadmap for their Marine Autonomy Challenge. Dubbed the MAChallenge, this is a competition designed to encourage young marine technologists and support them in developing careers that contribute to the future of the UK's Marine Autonomous Systems (MAS) industry.

Due to ongoing pandemic-related restrictions, the SMI had to figure out how competitors could develop their solutions without physical access to the boats, the water, and other hardware during the early stages of development. Dynautics, gold sponsor of the MAChallenge, is providing its simulator solutions to ensure that the 2021 competition goes ahead using a virtual testing environment, harnessing current technology to ensure the future resilience of the maritime sector.

BALMORAL ROV BUOYANCY FEATURING

AEROSPACE BONDING WON'T LET YOU DOWN

By Gregg Stewart, Technical Manager, Balmoral

Balmoral's ultra-low density syntactic foam (LDF) is typically used in ROV/AUV/HOV/XLUUV buoyancy at depths to 7000msw. The syntactic foams are specifically developed using premium low-density materials and specialised production processes to maximise uplift and permit long-term performance under the most demanding conditions.

Model of CNC-machined LDF finished in tough marine grade paint (Courtesy of Balmoral Group)

Balmoral ROV buoyancy is manufactured in our custom designed LDF production area at Aberdeen HQ. Due to the sheer scale of finished ROV buoyancy blocks and, in recognition that it is impractical to cast ultra-low density buoyancy syntactic blocks as a single entity, it is typical to manufacture smaller LDF 'slab stock' which is bonded to a near-net shape and subsequently CNC-machined in Balmoral's 'machine shop' to final, precise dimensions.

BLOCK BONDING

A critical aspect of successful ROV buoyancy manufacture and long-term integrity and performance is the block bonding process; our procedures were developed in conjunction with a global leader in adhesive technology with vast experience in the field. The resulting bond strength has been evaluated through overlap shear testing at our state-of-the-art polymer test laboratory. Balmoral selected a two-part, premium aerospace-grade adhesive which has an extensive and successful track record in service.

As well as tightly controlling bond thickness, Balmoral's dedicated ROV buoyancy assembly team is trained in carefully preparing the bonded surfaces of the block before application of the adhesive. Our block bonding process results in a consistent bond thickness across the entire structure and a strength that is stronger than the parent LDF syntactic itself, evident as cohesive failure through the syntactic during overlap shear testing.

CUSTOMISED FINISHING

Following bonding and CNC-machining to final dimensions, the buoyancy block is finished to individual customer specifications that can include application of a tough GRE skin, abrasion and impact-resistant polyurethane sprayed skin and/or spray-painted mirror-finish to specific colour requirements.

Balmoral's on-site team of development technologists and engineers continually review and optimise all materials and manufacturing processes to ensure continuous improvement, cost optimisation and product longevity. Contact our specialist LDF team to learn more about our unique in-house capabilities.


Balmoral's even bond thickness in bonded slab-stock. (Courtesy of Balmoral Group)


Balmoral LDF buoyancy features aerospace-grade adhesion (Courtesy of Balmoral Group)

ALERON ACHIEVE OPERATIONAL AND COST EFFICIENCIES

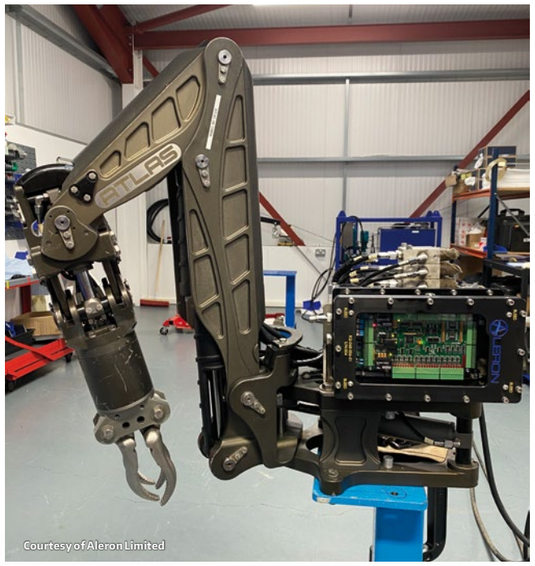
FOR ROV MANIPULATOR OPERATIONS

ROV Owners & Operators are seeking cost and operational efficiencies more than ever before, due to the current global subsea climate. The ROV industry relies on dedicated research and technical innovation from its engineering suppliers, to identify these cost management opportunities.

Due to the harsh environment of Subsea operations, Offshore project managers are often met with the issue of significant ROV Manipulator repair or replacement costs following task completion. Despite the project budget having been determined and the ROV performing well, following demobilisation the operator can be faced with a five-figure repair charge, due to the harsh environment, heavy lifting, and sudden movements from the ROV in operation. To mitigate this recurring concern, many ROV Operators have decided to utilise Schilling Atlas 7R (rate controlled) arms alongside Schilling T4 7P (position controlled) Manipulators. The pairing of the two 7 function arms allows a lot more flexibility compared to the traditional combination of the T4 7P and 5 function grabbers. The Atlas 7R is stronger and more robust than the T4 and can be used where heavy-duty work could lead to harm of the T4. This pairing is becoming more popular with ROV Operators who can see the advantages and realise the potential costs savings as well as reduced damage.

Previously, it has been recognised that a limiting factor of the Atlas 7R was smooth control. Aleron identified this limitation following discussions with customers, ROV pilots, peers & partners, and set out to bring innovative solutions to market to address the issues and improve control to better support their client's objectives.

Often ROV Operators may not be selecting the most appropriate manipulator for the task in hand. The high value, high specification T4 is often beyond requirement and not suited to certain heavy and high vibration jobs. The T4 can be damaged when used for the wrong task or used incorrectly completing that task. Some ROV Operators have also commented on



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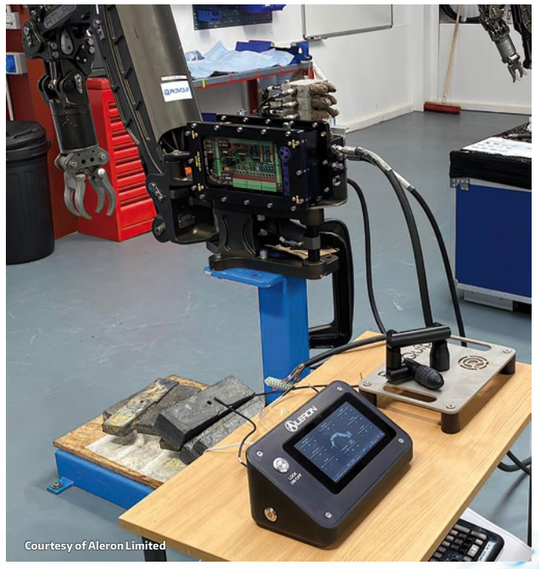

Courtesy of Aleron Limited

possible oil leakage when using the T4 which can be an area of significant environmental concern. The Atlas is environmentally proven to reduce oil spillage compared with the T4, as its joints are operated by cylinders, which have double barrier sealing arrangements and protected rods, resulting in limited leak points. The high dexterity and complex electronics in the T4 mean it is less robust and has the increased likelihood of damage, leading to downtime which has a large cost implication on the wider project. Furthermore, the in-depth training required to competently operate and maintain a T4 can be both timely, and costly. The training is imperative to reduce the risk of damage to both the ROV arm itself and more importantly the client's asset.

To combat these concerns Aleron offer a variety of manipulator upgrade packages for most 7-function rate-controlled manipulators. The basic package includes an 8 Station compact proportional Intelligent Valve Pack (IVP), compact touch screen Aleron Manipulator Controller (AMC) with Bluetooth or hard-wired gaming control and optional seven function Pendant control, which is familiar to all ROV pilots. The new Pendant is USB configured which will allow it to be remotely mounted on the pilot's console or chair. Targeted at Atlas, Orion & Conan manipulator arms, the upgrade offers an extremely cost-efficient solution to provide smooth and accurate proportional control of heavier duty manipulators. The use of this new solution could in turn save potential damage to the T4 and the resulting expensive repairs.

Aleron also cooperates with Olis Robotics to offer a further solution with the Olis Master Controller. The controller is plug and play compatible with Schilling T4 7P manipulators and upgraded Atlas 7P manipulators that have added positional sensors and alternative servo valve pack. This upgraded version of the Atlas 7P offers closed loop positional feedback similar to the T4, with the increased robustness of the Atlas and all the added features of the Olis Master Controller. The Olis Master Controller offers touch screen, memory functions, auto functions, repeat functions, safety limits, guided auto stow in/out and can shift control from joint orientated to jaw position control. The controller is IP enabled to allow remote piloting over ethernet offering a step forward in manipulator control from purely manual control to assisted automation locally and remotely.

Throughout development of the manipulator control solutions, the Aleron team were dedicated to addressing an array of issues experienced by all ROV pilots, utilising their expert knowledge on the practical use of manipulators subsea and installation onto existing ROVs. The compact Proportional Valve Pack and Servo Valve Pack reduce the need for additional hoses and increased leak points, as well as saving valuable ROV space.

The Aleron Manipulator Upgrade packages were completed in 2020 and deployed on the Aleron rental fleet. Aleron recently completed two Conan upgrades utilising the new IVP at a fraction of the cost of a new manipulator or a series of repair bills. The Aleron expert in-house team of software engineers can configure the software to varying requirements and customer specifics to create a bespoke and reliable solution.

Following the key appointments of John Walker & David Currie in 2019/2020 bringing with them over 30 years of experience in the industry, Aleron have been committed to developing & enhancing the Aleron ROV Tooling offerings and Manipulator services. Now with the largest and youngest Manipulator fleet in the market, Aleron stock an extensive rental pool of Schilling T4, Atlas 7R, Rigmaster, Orion & Conan manipulators utilising the upgrade packages, enhancing their controllability, and achieving significant cost efficiencies for Aleron clients.

Courtesy of Aleron Limited

DIGITAL EDGE INTRODUCES THE EDGEARCHIVE BACKUP SOLUTION

Following on from the success of their Version 5 DVR, Digital Edge are pleased to announce the latest addition to the Version 5 software suite. Digital Edge have just launched a brand-new backup solution: EdgeArchive.

EdgeArchive handles the transfer of data from the internal DVR drives to client storage, either on a NAS or Raid, or a phased delivery to multiple external hard drives.

Being a native app, the data transfer ensures that the quality of live recordings are not impacted by a third party program trying to access the same file that the DVR app is currently using. Ensuring recorded data integrity and quality are of the highest importance.

Archive can act as a simple data mirror to the correct internal drive data folders or can be used to create multiple simultaneous backups of client deliverables. This can be done in continuous backup or a phased approach i.e., after each dive.

Because Digital Edge are regularly in conversation with their customers, these exchanges often prove extremely valuable because they lead to innovations, like this one, that are entirely customer focused. And this wholly supports the philosophy of the company.

Operations Manager John Scott said, "Clients transitioning to 4k or 4HD channels from SD has had an impact in data storage terms. Previously they would be able to get months of data on the internal hard drives which is no longer possible. Hard drive space has become more of an issue.

Courtesy of Digital Edge Subsea

"In order to respond to our clients' needs dynamically Digital Edge has invested the last year of development into creating an archiving application that allows clients to remove data from the DVR without threatening the integrity of the DVR project.

"Using EdgeArchive ensures that access violations of "live recording" files do not occur when the data is transferred. It will be beneficial for clients in the field on extended campaigns."

In addition to their reputation for high quality and reliable products, the team also offer live demonstrations; you can see for yourself how the system can work for your project. And in acknowledgement of economic difficulties in the last 12 months or so, they even offer their DVR units under flexible rental agreements: both the rack mounted system and laptop version.

For more information or to arrange a demonstration contact info@digitaledgesubsea.com or www.digitaledgesubsea.com

Courtesy of Digital Edge Subsea

Courtesy of Hydromea

EXRAY

THE WORLD'S FIRST WIRELESS PORTABLE UNDERWATER DRONE

Hydromea unveiled the prototype of the world's first wireless underwater drone in a pool demo this month. The drone can fit into a backpack, can be remotely controlled, and sends HD video back in real time, without any physical connection to the pilot. The drone will deliver significant benefits in several inspection scenarios in confined flooded spaces, such as hydropower dams, closed waterways, and ballast tanks on ships. This will reduce cost and time and eliminate the safety risks posed by dangerous inspections currently performed by humans.

MEET THE HYDROMEA TEAM

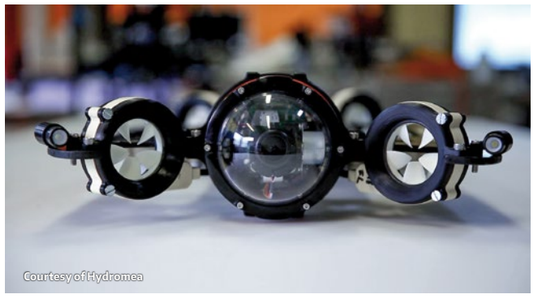
Founded in 2014, Hydromea is a Swiss-based autonomous underwater robotics company, delivering solutions that allow customers to have unparalleled access to subsea data and underwater assets. Ultra-fast and high-volume real-time data transfer and harvesting have brought a paradigm shift in our quest to explore the ocean and understand its impact on the subsea economy.

The Hydromea team started this journey in Australia over 15 years ago, where they put together their first portable underwater drone, Serafina. Years later they found a home in Lausanne, Switzerland, the hub of fine manufacturing. Having a passion for ocean exploration and exploring how big data is changing the world around us, they quickly realised that there is still a significant gap in our understanding of the oceans. Hydromea develops products and solutions

Courtesy of Hydromea

Courtesy of Hydromea

Courtesy of Hydromea



Courtesy of Hydromea

that allow customers to have autonomous high-speed and high-volume subsea data access in real-time. This new technology renders cables obsolete, making previous prohibitively expensive projects affordable, and keeping humans away from risky jobs by combining autonomous robotics and wireless communication network systems. This presents a a drastic improvement in affordability and speed of subsea data access. Importantly, it also reduces human risks to zero.

The core team at Hydromea consists of Igor Martin, CEO, who has over 15 years of corporate business management experience in DuPont. He works alongside Felix Schill, CTO, who is an expert in real-time systems, ad-hoc communication networks, aerial and underwater robotics, as well as designing and building electronics, embedded systems, rapid manufacturing/3D printing, composite manufacturing, and mechanical design. And finally, Alexander Bahr, COO, who is an expert in the cooperation and navigation of large groups of AUVs, and has hands-on experience with the design, testing, and deployment of underwater sensing equipment.

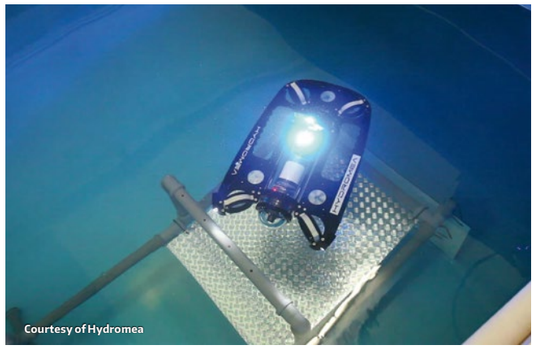
THE EXRAY™ VISION

The initial focus of the technology is on the complex confined spaces where tether management is particularly difficult. With EXRAY™, asset operators will be able to replace manned entry for inspections of such spaces, saving time and cost on the preparation of such entry: no need for draining, drying, and ventilating, or for scaffolding. Hydromea is funded by Aberdeen-based OGTC with the support of Total E&P UK. The trials of the system on Total's FPSOs in the North Sea are planned for later this year.

Once the dexterity of the system is de-risked in the confined spaces, Hydromea will take on the inspection and monitoring tasks in the harsh realities of the open water. The inspection and monitoring of industrial underwater structures today is labour and equipment intensive. It is performed by ROVs or divers, with the heavy involvement of offshore support vessels and helicopters. The inspection requirements will continue to increase as new oil and gas platforms are built and many legacy platforms will be decommissioned.

Additionally, the exponentially growing number of offshore wind farms and their adjacent infrastructures will further drive the need for a constantly available method to inspect both them and their impact on the environment. Operators incur substantial costs to maintain assets and verify compliance with regulations, and environmentally induced delays in infrastructure inspections cause loss of production revenue.

Remote operations which don't require surface vessel support, or complex power and data umbilical cable systems to offshore platforms or land, have the potential to offer tremendous savings over operations that would otherwise require manned vessels. This includes long-term environmental monitoring, frequent subsea equipment integrity inspections, and interaction with seafloor assets and sensors. As a result, complex AUVs are being developed by many established players in the industry, that cost less to own and operate than the large surface vessels but are still relatively expensive and hard to maintain devices.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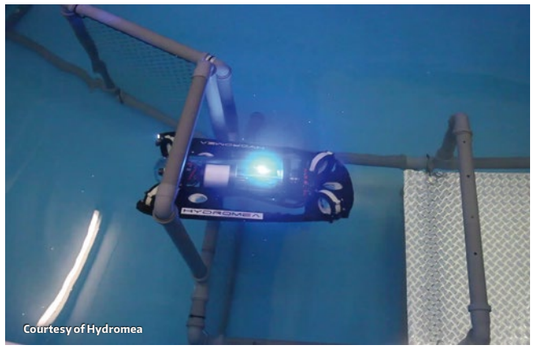
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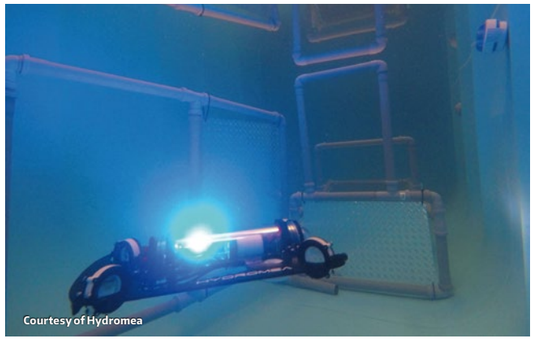

Courtesy of Hydromea

Hydromea takes a complimentary but unique approach to the future of asset integrity, with its expertise in compact, affordable, and robust underwater systems. Hydromea focuses on a scalable, small, autonomous underwater drone platform with swarm intelligence: tightly integrated with the autonomous subsea infrastructure of tomorrow. It will offer efficiency and marked affordability in routine inspection and monitoring operations and facilitate a timely response to ad hoc events like extreme weather or subsea equipment failure. Many of the challenges associated with the inspection of offshore oil and gas operations can be addressed by deploying compact, multi-vehicle, subsea inspection and monitoring systems, with fast data collection and communication capabilities.

IMPROVING ON THE CURRENT MODEL

The benefits of affordable swarm deployments include additional capabilities, such as: conducting cost-effective, short-term or ad-hoc environmental monitoring to establish and track conditions before, during, and after exploration through production. Delivering frequent, cost-effective inspections for cable infrastructure, risers, chains, and equipment integrity. Responding quickly to out-of-cycle inspection requirements. And pairing with seafloor sensors and monitoring equipment for quick data uploads and near real-time transfer to the control centre.

This represents a shift in the type of operations being performed offshore, and the need for specialist, agile systems to perform tasks that current market WROV's have struggled to do. They also represent issues that the larger AUV's currently being developed will not easily address, such as ultra-shallow water operations. Furthermore, employing large and expensive vehicles for light and short duration inspection tasks isn't cost effective today, nor will it likely be tomorrow. The emergence of compact, intelligent, and robust underwater drones will fill that niche, and Hydromea are one of the pioneers in this regard.

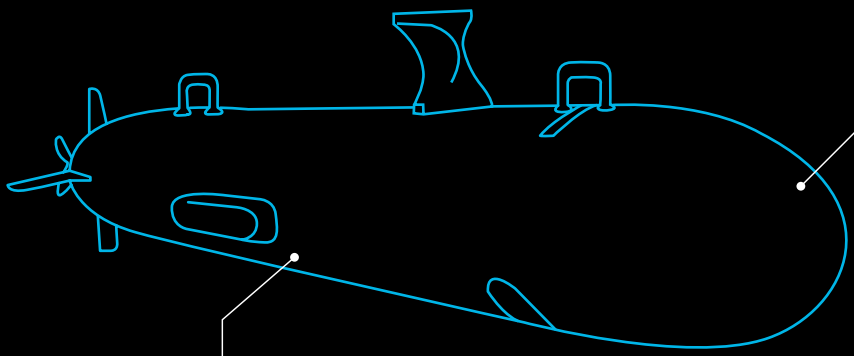
Hydromea plan to continue developing a platform that will introduce a suite of purpose-specific, low-footprint, underwater drones for various inspection scenarios. They will focus on adding autonomy features over time to eventually make this a fully autonomous swarm system for inspection and monitoring of submerged assets, at an affordable price tag and with smart intelligence built in.

So far, Hydromea have performed 11 open water campaigns with their initial drones known as Vertex, even performing one under an ice sheet. They were able to collect water quality data in continuous flow over a prescribed perimeter. This allowed them to build a 3D map each time, and help researchers understand the actual situation in the environment, without the need for post-collection modelling.

EXRAY™ recycles a lot of technology that went into the Vertex system. However, EXRAY™ is currently focused on confined spaces, and they haven't yet performed any industrial trials. Total is supporting them with this effort, and they will soon start running trials on Total's North Sea assets. We're very eager to report on EXRAY™'s progress in the near future.

Powering robust autonomy for all AUVs.

Ramses
SPARSE LBL TRANSCEIVER



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