ROV PLANET

20

ISSUE
Q3 / 2019

The magazine of choice for Subsea Construction and ROV Professionals


Teledyne Marine ROVs and Imaging Sonars

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WELCOME TO ROV PLANET

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

Dear Reader,

We have another exciting issue out this quarter for Offshore Europe, Gastech, and DSEi covering several sectors of the ever-expanding underwater robotics world!

In the offshore oil and gas sector Oceaneering has christened its new deep-water vessel, the Ocean Evolution. The Jones Act compliant multi service vessel with advanced capabilities is now available for work in the Gulf of Mexico. Subsea well intervention also relies on the use of ROVs and you can read about it here how that exactly happens.

In the defence sector we have interviewed the ECA Group to find out more about the drones being supplied to the Belgian and Dutch Navies as part of a major MCM defence contract. QSTAR have opened a new ROV training centre in Barcelona. This is in addition to their training centre in the Canary Islands. Military staff serving in the Spanish Navy whom are involved in submarine rescue and deep-sea diving operations have done their ROV training courses there recently.

John R. Potter discusses the potential impact of AI on the ROV/AUV and maritime systems of the future in his excellent article. He raises some very valid concerns and questions after a detailed explanation of these systems.

Finally, we will take a closer look at the Odysseus ROV from Pelagic Research Services, a deep sea ROV that was developed to support environmental baseline and post subsea mining activity and monitoring as well as bulk sampling programmes for the extraction of magnesium nodules – a very exciting industry that we will soon hear more about in the future.

Best regards,
Richie Enzmann

Please check out our website on:
www.ROVPlanet.com

UPCOMING EVENTS

3-6 September 2019 – Offshore Europe – Aberdeen, UK
SPE Offshore Europe is recognised by offshore E&P professionals as Europe's leading E&P event.

10-13 September 2019 – DSEi – London, UK
The world leading event that connects governments, national armed forces, industry thought leaders and the global defence & security supply chain.

17-19 September 2019 – Gastech – Houston, TX, USA
The leading exhibition and conference for the global gas, LNG and energy industries.

18 September 2019 – Subsea UK Underwater Robotics Conference – Aberdeen, UK
This conference will discuss the fast-approaching future of underwater robotics, discussing innovations and new technology, as well as the challenges and obstacles faced.

6-9 October 2019 – TMTW2019 – San Diego, CA, USA
Teledyne Marine Technology Workshop in which speakers, influencers, and attendees converge to explore, learn and share their experiences on products, applications and technology.

7-9 October 2019 – Offshore Energy – Amsterdam, The Netherlands
Leading event that addresses the technical, operational and commercial challenges associated with future offshore sector growth.

27-31 October 2019 – OCEANS 2019 – Seattle, WA, USA
The event for global maritime professionals to learn, innovate, and lead in the protection and utilization of the world's largest natural resource – our Oceans.

11-14 November 2019 – ADIPEC – Abu Dhabi, UAE
Major oil & gas event in the Middle East with ADIPEC bringing together professionals with real buying power, in 2018 US$17.99 billion of business was concluded onsite at the event.

OCEANEERING CHRISTENS OCEAN EVOLUTION

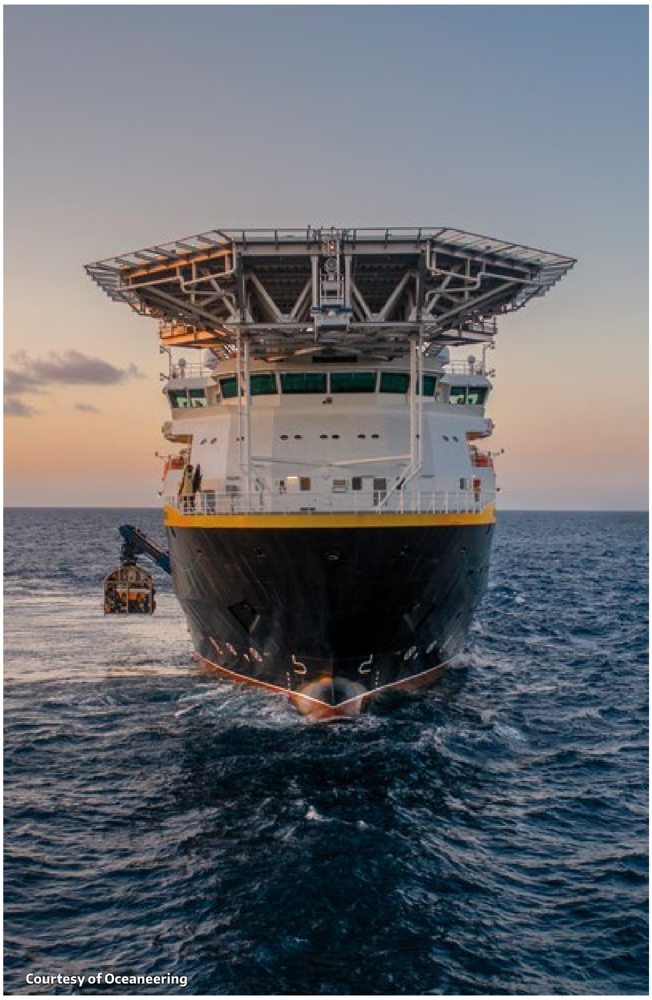
Oceaneering International, Inc. held a christening ceremony at Pier 21 in Galveston, Texas, for its advanced subsea construction support vessel, Ocean Evolution on Friday, May 24, 2019.

The vessel's home port will be in Port Fourchon, Louisiana. Its first project is scheduled to begin during the summer of 2019.

The Ocean Evolution is the most advanced U.S.-flagged, Jones Act-compliant multi-service vessel (MSV) in the market. Its capabilities are headlined by its 250 mT active heave compensated (AHC) crane, two work-class remotely operated vehicles (ROVs) with AHC launch systems, survey systems and subsea tooling all built for work in up to 4,000 m water depths.

The vessel serves the deepwater stimulation and intervention market with its well stimulation and well intervention design, ABS Well Stimulation and Well Intervention (WS/WI) ready notation and under deck capacity to store special products.

Mike Ellis, Vice President, Subsea Projects, said, "The Ocean Evolution is a world class vessel ready to service the construction and intervention needs of our customers in deepwater. We are excited about the upcoming integrated services that will be provided with this vessel when combined with Oceaneering's portfolio of subsea products and services. This combination will provide unmatched productivity, safety, and value for many years to come."



Courtesy of Oceaneering

Courtesy of Oceaneering

KEY FEATURES

Measuring 353 ft (108 m) long, 72 ft (22 m) wide and Light Ship weight 6,900 T, Ocean Evolution is an ABS class DP2 subsea multi-service vessel built in the US under Jones Act requirements for coastwise trade of personnel and equipment. The vessel has accommodations for 110 persons, helideck and a working moonpool measuring 23 ft × 23 ft (7 m × 7 m).

The vessel's 12,595 ft² (1170 m²) steel-constructed deck is designed to carry heavy loads and equipment which accommodates a wide variety of missions. The deck is rated to support 10 mT/m² with a total cargo carrying capacity of 1,900 mT. The steel deck and on deck utilities including water, power, fuel and communications enables easier and faster loading, welding tie down and hook up of specialized deck equipment during project mobilizations and demobilizations.

The vessel is equipped with a 250 mT AHC main crane with a 13,000 ft (4,000 m) working depth capacity. This crane has a special lifting mode that allows heavy lifts with alternate reeving of the boom eliminating the jib that provides increased hook heights of 118 ft (36 m) above the main deck. This provides the ability for crews to lift tall wellheads, large pin piles, and other oversized equipment off the deck utilizing the maximum lifting capacity of the crane. A second auxiliary crane on deck adjacent to the working moonpool is capable of 40 mT for lifting and handling of equipment on deck and to water depths of 600 ft (180 m).

Ocean Evolution features a unique layout bridge, configured with port and starboard redundant control stations. These control station locations provide bridge officers and DPOs a better view of crane operations, ROV deployment and simultaneous operations (SIMOPS) with other vessels and platforms on each side of the vessel. As a result, offshore operations are safer and more productive.

Ocean Evolution is built for reliability with five low-emission EPA Tier 4 diesel engines with a combined generating capacity of 16 MW on a three-bus system. The Tier 4 rating is the EPA's strictest emission requirements for non-road

Courtesy of Oceaneering

diesel engines and the combination of five engines and third bus provides enough excess capacity to allow full capability and redundancy of the vessel if one engine is down for maintenance.

Ocean Evolution features enhanced station keeping capabilities, which allows it to maintain position even during extreme weather conditions. The vessel's position is held using two Rolls Royce tunnel thrusters and a drop-down thruster in the bow along with two Rolls Royce Azipull thrusters in the stern. Props on the propulsion systems can be turned 360° and were designed to optimize dynamic positioning of the vessel. The vessel achieved an ERN station keeping reliability rating of 99.99.99.99 which is the highest rating possible further proving the ability of the vessel to keep station in difficult conditions.

The vessels design and construction were done with well stimulation and light well intervention in mind as a key capability. The underdeck storage capacity of up to 109,000 gal


Courtesy of Oceaneering

Courtesy of Oceaneering

(413 m^3) of special products maximizes use of the critical deck space for pumping and intervention equipment. The vessel layout and safety systems meet ABS class requirements for a special well stimulation and well intervention notation.

The vessel is equipped with two Oceaneering work class ROV systems. One 220 hp Millennium® Plus and one 250 hp NEXXUS systems are onboard each with active heave compensated launch and recovery systems installed in a custom indoor hanger for port and starboard launch. Integrated survey and communication systems round out permanently installed equipment that provide positioning and data services for all operations.

The features and capabilities for the vessel when integrated Oceaneering's related products and services will provide customers with world class installation services for subsea tie-backs, solutions for subsea maintenance, repair and decommissioning and well stimulation and light well intervention services.

ABOUT OCEANEERING

Oceaneering is a global provider of engineered services and products, primarily to the offshore energy industry. Through the use of its applied technology expertise, Oceaneering also serves the defense, entertainment, and aerospace industries. For more information on Oceaneering, please visit www.oceaneering.com

Courtesy of Oceaneering

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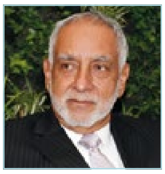

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ROVS AND SUBSEA WELL INTERVENTION

GREATER CONFIDENCE HERALDS MARKET GROWTH

The move away from the oil price lows of the recent downturn, combined with technological advances, innovative commercial models and significantly improved lifting costs, have triggered greater confidence in the global offshore sector and the prospect of increased activity once again.

Expro's Intervention Riser System (Courtesy of Expro)

This recovering optimism offshore is leading to a knock on rising demand for products and services required to support these projects, such as remotely operated vehicles (ROVs) and subsea well intervention. For example, Westwood Global Energy Group has forecast expenditure on ROVs to total almost $7billion from 2019 – 2023 on the back of a four percent annual growth rate.

In the lifecycle of a subsea well, ROV technology is utilised to support operations in many phases. During well drilling and completions, ROVs are used to assist in blowout preventer (BOP) operations, tree setting and hook up to production facilities. Within the well operational phase, ROVs will be deployed from an intervention vessel or workover rig when well entry is required. Finally, when a well reaches the end of its operating life, ROV technology will be used to assist in plug and abandonment operations, field infrastructure removal and tree and wellhead recovery.

Expro provides well access systems and well flow management services to support clients across all phases of the well lifecycle. Their well access solutions include Subsea Test Tree Assemblies (SSTTA) which are deployed through the rig's BOP and marine riser, Intervention Riser Systems (IRS) and Riserless Well Intervention Systems (RWIS).

ROV hot stab panel (Courtesy of Expro)

INTERVENTION RISER SYSTEM

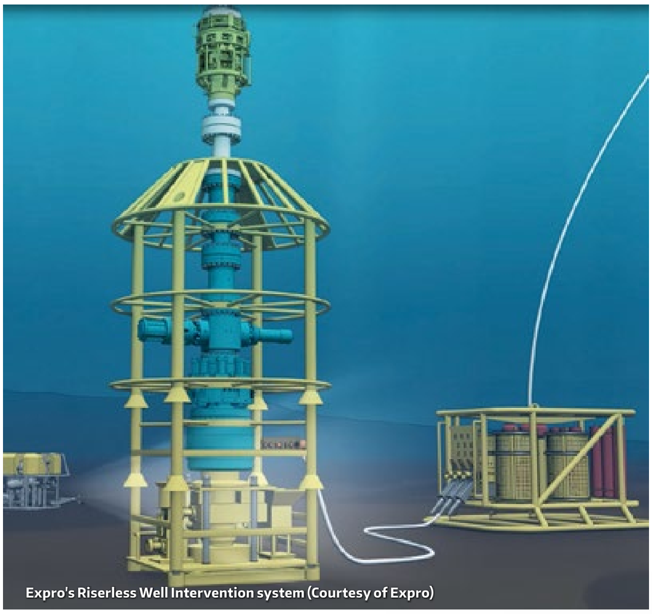
Intervention riser systems are deployed on a high-pressure riser from the rig or workover unit. They replicate the functionality of the rig BOP in providing a well control package connected to the Christmas tree. ROVs are utilised at several stages of the operation. These can include tree cap removal and the cleaning of connector sealing faces; guidance and monitoring of the IRS land-out onto the Christmas tree; hook up of the tree interface flying leads or connections; ROV override functions for valve operations; and ROV video monitoring for operations including leak checks and pressure or temperature gauge readouts.

When an emergency disconnection is required, ROVs can be deployed to verify the status of the lower well control package. They can also be used to verify the sealing faces are in good condition before reconnecting the upper section of the IRS to the lower well control package.

Expro's IRS subsea packages include industry standard ROV interface panels. As the IRS is typically deployed from a drill rig or drill ship, a standard drill rig support ROV package would be used to support these operations.

RISERLESS WELL INTERVENTION SYSTEMS

Riserless well intervention systems (RWIS) provide a well control package above the Christmas tree. However, in contrast to the IRS, they are generally deployed and operated from a monohull vessel. Riserless well intervention involves well access through a RWI well control package. Tools are deployed through the water column and an open water latch into the well. These can include logging, plug pulling and setting tools, cameras and many other technologies to inspect, repair or maintain the well structure.


Expro's Riserless Well Intervention system (Courtesy of Expro)

ROV panel showing torque tool main valve override (Courtesy of Expro)

In addition to the ROV intervention and monitoring tasks related to well control package operations, ROVs can be used to guide surface-deployed toolstrings into the latch mechanism on the upper section of the RWI lubricator pipe system. They can also verify or engage the latch mechanism prior to opening the wellbore to the lubricator and allowing the tool to enter the well. In shallower water, they may be used to connect guidewires to the wellhead/tree which can aid the guidance and land-out of the RWI well control package, and they can be used for guiding the toolstring into the lubricator.

Umbilicals provide services to the RWI subsea package including electrical, control and fluid supply and return. These umbilicals may be connected on the surface and either deployed on the seabed with the RWI system, or deployed separately and connected on the seabed. In addition, larger bore annulus access or kill line hoses may require to be run from the surface to the RWI package and connected subsea.

THE IMPORTANCE OF ROVS

All of the above tasks represent relatively standard ROV support operations that are performed as part of most subsea construction projects. However, they are critical to the success of RWI operations, particularly when dealing with live wells, where the wellbore contents are within the RWI system and safety and pollution prevention are key drivers to the success of the intervention operation.

RWI operations are performed from either dedicated vessels or vessels of opportunity. In all cases, vessels are equipped with at least one, but typically two ROV systems. Both systems consist of either workclass ROVs (WROV), or a combination of workclass and observation ROVs. Intervention operations may require one ROV to be located continuously on the seabed at the well – hence the importance of two systems. Also, at any time during the operation, ROVs can be called upon to support a variety of activities including toolstring deployment or recovery, monitoring instrumentation, overriding valve functions and verifying valve position indicators, for example.

ROV construction vessels can often be utilised for RWI operations and will normally have dual workclass ROV systems installed onboard. From an intervention perspective, these vessels are very capable of supporting such operations, although the RWI system deployment and recovery operational envelope may be more compromised than from a dedicated RWI vessel where the deployment system can operate in higher sea states.

Dependent on client specifications, a safety case may be required for the support vessel to ensure that all risks have been assessed and mitigations are in place for performing interventions on live wells. Readying a vessel of opportunity for RWI operations can therefore be a time-consuming process, and sufficient time must be factored in to allow for the preparation and submittal/approval of such a safety case if required.

THE EXPRO SOLUTION

Expro is a leading global provider of well intervention services, with an established record across all aspects of well intervention and employing some of the industry's most experienced hands.

Expro is committed to utilising this expertise and experience to lower the cost of subsea well intervention and improve the economics of such operations to enable operators to maximise their return on investment. By offering a full service solution to subsea well intervention operations, Expro can bring multiple services including the marine unit, the well access systems and the in-well conveyance and tooling under one contract.

The majority of riserless well intervention operations involve the use of wireline services. Expro is a leading independent wireline service supplier – employing more than 1000 people in support of wireline operations globally – and makes approximately 12,000 wireline runs every month. It continues to invest in developing leading edge technologies to optimise well performance.

Expro's RWI service is performed from a dedicated vessel, outfitted with two WROV systems deployed from heavy weather launch and recovery systems (LARS) located on the port and starboard sides. A system is installed on the vessel for RWI stack deployment and recovery. This also deploys and recovers the toolstrings. The heavy weather launch capability of the ROVs allows toolstring changeouts in high sea states where a ROV is required on location.

Interfaces between the ROVs and the RWI stack are verified prior to mobilisation. Onboard communications links and the adoption of approved procedures and planning enable the provision of safe and efficient intervention operations.

By providing the RWI well access system, as well as surface mounted wireline systems, in-well tools and well and reservoir engineering and logging expertise, Expro is able to combine its experience and reputation for technical excellence and innovation to deliver tailor-made solutions.

CONCLUSION

Intervention operations on subsea wells throughout the well lifecycle rely on ROV technology that was originally developed for drill rig support and subsea construction and is now applied to well intervention. ROV support on the seabed can be the difference between an intervention operation going ahead or being suspended or abandoned. The technology provided by the ROV suppliers and the expertise of their crews are key elements in the successful planning and performance of subsea well intervention.

ROV valve panel (Courtesy of Expro)

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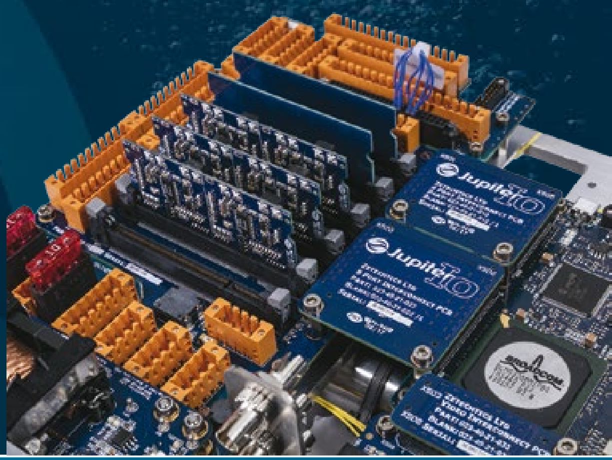

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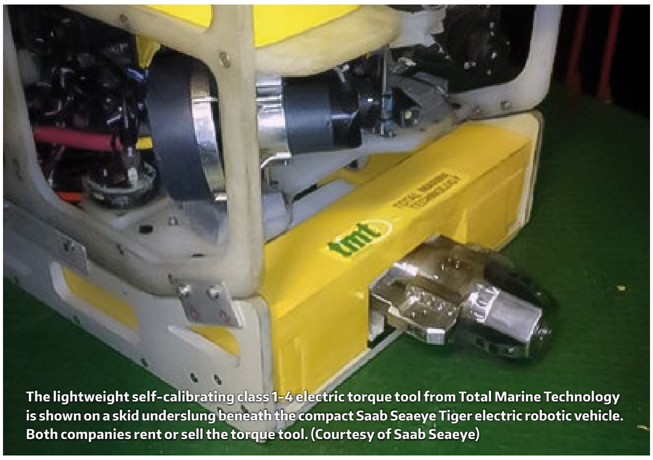
SMART ELECTRICS
OVERCOME FEAR OF OLD VALVES

Risk comes everytime an old valve in poor condition is opened and closed. Intelligent electric technology has now created a smart electric torque tool that can carefully operate the valve to the safe torque values needed.


The lightweight self-calibrating class 1-4 electric torque tool from Total Marine Technology is shown on a skid underslung beneath the compact Saab Seaeye Tiger electric robotic vehicle. Both companies rent or sell the torque tool. (Courtesy of Saab Seaeye)

Coming from Saab Seaeye and Total Marine Technologies, the tool operates from electric underwater robotic vehicles and demonstrates the inventive possibilities of electric technology that is creating solutions that are smaller, smarter, more powerful and more capable.

When compared it to an hydralic system an electric torque tool has considerable advantages. It is half the weight of an hydraulic system, easier to manhandle and can be operated from an electric robotic vehicle of a much smaller size than an hydraulic system. And being a smaller overall system size, a smaller support vessel may be used.

ADAPT AUTOMATICALLY TO CLASS

Cleverly, the electric tool can adapt automatically to Class 1 to 4 fittings and torques whilst performing the integrity-critical task of opening and closing seabed valves and other torque tensioning tasks.

As a software-managed system, it is possible to achieve much finer control and feedback than with an hydraulic systems. Operators control torque pressures by dialing in torque limits, speed, and number of turns and watch the response on screen immediately. Pitch and roll sensors in the tool aid rapid alignment during critical tasks. Unlike an hydraulic system, the electric tool can be set to very precise fine control at the bottem end of the torque range which is essential for old and risky valves.

SELF CALIBRATING

With its built-in drive and torque measurement, the electric torque tool is effectively self-calibrating across its full torque range, saving considerable operation and vessel time compared to the hydraulic option. Deck calibration is quick, repeatable and simple – saving setup cost.

Currently hydraulic torque tools operated by hydraulic vehicles are typically set and checked multiple times for a particular torque range before each dive, using a tested and certified calibration unit. Whereas the electric torque tool need only be calibrated by an independent body on an annual basis.

Being small and light, the electric torque tool can be fitted to a compact robotic vehicle, with the added benefit that, whilst on an inspection mission, the vehicle can intervene to operate a valve and thereby reduce follow-up excursions.

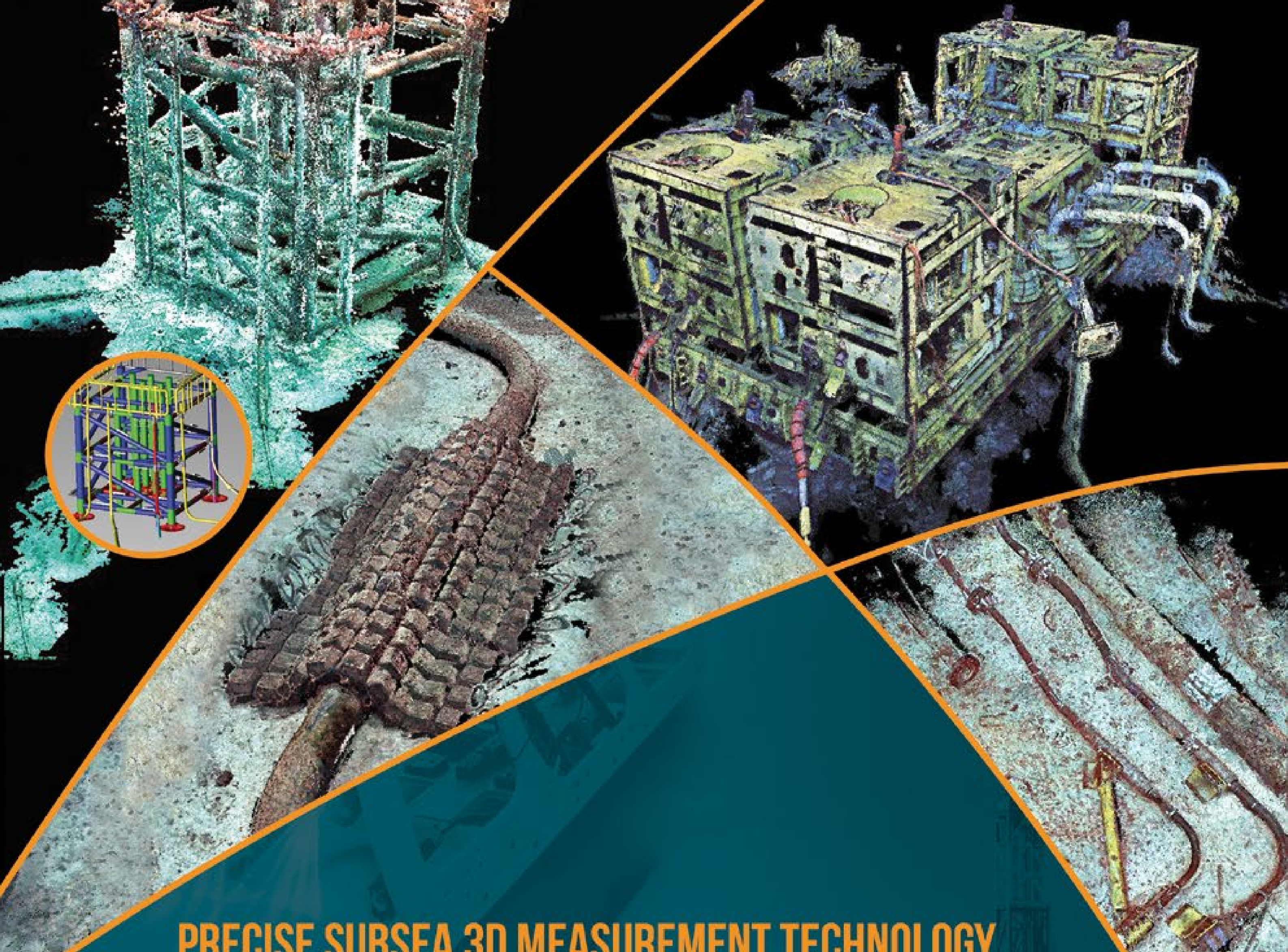
WIDE USAGE AND BIG VESSEL TIME SAVINGS

In addition to opening and closing valves the tool may be used in a wide range of tasks including installation and recovery of control leads and hoses, and closing and tensioning connectors and bolts.

Early adoptor, offshore operator, McDermott, found they could get a rapid configuration change to their electric tool with accurate torque operations and speeds up to 30 RPM, operating eight valves requiring 90 to 107 turns each. At an optimum time of 10 minutes per valve, considerable vessel time was saved.

Sold in the northern hemisphere by Saab Seaeye, the world's largest manufacturer of electric underwater robotic systems, and in the southern hemisphere by Australia-based Total Marine Technology (TMT), the tool is also available as a rental option.


The new small self-calibrating class 1-4 torque tool is bringing considerable savings to torque tool tasks. (Courtesy of Saab Seaeye)



EMPOWERING

WORLD LEADER IN UNDERWATER e-ROBOTIC SYSTEMS

SAAB

SAAB SEAEYE

THE FUTURE IS ELECTRIC

Courtesy of QSTAR

QSTAR SUCCESSFULLY LAUNCHES BARCELONA ROV TRAINING CENTRE

LEADING ROV TRAINING CENTRE LAUNCH REPRESENTS STRATEGIC DEVELOPMENT FOR ROV INDUSTRY

QSTAR, the world leading ROV Training Centre, launched its Barcelona ROV Training Centre back in 2018. This means that the company's subsea headquarters, (originally based in the Canary Islands since 2006), have since been supplemented by their new Barcelona training facilities, where ROV training courses and subsea services have continued fruitfully since last year's opening.

THE BENEFITS OF BARCELONA

Technical Manager for QSTAR, Victor Sepulveda, talked us through some of the positives of launching from the Catalonian capital. 'Barcelona, what some refer to as the "Capital of the Mediterranean", is a strong reference point for the maritime industries: it's in a central location with very good connections across the globe.

'Furthermore, Barcelona's Mediterranean climate, green areas, and stunning local cuisine make for some of the highest quality of life in the world. The training facilities are located at the Port Forum, and affordable accommodation options are available a mere five-minute walk from the training centre with good prices.'

MATCING REAL-WORLD REQUIREMENTS

Gaining experience in the ROV field requires passion and persistence, and QSTAR intends to inspire the future pilot-techs in their new careers. Back in 2014 we had the chance to participate in the IMCA issued training guidelines – IMCA ROV TSG (Training Steering Group). 'Therefore, the quality of our services is in line with the most recent requirements and guidelines.', explained Jose Maria Sepulveda, ROV Training Manager at QSTAR.

The QSTAR ROV updated training program is built on (though not limited to) IMCA guidelines. This has meant that our trainers can provide real-world knowledge and skills for students in compliance with the actual requirements of today's offshore

Courtesy of QSTAR

industry. This is in addition to expertise in other rising sectors such as windfarms, search and rescue, marine research, marine archaeology, subsea operations, and aquaculture.

Besides being able to provide the highest quality training based following IMCA guidelines, we provide real working conditions on board an active work vessel and quay. This allows students to experience and have the opportunity to work as part of a real ROV team. This provides the best training assessment for a newly qualified ROV pilot technician.

TRAINING AND FACILITIES

The QSTAR ROV courses are designed in accordance with industry requirements. The students are briefed about working offshore and the relevant safety regulations, and

here they can gain skills in ROV maintenance and operation. The classes offer theoretical and practical input – depending on the students' or company's needs – with the goal of preparing them for real-life situations.

CORPORATE ONSITE ROV PILOT TRAINING

In addition to providing high quality training courses, QSTAR specialises in supplying on site and corporate training. We also offer training for ROV personnel from different companies worldwide by performing specific on-site training, tailored to the company's individual needs. Furthermore, QSTAR Marine and Subsea Solutions division have been undertaking ROV installation and commissioning projects internationally, from both offshore vessels and onshore operating bases.

ROV TRAINING COURSES THROUGH 2019

One of the students from the 2019 February ROV Pilot Tech Premium course, James Morgan from the UK, is just starting out in the ROV industry. His interest came about from his father work as a rigger and crane operator onboard offshore vessels.

'Big thank you to QSTAR'S Elliott, Jose, and Victor for teaching the best structured course I have done, [I'm] in a great place to learn valuable skills and knowledge of ROVs.', says Morgan. '[The course] left no questions unanswered and me feeling very confident in being ready to start work in the ROV industry: a great and professional company that I would recommend anyone to do courses with...'

Another avid fan QSTAR's training scheme was Nic Franz. He jumped in during February's premium course. 'I would highly recommend QSTAR Pilot Tech II course to anybody who is interested in working in this field.', Franz says. 'With excellent service and friendly staff, it was a great environment to learn in. Even with no previous experience with ROVs, electrics or hydraulics I found the course easy to follow and understand.'

'I am now currently working as an ROV Junior Pilot Tech offshore in Australia, and would not be here without José, Victor, and Eliot at QSTAR! For the best ROV courses and training, QSTAR is the way to go.'

ROV TRAINING COURSE FOR THE SPANISH NAVY – MILITARY DIVING DIVISION

The Spanish Navy have even approached QSTAR to take advantage of our outstanding training programs. Members of the EMB (Military Diving School) Divers Unit's Cartagena base, and military staff from the Vessel Neptuno – both from the Spanish Navy – joined us back in March for the ROV


Courtesy of QSTAR


Courtesy of QSTAR

Pilot Technician 3-week training course. This group were interested in gaining in depth knowledge about ROVs, from operations, fibre optics, maintenance and safety procedures modules. All of this was to supplement their previous experience gained while onboard the rescue ship Neptuno.

QSTAR's ROV training Manager, Jose Maria Sepulveda, reflected on his experience with this particular group of trainees. 'Maria Jose Aguera Ros, Sergio Crespo Sanchez, Angel Torres Duran ...were excellent students with a very good attitude: both receptive and eager to acquire all the knowledge', explained the ROV Training Manager at QSTAR. The training will also be delivered on-site, on-board the Neptuno in preparation for its upgrade to a new ROV system.

The Neptuno is the only Spanish Navy ship in charge of submarine rescue missions and deep-sea diving operations. The ship carries out missions with deep-sea divers (up to 100 m) and different operations with the ROVs Scorpion and Navajo.

To carry out these diving operations the ship has a sophisticated gas mixing system (air, helium, oxygen) adequate for each specific depth, in addition to two hyperbaric chambers for decompression and health care in case of diving accidents. Divers can operate from diving bells or immersion lifebuoys depending on the mission. The former is used for deeper immersions, while the latter is used for fast but shallow operations.

Courtesy of QSTAR


Courtesy of QSTAR

NEPTUNE AT WORK

The Neptune is designed to carry out an array of different missions. One of her primary roles is in supporting submarine rescue operations with air pumping and re-floating capabilities. She can do this in conjunction with Scorpion and Navajo, and often makes use of GPS and a hydro-acoustic position reference (HPR) in order to do this.

This vessel is also very adept at searching for and identifying objects on the sea floor. She's able to pinpoint underwater objects with her side-scan sonar, and this comes in useful in her role as mine hunting support during mine sweeping and laying operations.

The Neptune also provides submarine flotilla support in torpedo launching operations, underwater search operations, and diver training. All in all, a very capable and busy ship.

FURTHER TESTIMONIALS FROM HAPPY STUDENTS

In May of this year during our 3 week ROV Pilot Tech II training course we had a group of students from Norway, Poland, USA, and Germany: Tilman Glötzner – Electronics Engineer, Jay Mitchell – Commercial Diver, Alexander Straume – Mechanics, and Robert Skibinski – Subsea Offshore Crane Operator. They all had a variety of different experiences and came from varied backgrounds. They also had positive things to say about their time at QSTAR.

'QSTAR was a great experience all in all.', says Jay Mitchell. 'The lecturer and staff were great at what they do and made my time at QSTAR very pleasant.

'The way of teaching the course was great as it was done in such a way that the theory part was interesting and captivating. Overall I would recommend QSTAR for the next learner as you are not a number and feel like your time matters.'


Courtesy of QSTAR

His positive recommendations were echoed by Alexander Straume, who says 'I attended the 3-week course at QSTAR Barcelona on the basis that I had some knowledge and experience with ROVs beforehand. It was a great course and our teacher Elliott has such passion for ROV's... it really showed through his teaching.'

He goes on to say, I've gained a lot of knowledge from the 3 weeks and it really helped me on the path to becoming an ROV Pilot. I had a lot of fun during my time at QSTAR and I really recommend everybody who are thinking of becoming an ROV pilot to attend this course.'

So, if you're all of this sounds like the right fit for you or your team, then please do get in touch. We would love to have you. ROV Training courses are held every month, and you can check out QSTAR ROV Training web site to see the full training schedule and special offers. www.rovtrainingcentre.com. We hope to hear from you soon.

Apply now with the following code and get an extra discount for the ROV Premium Pilot Course: ROVPLANET2019

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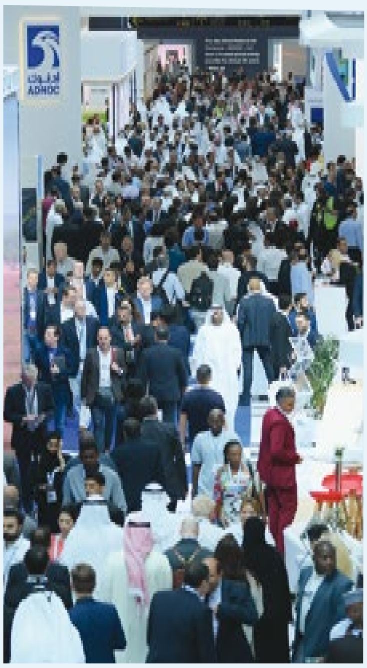

VALUE OF EXHIBITING

Focusing on marine services and logistics, the offshore and marine hall at ADIPEC covers the entire value chain of one of the most important segments of the oil and gas industry.

Innovative technologies and services are showcased across the exhibition floor in the dedicated hall 15 marquee, which will also see live demonstrations by certified divers from leading organisations.

The adjacent water channel and quay-side enables actual offshore support vessels and platforms, including jack-up barges, to anchor alongside the exhibition and conference, with guided tours available to all participants.

Top-level discussions and debates allow key decision makers from the world's leading NOCs and IOCs, EPC's, Service Providers to share knowledge with all across the ecosystem, including suppliers, market analysts and economists in order to get a thorough understanding of the future of the offshore and marine and determine ways to ensure its sustainability and increased productivity.

Building on its successful launch last year, **the Offshore & Marine VIP Club** will enable C level executives to network with their peers and undertake business discussions in a completely confidential environment.

Because of its commitment to best practice and overall industry excellence, **ADIPEC Offshore & Marine receives the support and backing of the major global oil and gas associations,** governmental energy bodies, IOCs and NOCs.

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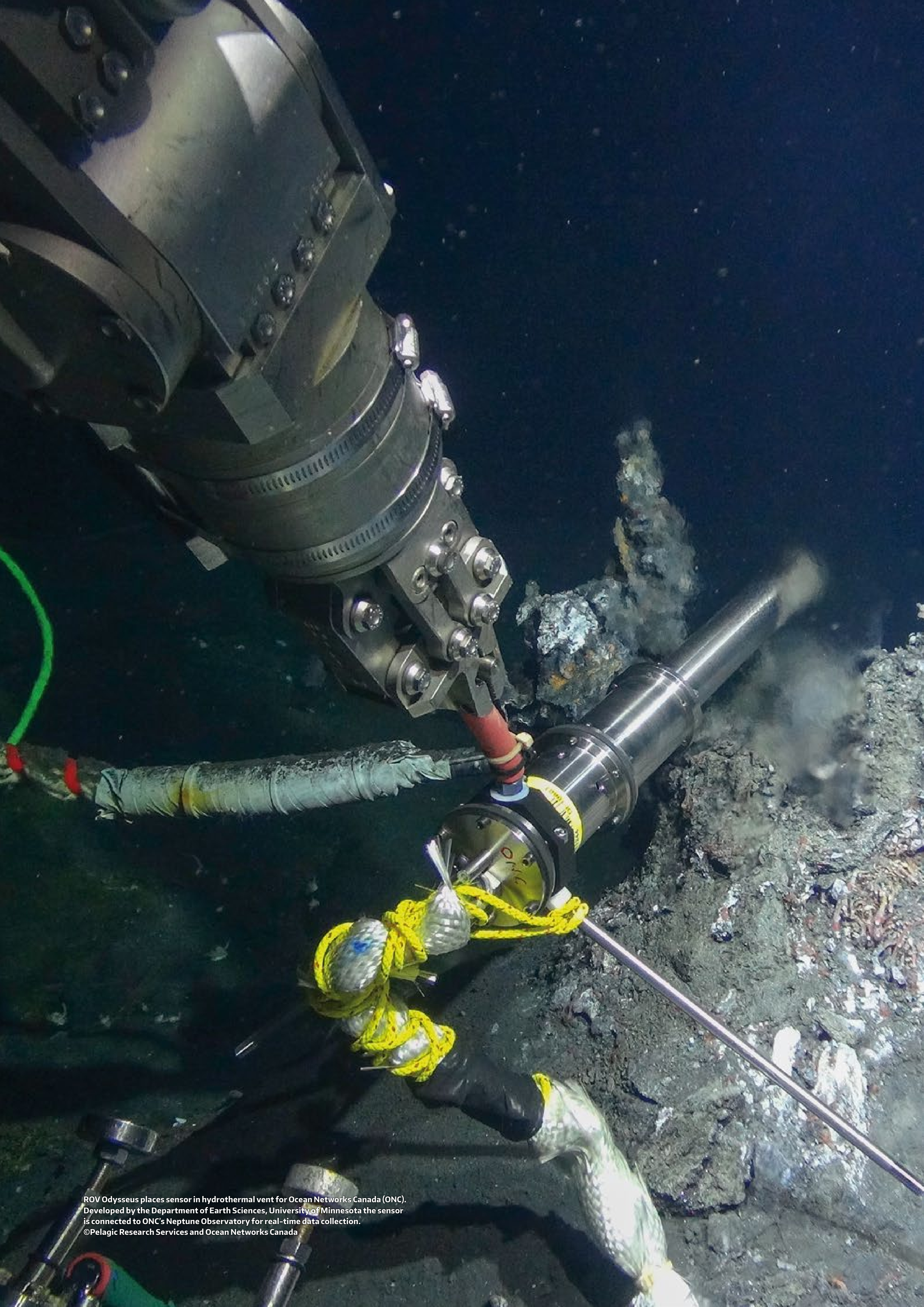
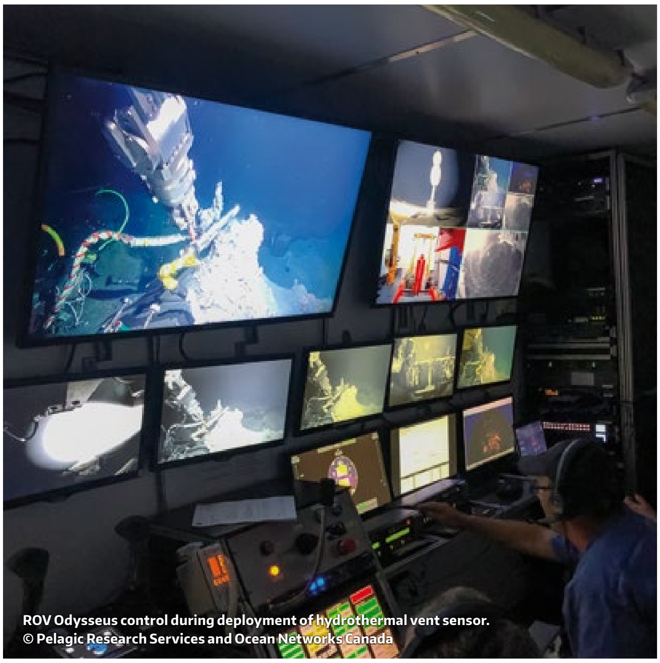


ROV Odysseus places sensor in hydrothermal vent for Ocean Networks Canada (ONC). Developed by the Department of Earth Sciences, University of Minnesota the sensor is connected to ONC's Neptune Observatory for real-time data collection.



ROV Odysseus control during deployment of hydrothermal vent sensor.
© Pelagic Research Services and Ocean Networks Canada

ROV Odysseus with integrated lifting bridge
© Pelagic Research Services and Ocean Networks Canada

Courtesy of XPRIZE

$7M

WINNERS ANNOUNCED IN SHELL OCEAN DISCOVERY XPRIZE FOR ADVANCEMENTS IN AUTONOMOUS OCEAN EXPLORATION

XPRIZE, the global leader in designing and operating incentive competitions to solve humanity's grand challenges, has announced winners in the $7M Shell Ocean Discovery XPRIZE, a global competition to advance ocean technologies for rapid, unmanned and high-resolution ocean exploration and discovery.

The results were revealed at an awards ceremony hosted at the world-renowned Oceanographic Museum of Monaco, part of the Oceanographic Institute, Prince Albert I of Monaco Foundation. The grand prize winner, receiving a total of $4M, was GEBCO-NF Alumni, an international team based in the United States, while KUROSHIO, from Japan, claimed $1M as the runner-up:

1, GEBCO-NF (INTERNATIONAL) – Led by Rochelle Wigley, Ph.D. and Yulia Zarayskaya, Ph.D., the 14-nation team integrated existing technologies and ocean-mapping experience with a robust and low-cost unmanned surface vessel, the SeaKIT, along with a novel cloud-based data processing system that allows for rapid seabed visualization, to contribute towards comprehensive mapping of the ocean floor by 2030.

2, KUROSHIO (YOKOSUKA, JAPAN) – Led by Takeshi Nakatani, Ph.D., the team integrated technologies from their partners to create a surface vessel and software platform that can operate with different autonomous underwater vessels, which increases the versatility of their technology.

The $1M National Oceanic and Atmospheric Administration (NOAA) Bonus Prize for teams to develop technology that could detect a chemical or biological signal underwater and autonomously track it to its source and was split between junior high school team Ocean Quest from San Jose, California, claiming $800K as the winner, and Tampa Deep Sea Xplorers, from Florida, taking $200K as runner-up.

"Currently, more than 80 percent of the world's ocean is unmapped, and I'm proud to have worked alongside the people who will change this as a part of this XPRIZE," said Executive Director of the Ocean Discovery XPRIZE, Jyotika Virmani, Ph.D. "Our vision is that these new technologies will enable the discovery of new ocean species, underwater resources, geological features, and safer methods of exploring the deep sea, while illuminating the mysteries of the deep and discovering what has remained unknown since the dawn of time."

Additionally, the judges unanimously recommended a $200K "Moonshot Award" for Team Tao from the United Kingdom for its unique approach to seafloor mapping, even though they did not meet the criteria of the competition.

"The Ocean Discovery XPRIZE teams' accomplishments are a true reflection of XPRIZE's core belief that incentivizing the crowd will drive innovation and investment, leading to a massive shift in the state of the market," said Anousheh Ansari, CEO of XPRIZE. "It is an honor to celebrate the winning teams GEBCO-NF Alumni, KUROSHIO, Ocean Quest, Tampa Deep Sea Xplorers, as well as Team Tao for their unprecedented, radical approach. We look forward to watching these pioneers shape the future of ocean exploration and discovery."

To determine winners, the panel of independent judges reviewed data from field testing conducted in Kalamata, Greece and Ponce, Puerto Rico. In Kalamata, teams had up to 24 hours to map at least 250 km^2 of the ocean seafloor at 5m horizontal resolution or higher. The gold-standard high-resolution baseline maps, against which the team maps were judged, were provided by Ocean Infinity and Fugro, while Esri, the global leader in geographic information system (GIS) software and geodatabase management, donated its award-winning ArcGIS Online platform for the teams and judges to use.

"At Shell, we are firm believers in the power of ideas and the value of collaboration to solve big problems," said Martin Stauble, Shell's Vice President Exploration North America and Brazil. "We are proud to be part of the Shell Ocean Discovery XPRIZE. This prize energized teams from across the globe and stimulated innovation, technology and learning, all in support of providing data for a better understanding of our oceans. We hope that the XPRIZE results will be a catalyst to create a step-change in the speed and quality of data that companies, research institutes and society can use."

As part of the total $7M prize purse, four teams opted to compete for the $1M NOAA Bonus Prize. In a field test in Ponce, Puerto Rico, teams needed to demonstrate that their technology can "sniff out" a specified object in the ocean by first detecting and then tracing a biological or chemical signal to its source. The judges determined that no single team was able to trace the signal to its source in the timeframe allowed, so the prize was divided among the two teams that came the closest.

Last year, nine finalist teams were awarded an equal share of the first $1M of the $7M prize purse, in recognition of their progress-to-date and to support the teams' continued technological development.

"NOAA is proud to support this important competition that is accelerating the development of new unmanned tools capable of tracking chemical and biological signals in our ocean," said Neil Jacobs, Ph.D., acting NOAA administrator. "The cutting-edge technologies that have emerged as a result of the NOAA Bonus Prize will help fuel a growing Blue Economy and inspire future innovation."

As part of its post-prize impact work, XPRIZE announced a partnership with Seabed 2030, a collaborative project between The Nippon Foundation and The General Bathymetric Chart of the Oceans (GEBCO) to inspire the complete mapping of the world's ocean by 2030 and to compile all bathymetric data into the freely-available GEBCO Ocean Map.

Courtesy of OCEANS

OCEANS 2019

SEATTLE SHOW PREVIEW

On October 27 – 31, leading marine professionals from all over the world will gather in Seattle, Washington to participate in one of the foremost events focused on marine technology and engineering – the OCEANS Conference, sponsored by the Marine Technology Society (MTS) and the IEEE Oceanic Engineering Society (OES).

Representatives from the biggest names in the industry will be presenting and participating in the event, while suppliers developing cutting-edge technology will offer demonstrations, hands-on workshops, and corporate presentations.

For the technical program, this year's theme is **"Blue Sea, Blue Sky, Blue Tech,"** and will explore new opportunities in the blue economy including local and sustainable practices and Washington State's new maritime business plans and progress.

OCEANS Topics to be covered will include:

- Underwater Acoustics and Acoustical Oceanography
- Sonar Signal/Image Processing and Communication
- Ocean Observing Platforms, Systems, and Instrumentation
- Remote Sensing
- Ocean Data Visualization, Modeling, and Information Management
- Marine Environment, Oceanography, and Meteorology
- Optics, Imaging, Vision, and E-M Systems
- Marine Law, Policy, Management, and Education
- Offshore Structures and Technology
- Ocean Vehicles and Floating Structures

Local topics will also be covered, including:

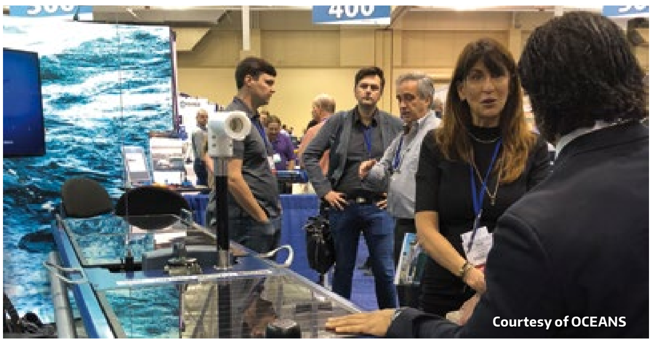
- Coordinated Multi-Vehicle Teams for Marine Applications (Air, Surface, Underwater)
- Polar and Under Ice Stationary and Mobile Observing Systems
- Offshore Earthquakes – Measuring and Mitigating Their Impact
- Wave, Current, Wind, and Gradient Energy Harvesting
- Best Practices in Sensor Design and Use, Systems Operations, and Data Management
- Plastics in the Ocean: Observation and Mitigation Methods
- Aquaculture: Technology for Management, Monitoring, and Mitigation
- Electrification of Marine Propulsion Systems and Digitalization of Marine Handling Systems

This year will feature the inaugural **Start-Up Pavilion,** providing an opportunity for new and emerging companies to experience the most productive conference in the industry during the most important phase of your company's growth. Positions for the Start-Up Pavilion are limited and will be sold on a first come first serve basis, so fill out the form on the OCEANS 2019 Seattle website to see if you qualify!

In addition, there are plenty of exciting opportunities for students and young professionals to connect with a thousand international leaders in academic, private, and governmental ocean research and instrument design at OCEANS 2019 Seattle.

Seattle, Washington is the perfect backdrop for 2019's ground-breaking OCEANS Conference. This progressive, oceanfront city serves as the headquarters of NOAA's Pacific Marine Environmental Laboratory, a federal laboratory that makes critical observations and conducts ground-breaking research to advance our knowledge of the global ocean and its interactions with the earth, atmosphere, ecosystems, and climate. With Seattle's maritime industry bringing in nearly $38 billion into the state's economy, it goes without saying that this location will enhance every aspect of the OCEANS Conference. While you're there, take a visit to the Space Needle, Pike Place Market, or the Seattle Aquarium. There's something for everyone to enjoy, so start planning your itinerary!

The best way to experience OCEANS 2019 Seattle is with your entire network by your side. If you are interested in becoming an OCEANS Ambassador for the chance at a discounted registration rate, please fill out the form on the OCEANS 2019 Seattle website.



Courtesy of OCEANS

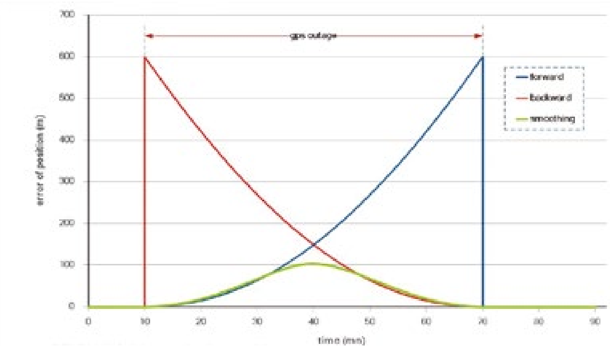
GETTING THE BEST OUT OF YOUR INERTIAL NAVIGATION SYSTEM

Accurate positioning and reliable data are crucial to conduct successful operations in the challenging subsea environment. Offshore operations often induce constraints that can jeopardize real time navigation data quality. A strong post processing tool is thus a valuable asset to secure operations and prevent time-loss and rework.

DELPH INS SUBSEA FOR ENHANCED INS PERFORMANCE

Recognized worldwide for the design and manufacturing of advanced inertial navigation solutions, iXblue launched, back in 2008, its Delph INS software to provide customers with advanced post-processing capabilities. Over the years, iXblue's Delph INS post-processing and batch productivity software has become a complementary and relied upon tool for the Fiber-Optic Gyroscope (FOG) based Inertial Navigation Systems (INS) developed by the company, including iXblue's Phins Surface, Phins Subsea, Phins Compact, Rovins and Rovins Nano INS. Highly intuitive and user-friendly, Delph INS is a powerful tool that makes offshore operations more efficient both operationally and cost-wise, saving important vessel time and not requiring in-depth INS knowledge, making it very straight-forward to use.

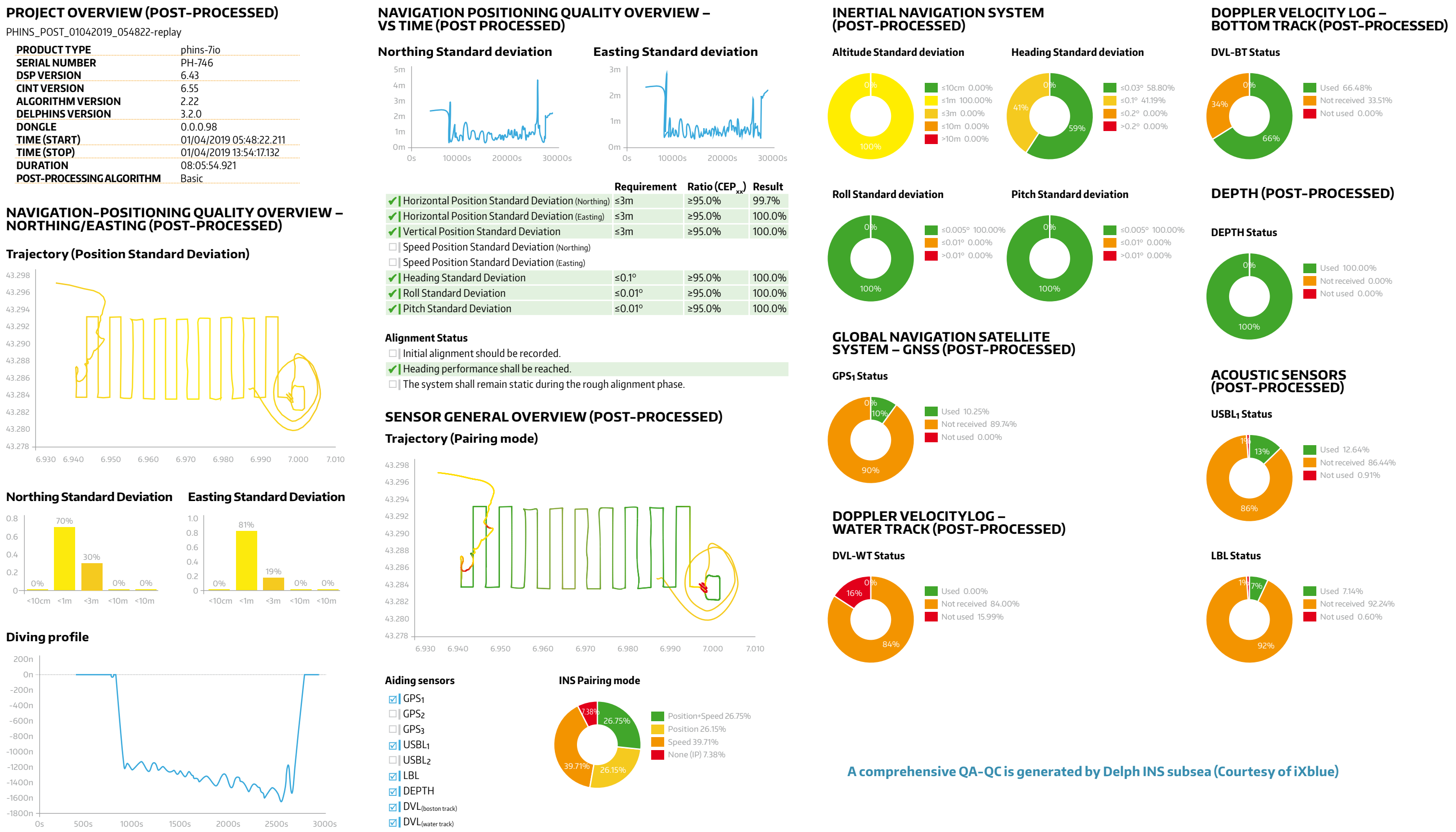
Strong data management, highly intuitive visualisation, editing and processing features together with diverse export capabilities (Google Earth, Geographic or user defined formats[1]) make iXblue's Delph INS Subsea software ideal for quick and easy navigation enhancements. By combining the raw data from the INS and from the complementary aiding sensors (GNSS, USBL/LBL, DVL, depth sensor...) during post-processing, iXblue's Delph INS Subsea provides higher accuracy for the position, velocity or attitude of the platform. Thanks to its advanced forward-backward processing algorithms, Delph INS Subsea can furthermore significantly improve the performance obtained in real-time (up to a factor 2-3), specifically for portions of the operation where some of the sensors or measurements were not fully available, or were recorded separately (see graph 1).



Graph 1 – Navigation enhancement principle (Courtesy of iXblue)

[1] Google Earth (KMZ) format: *.kmz data file that can be visualized into Google Earth, Geographic (SHP, KML ...) format: standard *.shp or *.kml files that can be visualized in any regular GIS application, POSPac SBET (out) format, User defined format: described by the user by writing a template file

Delphins Advanced Subsea



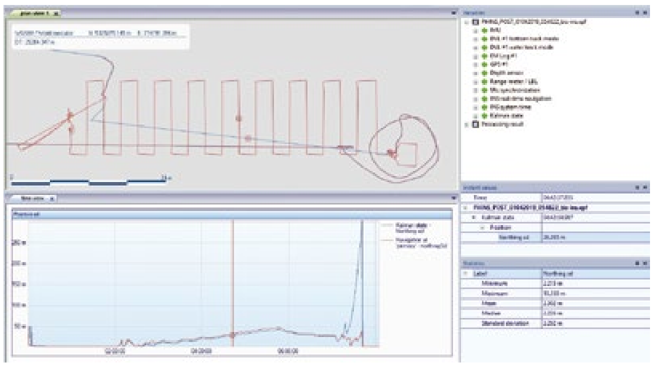
A comprehensive QA-QC is generated by Delph INS subsea (Courtesy of iXblue)

NEW FEATURES FOR THE UPGRADED VERSION OF THE SOFTWARE

An upgraded version of the Delph INS Subsea software is now being released by iXblue to offer enhanced performance and even more intuitive use of the tool for more efficient offshore operations.

New features include:

- An INS/DVL advanced calibration capability thanks to post-processed forward computation. This will allow the user to employ a non-calibrated DVL with an INS and to recover the calibration value afterwards. A very convenient and time-saving solution when a DVL needs to be replaced. Indeed, it enables the use of a non-calibrated DVL in real-time along with the INS and the complete alignment of the system during post-processing operations, offering a flexible and highly efficient solution to recover the navigation track.
- New enhancements have also been made to protect the post processing file logging against communication loss.
- Specific Project tuning for OOS (Out of Straightness).
- Plan view embedded into Delph INS Subsea (Time synchronized, Distance Travelled...)



- Finally, iXblue's Delph INS Subsea software now also produces new comprehensive quality analysis and quality check reports (QA/QC), providing quick, easy and highly intelligible information on the reliability of the collected data.

Overall, Delph INS Subsea software offers a cost-effective and scalable solution for all subsea applications (ROV, AUV, Towfish positioning), compatible with both industry standard and custom software. It is the perfect tool that will help offshore operators and integrators worldwide reach a higher degree of accuracy by easily post-processing all the data acquired by the various sensors used during their challenging subsea operations.

UNMANNED, AUTONOMY, AND ARTIFICIAL INTELLIGENCE IN MARITIME SYSTEMS

John R. Potter, PhD. (Fellow, IEEE) discusses the potential impact of AI on the ROV/AUV and maritime systems of the future

There's a continuing buzz around unmanned and autonomous systems for maritime use, and rightly so since the technologies being developed are game changers for almost every aspect of maritime operations and business practices. But there is also a lot of loose language around 'Unmanned', 'Autonomous', and 'Artificial Intelligence' that leads to confused expectations of what exactly is possible and desirable, both now and in the near future.

UNTANGLING TERMINOLOGY

Let me be clear. First, when I refer to an 'Unmanned' Maritime System (UMS), I mean that there is no person physically on the system platform at sea. There will very likely be one or more people 'in the loop' or 'on the loop' and they could be directly involved in relatively low-level control functions for the system (for example the crew who fly Unmanned Aerial Systems (UAS).

Secondly, when I talk about an 'Autonomous' system, I mean one that is capable of operating unassisted for extended periods: executing an entire mission from end to end, taking mission execution level decisions without outside input, supply or control. Sound reasonable?

But wait a minute, by these definitions so-called Autonomous Underwater Vehicles (AUV) are hardly autonomous at all; they generally require substantial manned surface vessel support at the beginning and end of a mission, are usually actively tracked – and possibly controlled to some extent – by the manned surface platform during the mission, and are rarely capable of taking mission execution level decisions without external support. In fact, probably the nearest thing we have to an AUV is a nuclear submarine, so 'Autonomous' is not even a subset of 'Unmanned'.

But is this just semantics or does it make a real difference? I would argue that there are fundamental differences in the appropriate choice of unmanned versus autonomous, arising from fundamental physical constraints. In my opinion effective autonomy at the highest level needs to be powered by Artificial Intelligence (AI), with operational behavioural assurance of these AI-empowered systems requiring nested autonomous loops with manned-unmanned teaming in the outer shell. Let's look at this one piece at a time.

THE IMPLICATIONS OF AUTONOMY

An Unmanned Aerial Vehicle (UAV) is an aircraft without a human pilot onboard. UAVs are a component of UAS which consists of a UAV, a control crew placed at a separate location and a communications system linking the two. For UAS, the communications are generally by radio, which provides sufficient bandwidth and low latency to permit rapid, short-cycle control loops, so that even low-level control of flight and data rich sensor output can be exchanged. For high-bandwidth, low-latency communications links, this is the obvious and easiest way to go, and partly explains why UAS development is a decade ahead of UMS. It does not require AI development (and the behavioural uncertainties that come with AI) and UAS can be weaponised without raising the spectre of 'killer robots', since there are humans in the loop at all levels of command. This is not to say that such weaponised systems are without controversy, however, and the suite of 'trolley car' thought experiments point to serious ethical issues even in this tightly integrated manned-unmanned teamed system.

While Unmanned Surface Vehicles (USV) can be used in a similar way to UAVs, maritime operations very often require subsurface activity, and this is where we run in to trouble with AUVs. Radio waves simply do not propagate well underwater, and while there are optical and radio solutions for very short ranges, fundamental physical constraints point to acoustics as the communications method of choice for most applications.

The problem with underwater acoustics is that the useful bandwidth is approximately five times lower than for radio, and the latency is typically on the order of seconds, if not minutes. This latency precludes low-level control, while the bandwidth limitation necessitates at least mid-level autonomy on the vehicle, which might include collision avoidance, emergency procedures, and so forth (this relationship between communications bandwidth, latency, and necessary vehicle autonomy in UMS is illustrated in Fig 1).

Autonomy is not a binary attribute and is usually classed into several distinct levels. The driverless car community is currently using a six-level model. For UMS I propose a five-level model, which I will loosely describe as follows:

0 NO AUTONOMY – all actuation events are externally driven, no local sensor feedback control loops.

1 LOW-LEVEL AUTONOMY – ability to operate control surfaces and propulsors to, for example, maintain constant speed, depth and heading and to follow simple pre-programmed trajectories based on simple in-situ sensor data feedback loops.

2 MID-LEVEL AUTONOMY – conditional activation of state-based protocols, e.g. collision avoidance, triggered surfacing to report, emergency actions, following deterministic pre-programmed conditions that may include fused sensor data streams to update state machine models.

3 HIGH-LEVEL AUTONOMY – on-board near-real-time analysis and fusion of heterogeneous sensor data to provide a local operational picture that can be used to take appropriate action to optimize the application of its own resources to achieve the stated mission objectives, given the experienced environment. Examples include re-designing planned survey paths in the light of currents, seabed conditions and changes in mission plan on discovery of important new elements in the environment. AI may or may not be involved at this level, deterministic algorithms are sufficient, but operational parameters may be modified from pre-programmed states. Tactical behaviour may not be predictable.

4 FULLY AUTONOMOUS – vehicles and systems communicate, co-operate, and collaborate with other autonomous systems, acting in concert to optimally achieve the desired over-arching mission objectives, as an end-to-end solution, combining and executing all phases of the mission without supervision. This requires AI elements to develop and adapt the strategic approach and enable the productive use of cloud-based Big Data and Deep Learning techniques. Not only behavior, but large-scale strategy is non-predictable, possibly even incomprehensible.

In this regard, UMS are ahead of UAS insofar as level 2 is commonly available in current systems in operation. Also,

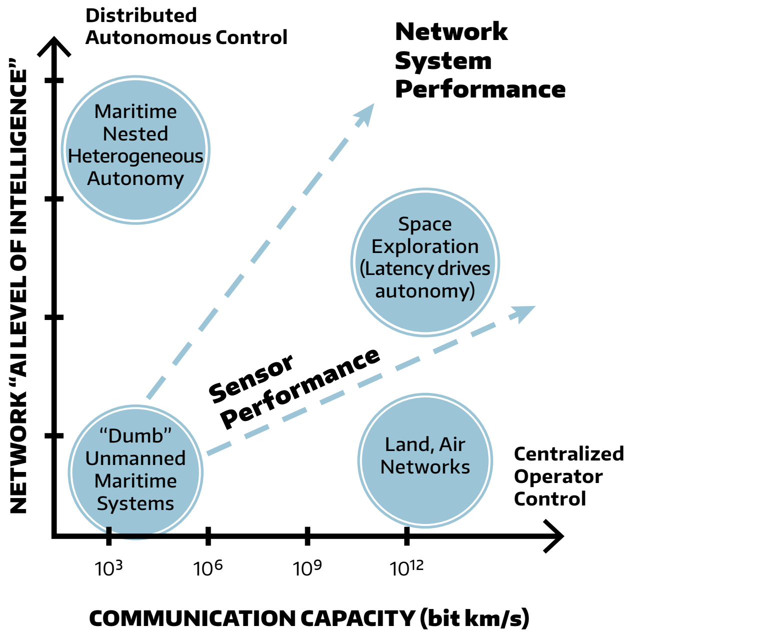


Figure 1: Relationship between communications bandwidth, latency, and necessary vehicle autonomy in UMS.

level 3 has been widely demonstrated in numerous R&D environments and is pipelined for next-generation products, and we are beginning to see proof-of-concept of level 4 in restricted domains. But it is at this point that we hit the thorny problem of AI behavioural assurance.

PREDICTING AI BEHAVIOURS

Perhaps I should first define what I mean by AI. An AI system is one which learns from its direct sensed experience and data that it has been exposed to, establishing actionable pathways that are defined by the relationships between things in its environment that it has learned to correlate with future outcomes. An AI system includes the capacity to perform all four elements of the OODA loop (Observe, Orient, Decide, Act). Because of its learning, in turn coloured by the data it has been exposed to and its experiences, an AI system is inherently biased and, to some extent, unpredictable. How then can we assure that AI behavior always leads to desirable outcomes?

Even deterministic algorithms at lower autonomy levels can display unexpected and undesirable behaviours. Algorithms must be extensively tested with the best practices of software design, exploring every possible outcome in the (often very large) parameter space. This must include anticipating the outcome of faulty sensor inputs. Failing this, the algorithm may produce unanticipated and possibly destructive behaviour. It appears that this could have been a contributing factor in the tragic recent crashes of two Boeing 737 Max8 aircraft, where new anti-stall flight control software may have produced undesirable behavior that was unforeseen by Boeing and the FFA, despite the extensive quality control processes of a major aerospace contractor.

But AI goes far beyond the risks of unexpected behaviour from deterministic algorithms, that can only produce results lying within a set of outcomes based on the programming and direct data inputs. With AI we must embrace the fact that outcomes are no longer deterministic and cannot be guaranteed to lie within a given performance envelope. It is well recognized that an increased diversity of contributing participants, whether from different cultural backgrounds, ages, or gender is positively correlated with the improved performance of teams. The converse is also true.

HARDWIRED BIASES

While great care is generally taken to reduce bias in the databases on which AI learns, several recent cases have highlighted ethical bias problems resulting from a lack of broad inclusion. A recent example highlighted how Facebook targets advertisements. As a result, they are now under threat of being taken to court for discrimination. Another example is Amazon's facial recognition software, which is apparently better at recognizing white men than women and/or people of colour.

Even before an AI algorithm is exposed to data, biases inherent in the coding and project management team will inevitably become hard-wired into the algorithmic approach. A prime example is the Microsoft chatbot 'Tay' that was designed to be a friendly character to entertain on Twitter. Tay was not Microsoft's first online AI application; a chatbot called XiaoIce had been very successful in China, where it has interacted with over 40 million people. Tay was an attempt to duplicate XiaoIce but for a very different culture.

Tay was given a Twitter account and autonomously tweeted and interacted with others. Despite extensive prior user studies with diverse user groups, Microsoft failed to identify a vulnerability that was exploited in a coordinated attack. In the process, absorbing and learning from data provided by tweets addressed to Tay, the chat bot rapidly diverged from the intended character role, becoming a racist fascist within hours of launch. Microsoft had to shut down Tay's account only 16 hours after it was released.

This type of uncertainty must be managed as a dynamic risk, with estimates of probability of occurrence and severity of outcome considered in a framework of risk management and contingency planning. It would thus be ethically prudent to consider any and all AI algorithms to be imperfect and in continuous development: subject to continuous risk analysis and management.

I believe that AI behavioural uncertainty must be formally managed as such technology is developed, and effectively controlled. Certainly, we will need to develop specifications for due diligence and algorithm stress testing, which must include extensive simulation and the use of generative adversarial networks to test its responses over the largest range of inputs.

KEEPING HUMANS IN THE LOOP

To minimise the risk of AI exhibiting pathological behaviour, we need high-level control processes that include people in the control loop, providing a 'sanity check' as it were. This means that future UMS will likely consist of (heterogeneous) vehicles exercising local distributed control at the 'edge', with an AI capability of at least 2 (see above), with at least some communicating with each other over a local ad-hoc network at AI level 3. Additionally, an AI level 4 outer shell of mission-level strategic control that has access to cloud-based Big Data and Deep Learning for strategic insight will wrap around the lower levels, teamed with people in or on the loop.

AI systems may soon become too smart for people to understand their strategy and too fast to follow tactical shifts (as has already happened with AlphaGo and AlphaZero) so there will be a need for a quick and effective Human Computer Interface (HCI) supported by plain-language parsers and other virtual and augmented reality tools so that the humans in the loop can ask what the AI is up to, what is the strategic plan, and how it plans to deliver the desired outcome. This concept of nested heterogeneous autonomy is illustrated in Fig. 2, adapted from a public-domain NATO report on future UMS.

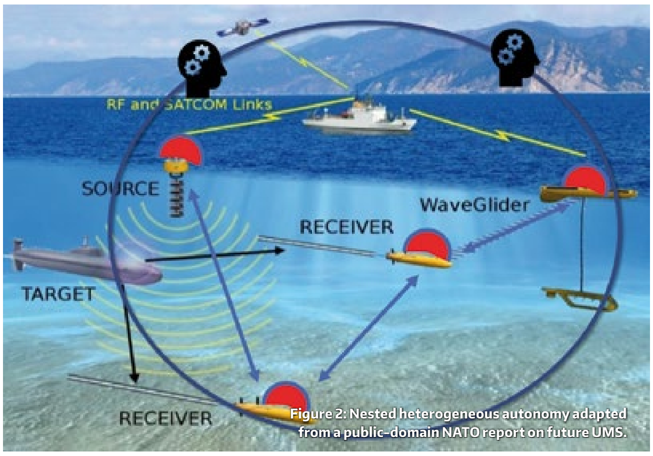


Figure 2: Nested heterogeneous autonomy adapted from a public-domain NATO report on future UMS.

A powerful example of the benefit of a human-in-the-loop at the outermost control level comes from the depths of the cold war. On September 26, 1983, lieutenant colonel Stanislav Yevgrafovich Petrov was in charge of a Soviet nuclear early warning center. On this night, his satellite sensing network reported five American nuclear missile launches. Rather than immediately retaliate, as protocol demanded, Stanislav followed his gut feeling and delayed his report to seniors, eventually convincing the armed forces that it was a false alarm. With his decision to ignore algorithms and instead follow his instinct, Stanislav prevented an all-out US-Russia nuclear war. Going partly on gut instinct and believing the United States was unlikely to fire only five missiles, he told his commanders that it was a false alarm before he knew that to be true.

These autonomy and AI challenges will not wait. The Chinese have already identified AI and robotics as key disruptive technologies, through which they intend to leap-frog western nations that currently lead the field in maritime technology. It is no less than the financial and technological maritime battleground over which global power projection supremacy will be fought and won. And lost. Let's be clear which side we plan to be on.

OCEAN INFINITY IN THE SEARCH FOR THE LOST ARGENTINIAN SUBMARINE, ARA SAN JUAN

By Richie Enzmann

Ocean Infinity, the seabed exploration company, confirmed the location of the ARA San Juan, the Argentine Navy submarine, lost on 15 November 2017. Almost exactly a year later, in the early hours of 17 November 2018 and after two months of detailed seabed search, the wreck of the submarine was found in a ravine 920m below the surface, approximately 600 km east of Comodoro Rivadavia in the South Atlantic Ocean.

The Seabed Constructor (Courtesy of Ocean Infinity)

The ARA San Juan (S-42) (Photo: Martin Otero)


Inside the AUV Work Hanger of the Seabed Constructor (Courtesy of Ocean Infinity)

ARA SAN JUAN

The Argentine diesel-electric submarine was one of the two operational TR-1700 German built submarines in operation. It had a crew of 44, including the first female submariner to ever become lost at sea.

The submarine departed from Ushuaia and travelled up north through the Atlantic to conduct a mission. The circumstances of the loss are under judicial review, but it is thought that a problem with the submarine's forward battery compartment led to reduced power, a lack of ability to control depth and a descent to crush depth.

Th resulting implosion caused a hydroacoustic anomaly that was detected by the hydrophone network of the Comprehensive Test Ban Treaty Organisation, information which combined with last reported positions and Iridium satellite communication handshakes determined the search area.

THE SEARCH

Ocean Infinity used five Kongsberg Hugin 6000 Autonomous Underwater Vehicles (AUVs) for the search operated by a team of approximately 60 crew members on board the Seabed Constructor. In addition, representatives from the Argentine Navy and family members of the crew of the ARA San Juan were invited to join and assist the search.

Ocean Infinity had committed to conduct the search operation for up to sixty days, and to take on the economic risk of the search, only receiving payment if the submarine was found. Now the company will receive a reward of $7.5 million for finding the missing vessel.

Ocean Infinity's permanently mobilised ocean search capability is the most technologically advanced in the world. Their AUV's are capable of operating in water depths from 50 to 6,000m and covering vast areas of the seabed at unparalleled speed. The AUVs are not tethered to their host vessel during operations, and this allows them to go deeper and collect higher quality data for the search. They are equipped with a variety of tools including side scan sonar, a multi-beam echo-sounder, HD camera, and synthetic aperture sonar.

From the host vessel Ocean Infinity are also able to deploy two work class ROVs and heavy lifting equipment capable of retrieving objects weighing up to 45T from 6,000m. To date the company has logged 29,000 survey hours, 140,000 km, and 181,000 square miles over the course of 700 missions.

Unlike the search for the now infamous Malaysian Airlines flight MH370, Ocean Infinity had access to a detailed bathymetric map of the search area. The air search for any wreckage on the water surface proved to be negative as nothing was found that could have belonged to a submarine, and this helped focus the search below the surface. In total 105 ROV dives were made to investigate possible contacts. Ocean Infinity went through the navigational areas that the experts identified based on the state of the submarine, and the possible behaviour of the captain as it was heading for home port.

DISCOVERING THE INEVITABLE

As the boat progressed onto the second round of search areas there were dozens of sonar anomalies found that could have been a submarine. Again, the ROVs were utilised


Inside the AUV Work Hanger of the Seabed Constructor (Courtesy of Ocean Infinity)

Ocean Infinity's Kongsberg HUGIN AUVs were used for the Search Mission (Courtesy of Ocean Infinity)

to take a closer look, while the AUVs continued their pre-programmed search paths.

The submarine was located on AUV dive 133 and was found sitting on a geological ridge at a 10-degree angle with parts of the submarine falling further down the slope. A large hull section was nearly perfectly aligned with the ridge line and the submarine sail had fallen off the edge. The hull was twisted and deformed into a non-linear feature. The thruster propeller had wholly fallen away from the shaft and the torpedo tubes were exposed. The damage inflicted was reminiscent of both the USS Thrasher and the USS Scorpion which met with similar ends.

When a submarine goes beyond the crush depth (in the ARA San Juan's case around 596m) it first implodes and then explodes. Hence the destruction field of the imploded submarine remains small. This explains why wreckage on the surface was never found.

DRAWING CONCLUSIONS AND LESSONS LEARNED

Overall this search was a great international effort with many experts involved. The surface and subsea currents were modelled. SAR was used for oil slick detection. Iridium and positioning experts, hydroacoustic and seismic experts, and submarine acoustic experts were all utilised.

Nick Lambert the Director of Operations commented on the findings, 'Ocean Infinity are constantly expanding the capabilities of subsea technology and challenging what people have previously believed to be operationally impossible'. Lambert added that 'Technology continues to push boundaries and go beyond human capability. Ocean Infinity's dynamic and innovative approach allows the company to adapt and grow with technological advancements.'

Besides deciding how best to use the data gathered from this incredible operation, it is also important to weigh the human impact of these findings. Oliver Plunkett, Ocean Infinity's CEO, said 'Our thoughts are with the many families affected by this terrible tragedy. We sincerely hope that locating the resting place of the ARA San Juan will be of some comfort to them at what must be a profoundly difficult time.

'Furthermore, we hope our work will lead to their questions being answered and lessons learned which help to prevent anything similar from happening again.' Plunkett went on to say 'We have received a huge amount of help from many parties who we would like to thank. We are particularly grateful to the Argentinian Navy whose constant support and encouragement was invaluable. In addition, the United Kingdom's Royal Navy, via the UK Ambassador in Buenos Aires, made a very significant contribution.

'Numerous others, including the US Navy's Supervisor of Salvage and Diving, have supported us with expert opinion and analysis. Finally, I would like to extend a special thank you to the whole Ocean Infinity team, especially those offshore as well as our project leaders Andy Sherrell and Nick Lambert, who have all worked tirelessly for this result.'

Overall the findings will mean very different things to all interested parties: confirmation of equipment capabilities for Ocean Infinity and their partners, demonstration of the ability of deep-sea search operations for professional rescue agencies; sorrowful confirmation and perhaps some closure for the loved ones of the ARA San Juan. What is clear, however, is how far the technology harnessed in this massive effort has come in recent years, and its incalculable value to future search missions.

Footage courtesy of Wael Dabbous, Ocean Infinity

Footage courtesy of Wael Dabbous, Ocean Infinity

Footage courtesy of Wael Dabbous, Ocean Infinity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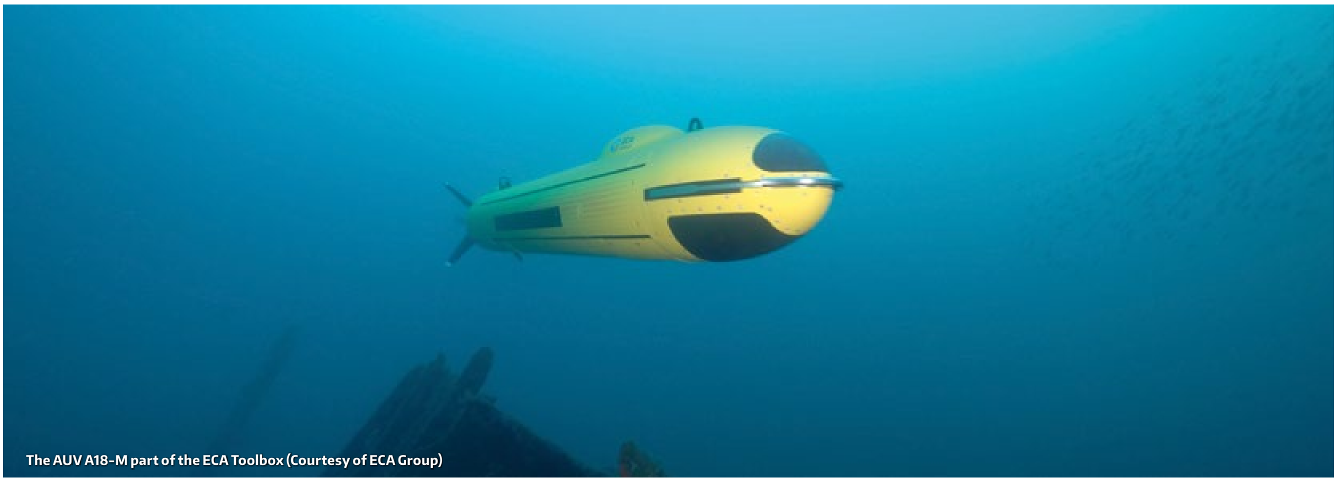
INTERVIEW:

THE ECA GROUP TOOLBOX INSIDE THE BELGIAN-DUTCH NAVAL CONTRACT

An overview of the warship from Naval Group with its toolbox from ECA Group. (Courtesy of ECA Group)

The Belgium Naval & Robotics consortium, composed of Naval Group and ECA Group, recently secured the contract to supply twelve mine-hunting vessels to the Belgian and Dutch navies. Equipped with a total of approximately 100 drones - approximately ten drone systems or toolboxes - six ships are destined for the Belgian Navy, while the other six will be delivered to the Dutch Navy. ROV Planet interviewed Daniel Scourzic, VP of Strategic Programs at ECA Group's Robotics Department to find out more about the drone systems part of this major contract.


The AUV A18-M part of the ECA Toolbox (Courtesy of ECA Group)


SEASCAN ROVs are part of the Mine Identification & Destruction Systems (MIDS) (Courtesy of ECA Group)


K-STER C ROVs are part of the ECA Mine Identification & Destruction Systems (MIDS) (Courtesy of ECA Group)

RICHIE ENZMANN (RE): **Please tell us about the types of drones developed by the ECA Group that are included in this major deal.**

DANIEL SCOURZIC (DS): The drone systems on board these innovative vessels are the latest generation of drones developed by ECA Group over the past four years. They are integrated into the C2 MCM UMISOFT™ system connected to the Naval Group's I4drones® system. This forms the mine-warfare mission system which is integrated into the ship's combat management system.

The solution includes among others A18-M AUVs, T18-M towed sonars and Mine Identification and Destruction Systems (MIDS) composed of SEASCAN and K-STER C ROVs. All these drones can be operated, i.e. launched and recovered, from the USV INSPECTOR 125.

The drone systems also include unmanned aerial vehicles (UAVs) and influence sweeps from third party providers. The program provides for the supply of drone systems that can also be projected. Containerised and equipped with handling and communication systems, mine-hunting drone systems can be airlifted and deployed directly from the coast without a ship.

RE: **Sounds like they come as a highly integrated package. Are these systems completely autonomous, or are some human operators on board too? What are their roles in the loop?**

DS: You're correct: there is a lot of autonomy built into the systems and when the man is in the loop for some operations, he remains at a safe distance out of the danger zone. This is the aim of the 'stand-off' operational concept for mine counter measures, for the operations to be safer for the crew... faster and cheaper with the ECA Group toolbox.

For example, the USV can be programmed to conduct survey missions autonomously when towing a Synthetic Aperture Sonar but also to deploy and recover its payloads: AUVs, Towed Sonars or ROVs. But it can also be remotely controlled or supervised by the operator from distance, through the UMISOFT C2 software or even be used in a manned configuration, according to the user's need.

The A18-M AUV when deployed will autonomously conduct its missions including the autonomous analyses of the sonar images. With ECA Group toolbox, the main role of the human operators – through UMISOFT C2 software suite – is to plan the missions of the robots, to supervise the operations conducted autonomously by the robots, and to manage the data collected.

RE: **Please tell us more about the deployment of these systems. How does the launch and recovery of these systems work?**

DS: The LARS systems are at the heart of our solution. Their design is crucial for the safety of crews and equipment as well as for the operational availability of the toolbox. For the launching and recovering of ECA Group toolbox, there are two types of operations to be considered: the launching and recovering of the USV from the mother ship, and the launching and recovering of underwater vehicles from the USV.

The first LARS system – deploying the USV from the mothership – is designed by our partner, Naval Group. Our teams worked very closely together in order to have a reliable system to deploy and recover the INSPECTOR USV in high sea states: up to 5. The solution is based on both companies' experiences in operating naval robots from ships with the support of partners with a long experience with LARS technologies.

The second types of LARS systems are designed by ECA Group. They're fitted onto an INSPECTOR USV to deploy and recover the AUV and the mine identification and disposal vehicles as well as the towed sonar. The AUV A18 and the towed sonar T18 have a common LARS since these two systems have been designed on the same platform basis.

Thus, three main advantages result from our choice. First, to have the same fixture and common equipment such as the ramp, power pack, C2 interface, etc. Second, to reduce storage requirement on the ship and onshore as well as reducing the number of spares and tools. Third, the training of the crew to use and maintain this LARS system is simplified.

RE: **Can you please describe a typical mission scenario? What would be the steps of operation?**

A typical mission scenario could be, for example, to clear an access to a seaport. An order is received by a ship from the headquarters that will sail and remain out of the possibly mined area. During the transit or after arrival, UMISOFT C2 software suite is used by the MCM operators onboard the mothership to define the areas to be surveyed.

UMISOFT C2 software will then propose the use of certain tools, e.g. USV and T18 towed SAS sonar and or A18 AUV than can survey different areas simultaneously that will then be endorsed or modified by the operators. When the various tasks are defined, the USV with its towed sonar or AUV is launched from the mothership. The INSPECTOR USV will then autonomously transit towards the area to be surveyed and will launch the towed sonar or the AUV.

The survey can then start. If the towed sonar is used, the USV will autonomously follow the defined pattern. The data can be either recorded and pre-processed or transferred in real time to the mothership to be analysed by UMISOST software.

If the AUV is used, it will survey the area assigned and will process in real time the data using its embedded Automatic Target Detection system in order to select possible sonar images of interest. These snapshots can then be transferred to the mother ship using the INSPECTOR USV as a radio communication relay to be analysed by the operators onboard the mothership. If among the sonar images analysed, a few objects are deemed to be mines, another INSPECTOR USV fitted with SEASCAN and K-STER vehicles is sent in order to identify the underwater objects with SEASCAN, and if necessary, prosecute them using K-STER. After the end of the task, the UMISOFT database is updated.

RE: **What's the timeline and value of the program?**

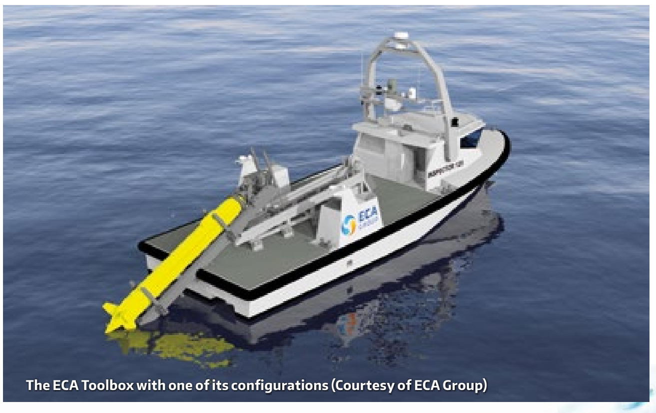
DS: The contract was entered into force on May 22nd, 2019. The construction of the first war ship will begin in 2021 by Naval Group and its subsidiary Kership in France. The first ship with its toolbox will be delivered in 2024. The next one will be 12 months later, and then one ship every 6 months.

The drone systems – also named toolboxes – will be produced in Belgium by ECA Group company ECA Robotics Belgium. The study and design works have started. We have already established our office in Brussels. In 2020 ECA Group will set up its production plant in Zeebrugge where the drone systems will be assembled, integrated, and maintained. For ECA Group the value of the program is around €450M.

CONCLUSION

As the Belgian Navy is a reference point in underwater mine warfare within NATO, this contract is a major asset for export. As with the tripartite mine-hunter program 40 years ago which generated sales of PAP mine disposal vehicles to over 20 navies in 20 years, this success in Belgium should generate many commercial export benefits in the coming years. ECA Group is already in discussions with several navies for the supply of robotic underwater mine countermeasure systems.


The ECA Toolbox with one of its configurations (Courtesy of ECA Group)

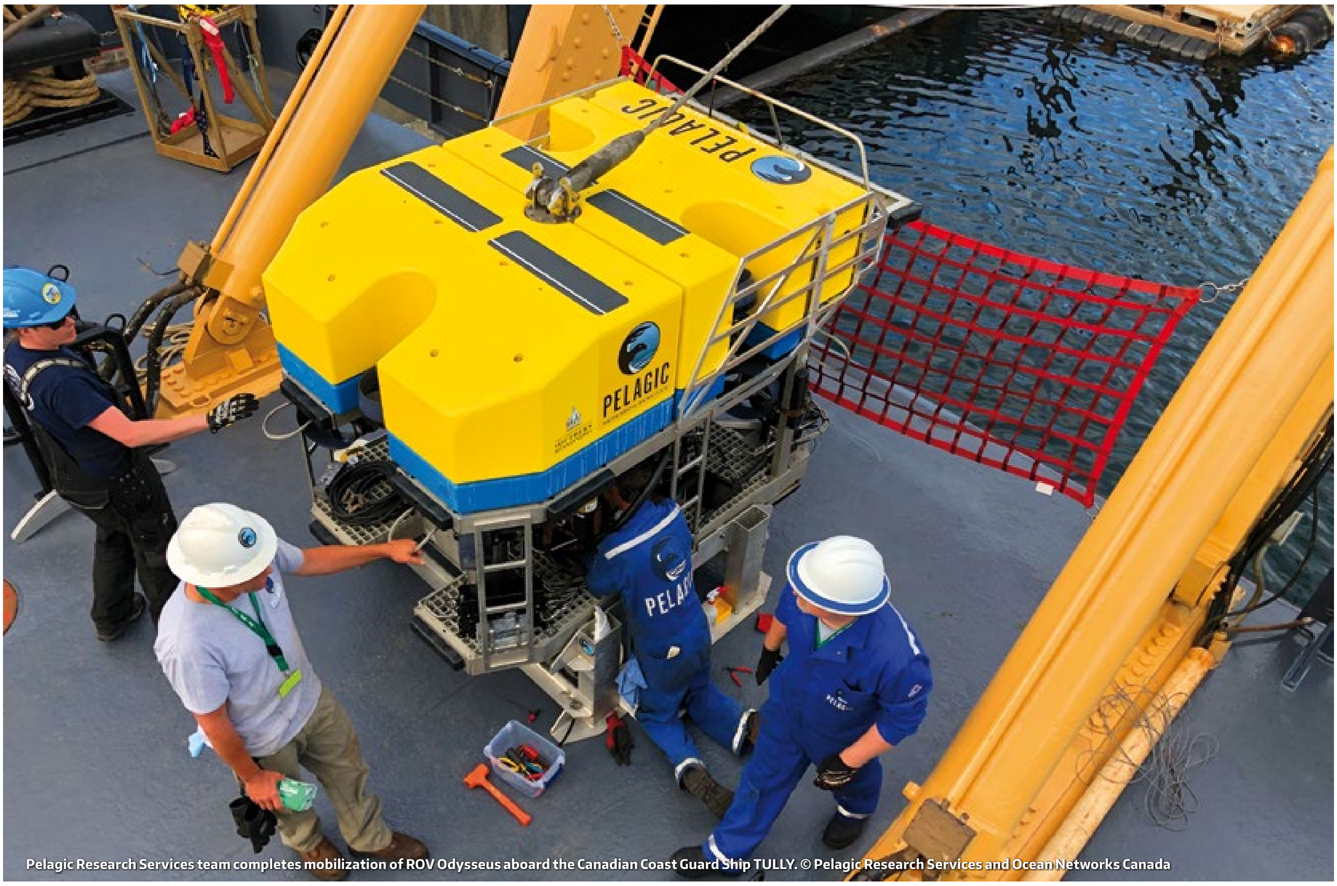

The ECA Toolbox with one of its configurations (Courtesy of ECA Group)

PELAGIC RESEARCH SERVICES' ROV ODYSSEUS: GOING SHALLOW AND GOING DEEP AND EVERYWHERE IN BETWEEN

Edward R. Cassano, CEO, Pelagic Research Services

ROV Odysseus begins dive hundreds of miles offshore Vancouver Island, British Columbia, CA © Pelagic Research Services and Ocean Networks Canada

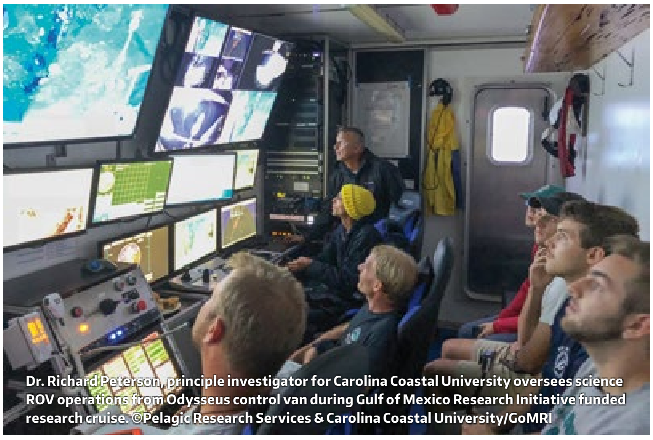
We have a need and responsibility to understand the world's oceans and interact with its myriad resources. We continue to discover the intricacies of the ocean's role in supporting our very existence on this planet, yet our understanding is far from complete. Uncovering the secrets of the undersea world requires advanced technologies and the forward thinking of outstanding universities, industries, governments, philanthropic organizations and NGOs. Pelagic Research Services (PRS) was founded to combine these assets and meet these needs, while providing stewardship today and for future generations.



Pelagic Research Services team completes mobilization of ROV Odysseus aboard the Canadian Coast Guard Ship TULLY. © Pelagic Research Services and Ocean Networks Canada

PRS ROV ODYSSEUS GOING SHALLOW AND GOING DEEP—AND EVERYWHERE IN BETWEEN

Pelagic Research Services (PRS) has developed a deep-water ROV system called Odysseus—a custom built, medium work exploration/science class 6000-meter ROV System. Odysseus became commercially available for operation in March of 2017 and has since completed close to 100 dives with over 350 hours of sub-sea operations from 90 meters to over 2500 meters. The ROV has been mobilized on 5 different ships in three different countries operating in the waters of the Pacific Northwest, the West Coast of the United States, and the Gulf of Mexico. Example of operations included precise science sampling, archeological and environmental surveys and heavy construction work for the United States and Canadian Ocean Observing Systems.



Dr. Richard Peterson, principle investigator for Carolina Coastal University oversees science ROV operations from Odysseus control van during Gulf of Mexico Research Initiative funded research cruise. ©Pelagic Research Services & Carolina Coastal University/GoMRI

The Odysseus system was designed from the ground up to focus on capability, flexibility, mobility and affordability. The system features proprietary design elements in sensor integration, hydraulic control, multi-faceted thru-frame lift capability and mission interface/ROV control systems. It also features integration of industry leading components like buoyancy from Engineered Syntactic Systems, manipulators from Schilling, SONARS and altimeters from Tritech, depth sensors from Paroscientific, heading, motion/heading sensors from iXblue, video/data video logging from Digital Edge Subsea, and cameras and lights form Deepsea Power and Light and SubC Imaging.

In support of the required navigational precision for projects PRS often provides the navigational and tracking support with expert survey team members and systems like Sonardyne's Lodestar Gyro USBL coupled with a surface DGPS system. This precise positional information for subsea data collection (samples, video, transects) assures industry-leading accuracy and repeatability.

HEAVY LIFT AND PRECISE DELICATE DATA AND SAMPLING CAPABILITY: ALL DEPTHS IN A SMALL FOOTPRINT

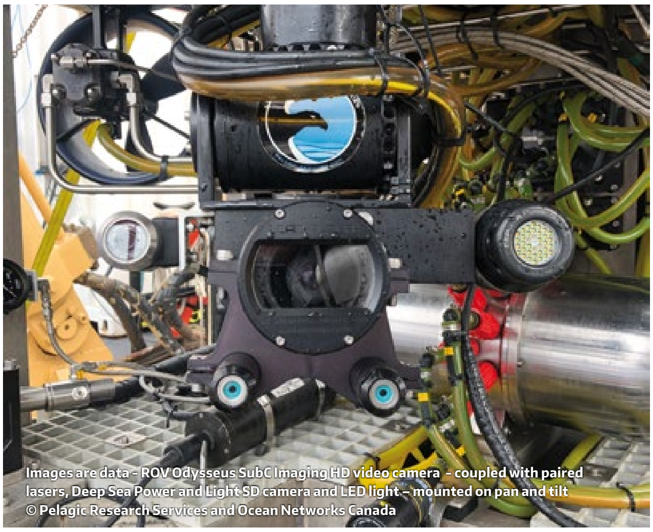
Autonomous systems dominate the headlines, but in many cases, clients still require real-time access to their work areas. Whether collecting tiny deep-sea coral samples for habitat assessment work on the Florida escarpment for NOAA at 400 meters (oceanexplorer.noaa.gov/exporations/17sedci/welcome.html) or replacing and installing a 1500-pound research platform at the Endeavor Hydrothermal Vent Field at 2200 meters for Ocean Networks Canada (www.oceannetworks.ca/observatories/expeditions/wiring-abyss) utilizing Odysseus for data collection, sample acquisition and subsea construction provides the client direct access. Odysseus is designed to easily integrate the standard tools and sensors of subsea research with custom built, one-off experiments and data collection devices.

The inner core of Odysseus and its aluminum frame supply a thru-frame lift of 5000 lbs. in-air weight with our lifting bridge. Designed in collaboration with Ocean Networks Canada (ONC) the Odysseus lifting bridge features standard docking receptacles that can be designed into custom tool baskets, experimental packages, bulk sampling systems, and more. This standard receptacle system has been adopted by ONC's Neptune and Venus Ocean Observing arrays and Ocean Observatories Initiative (OOI).

Flexibility in how Odysseus deploys and recovers sub-sea packages comes in the form of two hydraulic load releases, each with a capacity of 2000 lbs. in-air weight. A recent example shows the PRS use of these two lift systems together. During a dive to 2200 meters for ONC Odysseus carried and deployed one of their standard platforms docked to the Odysseus lifting bridge. The main object of the dive was to recover the old platform after its cables were disconnected and reconnected to the new platform. During pre-dive planning ONC noted the angle of the old platform could prevent recovery via docking to the Odysseus lift bridge. As a back-up recovery plan PRS rigged a lifting bridle to the load releases. Once on the seafloor and with the new platform positioned and released from the ROV, the recovery of the old platform was attempted. As noted, the angle of this platform prevented utilization of the lifting bridge system. Without any loss of time, the pre-rigged lifting bridle was attached to the lift point via ROV hook and recovered to the surface. The load was transferred to the ships crane, released from the ROV and then recovered to deck. This heavy-lift flexibility without having to return to the surface and re-rig the ROV is a time-saving (and thus money-saving) capability.

DEEP SEA MINING MINIMIZING IMPACT WHILE MAXIMIZING ACTIVITIES

Deep-sea mining is an emerging industry where working depths can be in excess of 4000 meters. Many interest groups and industry players are keen to gather baseline data and have the ability to accomplish short- and long-term environmental monitoring of ecosystems as efforts begin to extract mineral resources. The legal and regulatory framework under development by the International Seabed Authority (ISA) (www.isa.org.jm) requires significant detail for both pre and post mining activity programs. As an example, before any bulk sampling or mining survey activity occurs an entity is required to: 1) Establish an



Images are data - ROV Odysseus SubC Imaging HD video camera - coupled with paired lasers, Deep Sea Power and Light SD camera and LED light - mounted on pan and tilt © Pelagic Research Services and Ocean Networks Canada

Sampling at the source. Pristine oil sample from natural oil seep US Gulf of Mexico captured by Odysseus for Dr. Richard Peterson. ©Pelagic Research Services & Carolina Coastal University/GoMRI

ROV Odysseus prepares to dive aboard Canadian Coast Guard Ship TULLY. ONC experiment platform in foreground © Pelagic Research Services and Ocean Networks Canada

ROV Odysseus rigged for complex science and maintenance tasks on the Neptune Observatory © Pelagic Research Services and Ocean Networks Canada

environmental baseline to support long-term monitoring and to quantify short- and long-term effects; 2) Precisely document quantifiable seafloor impacts and have the ability to reacquire survey sites for multi-year comparisons; and, 3) Capture video of the pre and post measuring impacts of mining test activities.

With the regulatory requirement of the ISA in mind, PRS has developed Odysseus to support environmental baseline and post mining activity and monitoring as well as a bulk sampling programs for the extraction of magnesium nodules. For bulk sampling PRS proposes to implement a continuous nodule recovery program using our proprietary dredge system. This system will harvest nodules rapidly from the sea floor and transfer them immediately to a basket or hopper placed on the sea floor, with recovery from the ship via a second lift wire. The ROV will be used to detach the hopper so the second wire can be recovered to the ship. Another empty hopper will then be deployed while the ROV is filling the additional hopper at the work site. This process is continuous – an empty hopper is lowered to the seafloor and a full hopper is sent to the surface. The ROV will remain at depth and only be recovered when needed. The nodule recovery operation gains efficiency by keeping the ROV on the sea floor and actively engaged in nodule recovery.

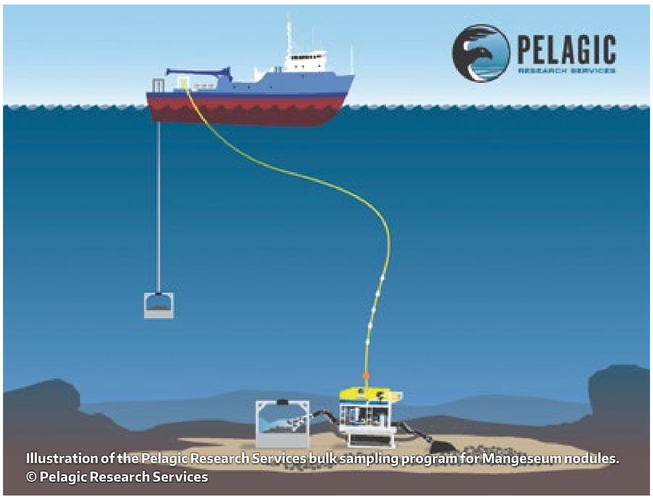


Illustration of the Pelagic Research Services bulk sampling program for Mangeseum nodules. © Pelagic Research Services

ONE MISSION ONE TEAM

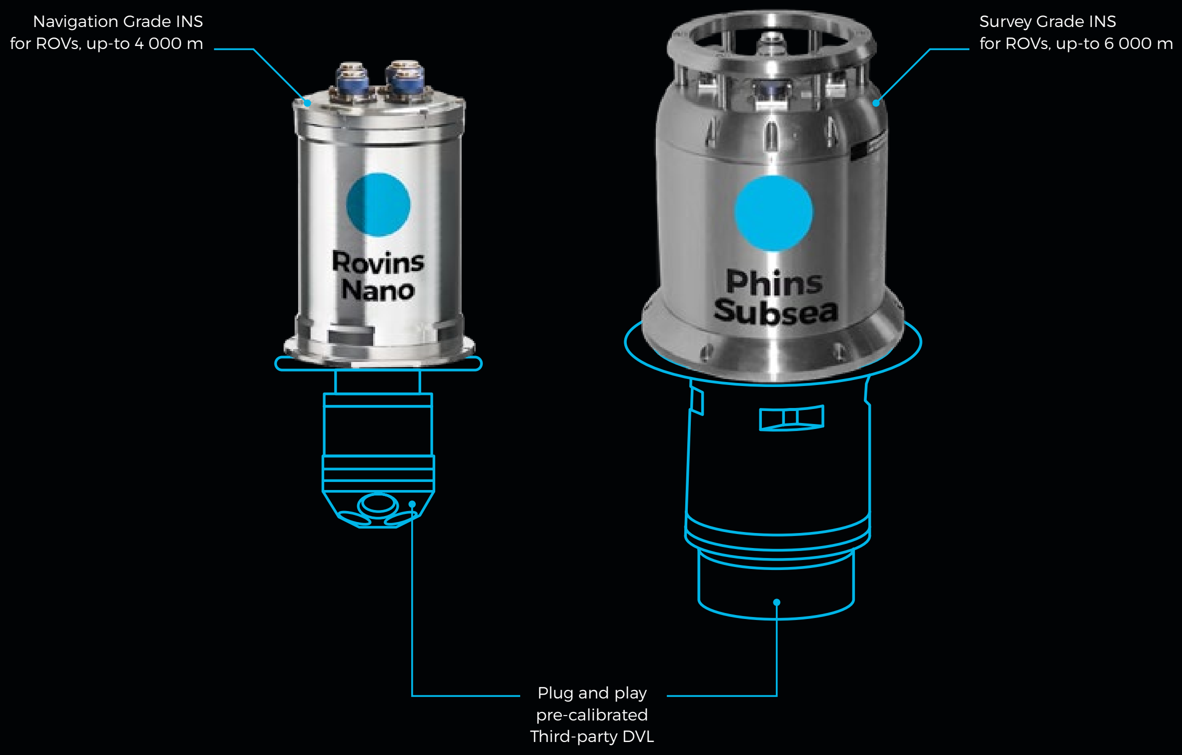
For all projects PRS collaborates with the client team and the ship team from the start of the mission timeframe ensuring that offshore time is efficient and cost-effective, while achieving mission goals safely and accurately. We fully understand that the best chance of success is when ship, ROV and client are on "one mission" and are "one team."

Every year we learn more and more about our inextricable link to the world's oceans—and ultimately our planet's health and our own well-being. PRS is honored to be part of the new "blue wave" of companies providing the technology and service to support all of those who seek to explore, study and understand our oceans.

ABOUT THE AUTHOR

Ed is CEO and co-founder of Pelagic Research Services (PRS) (**www.pelagic-services.com**), an international, ocean services company that brings project planning, execution, survey and state of the art sub-sea research, instrument, tool design and fabrication to the offshore industry and the global ocean research community. With 30+ years of experience in ocean conservation, marine management and complex offshore operations Ed has participated in and directed ocean research expeditions throughout the world's oceans. For more information on Pelagic Research Services and to contact Ed please send an email to **info@pelagic-services.com**.

Make no compromise between performance and ease-of-use.



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