UV2

UNDERWATER VEHICLES

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Front Cover: ***REV Ocean's Kystdesign Aurora and Borealis ROV and TMS during a scientific cruise***

EELUME FIRST COMMERCIAL CONTRACT

Survey and inspection company Argeo has selected Eelume's autonomous 'snake robot' to assist in its operations. The contract marks the first commercial contract for this technology.

Eelume's robotic solutions have been developed with the assistance of Kongsberg Maritime, who remain a majority shareholder in the venture.

Argeo's stated aim is to transform the ocean space inspection industry through robotics, sensors and data analytics technology. By enabling more efficient acquisition of data with higher accuracy, the company plans to construct advanced and highly accurate digital models based on geophysical, hydrographic, and geological data.

This, in turn, enables organisations in the Infrastructure, Offshore Wind, Oil & Gas and Marine Minerals industries to significantly reduce their operational carbon footprint, since large surface vessels are no longer needed.

Currently, 90% of these costs are vessel-related. Implementing Eelume as a resident inspection tool for Offshore Wind and Oil & Gas will replace up to 70% of vessel activities.

In operation, one Eelume robot can typically provide a serviceable footprint of 50-75km^2. Argeo proposes matching the technology with its Unmanned Surface Vessels (USV), making the Eelume an effective mobile survey solution complete with deployment and recovery system.

Eelume

FlipiX

iXblue has launched its first Remotely Operated Towed Vehicle (ROTV): FlipiX.

Designed to be operated autonomously from iXblue DriX Uncrewed Surface Vehicle (USV) or from a light vessel, FlipiX enhances autonomous survey capabilities and allows companies to conduct multi-sensor operations in a single run, ultimately offering unmatched operational efficiency.

Leveraging advanced motion control and a reduced operational footprint, FlipiX is a unique conveyance platform for Side Scan Sonars (SSS) and magnetometers.

Operating at towing speeds up to 7kts, the FlipiX ROTV altitude, pitch and roll are autonomously controlled to maintain measuring instruments at a fixed altitude and constant attitude. This active motion control bestows the ROTV with increased stability and manoeuvrability, even during U-turns, resulting in enhanced measurement quality in the most challenging maritime environments and in reduced survey time.

When combined with the DriX USV, FlipiX can operate down to 50m water depths in its standard version and provides optimal positioning of measurement instruments for a data acquisition as close to the seabed as needed.

SAAB SEAEYE E-WROV

Saab Seaeye's new eWROV all-electric, work-class underwater vehicle

Saab Seaeye has agreed a deal to sell 10 of its new electric work remotely operated vehicles (eWROV), including further options, to leading marine robotics company, Ocean Infinity.

“Ocean Infinity’s order is the largest in Saab Seaeye’s history and highlights the need for intelligent, adaptable and flexible underwater robotics," said Magnus Lewis-Olsson, Chairman of Saab UK. The company is reticent to disclose financial details of the contract.

Saab Seaeye says that the new eWROV product is the most capable and intelligent all-electric, work-class underwater robot that it has ever developed. It will be built in the company's new facility in Fareham within the Solent Freeport.

"The eWROV’s electrification is the key to its improved performance and sustainability-related attributes," said Lewis-Olsson "As well as being more efficient, electric systems use little or no oil, making the eWROV significantly more environmentally friendly than equivalent hydraulic work-class systems."

Most important, eWROV benefits from Saab Seaeye’s iCON intelligent system architecture, making it capable of fully autonomous operation.

The eWROV will be used across a variety of offshore energy sectors, ocean science and defence. It is the culmination of four years of research and development, resulting in a larger and more powerful ROV compared to those designed for light work and observation tasks.

"Saab Seaeye is among the first companies to produce a full-size electric work-class vehicle that can deliver the same overall performance as a 250 horsepower hydraulic vehicle, while offering a lower lifetime cost and reduced environmental impact," said Lewis-Olsson.

"Ocean Infinity is developing the world’s largest fleet of uncrewed robotic vessels and will be the eWROV’s launch customer. The eWROV will play its part in Ocean Infinity’s mission to use innovative technology to transform operations at sea, enabling people and the planet to thrive.

"Armada is set to revolutionise the maritime industry, delivering sustainable services that offer up to 90% emissions savings over a conventional vessel performing a similar offshore task.

“Lessening the environmental impact of operations at sea is the main driver behind the development of Armada.

"The all-electric eWROV, in addition to our already low-emission vessels, will enable us to support our customers with infrastructure integrity projects in the most environmentally responsible way."

Due to this and further future contracts Saab Seaeye is also to expand by 70% to an additional 3236m^2 (34 832 ft^2) site in Fareham, UK, by March 2022

The ROV with the Saab manipulator arm

SeaRAY during ocean testing in Puget Sound, WA in 2012

AOPS AUV CHARGER TO HAWAII

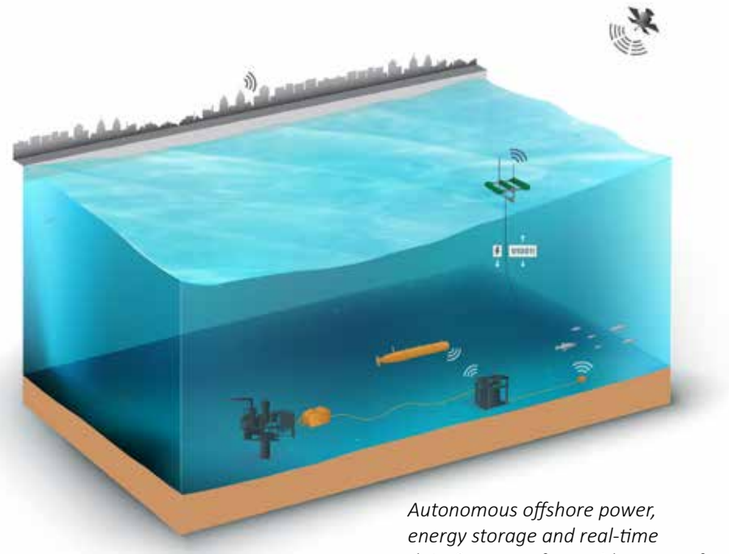
The components of the SeaRAY autonomous offshore power system (AOPS) will soon head to Hawaii for the start of an application demonstration, in partnership with the US Department of Energy, Navy and a host of commercial partners.

"No resident marine energy system providing power, data and wireless communication capabilities has ever supported the range of payloads the SeaRAY will in Hawaii," said a source.

SeaRAY is an autonomous offshore power system for resident vehicles, sensor packages, and operating equipment (50W to 20 kWs). It provides *in situ* power, energy storage and real-time data and communications support. This will advance the marine economy toward a future of autonomous, connected and resident technologies. It is designed to support unmanned offshore activities and equipment, including subsea vehicles, sensor packages, and operating equipment.

When deployed, the SeaRAY will significantly lower costs and carbon emissions, reduce operational complexity, increase safety, and enable capabilities not available today.

The AOPS' power capacity is easily scalable from <1 kW to 20 kW. It is transportable anywhere in the world in standard ocean containers and deployable with smaller, lightly-crewed vessels. The system supports a wide range of potential applications that will spur innovation in critical industries such as defence and security, offshore energy, aquaculture, and science and research.



Autonomous offshore power, energy storage and real-time data & comms for a wide range of payloads. Image: C-Power

EMPOWERING
world leader in electric underwater robotics

SAAB SEAEYE

SAAB

Fromthe platform, a SAAB Sabertooth autonomous underwater vehicle (AUV) will operate in untethered mode, without a topside vessel, for three weeks. The Sabertooth docking cassette connects to the AOPS' seafloor energy storage and gravity anchor base unit via an umbilical.

Missions will be downloaded from the cloud through the AOPS to the AUV, which will perform its mission, return to the dock, download its data for upload to the cloud, recharge and then repeat the cycle until the demonstration is complete.

- A Fugro seafloor data-gathering system will operate for four months, transmitting data real-time to the cloud.
- A Franatech methane emissions sensor that is integrated into the Fugro system.
- A BioSonics long-range subsea environmental monitoring system will be deployed for the entire six months, sending data real time to the cloud. The BioSonics echosounder will also serve as an intrusion detection system during the trial. Multiple assets will be supported with energy and data simultaneously.

DEMONSTRATION

The Hawaii demonstration will be the first time an AUV has been supported by a renewable energy system without a topside vessel and the first time that both mobile and static assets have been supported simultaneously by a renewable energy system.

The SeaRAY AOPS is a moored configuration consisting of a surface ocean energy and data system; a single, combined mooring, data, communications and power cable from EOM Offshore; and a seafloor base unit that provides energy storage and communications management for seafloor asset operation.

Below: The Sabertooth. All images: C-Power

IVER 3 IN PFW SURVEY

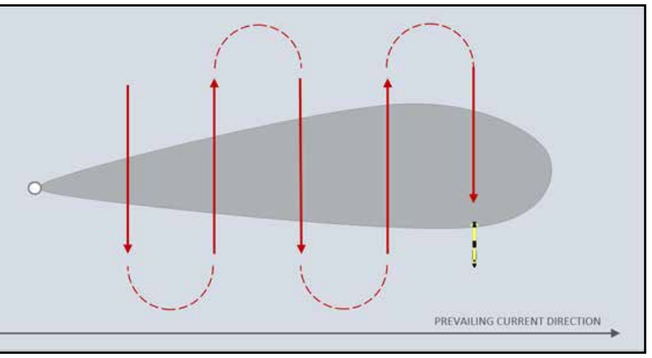
Blue Ocean Marine Services was recently contracted to conduct Produced Formation Water (PFW) discharge surveys in Western Australia using one of their L3HARRIS Iver-3 AUV. The AUV was used to support the field monitoring team by providing additional high-resolution 3D water quality information in the discharge and mixing zones.

The Iver-3 AUV, a low-logistics vehicle particularly suited to water quality surveys of this nature, was equipped with a Xylem YSI EXO1 Multiparameter Sonde, which is fitted with EXO conductivity & temperature (CT), turbidity, fluorescent dissolved organic matter (FDOM) and dissolved oxygen (DO) smart sensors.

The AUV survey missions were planned to record data along equidistant transects perpendicular to the direction of the prevailing current and expected plume path. Surveys were completed over three days at two offshore facilities, and no detectable plume was recorded in the data, confirming the PFW discharges were released within accepted regulatory limits.

The AUV survey was safely and successfully conducted, and whilst based on measured parameters the PFW could not be detected, the AUV demonstrated:

- Low logistical effort in mobilisation and demobilisation
- Safe deployment and recovery from vessel
- Flexibility of the system to allow simultaneous operations to occur
- Adaptability and speed of mission planning
- Speed of data availability



Example of PFW Plume Survey Track

REAV-28

Specialist survey contractor GEOSIGHT has placed an order for an Uncrewed Surface Vehicle (USV) from HydroSurv. The delivery is scheduled for early next year.

New for 2021, the REAV-28 is a 2.8m USV platform of catamaran hull form with a fully-electric propulsion system, which may be deployed and recovered from foreshores and beaches for a range of hydrographic and environmental survey applications.

Based on HydroSurv's smaller REAV-16, the larger vehicle has improved open-water sea-keeping and a more powerful propulsion system with greater endurance. In addition, the USV has a fully-integrated SVP winch and a series of enhanced and new control features.

The latest investment will enable GEOSIGHT to reduce the carbon emissions of its survey operations and offer a non-invasive survey acquisition tool which may be used in the presence of environmentally sensitive receivers. Additionally, the USV will reduce the need for surveyors to work afloat and reduce costs of mobilisation and operations.

HydroSurv vehicle

LEAK DETECTION

A breakthrough in leak risk detection at oil pipe flanges comes from research by the University of Houston using a Saab Seaeye Falcon robot as a development platform.

Called SmartTouch, the solution involves integrating innovative robotic manipulator controls into the Falcon that provide multiple stress wave sensors for touch-based inspection of bolted joints, along with the latest structural health monitoring and inspection technologies. Video cameras and scanning sonars are also integrated into the system.

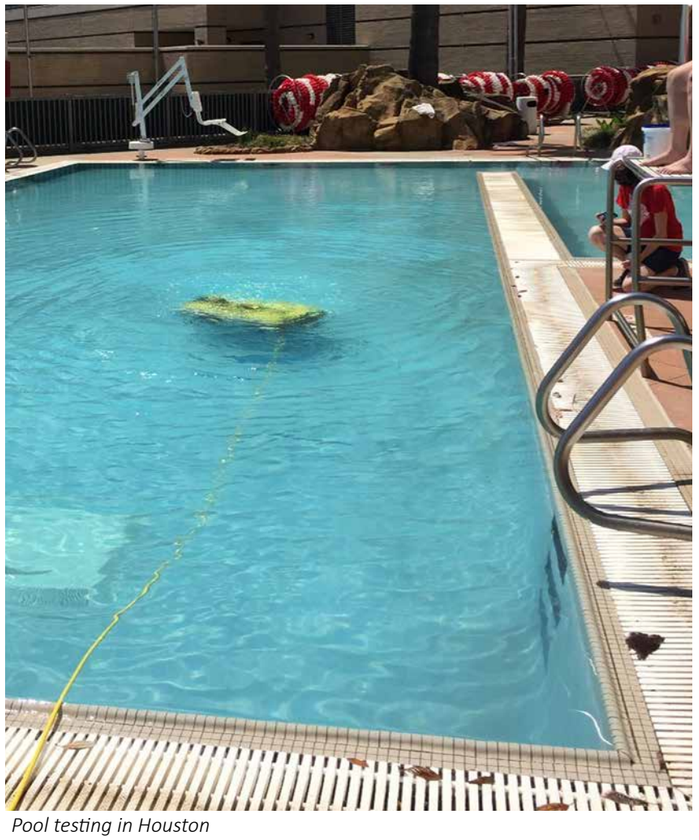
Finding a time-efficient and cost-effective robotic solution to identifying flanges at risk was the University's key objective as bolted flanges can loosen when ocean dynamics shift pipelines. The difficulty of locating flanges at risk makes their timely inspection key to the prevention of oil spills.

The research team led by Dr. Zheng Chen, assistant professor in Mechanical Engineering and director of bio-inspired robotics, together with Dr. Gangbing Song, professor in Mechanical Engineering, includes six PhD students.

"The testing results have demonstrated the reliability and performance of the Falcon in meeting the needs of the SmartTouch underwater pipeline inspection system," says Dr Chen.

TOTALLY AUTOMATED INSPECTION

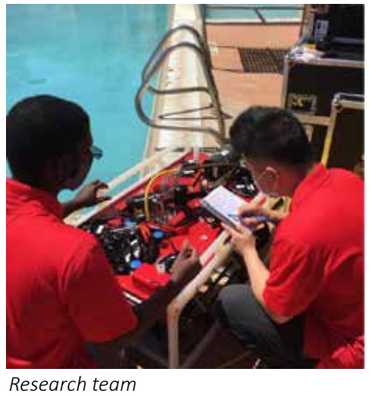
For the University, the ease of systems integration comes from the Falcon's iCON™ intelligent distributed control architecture. The module-focused



Pool testing in Houston

iCON endows each device with its own microprocessor for individual control and offers a future-flexible concept that can readily adopt evolving technologies.

"The SmartTouch robotic system," says Dr Chen, "can totally automate and dramatically reduce the cost and risk of subsea inspection, leading to safer operations of offshore oil and gas pipelines."



Research team

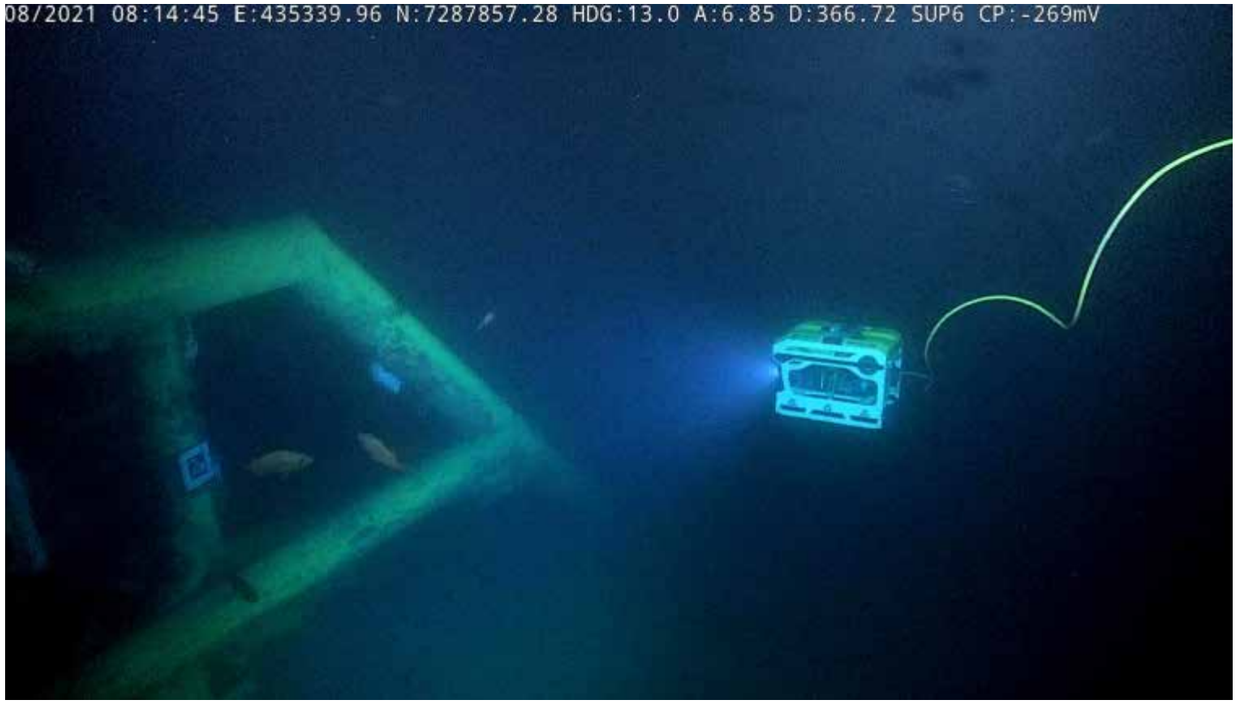
THICKNESS GAUGE

A recent Outland customer required a Cygnus ultrasonic thickness gauge for tank inspection work. The company was able to engineer, source components, fabricate, integrate the electronics, test and deliver within days.

"The modular design of Outland Technology ROVs allows for quick adaptation to client requests," said sales representative, Sean Mayfield.

The ROV-500 is designed for use in 1000 ft (300 meter). It uses brushless DC flooded thrusters and an Outland-designed control system to maximize the power, giving a high thrust to weight ratio. (11 lbs. thrust each).

AUTONOMOUS INSPECTION DRONE (AID)



Forssea Robotics and DeepOcean have been working closely to develop the Autonomous Inspection Drone (AID).

In August, the companies successfully tested the AID on subsea templates at AkerBP's Skarv field, 210 Km west of the Norwegian coast in water depths of approximately 400m.

The AID comprises what it claims is the most advanced subsea positioning and navigation systems available in the market. However, it is the embedded software developed by Forssea Robotics that brings the most disruptive smart features that transform this standard ROV into a fully autonomous subsea drone, with its dynamic positioning, auto-docking, path-following and object-tracking modes.

The first part, an inspection path, was pre-programmed using DeepOcean's 3D Mission Planner.

During this trial, the users could successfully manage the inspection missions remotely with the AID being fully controlled from DeepOcean's Remote Operations Center (ROC) in Killingøy (Haugesund), which lies more than 1200 Km far from the Skarv field!

The capability of accurately repeating an inspection path over a subsea structure with the AID brings many benefits.

The structural conditions can be better compared periodically regarding asset integrity management.

The tasks can be performed more efficiently with simultaneous work during subsea operations (thus reducing the number of days required for executing offshore operations and also reducing costs of interventions).

The operational risks for offshore personnel can be minimised due to remote control from onshore centres; etc.

TERRADEPTH

Terradepth is shortly to begin full sea trials of its new ocean data collection concept. The aim is to create a comprehensive and highly accurate virtual ocean model to allow humans to make better, faster decisions with respect to the underwater sector at large. This could help predict atmospheric weather patterns, build underwater energy and telecom infrastructures, and protect and ensure our coastal communities' future.

“We have decided that the best way we could make the most impact is to concentrate on two main components,” said Joe Wolfel, Co-CEO at Terradepth.

“The first is to scale ocean data collection and the second, to radically improve the user experience with that scaled ocean data in a similar way that the user interacts with Google Earth or Google Maps.

"In terms of accumulating ocean data collection, we considered that currently, perhaps the major limiting factor, especially when accumulating deep ocean high-resolution data, was the requirement for human support of the underwater robotic asset.

“The obvious answer was to replicate the functionality that humans provide to the underwater asset. At present, this typically is based on using a crewed ship, which provides two vital services—a precise geolocation reference to the asset and a recharge capability which typically equates to swapping out batteries after or within the operation.

"The vessel also provides a data transfer system. It can access the data from the underwater vehicle, process it and transmit it. We quickly recognised that we needed to do these three things fully autonomously.

“We consulted a number of AUV vendors and eventually settled on a baseline robotics platform provided by Cellula. The solution we selected was a SOLUS vehicle.

One aspect of the SOLUS design is its ability to stay at sea for a considerable length of time due

Terradepth's AUV

in part to its innovative fuel cell technology. We decided, however, at least for the time being, this was not a feature that we required to address our objectives. We opted, therefore, for a new version called the Solus Lite, in which the fuel cell is replaced by a more conventional source due to our intent to address customer needs more rapidly."

The Terradepth vehicle system is referred to as an AxV. In operation, the company plans to employ two (or more) identical vehicles, one operating semi-submerged and the other operating at depth.

During at-sea operations, the topside AxV provides sea surface data collection, communications and navigation assistance while the submerged AxV conducts its submerged mission. The two AxVs can then switch roles once the submerged vehicle’s energy is expended to a predetermined level.

Once surfaced, the vehicle employs a hybrid system of rechargeable lithium batteries and an air-dependent power plant capable of operating high-power, high-logistics instrument payloads.

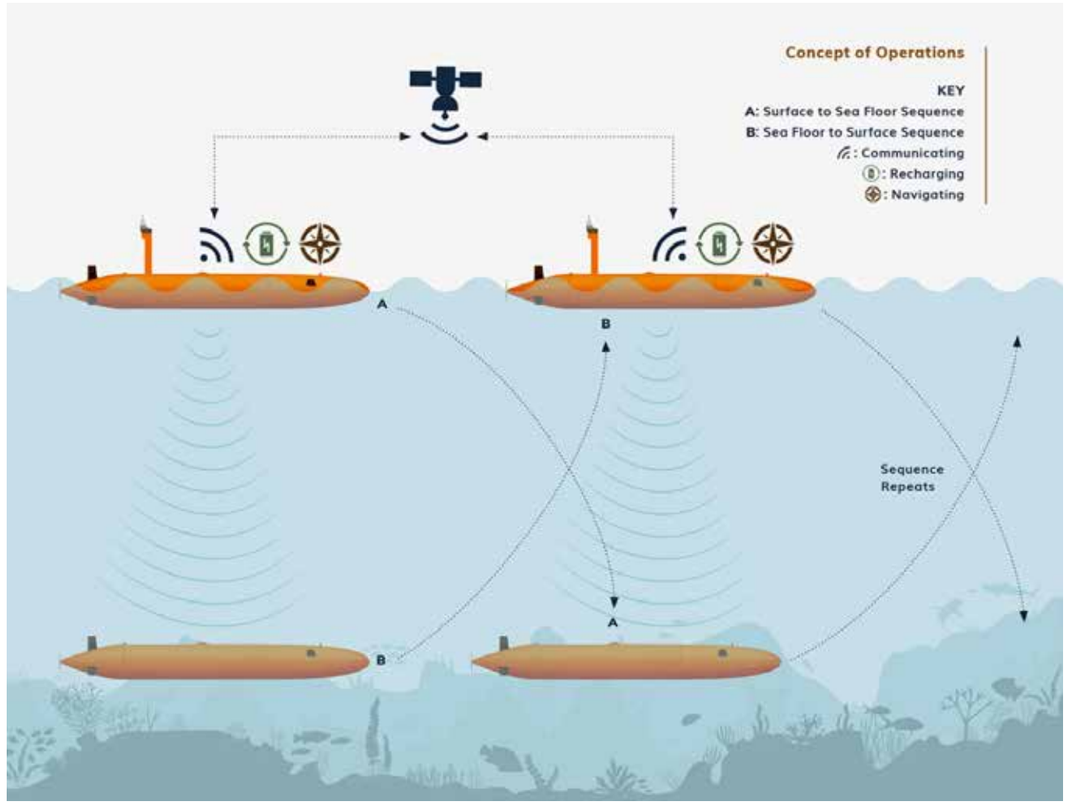
“We have not been funded by any non-profit or conservation fund to date despite having a strong conservation and ocean science aspect to what it is that we do.

"However, we anticipate providing as much information as possible to conservation and marine science entities for their own analysis and dissemination,” said Wolfel.

“Seagate Technologies, which makes about half the world's data storage, has made an investment in our company that has allowed us to understand the implications and potential of cutting-edge data storage solutions. Seagate is very interested in data mobility from edge environments and particularly long-term storage.

“Being so bandwidth constrained, the ocean is a fantastic use case for a lot of Seagate's core technology; they also have a significant corporate social responsibility and ESG aspect to what they do and what they believe in from a corporate culture standpoint.

"Understanding anthropogenic change in the ocean and stopping detrimental changes is of considerable interest to everyone - and I think Seagate’s senior leadership understands the power of data in making benevolent decisions better than most.”



The dual ROV operation

“At present, we have taken delivery of the AUV and are at the testing stage. There are two aspects to the testing that we need to complete. We integrated our own onboard data processing system into the frame in March/April of this year into the baseline vehicle.

"This will allow our onboard data processing module to carry out automatic target recognition and autonomous tasking. It means that we can conduct a mission and ingest data from the sensor the robot processes completely on board.

"Our onboard data processing module is transferable between vehicle types and is a custom integrated design predicated on NVIDIA and Intel processors.

“The onboard data processing enables automatic inferences about the data it receives and then retasks itself with no human intervention. Snippets of that data can be sent for human consumption based on the way the robot prioritises itself.

“The second piece that is critical to our concept of operation is autonomous energy recharge capability.

"We have been looking at a run time of 14 days for the prototype, but this could easily extend to 30 to 60 days depending upon fuel capacity. This is what we're integrating into the vehicle currently and anticipate commencing in water tests imminently.

"Battery technology continues to improve, which is fantastic- but the ability to autonomously recharge those batteries to run sensor payloads for significant duration is the key to scalable ocean data collection.

“We run the company from Austin, Texas, not particularly near the coast but a world center for digital communication technologies. From here, we will collect a repository of scalable, cost-efficient data that will inform and transform every industry with a connection to our oceans.”

ECOSUB

Surrey-based ecoSUB Robotics, a division of Planet Ocean Ltd is currently embarking on a £2 million Innovate UK project focused on employing its pocket AUV in swarms. The vehicles will be used in association a range of autonomous platforms under a centralised planning, monitoring and fleet management autonomy engine.

The original ecoSUB AUV concept dates back to 2015 when a group of robotics engineers from Planet Ocean & the National Oceanography Centre MARS Group began to consider the autonomous vehicle market and discuss what they would do differently.

At the time, AUVs were largely the preserve of institutes and companies with both large budgets and access to infrastructure. Instead of large vehicles, however, ecoSUB's vision was to develop micro-sized units that could be used individually to either execute smaller individual projects or alternatively, could be deployed in large numbers, closely interacting with each other.

"We didn't set out to maintain the status quo," said Iain Vincent (business development manager), "We wanted to democratise the AUV and enable its use by the wider marine science community. We saw larger vehicles on the market costing £2 million, not to mention the need for sophisticated infrastructure necessary to launch and recover these assets, and we wanted to increase the number of people that could practically enjoy the benefits of these vehicles.

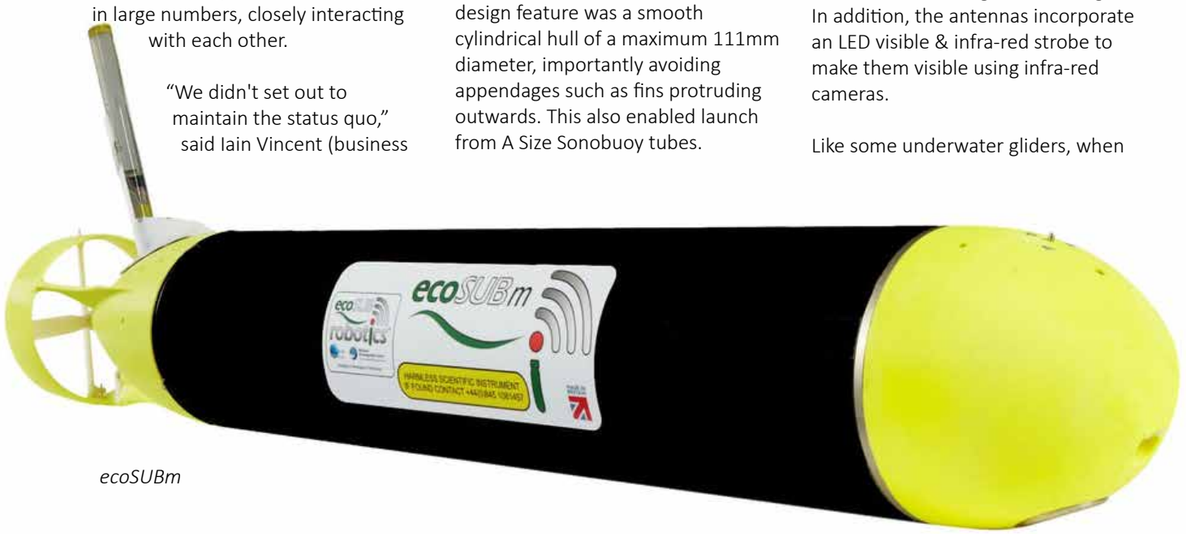
Fundamentally, it would demand a disruptive low cost vehicle design, small enough to be physically placed into the water by a single person. Its dimensions meant that it could be transported to site in cars or aircraft and could be piloted locally or remotely."

In an early iteration, the ecoSUB was to be launched through a tube and the company worked closely with ASV, (now L3 Harris) to install such launch tubes to its C-Worker autonomous surface vehicle. Tube launching meant that a vital vehicle design feature was a smooth cylindrical hull of a maximum 111mm diameter, importantly avoiding appendages such as fins protruding outwards. This also enabled launch from A Size Sonobuoy tubes.

"Designing an underwater vehicle without fins for steering or stabilisation is challenging," said Vincent. " We inserted a rudder in the Kort Nozzle just behind the propeller for lateral movement but satisfied the greater issue of pitch control by incorporating a 'moving-mass' arrangement to modify the vehicle's pitch. This manifests as a battery carriage that is able to drive itself forward along the inside of the hull. As this gradually passes across the centre of buoyancy, the nose becomes heavier and the vehicle slowly starts to dive. Conversely, moving the mass backwards causes the vehicle to rise to the surface."

In many AUVs, the comms antenna often stands within a tower arrangement, proud of main hull. In the ecoSUB-µ, however, the antenna is raked backwards along the axis of the vehicle to effectively form a tail. The antenna incorporates a GPS system as well as WiFi for short range communications transfer. It also has Iridium SBD for full global coverage. In addition, the antennas incorporate an LED visible & infra-red strobe to make them visible using infra-red cameras.

Like some underwater gliders, when the AUV reaches the surface, it can float on station with its antenna protruding upwards out of the water. ecoSUB can be fitted with acoustic nanomodems within each vehicle to enable the ecoSUBs to act as surface nodes in a Long Base Line (LBL) positioning system. This enables them to triangulate and localise themselves, position fixing with + 5 to 10 metres accuracy. Especially around the UK, the tides and currents are quite adept at moving vehicles and the position fixes ensure that the vehicles & user knows where the ecoSUBs are at all times.



ecoSUBm

"Being able to use a GPS signal and broadcast underwater using the modem allows the AUV to be used as a fairly undetectable gateway node, able to pass messages from satellite to underwater and even daisy chain vehicles for passing information," said Vincent

"Ironically, at the start, we thought that we didn't need this small AUV to be particularly intelligent in terms of its navigation as we mainly envisaged it being used for operations such as following a transect and collecting data such as, say, detecting a thermocline by measuring sound velocity. In this instance, it wouldn't be vital that the transect line wasn't exactly straight as we accepted that currents would move the small vehicle.

"Things started to change, however, when we began to engage more with users requiring geo referenced data such as side scan sonar and cameras. The later addition of a DVL, further enhanced the navigation accuracy and reduced the reliance on the LBL system.

"The original was called the micro, ecoSUB-µ5. This weighs about 4kg, is rated to 500m and is designed for relatively simple science missions, typically with single sensors suites. It is capable of measuring parameters such as conductivity, temperature, dissolved oxygen or pH. The units may incorporate devices such as a fluorometer altimeter or even a hydrophone.

"It soon became clear that there was demand for a more feature-rich single-person portable vessel with a greater payload capacity and more sensors, possibly for use in deeper waters. The result was the design of the milli- or m series, being the next size up from the original micro. It would have roughly the same length of around 1m, but a larger diameter of 146mm increasing the weight to around 12kg- still quite portable."

There are two different types of ecoSUB-m- a 500m rated version and also a 2500m model, virtually identical except for the internal ribs within the pressure hull. The extra size of the micro series gives a greater payload capacity which not

only allows multiple sensors, but they can also incorporate heavier duty, more power-hungry devices such as a sidescan sonar and DVL.

"The micro AUV has a typical endurance of 8–10hrs," said Vincent "but we are seeing a continual improvement in this as the internal technology and battery management improves." The Larger milli has endurances of around 30 hours, o 5-8 hours with side scan and DVL, providing full working days use.

"The power comes from a hot swappable battery systems which can be replaced in minutes.

We normally use primary alkaline cells which cost around £20 a set which are ideal with small loads but as soon as a larger consumers such as a sidescan or DVL are connected, instead of getting 8hrs out of the vehicle during trials, we started getting nearer 9 mins because it drained the voltage down in the battery cells.

"The alternative is nickel metal hydride rechargeable cells. These cost nearer £100 for a set but it is possible to get around 1000 recharges from them. These hold the voltage much better given the way we take the energy.

"We did look at Lithium batteries and found that the energy density was great, giving achieve ranges up to 100km and endurances of up to 30 hours, but the amount of current profile didn't always sit set very well when we got payloads onboard. Additionally, they were not so transportable."

ecoSUB-μ,

SENSORS

Over the years, sensors have become a lot smaller and easier to incorporate in limited spaces. Multiple sensor heads are often ideally located in the nose section, and these can be 3D printed to accommodate complex shapes.

"We use a front seat /back seat architecture," said Vincent "The front seat contains all of the system management and embedded controls while the back seat allows anybody else to incorporate their own algorithms control systems or third party payloads.

Altimeters can tell you how high off the bottom whilst a precision pressure sensor informs about depth. When exploring unknown areas, it is possible to define a particular depth or altitude in the mission planner and the vehicle will maintain this.

This can provides some level of collision avoidance with the bottom but not with obstacles in front and at present, sonar systems that provide this are either too big for the vehicle or take too much power from the available budget.

"We are potentially looking at locating altimeters in the nose and that would give us some level of forward looking ability but if we are going to bump into something, the ecoSUB is such a low mass system, that it is not likely to result in damage."

"We can already integrate cameras – we have a simple GoPro in a 300m housing but we are looking at fully integrating a camera to the full 2500m and beyond. We are working with universities to use the cameras for navigation. The problem is the lighting because it consumes power quickly

During the course of the ecoSUB development it was recognised that it was not sufficient to produce the vehicle in isolation.

This led to the development of the HERMES C3 Command, Control and Communications system, which allows direct communication with the vehicles via WiFi, Iridium and acoustics in internet denied locations as well as very comprehensive mission planning, diagnostic, recovery and data processing software package.

SUNFISH INTERTIDAL TRENCHING VEHICLE

Surveying the Luchterduinen offshore wind farm in the Netherlands, Eneco decided that they had to re-bury a stretch of existing export cable. The company approached Jan De Nul to develop an underwater/surface vehicle to carry out the operation.

In order to carry out the operation, Jan De Nul modified its in-house designed and fabricated intertidal trencher Sunfish and successfully reburied the nearshore section of the cable to a minimum depth of 2.5 metres below the seabed.

The Eneco Luchterduinen Wind Farm is located in the Dutch sector of the North Sea, approximately 23 kilometres off the coast between Noordwijk and Zandvoort. 43 Vestas V112 offshore wind turbines produce a combined capacity of 129 MW. From the Offshore High Voltage Station (OHVS) one 150 kV export cable of 25 kilometres directs the current to the shore.

Over the last few years, morphological changes in the export cable burial has resulted in a decreasing burial depth within the nearshore section. To guarantee the cable will remain sufficiently buried and protected at all times, Eneco requested a reburial campaign.

Since the section of decreased burial depth was located in the nearshore zone,however, it was not accessible with typical offshore trenching vehicles nor could it be easily accessed from the beach. Jan De Nul offered Eneco the solution by mobilising its intertidal trencher Sunfish.

The Sunfish

The Sunfish successfully lowered the nearshore section of the cable working up to 1 km offshore and a water depth of 8.5m.

Specifically to carry out this project, the Sunfish was modified to perform suitable post-lay jet-trenching operations with the incorporation of a pair of water pumps delivering each 1250 m³/hr jet water and 3.5 m long jet swords.

The Sunfish was initially designed as a ploughing machine suitable for working in tidal areas. In this configuration, the Sunfish successfully buried export cables on the Race Bank project in the UK in 2016.

Jan De Nul engineers converted the machine later into an excavator with a chain cutter, a configuration which was used for the burial of the Rentel export cable in Belgium in 2017.

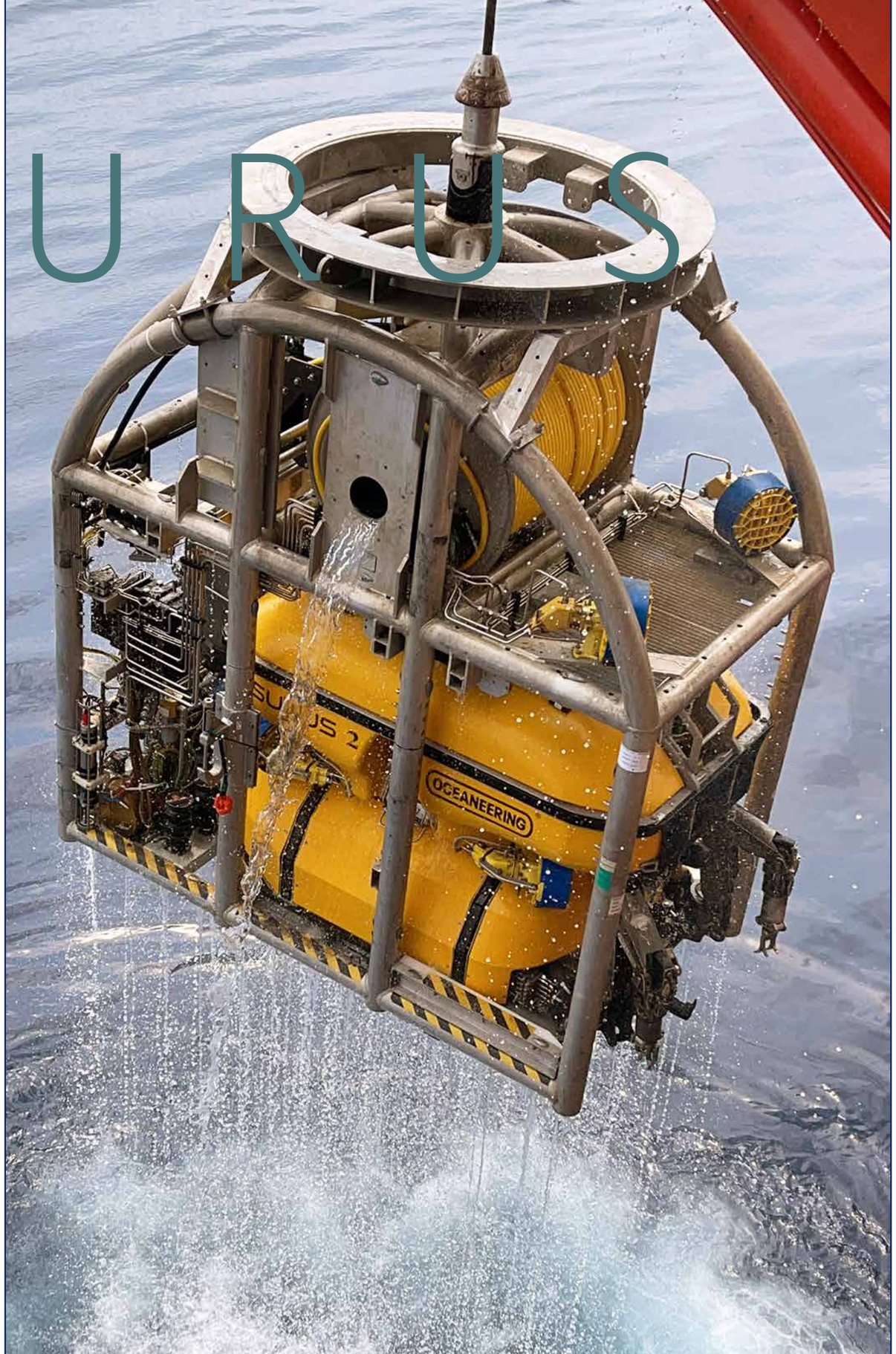
I S U R U S

For many years, the Magnum ROV stood out as the backbone of Oceaneering's fleet of high-powered workclass ROV systems. Later, the product range was supplemented by the heavier-duty Magnum Plus. Designed for work in water depths up to 10,000ft, it could deliver a total of 170hp to consumers.

Understandably, the Magnum Plus consequently became the vehicle of choice when Oceaneering looked at the renewables market. It soon became clear, however, that the shallow waters and high-power currents presented new challenges to the ROV that was ostensibly designed for much deeper water applications.

Oceaneering began by looking closely at key sites such as the East Coast of the USA which was affected by the Gulf Stream and other areas in the shallow North Sea and strong East Asian currents, and monitored the prevailing underwater conditions. Armed with this data, Oceaneering designed a specialist vehicle able to increase the operational window in these niche areas.

The Magnum Plus



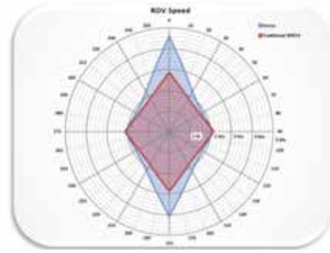
The result was the Isurus.

"Water currents typically impact against the side(s) of 'box-shaped' ROVs, pushing them out of position and conversely, requiring thrust to maintain position and orientation," said Nick Rouge, Product Manager, Subsea Robotics at Oceaneering. "This flow is not constant and requires continual movement from the ROV just to hold station. The key design challenge, therefore, was to reduce the resistance.

"This challenge was met by sculpting the body shell into a much more hydrodynamic shape. Instead of a big yellow rectangular syntactic foam block, the buoyancy of the Isurus assumes a much more streamlined morphology.

"Most workclass ROVs have the pumps, control, equipment and sometimes even the thrusters area under the buoyancy block. These obstruct the flow, and the resistance causes turbidity and destabilises the vehicle. In the Isurus, however, this area is enclosed in a skirt which encourages the water to flow around the vehicle, further increasing the hydrodynamic efficiency. The skirts can be easily removed for maintenance and repair, and the vehicle can be operated without them with a slightly reduced top speed.

"This enclosed shape is not uncommon in small eyeball ROVs designed mainly for inspection and monitoring," noted Rouge, "but is almost unique in workclass ROVs."



An ROV speed rose. The Isurus (blue) achieves a greater speed than traditional ROVs (red)

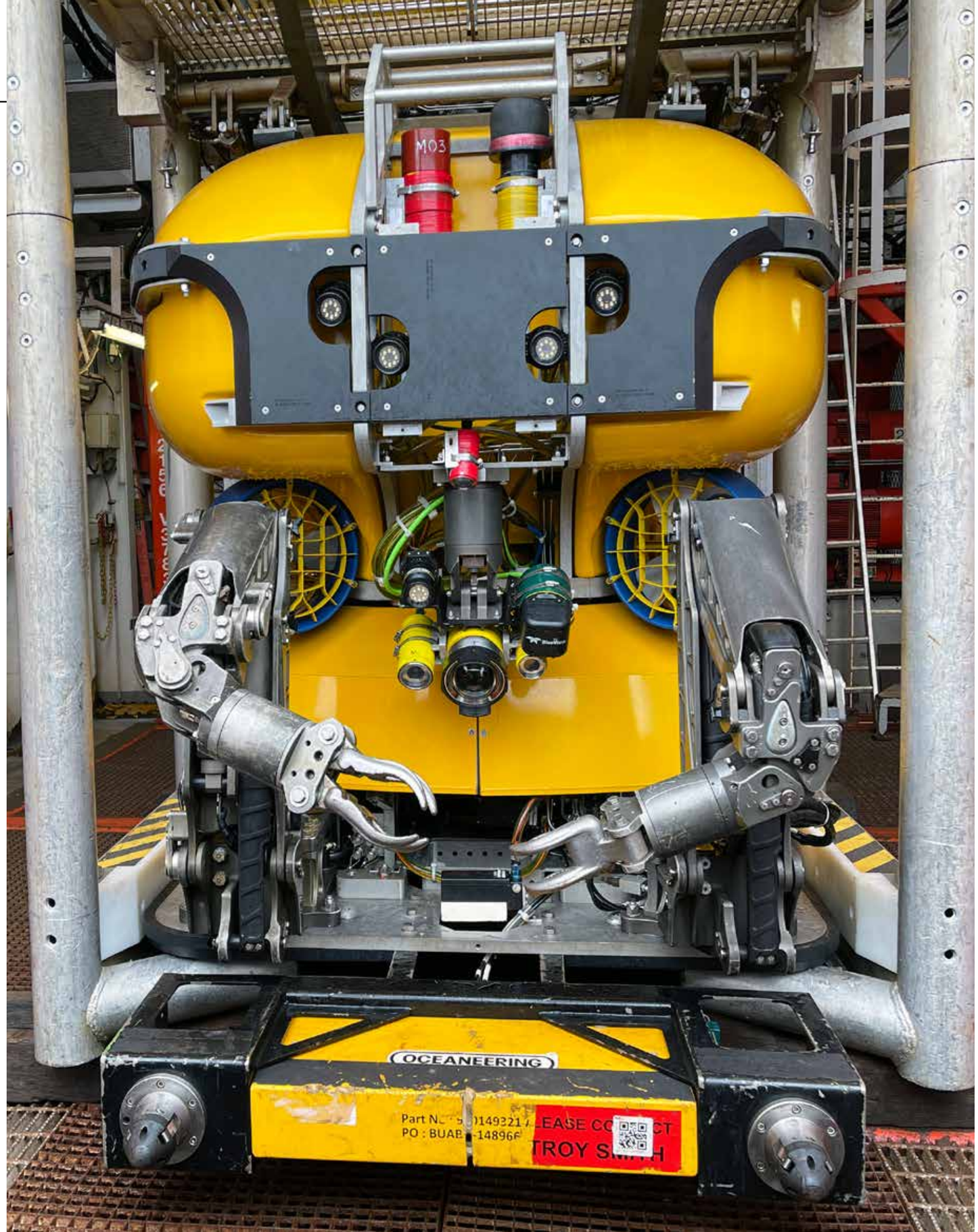
The results have been spectacular.

"When compared to traditional ROV systems that were limited to speeds of 1.5 to 2kts, we have been achieving speeds up to 5kts– more than any other work class vehicle in the fleet," he said. "The step-change in performance has transformed the ability to complete work scopes in high currents and harsh environments, efficiently and economically.
Selection of the existing field proven Magnum Plus design as the basis for Isurus has resulted in an highly reliable ROV service totalling 6,695 dive hours with 99.75% uptime without encountering a current exceeding its capabilities."

"While the Isurus is rated to 3000m water depth, the scopes of work requiring high current vehicles are typically found in water shallower than 500m, including cable touchdown monitoring (TDM), cable installation, cable pull-ins, and foundation installations."


ISURUS 2
OCEANEERING

ISURUS



VEHICLE DESIGN

The Isurus engineering was completed by a global-based Oceaneering team and was manufactured in Morgan City, Louisiana where it also underwent full and robust factory acceptance testing. In late 2019, Isurus completed speed and agility testing where its capabilities were confirmed.

The first vehicle was mobilised in October 2019 and has been delivering operational support since.

“We have had two vehicles working on average of 250 days for the past year," said Rouge.
“Isurus #2 and #3 have been operating continuously in Asia supporting foundation installation since they were mobilized in Q1 2021," said Rouge.
"Isurus #1 has performed cable lay and construction operations in Europe and Asia while Isurus #4 has been supporting site surveys in Europe since it was introduced in Q1 2021.”

"By the first quarter of 2022, we plan to follow up with two more vehicles, #5 and #6. We will also revise the Isurus design to accommodate a new configuration.”

At present, all the vehicles are configured for a fast forward speed, but the new configuration will have more balanced output, sacrificing forward speed to provide a greater lateral movement and control.

“The forward speed is very useful for mapping cables and route survey etc, but for foundation installation jobs, there is often a particular demand to hold station within a high current and observe operations from a particular angle. It might be, for example, that a USBL transponder requires mounting or removing, and this is only possible from a certain angle or orientation.

"Sometimes when a structure is in the water, the flow around it can be higher and the vortices can mean the local flow is more multidirectional and greater than the tidal or oceanic currents.

“Based on customer need and contracts won in 2022, Oceaneering expect to deliver Isurus #7 and #8. Future configurations of the Isurus ROV will include a Top Hat tether management system (TMS) and electric propulsion.

“Hydraulic thrusters have greater energy density," continued Rouge, "Yet, by not converting from electric to hydraulic in the first place, we create a greater efficiency across the entire system. The whole renewables venture is to reduce carbon footprint and by using an all-electric system, we can fully play our part in reducing the carbon budget of the specific project."

In addition to high currents, offshore renewable construction struggles with visibility due to high water turbidity. Oceaneering has worked with high resolution acoustic sonar vendors to develop solutions for Isurus and its other ROVs.

“Oceaneering’s unique solution for subsea switching between multiple acoustic and optical vision systems has provided expanded operational capabilities to the renewables market,” noted Rouge. “In the future, Oceaneering will be upgrading the fleet to enable faster installation of additional sensor systems and subsea switching between sensors as required by the operational conditions.”

Oceaneering says that the Isurus has provided an increased working window of up to six hours per day in areas with strong tidal currents. With vessel day rates and carbon footprint a high priority, this is clearly an advantage that the team is leveraging to deliver the desired results to their end clients.

XLX-C

Forum Energy Technologies has secured an order from DOF Subsea to supply two of its improved 200HP Perry XLX-C work-class remotely operated vehicles (ROVs).

The ROVs will add fresh capability to the DOF Subsea fleet and can pave the way for aged asset renewals with a new and improved class of ROV.

The systems will be manufactured at FET’s UK facility at Kirkbymoorside, North Yorkshire and will be delivered in the second half of 2021.

The compact 200HP XLX-C delivers high performance in a small form factor, which is increasingly requested in many projects globally. These vehicles are the first of their kind to be delivered to the market boasting this footprint and capability. FET has increased the power available on the ROV to suit the current specifications required by DOF Subsea and its prospective clients.

It boasts an impressive auxiliary hydraulic circuit that is capable of meeting the most demanding of contractual requirements, paired with a high payload capacity to carry additional tools.

DEEP OCEAN

DeepOcean has been awarded a frame agreement contract by an undisclosed US-based operator for delivery of engineering, project management and vessel support to execute a wide range of subsea activities throughout 2022. The contract covers provision of project management engineering capabilities for specialized subsea services, including the use of light construction vessels and ROVs from DeepOcean’s fleet in the US Gulf of Mexico to execute the offshore work.

DeepOcean ROV

FALCON ACROSS TURKEY

Turkey's marine operations company, ARAS Marine, has chosen for its expansive operations the deep-rated Saab Seaeye Falcon as a key underwater robotics resource.

The versatility of the Falcon will support the wide range of projects undertaken by ARAS in both International and Turkish territorial waters.

These projects range from marine construction and offshore supply services, to seismic research support, emergency response and salvage and wreck removal.

Equipped for the wide array of tasks ahead, ARAS's 1000m depth-rated Falcon comes complete with a fibre optic upgrade, manipulator, soft rope cutter, cameras, Tritech sonar and Applied Acoustics' USBL system.

ARAS can add further systems any time as the Falcon can handle an array of cameras, sensors, tooling and complex systems typically found on much larger robotic vehicles.

The ease of adding systems comes from the Falcon's iCON™ intelligent distributed control architecture. Module-focused iCON™ endows each device with its own microprocessor for individual control — a concept that also makes it future-flexible for evolving technologies.

As the world's top selling robot of its class, the Falcon's 20-year success comes from being a portable, metre-sized, intelligent, powerful, five-thruster, highly manoeuvrable, multi-tasking, easy to use vehicle, depth rated to 1000 metres.

With a reliability record covering over a million hours underwater, including deep tunnel work, the Falcon can remain stable in turbulent waters and strong currents whilst undertaking both robust and precision tasks.

ARAS see the Falcon as an ideally adaptable resource for their expanding future.

The contract was negotiated through Saab Seaeye's Turkish distributor, Aspiro.

FALCON FOR GEO OCEANS

Further expanding their robotic vehicle fleet, Geo Oceans has chosen the Saab Seaeye Falcon for its "reliable and hard wearing" reputation.

As a global underwater services company, Geo Oceans is committed to adding industry-leading robotic vehicles to their fleet for deployment over a wide range of tasks.

Such tasks include non-destructive testing, high-definition visual inspection, 3D modelling and photogrammetry, high pressure water blasting and numerous maintenance undertakings.

1000 DIVES

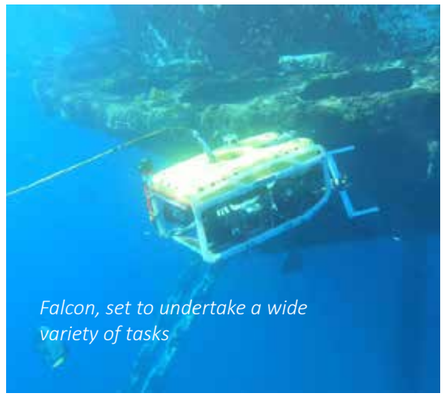
The Falcon completed 1000 dives during a challenging seismic survey project in Southeast Asia, with zero incidents and no loss of productivity.

As the world's top-selling robotic vehicle in its class, performing thousands of hours of undersea operations, the Falcon gives Geo Oceans the versatility, power and control intelligence to perform the vast array of tasks needed.

At the heart of the Falcon's success is Saab Seaeye's iCON future-flexible intelligent control architecture, a concept that pioneered distributed control technology.

Together with five powerful thrusters, the metre sized, 1000m rated Falcon, makes it a highly manoeuvrable, multi-tasking vehicle, that can be packed with cameras, sensors and tools, while holding steady in strong cross currents.

Supporting the sale was Saab Seaeye distributor, BlueZone.



Falcon, set to undertake a wide variety of tasks

GEMINI 2 YEARS ON

In mid-2020, TechnipFMC subsidiary Schilling Robotics launched its iconoclastic deepwater work class ROV GEMINI. Since then, it has been used on a number of offshore projects.

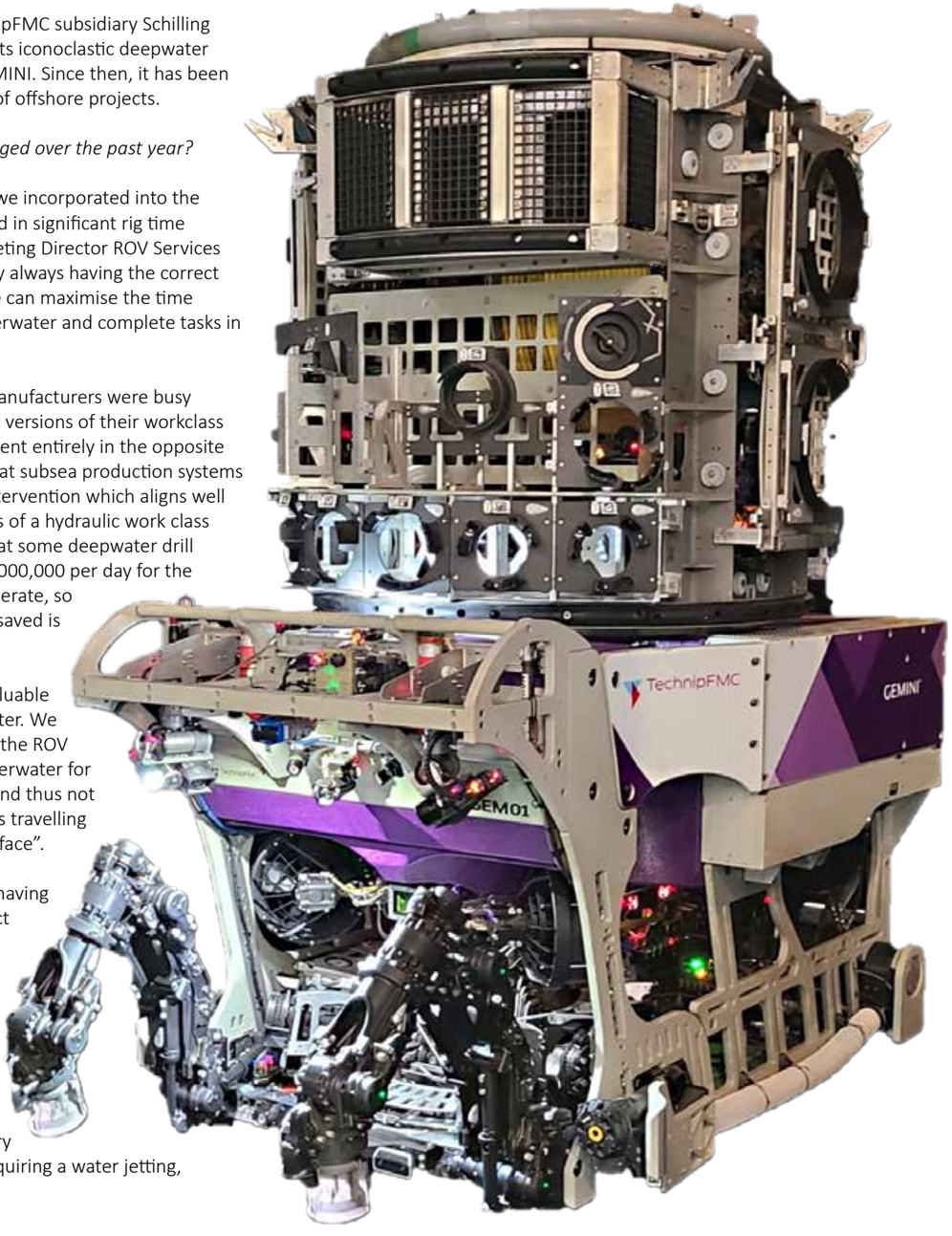
So how has it managed over the past year?

“The features that we incorporated into the design have resulted in significant rig time savings,” said Marketing Director ROV Services Peter MacInnes. "By always having the correct tooling available we can maximise the time spent working underwater and complete tasks in minutes."

While many ROV manufacturers were busy announcing electric versions of their workclass vehicles, Schilling went entirely in the opposite direction, stating that subsea production systems require frequent intervention which aligns well with the capabilities of a hydraulic work class ROV. They noted that some deepwater drill ships cost up to $1,000,000 per day for the E&P company to operate, so every hour of time saved is significant.

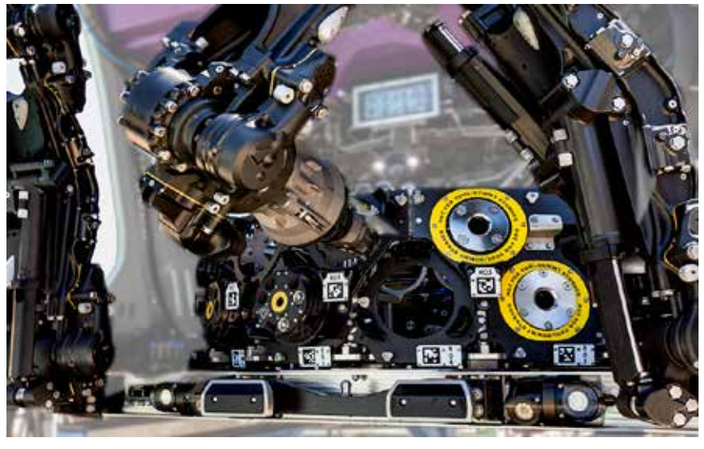
“The ROV is only valuable when it is in the water. We therefore designed the ROV to work or stay underwater for a month at a time and thus not have to spend hours travelling to and from the surface”.

This means always having access to the correct tooling. It is not uncommon that when carrying out deepwater intervention work, the pilot discovers that it is necessary, say, to carry out preliminary cleaning, maybe requiring a water jetting, nylon brush or grinding tool before embarking on the operation. It may also be necessary to cut away soft line (e.g. rope) that has entangled itself around a structure and needs to be removed to allow access.



In conventional operations, the ROV would use the manipulator jaws to reach down into a tool basket and acquire the correct tool by a simple handle interface. These tools also have to be interfaced with hydraulic hoses and cables to the host ROV, so very few tools can be utilised before having to return to surface for reconfiguration. Additionally, when changing or engaging tools, it has been known for the handles to slip out of the manipulator jaws, which can be a very challenging and time-consuming issue to recover from.
For GEMINI pilots, these issues are no longer a concern.

VIDEO: Conventional ROV operation. Peter MacInness from TechnipFMC talking at OTC



SKILL SETS

Offshore workers require many skills sets

They require an electronics capability, electrical skills maybe even some soft-ware skills to interface different tools and equipment to the vehicle

Particularly important are problem solving skills, able to work on the fly and change the plan if needed in response to changing conditions and adapt.

Working well with the client . This often involves have some knowledge of the actual tasks at hand is being performed beyond just piloting the vehicle

It is very difficult to train large numbers of people to be experts in such a wide variety of skill sets

As part of the programme , the designers looked at skills are the most difficult to acquire and perform precisely and repeatedly

They then focussed on automating these. This has resulted in performance improvements.

Most ROVs have a manipulator and a grabber, the function of the latter often being just to hold onto the target to provide a steady platform for the intervention work.

VIDEO: Tooling systems of Gemini Peter MacInness from TechnipFMC

Instead of the tools being held in manipulator jaws, the designers have developed a standard interface that provides all services including hydraulic power, optical communications and electrical power to the tools.

The tools can be exchanged automatically with a single command and, once acquired, the tool is securely latched into the interface preventing any risk of slipping out of the jaws.

This arrangement obviates trailing service lines between the ROV and the tools as the power and communications supply is housed inside the arms- up to 120W of electrical power, a hydraulic supply and 100 megabits / second Ethernet link for data and video. It is inherently more robust, reliable and quicker to operate.

The second main design feature is the novel tooling carousel built into the GEMINI ROV itself, with capacity for 15 different tools, and it is this feature that pilots have attested to as being particularly useful.

When the pilots need to exchange tooling, the current tool is automatically stored in a vacant slot on the carousel. After disengaging, the tooling carousel then rotates to present the newly selected tool which is then automatically acquired, and the vehicle can continue work.

Tooling attachments

As an example of how this ability to continually perform work enhances the overall operation, during a recent job in the Gulf of Mexico, the ROV supported the installation of a subsea tree.

This procedure required 16 different operations utilizing nine different ROV tools. As a result of being able to perform this work in a single dive and automatically exchange tools subsea, the GEMINI ROV saved almost 13 hours of critical path rig time.

Having numerous tools instantly available is particularly useful, but what is more remarkable is the speed at which this tool exchange takes place.

“It is a repetitive and challenging task and as such, lends itself to autonomy," said MacInnes. "Five machine vision cameras on the vehicle can look at 'fiducials'- similar to QR codes – placed adjacent to each of the tool slots on the carousel. These two-dimensional fiducials enable the system to determine a three-dimensional trajectory for moving the arm to engage precisely with the tools.

The automation means that it is possible to carry out an entire complex tool-swap operation in under two minutes, irrespective of who is performing the operation.

Having a wide range of tools available can save the pilots from having to return to surface, but what if they need a tool that is not in the vehicle’s carousel?

The solution developed by Schilling, is based on incorporating additional larger tools and consumables such as seals on the tether management system to store even more tools for the GEMINI to access.

The process of selecting a tool from the tether management system located midwater is usually a particularly challenging task for any pilot because both are moving in currents.

A conventional system would involve having to grab hold of the tether management system with one arm and perform the tool acquisition with the other. With GEMINI, the ROV has a strategically important feature that enhances traditional StationKeep capabilities using machine vision to hold position far more precisely.

"This is a highly accurate positioning system that allows GEMINI to remain on location within an accuracy of 25mm" said MacInnes. When the TMS moves in the water, GEMINI automatically tracks its movement and simultaneously adjusts the position of the ROV and the manipulator accordingly.

This allows the ROV to approach the TMS safely and permits the automated transfer of tools to take place without the two being physically attached.

GEMINI’s enhanced StationKeep allows another game-changing ability that the pilots have said increases efficiency. Up until now, the port grabber on ROVs has been needed to steady the vehicle by holding onto rails while the starboard manipulator is used to carry out the intervention work.

VIDEO: Tooling exchange . Peter MacInness from TechnipFMC

GEMINI, however, dispenses with the need for the grabber which means that the ROV can use two 7-function manipulators with two tools simultaneously, that can increase the speed and efficiency of the pilot teams.

For more information, please refer to TechnipFMC's OTC video

API 53 COMPLIANCE

Within the last few years, one requirement from clients working on wells is API 53 compliance. This relates to having the ability to operate the shear rams on a BOP with either the drill string or casing being sheared and the BOP sealed within 45 seconds. This essentially means that the ROV has to be able to pump 50 gallons per minute of fluid at 5000psi.

In some ROVs, this fluid storage and pumping system is incorporated into a skid slung under and docked to the ROV. This has to be connected physically on surface, which takes time.

The GEMINI also obviates this by incorporating the ability as standard with over 100 gallons of intervention fluids on the upper portion of the vehicle and a rather clever pump. The ISOL-8 pump from Schilling is a compact unit that is integral to the core GEMINI system and provides auxiliary power to run all of the system tools and has been demonstrated to achieve API 53 compliance during actual testing with a BOP, drill string and casing samples.

VIDEO: It Isol8 pump. Peter MacInness from TechnipFMC

SO.. WHAT *IS* A MULTIPLEXER?

Electronic subsea equipment often requires one or more wired connections. Most require a power source. Others also have data line lines. Lights only have an input control feed for on-off and intensity.. A simple camera, for example, may also have an audio and a video output feed.

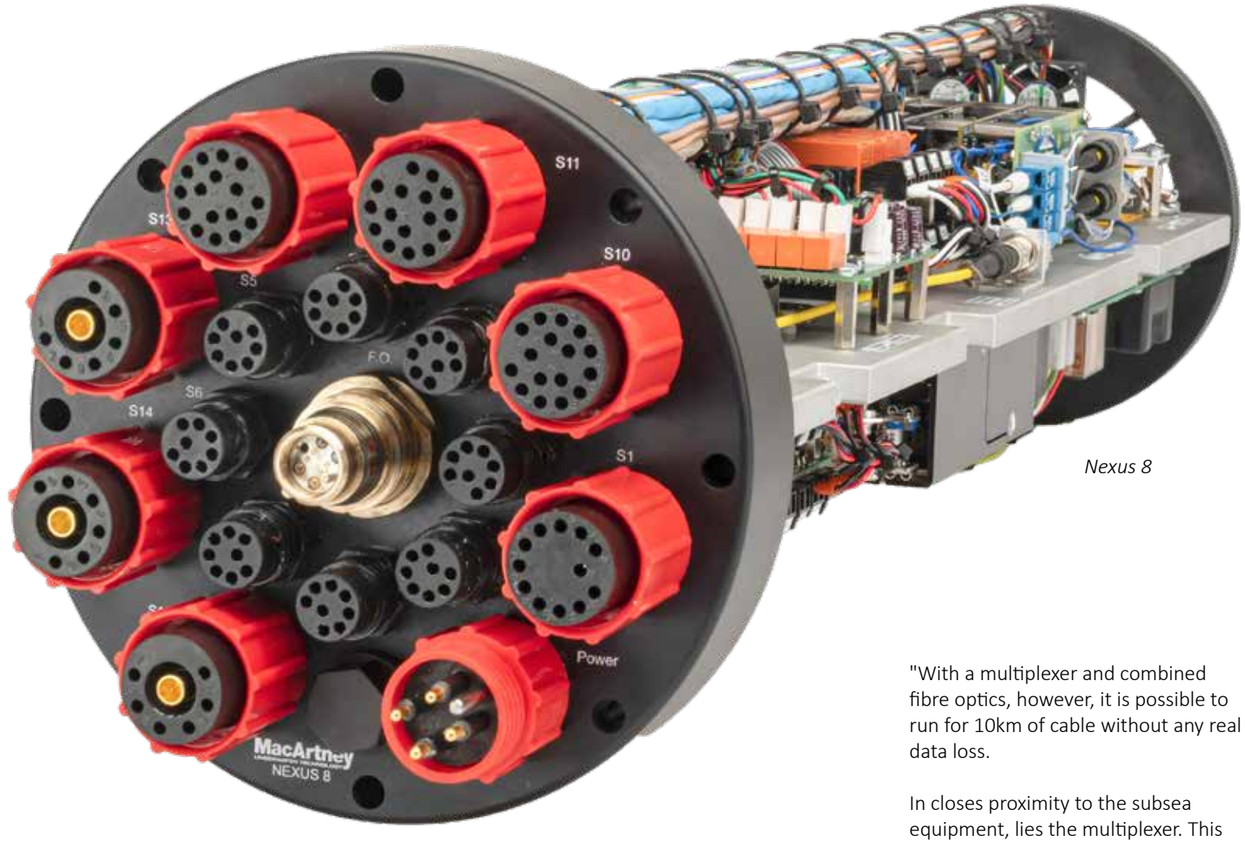
Another consideration when specifying the cable size is calculating data throughput. Equipment such as a large multibeam sonar is not only more power hungry, but also provides a much larger data output. All things being equal, the larger and more complex the device, the larger the cables.

Most underwater vehicles carry a multitude of electronic devices which have to be connected to the surface. This would require a commensurate number of leads to pass possibly thousands of metres through the water column up to the surface. There would also be spare lines to allow other devices to be retrofit.

The alternative is to use a multiplexer.

Instead of, say, 20 lines, the signals are commingled into a single fibre. At its minimum, this would reduce the number of lines required to just two – a power source and a fibre to transmit two-way data signals.

"Generally speaking, a multiplexer is simply a system for combining a number of channels," explained Lars Jørgensen, Head of Product Management at MacArtney. "The idea is that if you attach one end to a piece of subsea equipment, you will get the same data on your topside vessel, transparently. Think of it is a very complicated extension cord."



Nexus 8

Modern multiplexers rely on a fibre optic line.

"For short distances or less complex systems, it is possible to send a multiplexed signal down a copper wire," said Jørgensen, "but this limits the bandwidth of the data that the vehicle is attempting to transmit.

"If the application requires multiple Gigabit Ethernet channels, it is not possible to run that on a long copper long cable and after a few hundred metres, everything becomes more difficult depending on the type of data being transmitted.

"Serial channels can only run up to 1000m while Ethernet equipment has a range of 100m above which, some sort of media converter is required.

"With a multiplexer and combined fibre optics, however, it is possible to run for 10km of cable without any real data loss.

In closes proximity to the subsea equipment, lies the multiplexer. This is normally contained in a pressure housing that allows its use in whatever depth the system is rated for.

Meanwhile, at the surface, the line typically terminates into a 19in rack that can interface data with the topsides and PC systems or connect the Ethernet into the ship's network and distribute it further

NEXUS 8

Recently, Macartney introduced of the most advanced multiplexers in the world, the Nexus 8.

"We produced our first Nexus in 1999," said Jørgensen."It had no video and just serial channels. Since then, however, we have seen a significant shift in market requirements. There is no longer the same amount of sensors using serial connectors and, therefore, moved towards the higher bandwidth type of communication hub. Ethernet systems, driven by the mainstream computer and communications sector, have been adopted by underwater systems.

"In Nexus 8, have increased the number of channels since the early version," continued Jørgensen. "In the standard version there are full serial channels, three Gigabit Ethernet channels and five 10/100 Ethernet channels as well as three HD videos which is all most clients really need.

RELIABILITY

One particular area common to all subsea systems is the need for high reliability. On the surface, if systems fail or need to be modified, it is possible to open up the enclosure and work on the electronics. This not true for underwater systems where it particularly undesirable to open up the bottle enclosure.

"We purpose- design the enclosures to make them watertight under pressure," said Jørgensen. "Opening the bottle means removing the seals and even replacing them increases risk from leakage.

"One way we have worked around this conundrum is to remove the need for opening the bottle. We have discarded regular fuses and instead, made them programmable. We have also made it possible to select what sort of power consumption the user requires before the fuse is triggered.

"We have also managed to make the power management systems programmable. We can basically provide 12, 24 and 48volts on demand as required by different sensors. Alternately, we can feed the full power supply through the bottle and take it out again for a particularly power hungry consumer.

PRESSURE

"At the moment, by manufacturing the casing out of adonised aluminium, the maximum design pressure the bottle is 3000m. We do, however, see a demand for the development of deeper systems.

"This will come from the general desire to explore and record detailed information on the deeper ocean floor but in recent years, there has emerged a new demand for 6000m rated systems in the form of subsea mining

"This is a massive challenge. There are some very good companies out there currently working on taking this next step. Unfortunately, the equipment used subsea gives off a significant amounts of vibration when physically moving soil and extracting minerals from the sea bed, so reliability becomes particularly vital.

"With our philosophy of housing the equipment in a one atmosphere housing, we can increase depth ratings without requiring different types of electronics.

FORWARD LOOKING SONAR

Underwater obstacle avoidance technology from maritime defence technology companies, Sonardyne and Wavefront, has been successfully demonstrated on board an extra-large, uncrewed, underwater vehicle (XLUUV) built and operated by Plymouth-based MSubs.

The demonstration of the Vigilant forward looking sonar was part of the first phase of the UK's Defence and Security Accelerator's (DASA) 'Uncrewed Underwater Vehicle Testbed – Opportunity to Integrate' competition, run jointly with the Royal Navy and the Defence Science and Technology Laboratory (Dstl).

The DASA competition is focused on testing and validating commercial-off-the-shelf technologies (COTS) sensors and payloads, like Vigilant, to help the Royal Navy understand the future roles for XLUUVS for surveillance, reconnaissance and anti-submarine warfare, and deliver new capabilities to the Royal Navy years earlier than otherwise be possible.

Vigilant, developed by Wavefront and manufactured and commercialised by Sonardyne, is a navigation and obstacle avoidance sonar for ships, uncrewed surface vessels (USVs) and underwater vehicles. It provides crews with automated long-range detection of objects in the water column, showing them where it is safe to navigate and alerting them to potential underwater dangers that could result in a collision or grounding.

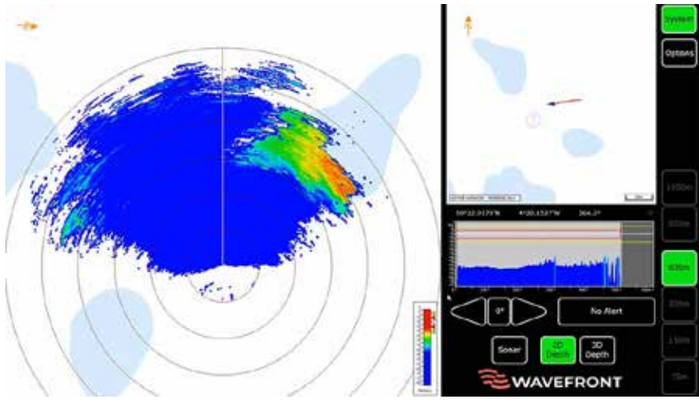
M Subs vehicle

The system has two operating modes. In 3D mode, Vigilant produces accurate 3D bathymetry and colour-coded depth imagery out to 600 m and to depths down to 100 m. In Sonar mode, Vigilant processes the intensity of the acoustic data to extract long-range positional data out to 1.5 km and over a 120-degree field of view. The sonar returns are used to generate alerts highlighting the presence of a navigationally relevant obstacle.

For the trial, the system's sonar projector and receiver array were mounted in the bow of the 9 m-long MSubs' S201 XLUUV. At just 31 cm-wide and weighing only 14 kg in air, Vigilant is easy to retrofit on a wide range of platforms including ships, USVs or, as in this case, an XLUUV.

As part of the demonstration, the XLUUV was programmed to travel beyond the breakwater outside Plymouth sound. Vigilant was used to create a bathymetric map that was used by the XLUUV to navigate. The data was also overlaid over existing charts of the area, demonstrating the higher resolution provided by Vigilant.

Ioseba Tena, Head of Defence at Sonardyne, said: "Seaborne collision avoidance is a vital consideration for autonomous and uncrewed naval platforms. Vigilant can be integrated into these ocean robots to provide essential information to autopilots and command and control systems, to aid safe navigation and manoeuvres around hazardous obstacles."



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