MARINE TECHNOLOGY REPORTER

September 2020

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NOAA's RDML Gallaudet

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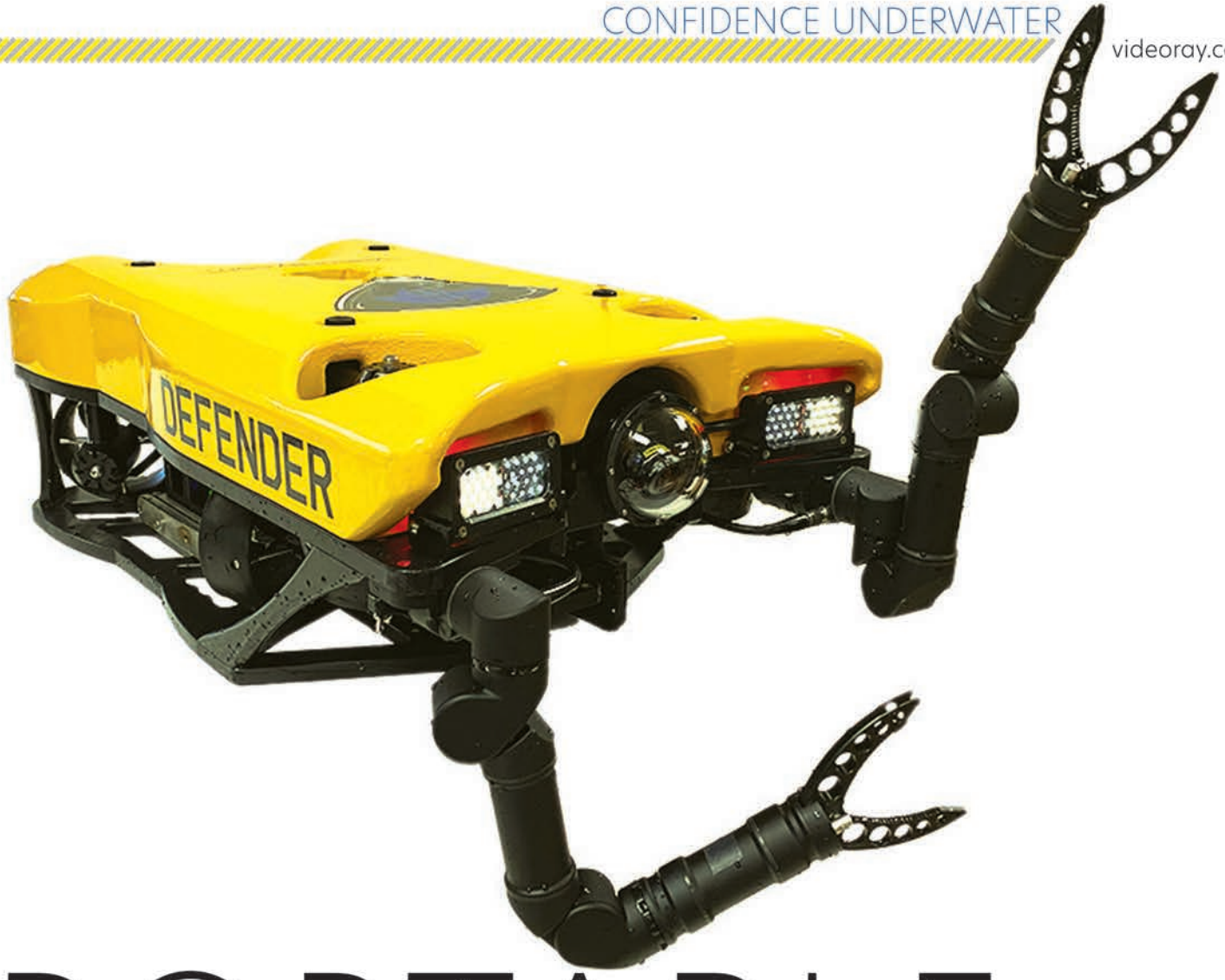
New Routes to **Subsea Residency**

Thruster Tech **Enhancing Propulsor Performance**

Volume 63 Number 7



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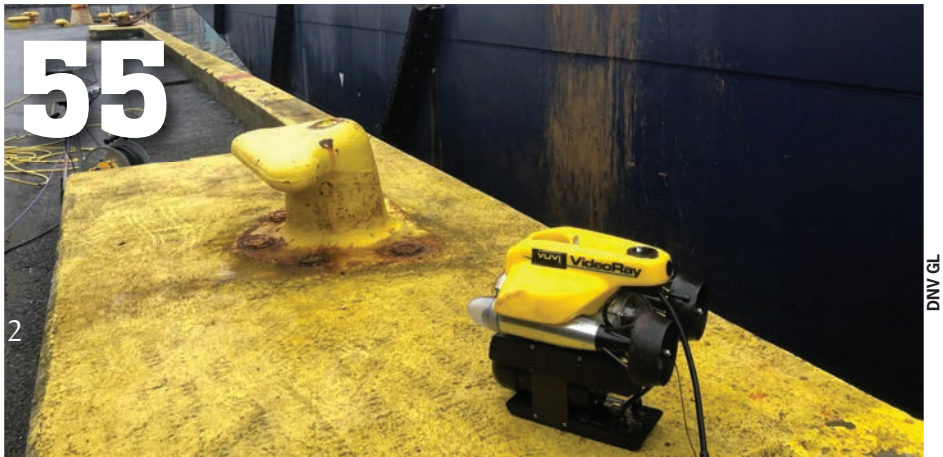

DNV GL

On the Cover

(Retired Navy Rear Admiral and Deputy NOAA administrator Tim Gallaudet meets with scientists at NOAA's National Weather Service Space Weather Prediction Center in 2018 in Boulder, Colorado. Credit: NOAA)

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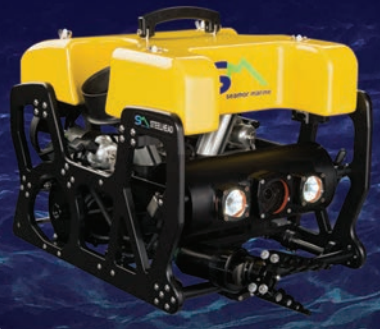

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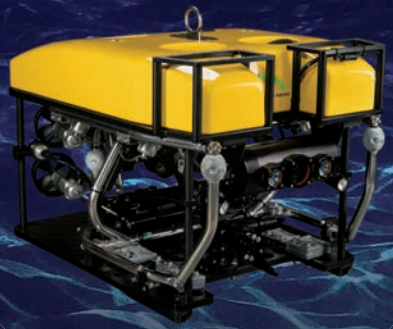

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Editor's Note

There could be no better cover feature for our autonomous vehicles edition than our interview with **RDML Tim Gallaudet, Ph.D.**, assistant secretary of commerce for oceans and atmosphere and deputy NOAA administrator. It was last month when NOAA and the United States Navy signed a new agreement to jointly expand the development and operations of unmanned maritime systems in the nation's coastal and world's ocean waters, combining the resources of two of the heaviest hitters in the world in regards to the funding, development and use of uncrewed vehicles.

RDML Gallaudet was gracious with his time and direct in his answers in assessing the future pace and direction of autonomous vehicles to conduct and complete missions that are cornerstones of U.S. commerce and interests. The interview was timely, too, as NOAA – and in fact the world – continue to adjust operations in the face of restrictions stemming from COVID-19. Just last month NOAA ships were pier-side because of COVID, but there were three critical missions that needed to be done, resulting in three major uncrewed system efforts to fill a collection gap that NOAA had. Read about these missions, and the technology used to complete them, starting on page 26.

Completing missions efficiently, effectively while removing humans from the dull, dirty and dangerous jobs is a recurring theme in our pages, print and electronic, continued this month with **Elaine Maslin's** take on *"New Routes to Residency"* starting on page 38.

It is little secret that autonomous solutions that offer reliability, accuracy and duration are starting to take the place of sending a more expensive ship and support crew. Keeping assets under the water for increasingly long times to increase remote capability go hand-in-hand with ROV residency. While many efforts are still in the development phase, Maslin finds that, already, the forms that residency takes are diverging.

Gregory R. Trauthwein
Associate Publisher & Editor

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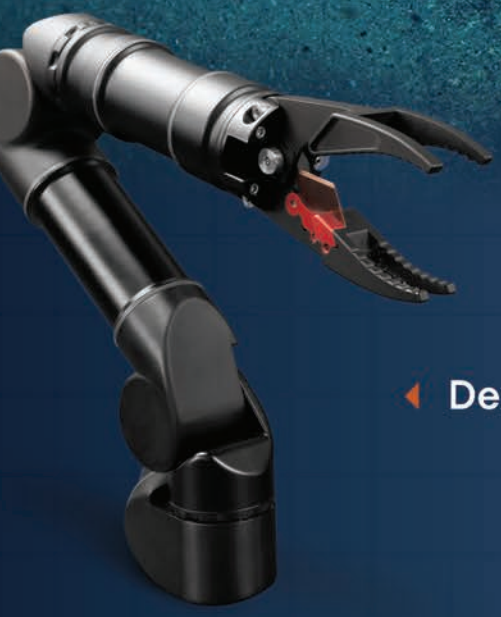

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Maslin

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MacPherson

Donald MacPherson is Technical Director of HydroComp, Inc., a research consultancy specializing in applied hydrodynamic and propulsion system simulation. Widely regarded as one of the industry's foremost experts in analytical prediction methods for the performance of marine vehicles and propulsors, he oversees all software product development and is principal investigator for engineering services. A graduate of Webb Institute, Don is a Fellow of the Society of Naval Architects and Marine Engineers, and member of its Propeller Hydrodynamics and Underwater Noise panels.

Maslin

Elaine Maslin is an offshore upstream and renewables focused journalist, based in Scotland, covering technologies, from well intervention to subsea robotics.

Weinstein

Steve Weinstein is the senior vice president of strategy for the innovation firm BMNT and a board member of The Common Mission Project, BMNT's non-profit arm dedicated to building an ecosystem of mission-driven entrepreneurs. He also teaches entrepreneurship at UC Berkeley and Stanford.

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Inside Fabien Cousteau's PROTEUS

An Underwater Scientific Research Station and Habitat

If Aquanaut and Ocean explorer Fabien Cousteau's dream comes to fruition, by mid-2023 the first inhabitants will be heading down to occupy PROTEUS, an underwater scientific research station and habitat to help address medicinal discoveries, food sustainability, and the impacts of climate change.

PROTEUS, which has a $135 million budget over the next three years to build and operate, is a project of the Fabien Cousteau Ocean Learning Center (FCOLC), conceived as the underwater version of the International Space Station, a platform for global collaboration among researchers, academics, government agencies and corporations.

"As our life support system, the Ocean is indispensable to solving the planet's biggest problems," said Cousteau at the time of PROTEUS' launching. "Challenges created by climate change, rising sea levels, extreme storms and viruses represent a multi-trillion-dollar risk to the global economy."

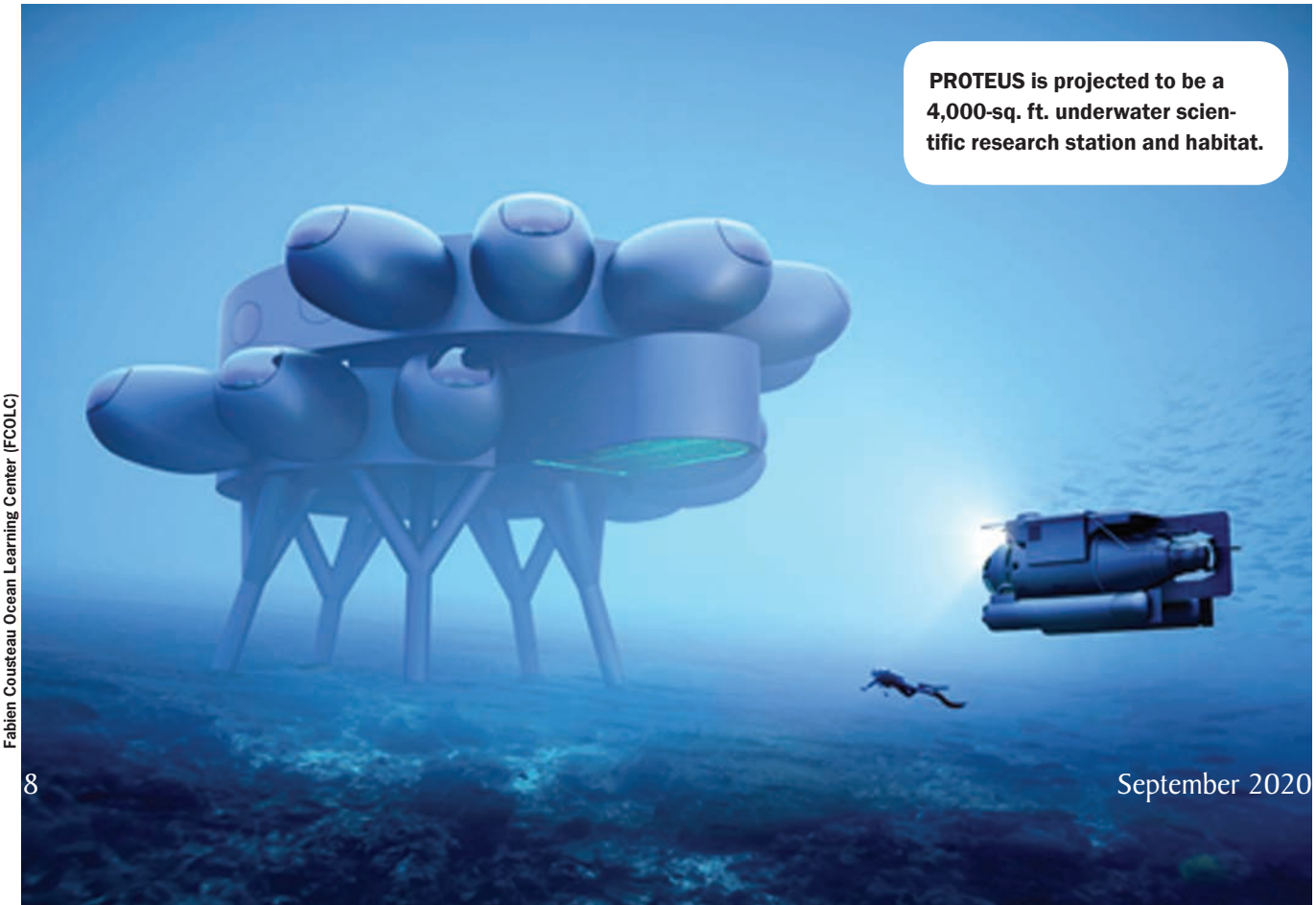
PROTEUS is envisioned to be approximately 4,000 sq. ft. when complete, or more than four times the size of any previously known underwater habitat, and will feature:

- Labs, sleeping quarters and a moon pool.
- The first underwater greenhouse
- Power via hybrid sources including wind, solar, and Ocean Thermal Energy Conversion (OTEC).
- A full-scale video production facility to provide continuous live streaming for educational programming, and delivery of augmented and virtual reality to collaborators worldwide.

"PROTEUS is a hopeful step forward in spreading the message that we must protect the ocean as if our lives depend on it," said Dr. Sylvia Earle, Ocean Ambassador of the FCOLC and American marine biologist, explorer, and National Geographic explorer-in-residence, and fondly known as "Her Deepness". "Living underwater gives us the gift of time and the incredible perspective of being a resident on the reef. You're not just a visitor anymore."

The onsite labs will facilitate processing of organic samples that can be studied in real time, rather than the specimens rapidly degrading or dying during the journey to the surface and onward to far-reaching land laboratories.

PROTEUS will be located off of the Island of Curaçao, at a depth of 60 feet (3 atmospheres) in the richly biodiverse



PROTEUS is projected to be a 4,000-sq. ft. underwater scientific research station and habitat.

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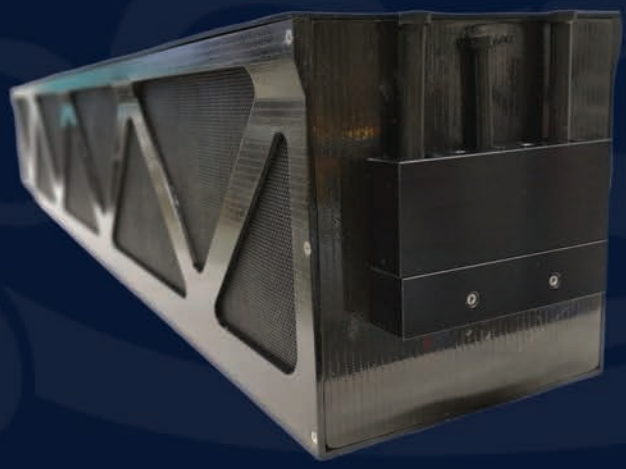

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waters in a marine protected area of the Caribbean Sea.

PROTEUS' strategic partners include Northeastern University, Rutgers University, as well as the Caribbean Research and Management of Biodiversity (CARMABI). Other academic experts include University of Rhode Island's Graduate School of Oceanography. The initial concept design of PROTEUS is co-conceived by industrial designer, Yves Béhar and his firm fuseproject. "PROTEUS's design intent is to offer an effective, comfortable and attractive facility for researchers, and an exciting underwater structure that garners the same passion for ocean exploration as we have for space exploration. The PROTEUS spiral architecture houses social and work spaces as well as a communication studio and a submersible moonpool."

PROTEUS builds off of the success of Mission 31 (2014), when Fabien Cousteau led five aquanauts at Aquarius, a 400-sq. ft. station in the Florida Keys. There he set the (then) record for longest amount of time living underwater of 31 days.

The Cousteau family is well-known for achievements in underwater living, discovery and ocean cinematography, including the first underwater research habitats built in 1962, by Jacques-Yves Cousteau: Conshelf I, II and III, documented in his Academy Award-winning film, Le Monde sans Soleil (World Without Sun) (1964).

Jean-Michel Cousteau, Fabien's father, an oceanographic explorer, environmentalist, educator, and film producer, supports the evolution of underwater exploration and research that PROTEUS will provide.

https://www.fabiencousteauolc.org

Photo by Carrie Vonderhaar

Qinertia

The Next-generation INS/GNSS Post-processing Software

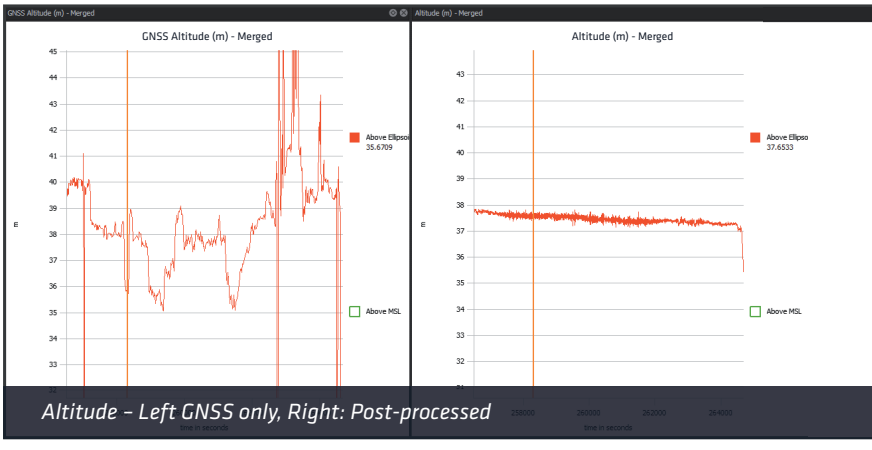
Quality: *Green -> centimetric position; Blue -> decimetric < 30cms; Red -> Raw GNSS data*

SURVEYING UNDER BRIDGES MADE EASY

This survey has been done with an APOGEE INS under very challenging conditions for the GNSS receiver (red dots).

The boat is crossing multiple times three large bridges including one made of steel.

With Qinertia and its unique 100% in-house GNSS/INS tightly coupled forward / backward processing, data collected under the bridges are fully exploitable (blue / green trajectory).



Altitude – Left GNSS only, Right: Post-processed

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Example: up to 80 seconds *outages and multi-path effects*
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Full data available upon request at marketing@sbg-systems.com
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Images courtesy: WWF/NorShipping

Funnel Vision

Plastic is suffocating our oceans. Christine Spiten, Nor-Shipping's latest ***#ACTION*** *hero, provides a breath of fresh air, explaining how she left Blueye for the WWF and a mission to stop the problem at its source.*

"Eight million tons."

Christine Spiten lets the number sink in for a second…

"That's how much plastic enters the sea every year from our cities and rivers. It threatens not just local ecosystems and the wider environment, but also us – our food sources, our livelihoods, our very existence. It is the fastest growing environmental problem we face. And it demands action. Now."

Empowering move

Spiten doesn't like wasting time.

The 30 year old Norwegian is a former national sailing champion, co-founded pioneering underwater drone company Blueye Robotics in 2015 – with the goal of making underwater exploration more accessible, for both individuals and industry – was shortlisted for Nor-Shipping's Young Entrepreneur Award in 2017 and, in 2019, decided to use her passion and business network to help the World Wildlife Fund. She is now their Senior Advisor, Plastic & Circular Economy.

"I was sick of being at the 'end of funnel'," she explains.

"Through my work with Blueye I wanted to help people fall in love with the ocean. To both reveal and immerse them in the beauty beneath the waves, hopefully sparking a lifelong interest and passion. People care for things they experience, enjoy and understand. Blueye drones open up a new world of wonder.

"However," she adds, "I also saw at first hand, through both research projects and commercial and recreational use, just how much pollution was entering our oceans. I saw it's impact and felt, I don't know… a little powerless. I wanted to change that. I wanted to help address the problem at its source – to try and block the funnel.

"But that," she says with an air of marked understatement, "is a challenge."

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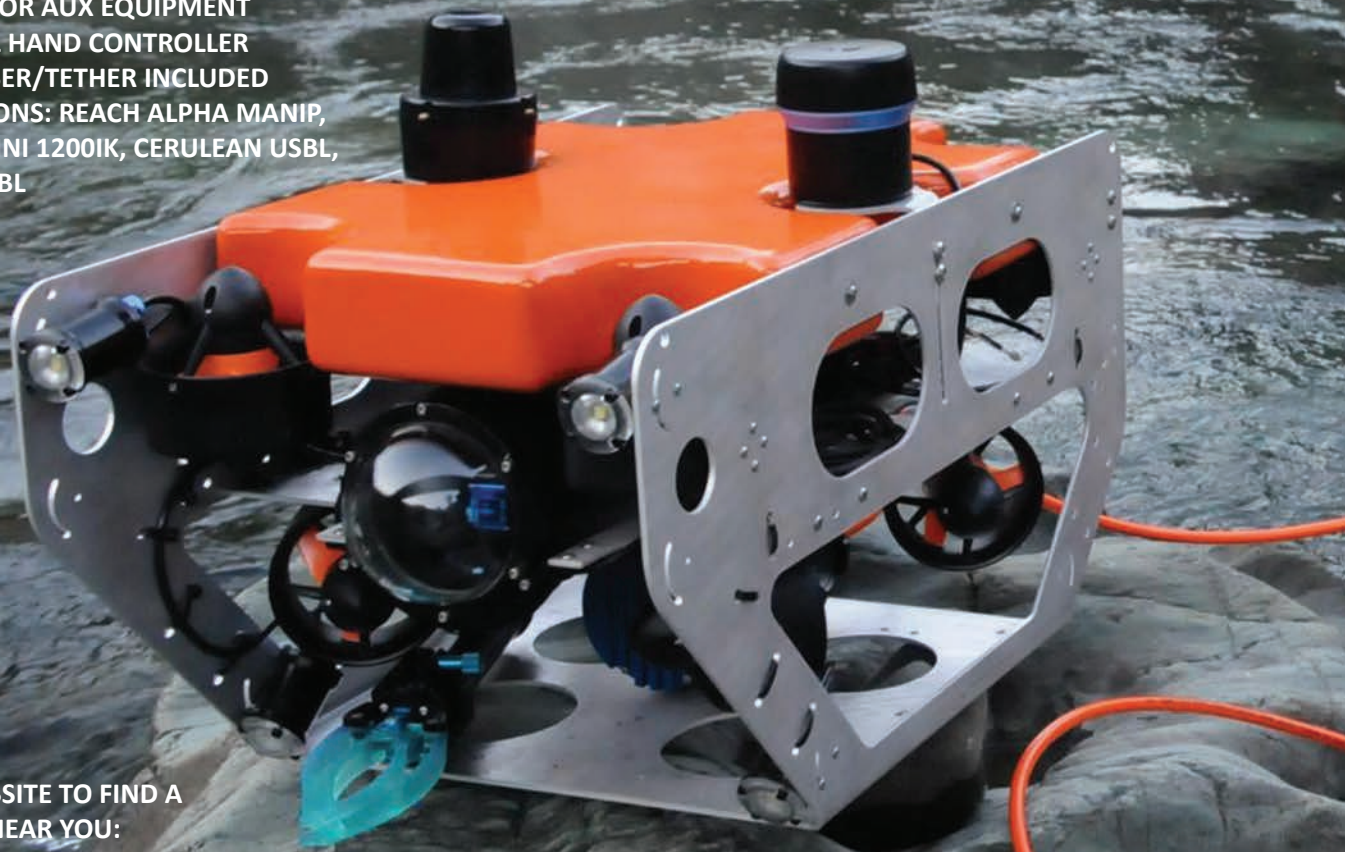

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Collaborating for change

Spiten wouldn't have it any other way.

It's rare to speak to someone that oozes this much ambition. She speaks with a calm, focused manner that belies the obvious energy she possesses. A quick look through her CV reveals various business founder and board roles – including a position as a co-Captain of EnterpreneurShipOne, an organization working to tackle ocean challenges through collaboration and innovation – and an advisor job with Rev Ocean, Norwegian billionaire Kjell Inge Røkke's not-for-profit research organization.

"This is what I love doing, working with the ocean" she states. "And if I can help affect positive change then it's the ultimate win-win."

And it looks like she's already scored some double victories.

Spiten's chief responsibility is to work with the corporate sector to help bring about transformation in how business addresses the use (and ownership) of plastics, helping enable a more circular economy and drastically reducing waste. Her remit ranges from engaging with FMCG firms through to political initiatives and collaborations. With her established business network and profile through Blueye, the maritime sector is an obvious area of focus. And initial success.

"I was delighted to announce our collaboration with the Grieg Foundation earlier this year," she notes. "That's a clear example of how we can work together with industry on a solutions-orientated approach – utilizing commercial expertise and assets to deliver on environmental objectives."

Local impact

The two partners have set their sights on the Philippines – both home to the majority of Grieg Group's seafarers and, sadly, a major ocean polluter. The sprawling archipelagic nation is the world's third most plastic-polluting country, after China and Indonesia, despite the fact that around half of its 100 million strong population depend on ocean fishing for their livelihoods.

Grieg and WWF are launching a multi-faceted initiative where they will work with local partners, including port authorities and waste management firms, to map the waterborne pollution in three key harbor areas. Innovation projects to address the issue will then be initiated, again with local involvement, while education campaigns will engage the businesses that are seen to have an impact on localized plastic pollution.

"It's about taking responsibility for the future as well as addressing the issues today," Spiten comments. "We need a behavioral change to engender an environmental one."

The activity will be supported by a national TV fundraising campaign in Norway, which aims to raise enough money to improve waste management systems for around one million people in The Philippines, Indonesia, Vietnam and Thailand, while also reducing annual plastic pollution flowing into the sea by approximately 7,000 tonnes a year.

The Grieg collaboration, meanwhile, has set its sights on a reduction of 50% in waterborne plastic waste across its three target areas.

"We have to be positive when we look to future goals," Spiten smiles. "Ambition is a good thing to have!"

Platform for progress

The future is a theme the WWF advisor frequently returns to. She sees a clear need for the maritime business to engage with and nurture the next generation of ocean space enthusiasts – bringing in fresh perspectives and innovation, while tapping into their passion and energy.

"We need more platforms like Nor-Shipping for example," she explains. "At Nor-Shipping you have an arena whereby start-up companies – like Blueye was – have an opportunity to build networks and communicate concepts to industry leaders. It's a place where innovation meets established players, and that is vital for overall maritime development.

"At the same time you have students and young people interested in careers in the ocean space discovering not only opportunities, but also seeing where the industry needs help – where they might be able to deliver with unique talent and ideas, for example in the area of sustainability.

"Shipping can't stand still in a world of change," she surmises. "It needs to evolve in line with growing challenges, opportunities and awareness. Arenas like Nor-Shipping have a role to play in that process."

Spiten is pleased to hear that the next Nor-Shipping, taking place in Lillestrøm and at a variety of venues across nearby Oslo from 1-4 June 2021, is focused on #ACTION. Because, she stresses in conclusion, that's what the ocean desperately needs.

"Environmental awareness is growing and many businesses have adopted positive approaches with regards to, for example, the UN Sustainability Goals. But the world needs more than positive sentiments, it needs solutions to its challenges. We need transformation.

"A new approach to plastic is central to that. It really is time for action. Now."

Spiten and Blueye –
opening up the ocean to new audiences

Images courtesy: WWF/NorShipping

Elisabeth Grieg & Chrstine Spitten –
Greig and WWF joins forces to fight plastic pollution.

UV Tail Shape and Vehicle-Propulsor Performance

Successful underwater vehicle (UV) performance is all about a properly functioning system. The components of a UV's Vehicle-Propulsor-Drive system are not individual performers. They must be in harmony.

By Donald MacPherson, Technical Director of HydroComp, Inc.

Often overlooked during system design is the relationship between the propeller and the vehicle body, particularly how the water reaches the propeller and – and perhaps even more importantly – how the local pressures between the vehicle and propeller can affect development of useful thrust. This article is intended to give UV vehicle designers and builders a little insight into this critical hydrodynamic interaction.

Propeller pressures

Let's begin our story by focusing on the propeller. There are two principal pressure zones on either side of a propeller blade that coexist and develop the thrust that moves the vehicle. On the aft side of the propeller is a "positive-pressure" zone (noted as P+ in the graphic). Hold your hand out your car's window. Slightly rotate your hand to bring your thumb up. As your car moves, air is captured under your hand creating a "positive-pressure". This is equivalent to the propeller's aft-most side (its "face"), and it pushes the blades forward.

Simultaneously, there is a suction that is also developed on your hand due to the curvature of the flow that wraps around your thumb and along the back of your hand. (You probably cannot feel this as our hands are not great airfoils, but it is there.) This suction is a "negative-pressure" zone that pulls the blade forward on it forward-side (its "back"). What might be surprising is that for most propellers used on UVs, the suction "negative-pressure" is the principal contributor to propeller thrust.

Vehicle tail shape

So what does this have to do with my upstream vehicle shape? Well, the negative propeller suction can have influence at quite some distance. Not only will this suction zone pull in water to the propeller, but it also pulls back on the hull or vehicle body in front of it. This sacrificial pulling back of the vehicle can be effectively considered as an added drag, but more often it is dealt with as a system "thrust deduction". And vehicles that have a rearward-facing shape that is close to the propeller are particularly susceptible to thrust deduction losses.

The graphic shown here illustrates three different tail shapes frequently seen on contemporary "body-of-revolution" or "torpedo-like" UVs. Let me first acknowledge that hydrodynamics can indeed take a back seat to other design constraints, such as a prescribed maximum body diameter or length. That said, the UV design process will always achieve better outcomes when the consequences of body shape decisions are understood by designers. So to that end, there are four principal shape characteristics that we want to identify during design – 1) the slope of flow into the propeller, 2) the curvature of the transition from the main cylindrical body to the propeller, 3) the distance between the propeller blade and the upstream body, and 4) the ratio of the propeller diameter to body diameter.

Slope of flow into the propeller

A propeller ideally wants inflow that is as axial as possible. The reasons for this are partly hydrodynamic and partly practical. There is a natural hydrodynamic compression and increase in velocity as water passes through a propeller. If the local environment further enhances this compression with a (more-or-less) conical inflow slope angle, we get a lot of convergence of water aft of the propeller leading to energy losses, cavitation, and hydroacoustic noise from a strong hub vortex.

The practical considerations are actually due to a limitation in most propeller design tools, which are based on axial inflow. Special codes are needed that allow for conversion of the blade section foil geometry from circular to conical coordinate system.

We can see how tail slope angle is (A) very steep with a short tail section, (B)

reduced as the tail is lengthened, and (C) becomes nicely axial when the local tail shape is inflected into the propeller hub. (An inflected tail can also often provide the added benefit of a smaller hub.)

Curvature at the transition shoulder

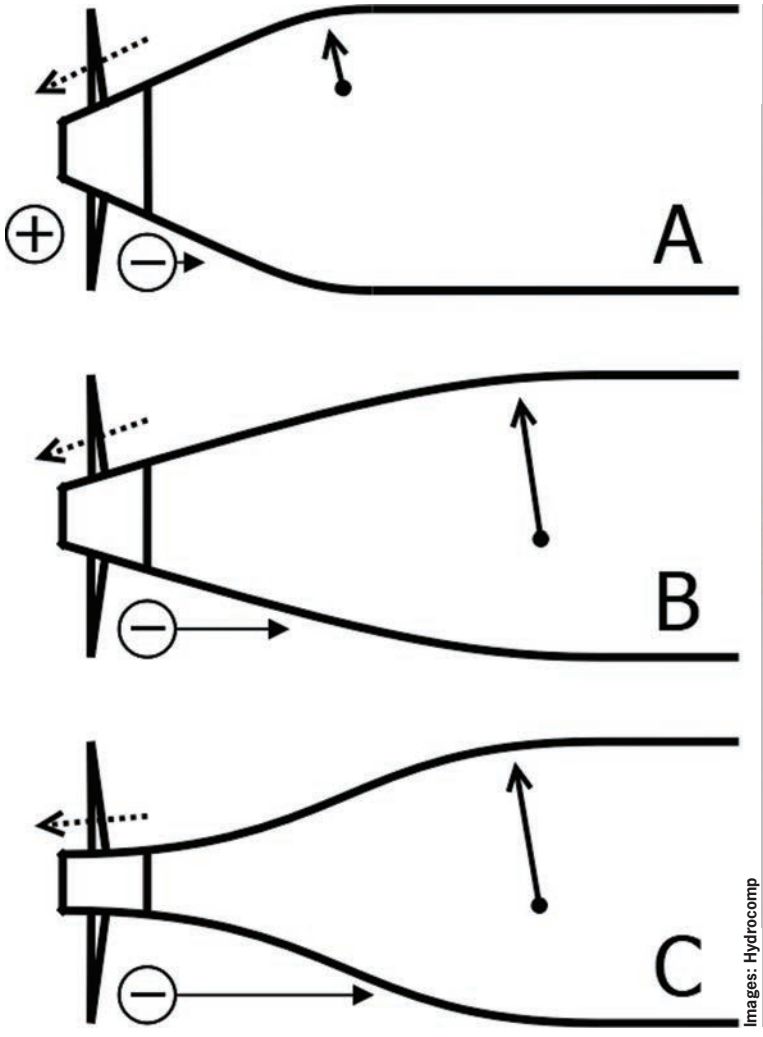
Let me encourage you to "think like the water" when considering all things hydrodynamic. Let's say that you are a particle moving along a cylindrical body and you come upon a need to alter your direction because the body is narrowing. Your momentum wants you to continue your axial path, but as pressure is lowered with the contraction, you are encouraged to follow the body. Now, if your momentum is strong enough or the curvature is tight enough, you cannot stay attached to the body and flow separation occurs. There is nothing good that comes with flow separation on a UV body. (Separation is appropriate in other circumstances, such as high-speed planing or super-cavitating propellers, but not in the UV world.)

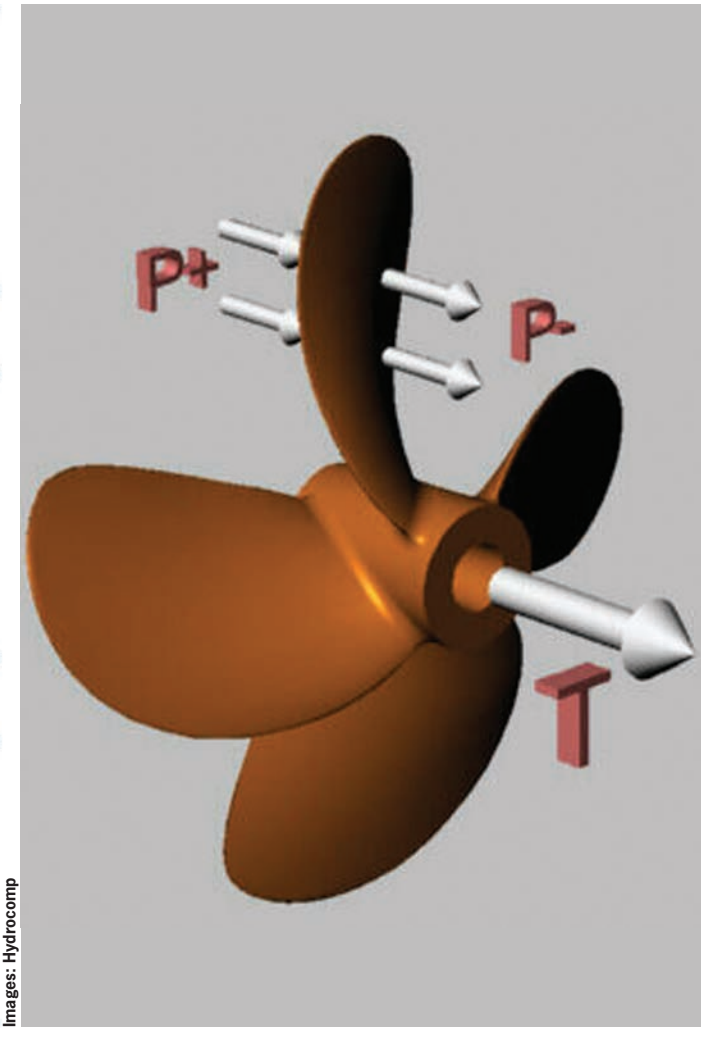
We have developed some in-house design guidelines to help quantify curvature thresholds, but in general less is always better. Curvature is (A) often too tight with a short tail length, but (B and C) softer and more flow-friendly with a longer tail.

Axial distance from blade to body

This parameter is the principal contributor to a high "thrust deduction". The influence of the propeller's "negative-pressure" zone lessens with distance, allowing more of the propeller's thrust to be effectively used to overcome the resistance of the UV. How much more? Thrust deduction losses can be quite small (close to zero) with adequate distance to more than 20% for short and steep tail sections. For example, a US Navy research study [1] showed how increasing the axial distance from approximately 0.3 to 0.7 body diameters reduced thrust deduction by half for a recovery of nearly 8% lost thrust. (The measurement was taken axially from the blade's 80% radius to the body at the same radial position.)

Axial distance is (A) quite close with a short tail section with a steep tail slope angle, (B) naturally greater with a longer tail section, and (C) can be pushed even further forward with an inflected shape.





Images: Hydrocomp

Propeller-to-body diameter ratio

This simply describes that a smaller diameter propeller will have the thrust-making part of the blade closer to the vehicle body, with a corresponding increase in the thrust deduction influence. The magnitude of influence varies with the type of tail section, of course, but in round terms we would expect to see a doubling in thrust deduction when the propeller diameter is reduced from 100% to 50% of the body diameter.

Calculation methods and design tools

Prediction of thrust deduction for body-of-revolution UV vehicles is being addressed by new capabilities in HydroComp's NavCad® software. A new development initiative to better support UV designers started with an update for the data definition of nose, mid, and tail geometries. This allowed for implementation of new drag prediction methods, as well as for the hull-propulsor coefficients of wake fraction and thrust deduction. Coming late in 2020 is new support for electric motor drivelines with a proprietary partial load motor efficiency prediction capability. Now UV designers can reliably predict current draw, electrical input power, and overall motor efficiency for all operational speeds and conditions.

Of course, more complex computations may be justified for specific body design projects. In addition to engineering services for specialized UV hydrodynamic analysis and propulsor design, HydroComp is also developing a reduced-order analytical flow code for NavCad to provide design prediction of body pressures, hull form drag, boundary layer velocity distribution, and thrust deduction. We are also leading an effort to support designers with a pipeline for the use of CFD in UV body design. Working with other software developers, we are establishing best practices for the integration and use of NavCad's UV modules with naval architectural software and CFD codes, as well as to provide corresponding guidance, training, and professional development to the UV community.

[1] Huang, T.T., et al., "Propeller/Stern/Boundary-Layer Interaction on Axisymmetric Bodies: Theory and Experiment", DTN-SRDC Report 76-0113, 1976

CEO Joe Wolfel (L) & President Judson Kauffman (R)
Photos: Terradepth

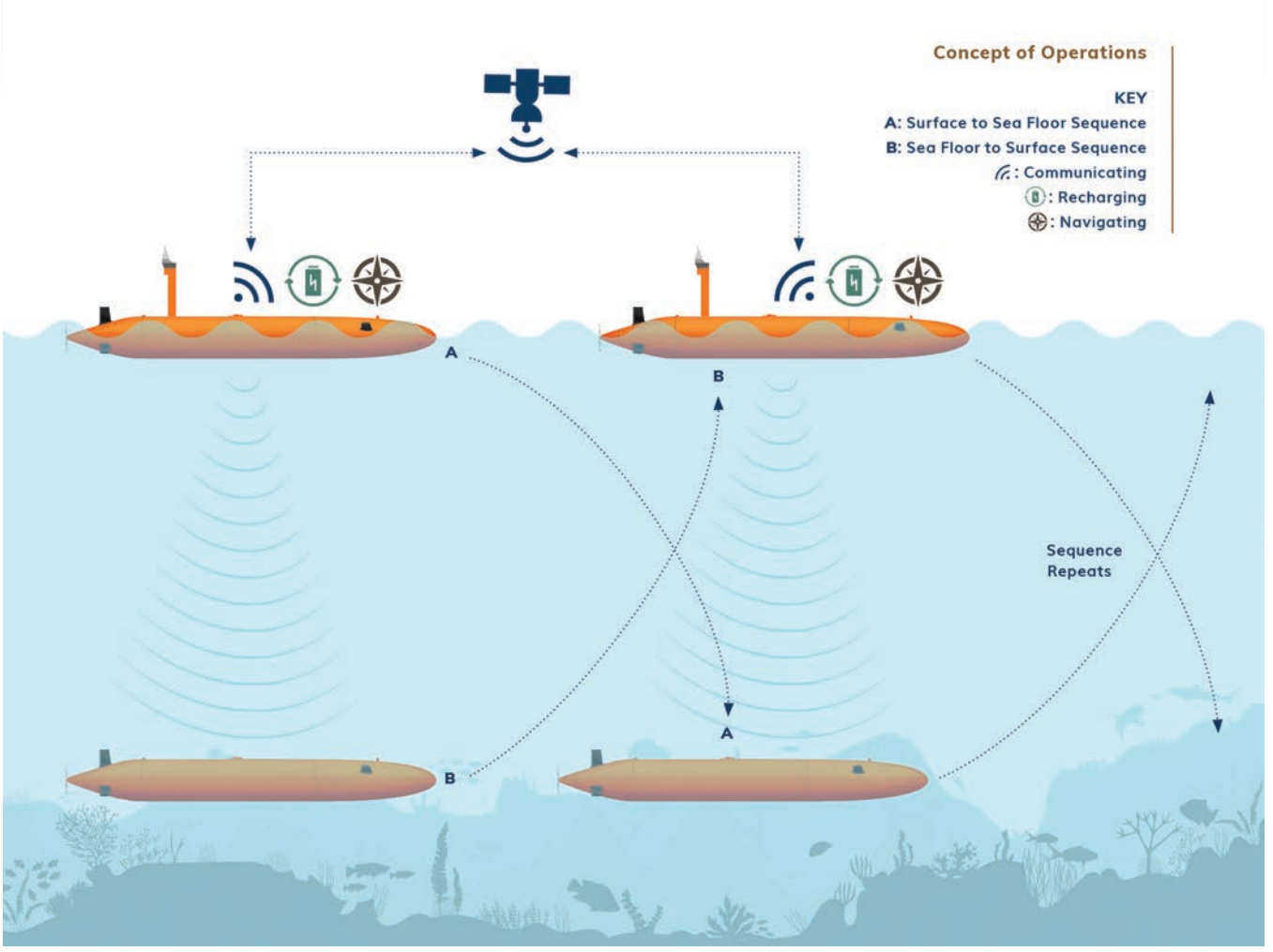
Terradepth

Ocean mapping at scale is the target of a new unmanned systems player started by two ex-US Navy SEALS. They have big ambitions, from new building unmanned vehicles to creating the intelligence that will drive them to changing how accessible ocean data is. ***Elaine Maslin learned more.***

The pace of change in the ocean mapping space has been fast in recent years. New entrants have come into the scene offering "force multiplier" mapping using autonomous underwater vehicles (AUVs) and unmanned surface vessels (USVs). Shell's Ocean X-Prize challenged technology developers to come up with ever faster mapping techniques in deep water and to push new boundaries. And yet, largely, many operations are still being done the same way. AUVs are now also a relatively mature technology, although companies are nibbling at alternative ways to deploy and recover them without the need for manned vessels. The latter is just what a new outfit, Terradepth, is working on – complete with a new design of AUV, with hardware build support from Canada's Cellula Robotics. Founded in 2018, Terradepth wants to bring a new multi-AUV mapping concept to market. Crucially, it's one that doesn't rely on surface vessels. Terradepth is also looking to change the model around how underwater data is owned and sold. The company, based in Austin, Texas, doesn't come from a subsea or even hydrographic background. It was formed by two former US Navy SEALS, CEO Joe Wolfel and President Judson Kauffman, with a mission to increase seafloor mapping rates economically and to create a business based on the data it gathers.

How a Terradepth UxV will look.

Graphic from Terradepth



AN OCEAN DATA CHALLENGE

Their focus came from personal experience, specifically the collision of the USS San Francisco – a nuclear powered submarine – with a seamount at flank speed in 2005. While they were deployed in Iraq at the time, it was big new. "How does the US navy not know there's a mountain underwater? That idea stuck in our heads," explains Wolfel. They did a little digging and discovered that 70% of the earth is ocean "and we really don't know anything about it. The ocean is drastically underexplored. So we want to create a data repository so we can change the information market.

"But we have a data acquisition problem because it's too expensive to collect deep ocean data today. A ship goes out to sea, takes an AUV, it goes out for 12 to 48, maybe 72 hours, depending on energy use and sensor payload; it could be doing bathymetry, physical imagery, it could be a side scan sonar looking for a snapshot. You pull the robot up, swap the batteries, get the data and put it back in the water. The cost of this is between US$50,000 and $250,000 a day, just to run this ship. It's a lot. And it's not scalable. We can't get the data, so we're going to go get it with a fleet of autonomous hybrid vehicles (AxVs) that will remove the requirement for that surface ship that we see as the main cost driver."

NOT AN AUV BUT AN AXV

Wolfel says they looked at the current AUV market, at Hugins and Slocums, but decided to build their own with their own concept of operation, focused on deepwater, where they see their concept having market-changing potential. The result is a lithium-ion battery-based multi-AxV system with hydrogen fuel cell repowering with each vehicle acting as a receive and transmit node so it can operate both at the surface as a gateway to send data to shore – building on constrained communications environments the pair experienced in Iraq.

"The AxVs are powered by lithium-ion batteries which, given our heavy payload requirements and small size, must be recharged after each day of use," explains Kauffman. "So, at the end of a day of subsea data collection, the AxV comes to the surface and it's twin dives down to pick up where it left off. The now surfaced vehicle establishes GPS signal with a satellite, establishes acoustic communication with and positioning to the submerged twin (which will also use its own INS and DVL for positioning), and turns on its generator to begin recharging its batteries. This process repeated itself until we're low on fuel."

Kauffman says this could run for 30, maybe 60 days. They call it the leapfrog, named after for a basic tactical combat manoeuvre the pair learned as Navy SEALs). "This way we always have accurate positioning and SATCOM and we're constantly collecting data without the need for a surface support ship," adds Wolfel. It's a bandwidth constrained environment, so processing and transmission via satellite will be done while each AxV is at the surface.

FAIL FAST

Terradepth is aware of the underwater challenge and are taking a fail fast approach but with experts from various fields on their books, including Seagate Technologies, a data storage firm, which also led an $8 million investment round into the company last year. A lot of focus is on the system's intelligence.

"Most of what we're doing isn't very innovative," says Kauffman. "Where we're innovating on the software side, around the brain of the submersible. It will know when it sees things like a shipwreck or a thermal vent and it will know if it needs to turn on a camera or a video camera or do a second pass or surface and contact headquarters here in Austin and say 'I don't know what

this is what should I do'."

It's a big challenge. "Submarines have been able to go to bottom of the ocean and collect whatever data we want but we can't do it at scale because it's been impossible to build autonomous systems that can do that. It's only in last five years that technology i.e. machine learning and artificial intelligence has come to the point where it's even feasible to put a massive fleet of autonomous deepsea submersibles out there and have them map the ocean."

The other side of the coin is cost. The only subs with autonomy are the likes of Boeing's Echo Voyager. "But that's different; it's not scalable at US $120 million apiece. We're building these for, we think, less than $2 million apiece," says Kauffman.

GOOGLE EARTH - UNDERWATER

Terradepth has hired people from Tesla, people who know autonomy and AI, software specialists and technologists from other industries to all put their minds to this. "That's where you get disruption and that's critical to make everyone's job easier, because academics and researchers can't get the ocean data they need," says Kauffman. Sonar systems are already being tested in Lake Travis, Texas, and this has included gathering data to put into training machine learning systems. Indeed, AI and machine learning on sonar data is a big part of the company's focus. "Our robots will be able to automatically detect anomalies within the sonar data in real-time, while submerged, and make decisions around that target recognition without needed a human's input or oversight," says Kauffman. Testing of a 9m-long, 1 m-deep prototype (the commercial system will be smaller) is due to start in Lake Travis and then the US Gulf of Mexico closer in October. Tank testing of the energy recharge system was due to start in August.

The ultimate goal is something like a Google Earth type software system users can sign into and then go to the bottom of the earth and fly through a 3D point cloud terrain we've built, says Kauffman. And they're not just talking about a map. They're looking at building multi-dimensional data set to include <1m bathymetry, but also water column data, temperature, salinity and other chemical properties, as well as organisms detected there, and how that compares with one or five years ago in the same area.

"Climate change is a real thing, but a lot of people think we know why or how – and we don't because we don't know what's happening on our planet because it's too expensive," says Kauffman.

TARGETED MAPPING

The company is already looking at where needs mapping, something projects like The Nippon-Foundation-GEBCO Seabed 2030 project will help inform, based on conservation and commercial metrics. As for who will buy the data, Wolfel suggests governments, exclusive economic zone authorities, bodies like the US' National Oceanic and Atmospheric Association, but also telecommunications firms and others. There's also potentially salvage hunters. There's $400 billion of sunken treasure we know about but don't know where it is because it's too expensive to go looking, says Kauffman.

It's not quite the carer Kauffman originally envisioned when he left the Navy – he'd fancied the music industry, but then went into focusing on human capital in Silicon Valley, including working for Seagate Technology. "In Silicon Valley, I learned about some impressive stuff happening with autonomous systems, robotics and VR, and one day I just thought 'is anyone applying this to the undersea space', and took a high level look at it; Ocean Infinity, Sail Drone and so on were just getting off the ground."

Now Terradepth has joined the pack and Kauffman and Wolfel haven't looked back.

In-build
a frame that will become a Terradepth UxV.
Photo from Terradepth


NOAA
FUEL FILL
FUEL SHUT OFF
CAPTAIN
EMERGENCY PROCEDURES

Taking the Helm: Retired Navy Rear Admiral and Deputy NOAA administrator Tim Gallaudet takes the vessel's wheel during an August 2019 tour of the Weeks Bay National Estuarine Research Reserve in Alabama, with Eric Brunden, the stewardship coordinator for the reserve.

Photo: NOAA

RDML Gallaudet

Steering NOAA's Path Toward Uncrewed Maritime Systems

Last month NOAA and the United States Navy signed a new agreement to jointly expand the development and operations of unmanned maritime systems in the nation's coastal and world's ocean waters. Headlining MTR's Autonomous Vehicle Operations coverage this month is our interview with retired Navy Rear Adm. Tim Gallaudet, Ph.D., assistant secretary of commerce for oceans and atmosphere and deputy NOAA administrator, for insights on the direction and pace of the use of unmanned maritime systems for NOAA's future.

By Greg Trauthwein

Photos: NOAA

Photo: iXblue

"We partnered with (iXblue's) DRiX, which is a USV with a wave piercing bow capable of 14 knots. I would not have dreamed that we could collect IHO Order One bathymetry with a USV at that speed in significant sea states, but it can."

RDML Tim Gallaudet, NOAA

Photo: iXblue

When did you realize that yours would be a career dedicated to Oceanography?

I grew up in Southern California and hit the beach a lot. My dad was a naval officer so that brought me in contact with the service and working on the sea. As long as I can remember I always wanted to study the ocean and have a career on it.

Using the start of your career to today as bookends, put in perspective how the focus of "ocean issues" has changed the most.

In the 1980s when I was starting my ocean career, ocean issues were not as big as they are today. The areas that I've seen advance the most can be categorized in three main areas:

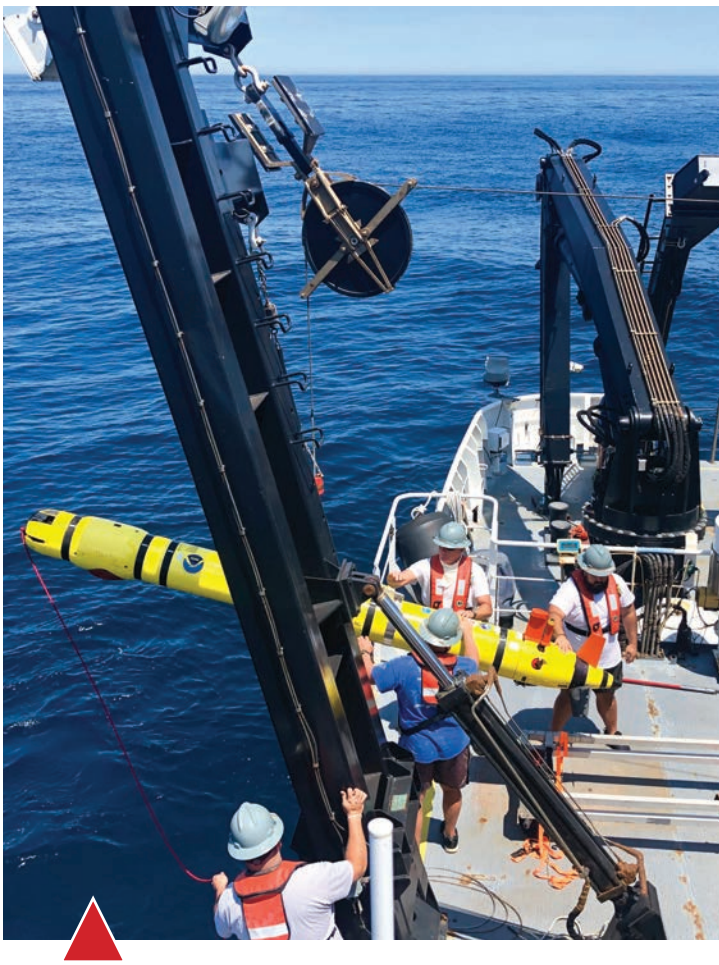
- Ocience Science & Technology: understanding has accelerated exponentially via technology. The things we know now about our ocean and its impact on our planet and climate are light years ahead of what we knew when I started.
- A growing appreciation of ocean health and conservation by the public. There's an increased awareness about the dependence of our security and our economy on the oceans. People simply care a lot more (today).
- A growing awareness of the necessity for sustainable use of our oceans, which includes everything from fisheries, to marine transportation, to critical minerals and pharmaceuticals.

Using that same time frame, put in perspective the evolution of unmanned maritime systems as you see it.

To start, just this week we've decided we are going to move from the word 'unmanned' to 'uncrewed.' I know 'unmanned' is an industry standard, but that's changing for all the reasons that it should: we have a lot of bright young women that are advancing these technologies. Looking at the evolution, when I first went to Scripps as a Masters student in 1989, the state-of-the-art was side scan sonar being towed behind ships, or the deep-tow that the Scripps marine physical labs used to conduct deep bathymetric surveys and exploration with cameras.

That was it. Today we have remotely operated vehicles rated to the same depth with HD optical and acoustic sensors, and then we have a plethora of UUVs, AUVs, ASVs, Hybrids – the collection capabilities of some of our multibeam sonars on our ships is like HD TV compared to what we had in the 80s. (The technological advances are) great to help us understand our oceans, (but) now you see it is more than simply a science exercise, as we are using this commercially for oil and gas exploration and for defense.

ROV Deep Discoverer
NOAA's remotely operated vehicle Deep Discoverer is recovered on NOAA Ship Okeanos Explorer following a dive exploring the Musicians Seamounts in the Pacific.
Photo: NOAA



AUV Recover
AB Peter Brill, AB Chris Remaley, GVA Sidney Dunn, and Acting CB Michael Collins recover the REMUS 600 using the J-frame on the CTD deck of the Okeanos Explorer.
Photo courtesy Charlie Wilkins

Arctic Mapping with Saildrone
Saildrone readied for deployment on the 2020 Arctic OCS Mapping mission in Alameda, CA. Saildrones are typically deployed to the Arctic from Dutch Harbor, AK, but due to COVID-19 travel restrictions, had to start the mission from San Francisco and transit across the North Pacific and the Bering Sea to survey the area.
Photo: Saildrone

Please give an overview of the size and shape of uncrewed maritime systems currently in the 'fleet' or at the disposal or NOAA, and discuss how you see this expanding and evolving in the future.

There is a rich array of capabilities. In my agency, we have a fleet of about 100 platforms; with our partners – primarily the Navy – we have a fleet of about 300 to 500. It offers a range of capabilities from long endurance to deep diving to surface vessels and gliders. We partnered with (iXblue's) DRiX, which is a USV with a wave piercing bow capable of 14 knots. I would not have dreamed that we could collect IHO Order One bathymetry with a USV at that speed in significant sea states, but it can. Then we're advancing our deep diving 6000m ROV capabilities and we're going to move more into AUV applications too. We have developed an unmanned systems strategy – soon to be renamed 'uncrewed' – that looks at the dramatic acceleration and expansion of our applications of these systems. We rely heavily on partnerships, and the goal is to make all of our ships 'Mother Ships' of these types of systems, to include uncrewed air systems, too.

The impetus for this interview was the recent agreement between NOAA and the U.S. Navy "to jointly expand the development and operations of unmanned maritime systems in the nation's coastal and world's ocean waters." Why is this agreement significant, and perhaps more importantly, why wasn't this type of agreement already in place?

NOAA has been working with the Navy, in fact they've been working with the Navy since I was in the Navy as the head of all Navy oceanography assets. Growing our autonomous systems was a goal then, and I developed a similar strategy to expand our operations and research in that realm. This new re-signing of an annex of a broader MOU is to implement a recent act signed by the president – the CENOTE Act or the Commercial Engagement Through Ocean Technology Act – that has specific provisions about the Navy and NOAA partnering, leveraging the Navy's infrastructure and best practices as well as other assets on the Gulf Coast. This includes a new Ocean Enterprise facility in the Port of Gulfport which is being built, and is intended to be our base of operations for uncrewed maritime systems. This partnership with the Navy is one of about a dozen that we have signed or will sign in the coming months (with commercial, philanthropic and academic organizations) – surrounding Ocean S&T, ocean exploration or autonomous systems. It's exciting to see how we're leveraging all that's out there in a smart way.

Okeanos Explorer
NOAA Ship Okeanos Explorer in port in Norfolk, Virginia, following the completion of the Windows to the 2019 expedition.

Image courtesy of the NOAA Office of Ocean Exploration and Research, Windows to the Deep 2019

Gearing Up to See Below
Jan Albiez, an engineer with Kraken Robotics, inspects Kraken's SeaVision, a compact underwater laser imaging system that was attached to a NOAA remotely operated vehicle for testing in 2019. NOAA entered into a formal joint research and development partnership with Kraken to combine Kraken's technology and desire to design and manufacture advanced mapping and ocean exploration systems with NOAA's ability to test and establish functionality while at sea.

Photos: NOAA

How does NOAA use uncrewed maritime systems today, and perhaps more importantly, how do you see the use of UMS expanding in the near- and long-term?

We are already conducting a wide array of activity, from marine mammal and fishery surveys using aerial drones; coastal mapping surveys with aerial and surface drones (to name but a few). Those are important because we have a new national strategy to map the U.S. EEZ. All in all, we are already using these tools widely, but not exclusively. Increased use of autonomy for every NOAA mission needs to become the standard.

When you look at the uncrewed marine systems today, what do you see as the number one technical hurdle to make these systems as prevalent as we've seen the systems become on land and in the air?

The ocean is a difficult place to work. I had the pleasure to meet Scott Carpenter, who has the distinction of being an astronaut and an aquanaut. I asked him to compare space to the ocean, and he said: 'Space is glorious, it's bright and shiny; the ocean is cold, dark and hard.' But we're overcoming (some of the challenges) with materials science to prevent corrosion; advances in battery technology to extend endurance. Jim Bellingham has this great hybrid AUV that we're working with the Alaska Domain Awareness Center to deploy this 600-nm rated Hybrid AUV in the Arctic.

Looking at the full scope of responsibility under your command, can you distill what you count as the top three or four advantages that come with a larger, more capable and connected uncrewed maritime system fleet?

As we expand this fleet of ours and apply them to all of our missions, performance is one. It used to be that you couldn't get the quality, but that has changed and you can get nearly the same quality of data from autonomous system. It is efficiency, too. We don't even need a ship with some of these systems, and they are particularly valuable in doing the dull, dirty and dangerous jobs. Just this last month, because of COVID our ships were pier-side and we had three major uncrewed system efforts to go perform missions and fill a collection gap that we had. We sent out saildrones to collect acoustic data for a pollock survey in Alaska, which is one of the most economically critical fisheries in our country; data which is essential to manage that fishery. We conducted an Alaska North Slope coastal survey with the same system, part of our Alaska mapping strategy. And then as the hurricane season started, we deployed with the Navy about a dozen gliders to sample the water column and the temperature near the surface, because that is a critical parameter to better forecast hurricane intensification. With these systems we are better able to predict, to save lives and property. All of this was done under COVID protocols.

In your career, what do you count as the number one technology evolution that has helped oceanographers to do their business more safely and efficiently.

I think technology is important, applying it smartly, but what I've found is the importance of culture. Big government agencies tend to move slow, (because) to be good stewards of taxpayer dollars we have rigorous regulations and policies. But they can be burdensome at allowing rapid change and quick transformation. At NOAA we released six strategies to advance S&T areas: uncrewed systems, artificial intelligence, 'Omics, cloud, data and crowd sourcing. This was to better foster collaboration among stove piped offices at NOAA. This lays out our collaborative areas, and partnerships are key to this, both with the Navy and private organizations.

Every leadership position has its challenges. What is your biggest challenge?

Resources. We never have enough in our budget for what we want to do. We are addressing the resources piece through the partnerships that I mentioned, allowing us to do a lot more with less, and this agreement with the Navy is a great example.

Meet RDML Tim Gallaudet, Ph.D., Assistant Secretary of Commerce for Oceans and Atmosphere & Deputy NOAA Administrator

Rear Admiral Tim Gallaudet is the Assistant Secretary of Commerce for Oceans and Atmosphere and Deputy Administrator of the National Oceanic and Atmospheric Administration (NOAA). From 2017-2019 he served as the Acting Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator. Before these assignments, he served for 32 years in the U.S. Navy, completing his service in 2017 as the Oceanographer of the Navy. In his current position, Rear Admiral Gallaudet leads NOAA's Blue Economy activities that advance marine transportation, sustainable seafood, ocean exploration and mapping, marine tourism and recreation, and coastal resilience. He also directs NOAA's support to the Administration's Indo-Pacific Strategy, oversees NOAA's Arctic research, operations, and engagement, and is leading the execution of the NOAA science and technology strategies for Artificial Intelligence, Uncrewed Systems, 'Omics, Cloud, Data, and Citizen Science. Rear Admiral Gallaudet has a Bachelor's Degree from the U.S. Naval Academy and a Master's and Doctorate Degree from Scripps Institution of Oceanography, all in oceanography.

Who do you count as the key mentor(s) in your career?

There are too many, and I would do a disservice if I tried to mention just one over the other. I will say the one that I always give credit to is my wife Caren. She was an oceanography major at the Naval Academy in the late 1980s, and we didn't know each other because she was an underclassman and the classes don't always mix it up that much. But she became a Navy salvage diver, then left the Navy to go to Scripps, which is where we met. She's an inspiration to me, first because she was a Navy diver, and you don't need to say more. And second, she was a Navy diver as a female during a time when it was not easy. In the late 1980s/early 1990s there was a lot of sexual harassment in the Navy, she was subject to it and that's why she left. To me, I would never want any of my employees or my 3 daughters to experience what she did; I'm committed to women empowerment, as well as diversity and inclusion in general in regards to race or gender. I'm a champion for that because of her. That's my hero.

If you had best advice for young people thinking of pursuing a career in oceanography, what would it be?

Just do it. Get into the field; it doesn't matter your skill set or experience base. There is a job for everyone in this community; we're making discoveries every day, and the well-being of everyone (on the planet) depends on our oceans.

"(My wife Caren) is an inspiration to me, first because she was a Navy diver, and you don't need to say more. And second, she was a Navy diver as a female during a time when it was not easy. In the late 1980s/early 1990s there was a lot of sexual harassment in the Navy."

RDML Tim Gallaudet, pictured with his wife **Caren**

If you had to recommend one good book, what would it be and why?

I'll recommend two. The first is *The Wave* by **Susan Casey**, a great read about oceanography. She's a great story teller, and probably more than any book I've ever read, it makes oceanography look cool. The other book is by a friend of mine and a mentor, **Admiral Bill McRaven**. He was the Chancellor of University of Texas, he led the Bin Laden raid, and he wrote a book called *Make Your Bed*. To me this is a must read for any American leader for the examples and lessons it teaches.

Outside of the job, what do you enjoy doing in your spare time?

We are an ocean family, we love to scuba dive, I love to free dive, I was an All-American swimmer and I keep that up with my girls. I surf when I can and we love to boat, I love to fish when my kids let me. Really, anything ocean related, from museums to aquariums, we do for fun. I consider myself lucky to have a job in a field that I love.


AQUA LUNG
BLUE MARLIN
DIVING ADVENTURES IN PALAU
BM

Samples Study
NOAA's Megan Cromwell retrieves as sample collecting during a dive off Puerto Rico.
Photo: NOAA

Samples Study
Dr. Nancy Foster Scholar Alexandra Avila recovers a crinoid sample collected using a remotely operated vehicle during a dive in the Gulf of Mexico.
Photo: NOAA

Uncrewed in the Air
Group photo on the Ronald H. Brown with an L3Harris FVR-55.
Photo: NOAA

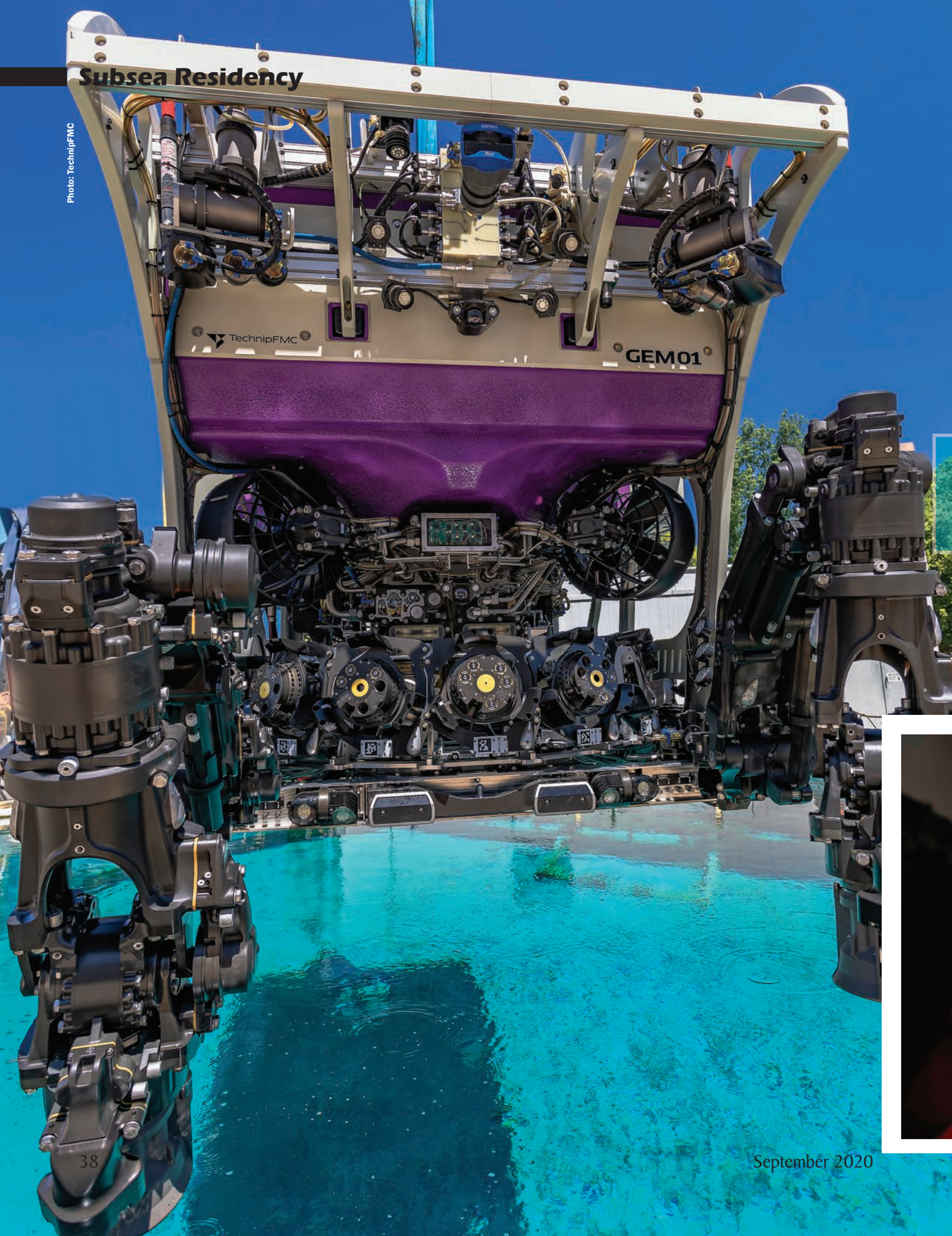
Ready to Go
Leaders and crew aboard NOAA Ship Okeanos Explorer.
Photo: NOAA

KATFISH
The Kraken towed KATFISH being deployed from NOAA Ship Okeanos Explorer.

Image courtesy of the NOAA Office of Ocean Exploration and Research, Windows to the Deep 2019

Gliders ready for deployment July 2018.
Photo: NOAA

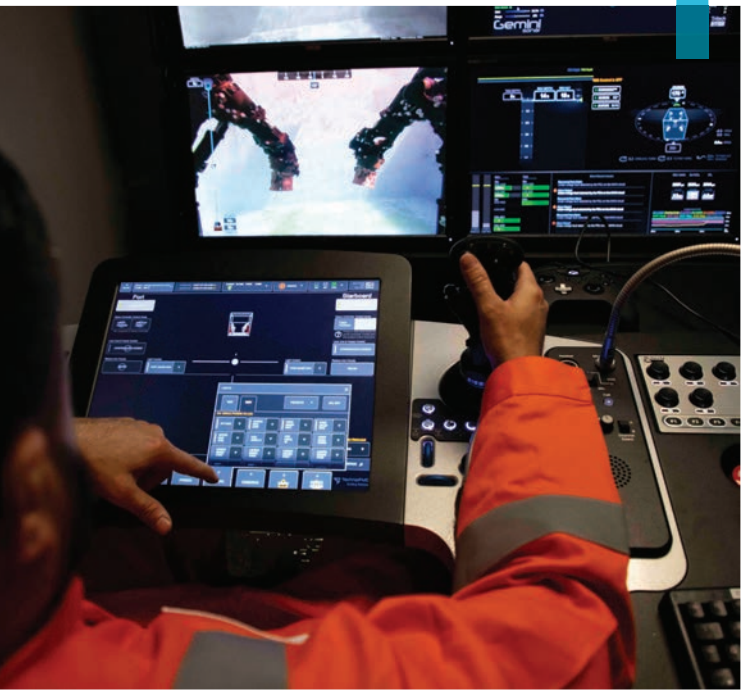
Photo: TechnipFMC



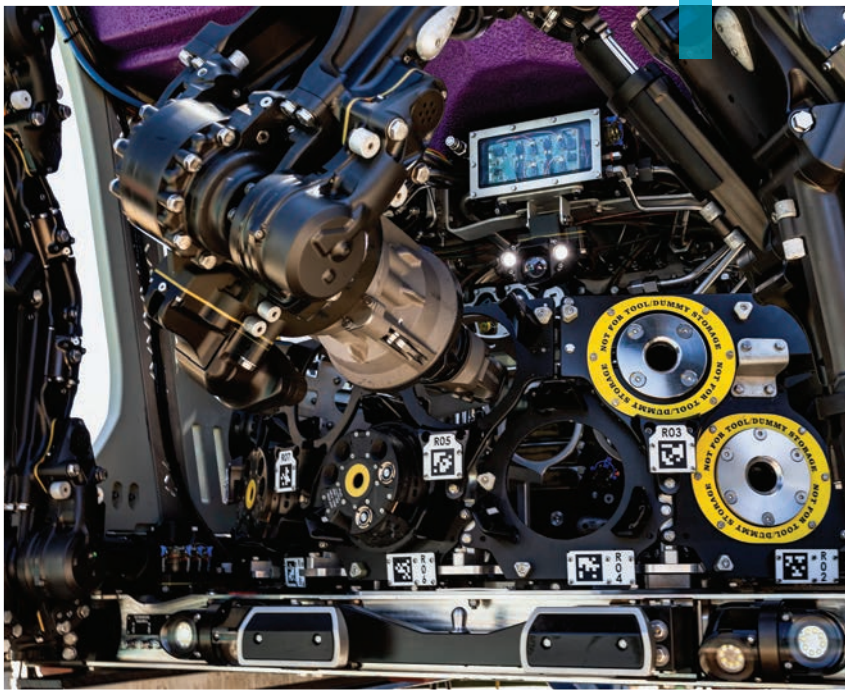
New Routes to Residency

Efforts to increase remote capability often go hand in hand with increasing ROV residency. But exactly what form residency takes is diverging. Elaine Maslin takes a look.

Touch screen controls allow pilots to press one button to select a new tool and let the ROV do the rest.



TechnipFMC's new Gemini ROV is already working in the US Gulf of Mexico for Shell. It comes with new manipulator interfaces and an onboard tool carousel.



Images from TechnipFMC

Subsea Residency

Dial back the clock five years and there was a movement towards an idea dubbed subsea resident remotely operated vehicles (ROVs). The idea, in simple terms, is that you increase ROV availability and reduce cost and carbon emissions by having the vehicle permanently based subsea in underwater garages. A number of vehicles could even cover a cluster of fields, potentially with different owners who can dial up, on demand, a vehicle when they need it.

The resident ROV wasn't an entirely new idea and there is still momentum behind the concept. But there's also fragmentation; different approaches and concepts and even alternative routes to providing remote ROV services without the need for a fully crewed vessel.

Subsea 7's tetherless autonomous intervention vehicle (AIV) has demonstrated its autonomous behaviours for inspection work offshore Norway and in the US Gulf of Mexico. In August, Norway's IKM Subsea reached a 100-day continuous subsea operations milestone with its tethered Merlin UCV R-ROV at the Snorre B facility offshore Norway, where it's been based since 2018, along with a tool stand, supported by on and offshore staff.

Oceaneering has been supplying ROV services through its E-ROV – an electric ROV deployed in a cage with batteries from which it can work for weeks at a time wherever it's been put – while its Freedom ROV (more of a hybrid AUV/ROV) was expected to start untethered offshore trials in August with operations focusing on pipeline inspection starting in Q4.

Other ongoing projects include Italy's Saipem and Norway's Eelume working on systems able to work from a universal docking station, built by Blue Logic in Norway, with support from Equinor. For Saipem, that means its Hydrone-R vehicle, which is set due to be deployed at Equinor's Norne field in the Norwegian Sea. Eelume, meanwhile, is targeting TRL5 by the end of 2021 for its snake-robot, culminating in two of them being deployed with a docking station at the Åsgard field offshore Norway in Q4 2021 for pipeline inspection, near template visual inspection and valve operation. Other concepts have also been covered in these pages, including Houston Mechatronic's shape-shifting robot and Modus Seabed Intervention's AUV system, as have moves to deploy ROVs from USVs.

Shorter stays, more capability

Part of the reason for this fragmentation is due to the range of operations ROVs can perform, from inspection to heavy duty intervention and a lack of definition of what a resident system needs to be, how long it needs to remain subsea and when remote operations is remote operations, says Peter MacInnes, marketing director, ROV services, at TechnipFMC, which has recently unveiled its new Gemini ROV, two of which are already working in the US Gulf of Mexico from two deep-water rigs. Most of what has been done to date, in terms of residency, has been at the observation end of the scale, he says.

With Gemini, TechnipFMC is targeting the heavy intervention end of the scale, for work on BOPs and subsea trees, for example, including fluid intervention, which is why it's a hydraulic ROV and not fully electric, says MacInnes. For

this type of work, it's not about the length of deployment, it's about what it can do while it's there, he says. That's why Gemini has been designed for month-long deployments, with some significant advances around tooling and automation (as well as having two manipulators as standard).

An ROV with a tool belt

In terms of tooling, Gemini comes with an inbuilt tooling carousel, with 15 tools, and a further 15 on the tether management system. These have a new interface; instead of the traditional manipulator jaws that grab a T-bar on a tool, the manipulator tip is a stab that picks up a tool and provides a hydraulic, electric and communications interface. The vehicle also has up to five machine vision cameras, so the vehicle knows what it's looking at and can more accurately measure distance; the machine vision cameras help fine-tune station keeping capability to within 25mm (better than what can be achieved with current navigation sensors, MacInnes says). Together, these capabilities enable the vehicle to perform predetermined tasks, such as tool selection, helping to overcome any issues with latency. The pilot (remote or otherwise) simply taps a touch screen to select the tool (an "intent based instruction") and the ROV does the rest – instead of having to bring the ROV to surface to reconfigure the tooling, says MacInnes. These capabilities take it a step closer towards operating under a level of supervised autonomy. And it means there's more consistency in the performance of these tasks (it could take anywhere between 10 minutes to two hours to insert a hot stab, depending on experience, with the current generation ROVs, says MacInnes).

"It's the similar technology to companies such as Tesla but more complex," he says, "because, for a car, all it has to do is avoid hitting something. As long as it avoids being within 2-3cm, it's done its task. We need to physically engage with things, such as insert a hot stab, and that creates additional complexity."

The move towards supervised autonomy will support a reduction in the amount of support required offshore, including ROV crew, says MacInnes. But whether full autonomy is needed – and if it could justify the investment that would be required – is questionable, he says. One thing that is viable, with the level of supervised autonomy that TechnipFMC is moving towards, is operating these systems from a USV, he says. "With supervised autonomy, we can start to interface this new generation of work class ROV technology with new generation of USVs," says MacInnes. "It's achievable and we

IKM Subsea has notched up 100 days continuous operations at Snorre B with its Merlin UCV R-ROV.

Photo from IKM Subsea

are on a path to achieving that."

On-board remote residency

Operating an ROV from a USV is on the target list for Fugro. It says that, by the end of this year, it will be the first company in the world to provide offshore subsea inspections via USVs and ROVs that are operated from onshore Remote Operations Centers (ROCs); including ROVs and autonomous underwater vehicles (AUVs) deployed from USVs.

Being able to use a remotely operated USV, ROV inspection solution to cover, according to Fugro, potentially 75% of today's inspection scope has the obvious safety, efficiency and sustainability benefits. It could also enable operations within the 500 m exclusion zone, due to the lower threat posed by a 12-tonne vessel compared with a full size ROV support vessel, says Ivar de Josselin de Jong, Global Director for Remote Inspection, Fugro.

The firm has a strategic partnership with USV builder SEA-KIT, from whom it has ordered its first two 12m vessels; one due to enter operations in Australia by the year end and the other coming into the North Sea early next year. The 12 m "Fugro Blue Essence" vessels will host a new "Fugro Blue Volta" high-power inspection eROV (electric ROV) able to do inspection work down to 450 m, says de Jong. In addition, a 24 m vessel is being designed, targeting 2,500 m depth deployment with a new "mid-range" eROV able to perform intervention work. The new hydrodynamically designed eROVs have been designed and developed by Fugro and the first two units are being built in their ROV factory in Singapore, with delivery due in October.

Delivering ROVs with USVs

As part of its new fully electric eROV design, Fugro is moving navigational intelligence to the vehicle to facilitate more efficient piloting and to prepare for future tetherless operations. Increasing the level of autonomy will aid vehicle control when deployed from an USV, with the USV acting as a surface gateway, when needed. Alternative scenarios could involve a development that enables the upload of a mission and let it execute the task, says de Jong. This could potentially support field resident scenarios with the USV acting as a taxi

Fugro has Remote Operation Centres from which to operate its ROVs and USVs.

Image from Fugro

for an ROV. The company is also paying close attention to developments in electric tooling.

"It's an important change and transformation, the ROV business is going through," de Jong says. But it's not without its challenges. "The big challenge with ROVs is that they need so much attention day to day. Field resident or USV based ROVs need to be left alone," says de Jong. "We're aiming at 30 days continuous ROV operations from the Fugro Blue Essence, remotely controlled from one of our ROCs. Compared to the current situation that's unimaginable. Changing from an 80 m ROV support vessel with 60-70 people on board moving to a situation where they are onshore."

Bandwidth, regulatory and HR challenges

The transition to remote and autonomous operations also brings connectivity challenges, he adds, Fugro's ROCs are equipped to facilitate the required bandwidth, uptime and reliability of the satellite connection, which is key to safe operations and effective data delivery To enable smooth operations upon delivery of the first systems, Fugro has taken up a front running role in developing the legal and operational framework, maritime regulations, etc. They are working together with regulatory bodies and flag states to jointly work on a guideline for uncrewed offshore operations, he adds.

It's also going to be a human resources challenge. "It's a super exciting environment and it's extremely interesting to be involved in these developments and at the forefront of this massive transformation," says de Jong. It's a transformation that is going to change the way people work, change the type of assets used and the legislative environment we operate in. "We won't have client representatives onboard because we

Touch screen controls allow pilots to press one button to select a new tool and let the ROV do the rest.

Image from TechnipFMC

won't have anyone onboard," says de Jong. "We have a remote client solution where clients from any location around the world, enter chat rooms, look at real time data acquisition and back deck CCTV that ties into the ROCs."

Power to the resident subsea robot

Meanwhile, others have been focusing on subsea power for underwater vehicles. Independent North Sea operator Chrysaor, for example, is working with wave energy firm Mocean Energy, subsea energy storage company EC-OG and AUV specialist Modus in a project to look at using renewable energy to supply subsea power for resident AUVs or subsea tiebacks. The project, supported by the Oil and Gas Technology Centre, will look to use Mocean Energy's Blue Star wave energy converter and EC-OG's HALO subsea energy storage system.

New Jersey based Ocean Power Technologies have launched a lithium-iron phosphate based Subsea battery system with a nominal storage capacity of 132 kilowatt-hours. It utilizes OPT's battery management system, can be scaled up, for higher power demand, and can be integrated with the firm's PowerBuoy wave energy convertor for recharging or used standalone.

What's clear is that all roads point towards increasing remote capability, which requires a level of automation, and ultimately towards autonomy. But opinions over the shape and form these systems take is, depending on their use, differ.

Eelume and Kongsberg Maritime have also formed a collaborative partnership with Triumph Subsea Services to support its and its underwater garage development. The partnership is focusing on 500m and then 1500m and 4000m systems, including a docking system that will allow Eelume to be deployed with ROVs and subsea packages to create an integrated autonomous subsea inspection and light intervention robotic system for easy launch from a vessel. Triumph will also fit two Eelume vehicles with residency garages onto all its construction vessels, including wind turbine installation vessels.

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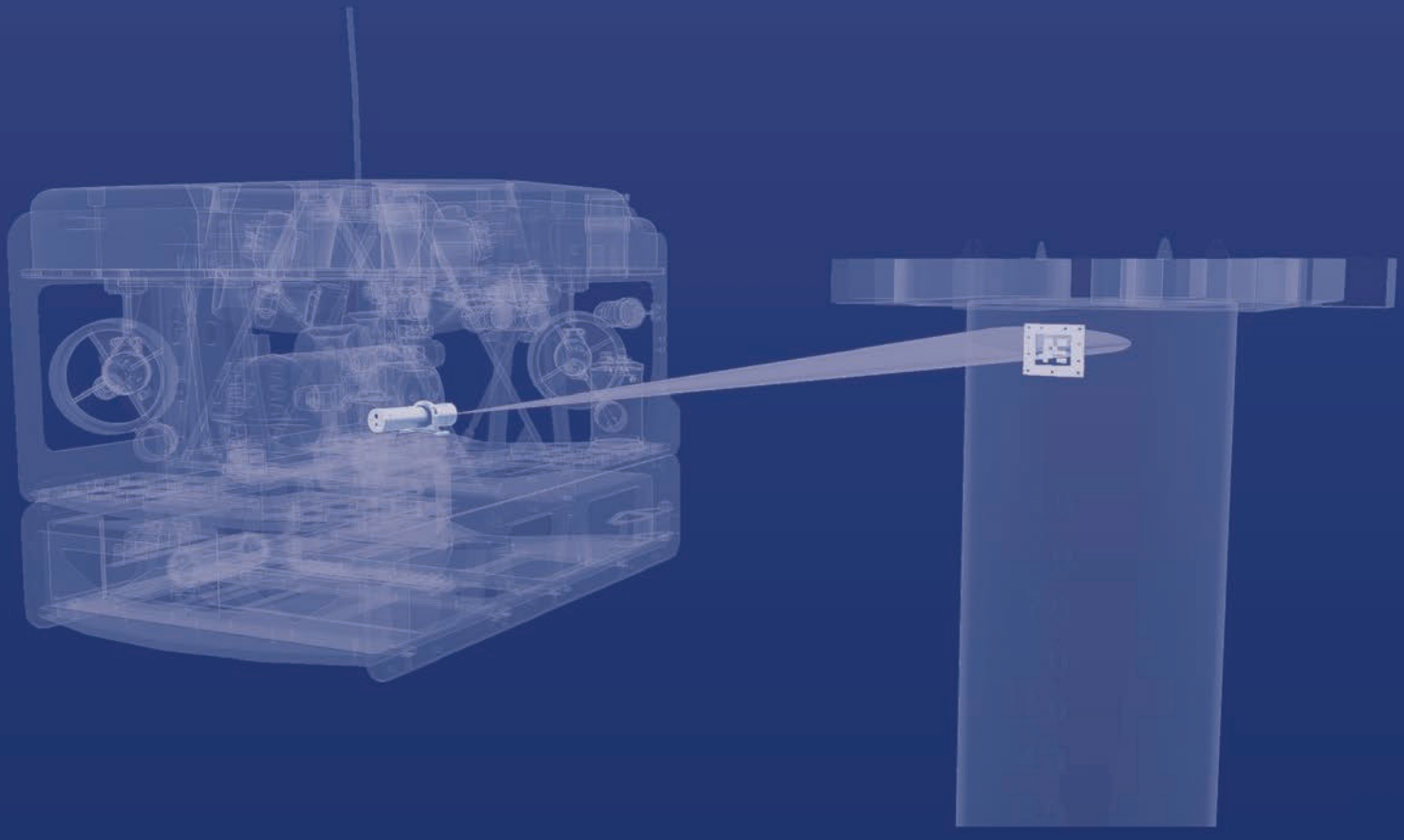

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FORSSEA ROBOTICS

Hacking 4 Environment

Oceans - Creating Entrepreneurs from Scientists, Students

The University of California Santa Cruz and the University of California San Diego completed a first-of-its-kind course that had student teams working to develop creative solutions to complex challenges facing our oceans – and the results are a reminder of the value in trying new approaches.

By Steve Weinstein

In the 10-week classes, held over spring quarter, 50 students grouped into teams of four used agile entrepreneurial approaches (Lean Startup method and Problem Curation techniques) to address an ocean-related problem that could use a new solution.

Student teams experienced what it is like to create a startup or policy solution focused around solving such challenges as kelp forest restoration, weaknesses in the fishing supply chain, water pollution analysis, flooding detection systems, using unmanned surface vehicles (USVs) to detect harmful algae blooms, and exploring new applications for eDNA measurement technology.

Equally important, the courses gave students the chance to make a difference in the world.

The class was co-created with the BMNT consultancy, and – working at UCSD, where it was called Hacking for the Environment: Oceans, with Sophia Merrifield and Eric Terrill; and at UCSC, where it was called Hacking 4 Oceans, with Radhika Malpani, Vikram Sahai, Anne Kapuscinki, and Sarah Eminhizer. We focused on creating solutions to complex social and environmental issues, addressing climate change through the lens of oceans and their interdependencies with land, air, and energy systems, using the Lean Startup method. One of our main goals was to have students learn lean innovation while coming up with new and creative ways to solve ocean problems.

To address these problems, the students blended academic research with market research and interviews of different stakeholders, ensuring that knowledge was translated into scalable solutions that could be successful in the business/real world.

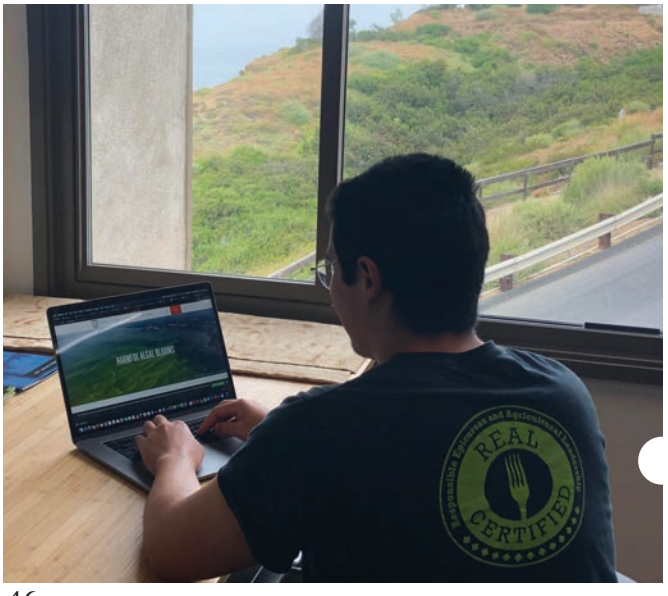

Image BMNT

UC San Diego mechanical engineering major Raymond Young works on a team project, sponsored by Boeing, for the class Hacking for the Oceans. His team is developing a software suite of autonomous unmanned surface vehicle behaviors that could help scientists monitor the environment for harmful algal blooms.

Thinking Differently for New Answers

UCSC's Team Blue Waltz Bio is one example of how this course helped bring together the best of scientific and entrepreneurial thinking. Blue Watz Bio students examined the pitfalls of current Environmental DNA (eDNA) measurements, as well as how they could apply the nascent technology to other needs, like endangered species and environmental impact assessments. One of the biggest hurdles was that eDNA tools require custom sampling equipment and expert users to generate useful data and insights. The project looked specifically at GenBank, an admittedly clunky software that serves as the National Institutes of Health genetic sequencing database.

Their solution improved the efficiency of GenBank by cutting time-consuming search terms and download requirements. Moving forward, the team is exploring alternative funding options, like grants and sponsors, and hopes to further improve on features.

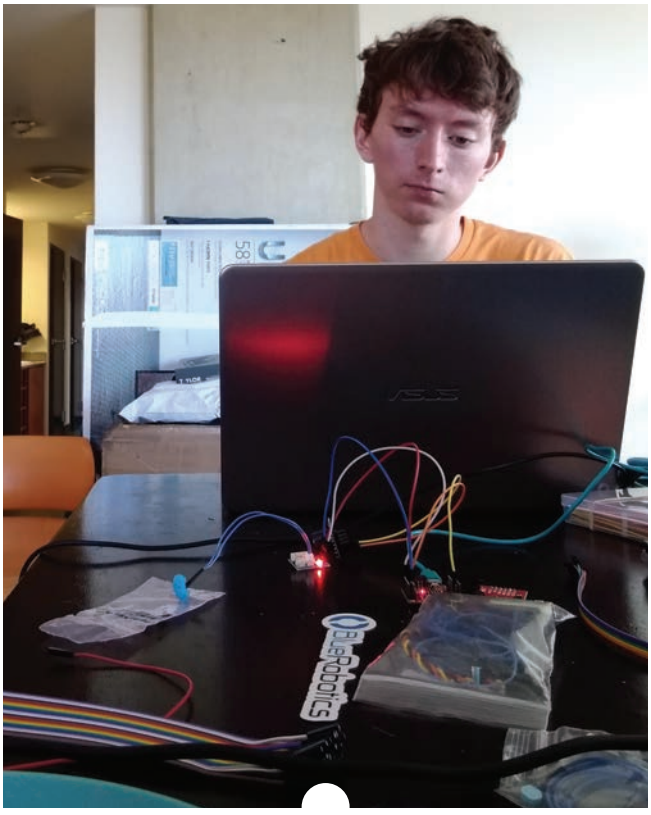

Image BMNT

Undergraduate electrical engineering major Seth Litman writes code for a sensor unit used to measure water level. Litman is on the CCCIA-sponsored team, which received mentorship from marine robotics company Blue Robotics.

Inspiring Mission-Driven Entrepreneurs

Hacking for the Environment: Oceans and Hacking 4 Oceans are the latest in a series of mission-driven entrepreneurship courses that have students across the country thinking differently about how to solve real-world problems.

The course series launched in 2016 at Stanford University with Hacking for Defense (H4D) – the idea of Steve Blank, creator of the Lean Startup movement; and (Ret) Army Colonels Joe Felter and Peter Newell, who had identified a need for national security innovation at speed. They hypothesized that graduate students could use Lean Startup principles to solve some of the nation's toughest national security and intelligence community challenges at speed. Four years and 40 universities later, H4D has helped create a national security innovation pipeline and given hundreds of university students a new platform for performing national service.

At the same time, creating "Hacking for" variants focused on social challenges, applying the same tools and processes to local municipal issues like the need for affordable housing and access to mass transit (Hacking for Cities), social issues (Hacking4Impact) and State Department issues (Hacking for Diplomacy).

The classes use Steve Blank's experiential Lean Launch-

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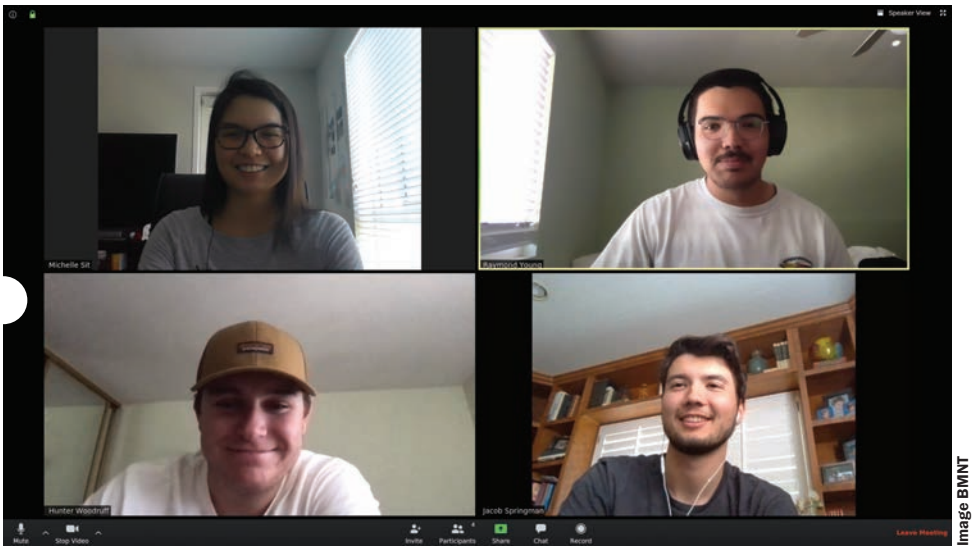

Image BMNT

UC San Diego students Michelle Sit, Raymond Young, Hunter Woodruff, and Jacob Springman collaborate via Zoom on their team project, which is sponsored by Boeing. The group is developing a software suite of autonomous unmanned surface vehicle behaviors that could help scientists monitor the environment for harmful algal blooms.

Pad curriculum. In 10 weeks, students work with sponsors and mentors to test their solutions for specific, real-world problems. In the case of Hacking for the Environment: Oceans and Hacking4Oceans, mentors and sponsors included the Nature Conservancy, the Oceanic Society, and NOAA Fisheries; policy experts from Scripps Institution of Oceanography as well as representatives from the innovation company BMNT, synthetic aperture radar company Capella Space, Boeing and NASA.

For the duration of the "Hacking for" courses, students interview stakeholders and beneficiaries each week to better understand the problems they're trying to solve and how people are affected by them. Just as successful entrepreneurs do, the students must also create and test minimal viable products (MVPs) to see if they have a workable solution, validate those MVPs with stakeholders, and figure out how to get their solution into the hands of those who would benefit from it.

Lean Approach to the Traditional Classroom

In Hacking for the Environment: Oceans and Hacking 4 Oceans, students came from various disciplines across the schools, but threw themselves into tackling ocean problems. The class is designed around a structured exploration process, which starts with identifying a pain point and proposing a theory of change hypothesis. Each team got to the finish line at a different pace, all of them dividing the effort into interviewing and learning ("understanding the problem"), testing minimum viable products, and expanding knowledge for ocean solutions.

Much like researchers in academic settings whose discovery process often requires a shift in focus, teams had to work their way through some pivots--rethinking their course as they discovered more about a problem--with the help and guidance of experienced business leaders who served as mentors. Blue Waltz Bio, for example, experienced this when they realized their initial idea was up against unbeatable competition (major companies and institutions were already working on a similar solution).

The rigorous interview process requires students to understand all the people affected by the problem they're looking to address, then do something highly effective: talk with them to understand how they experience the problem students are working to solve, who else might be affected by it, what the stakeholders have done to address the problem on their own, and whether the students' suggested solution would fix the issue. UCSD's Team Arctic Oracle, for example, spoke to 100 stakeholders on the way to devising a solution that uses SAR data and other sensors to measure ice thickness and other criteria to optimize shipping routes through the Arctic Sea.

Tracking Climate Change onboard SeaExplorer

Understanding the ocean's role in the global carbon cycle and its response to a changing environment is of crucial interest. The ocean is indeed known to be the only true net sink for anthropogenic carbon dioxide (CO2) and without this oceanic uptake, atmospheric CO2 would be significantly higher today than what is currently observed. The impact of this ocean acidification can already be perceived and current projections suggest that those changes will persist in the future. The reliable measurement of oceanic pCO2 at large spatial and temporal scales is therefore becoming critical.

A strong effort has been made recently for the development of low power, small in size and accurate enough CO2 sensors, which can be deployed in autonomous platforms such as underwater gliders. ALSEAMAR has participated to this movement by integrating the Mini CO2 sensor from Pro-Oceanus into the SeaExplorer glider rated to 1,000 m depth. The Mini CO2 sensor uses infrared detection to measure the partial pressure of CO2 gas dissolved in water.

In order to strengthen the understanding of CO2 dynamics in the ocean, a SeaExplorer underwater glider performed a campaign in the North Western Mediterranean Sea during the first half of 2020. For a comprehensive interpretation of the data, the glider was also equipped with a GPCTD-DO from Sea-Bird Scientific. The first deployment was realized in January 2020 (winter) and the second in June 2020 (summer). This mission aimed at studying the seasonal distribution of CO2 at sea in both winter and summer, by performing an inshore-offshore transect between the south coast of France and the DYFAMED time-series station (SOERE MOOSE). Operating in this area offers the double advantage of being able to sample contrasted oceanic conditions and to consider inter comparison exercises between glider data and reference DYFAMED's fixed mooring measurements.

Processing the CO2 data acquired during this mission required to deal with the response time of the membrane-based Mini CO2 sensor. Although the glider is a rather slow profiling device, the sensor response time led to a hysteresis in the obtained vertical pCO2 profiles. This was overcame by adapting published algorithm, i.e. by considering a linear dependency of response time on water temperature and by correcting the raw signal applying an exponential fit (Fietzek et al., 2014).

Once corrected, the data acquired with the SeaExplorer glider revealed contrasted situations between seasons, especially in the first hundred meters of the water-column. The most striking is that temperature and pCO2 were lower in winter and higher in summer, with a measured increase of about 50 µatm for pCO2. Such a co-variation is not surprising since changes in pCO2 in the mixed-layer are expected to be primarily driven by temperature changes. Another interesting feature is the subsurface pCO2 minimum (~370 µatm) that develops in summer, when the water-column is well

Image: Alseamar

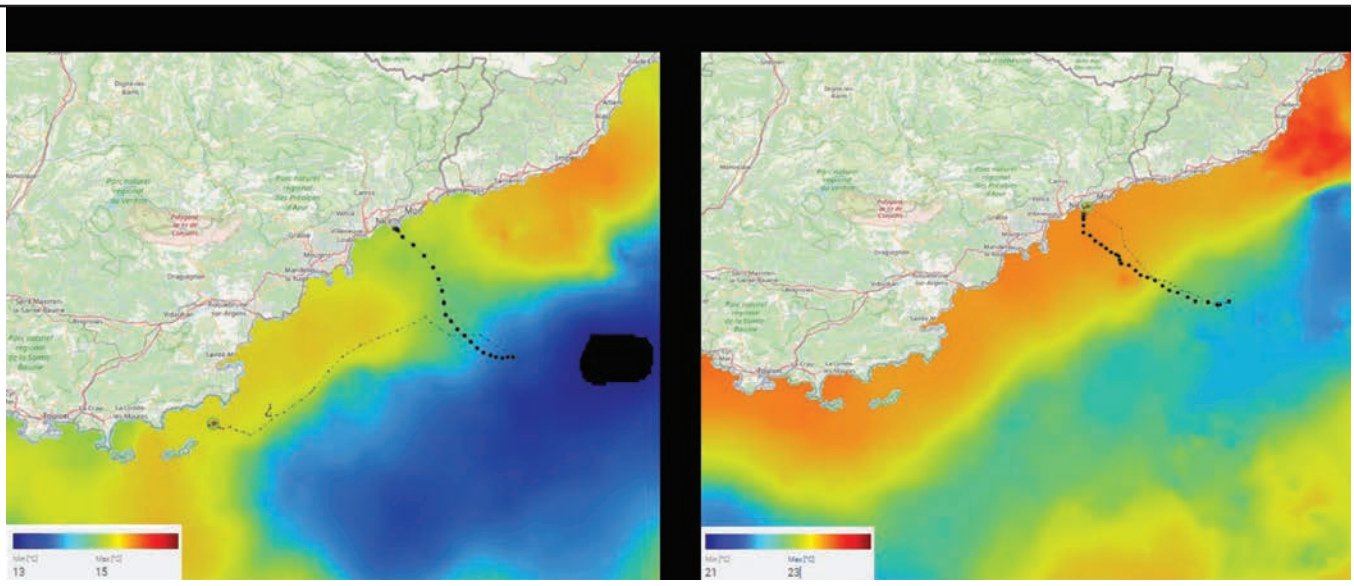

Image: Alseamar

Figure 1. **Glider trajectories superimposed to maps of Sea Surface Temperature. (SST data source: E.U. Copernicus Marine Service Information)**

stratified. This CO2-depleted layer is found between the 1028.2 and 1028.6 kg m-3 isopycnal levels and coincides well with an O2 maximum. This pattern is very likely to mirror the net biological effect, which includes primarily the CO2 utilization by the phytoplankton (photosynthesis). Below the 1029 kg m-3 isopycnal level, waters are CO2-enriched (~440 µatm) whatever the season, as a result of respiration processes. At these depths, variations in the pCO2 vertical distribution follow for the most changes in the density fields.

Those first results from this campaign are promising and highlight the great potential of measuring pCO2 with a glider for the scientific community. Further analysis and evaluation of the sensor performances will be conducted through a comparison with reference measurements made by autonomous Carioca sensors at the DYFAMED time-series station. The combination of a well-suited sensor with a highly enduring autonomous platform demonstrates here the possibility to perform persistent observations at sea with greater spatial and temporal resolution than traditional methods and at a fraction of the cost, thanks to the reduced operational costs of the SeaExplorer glider.

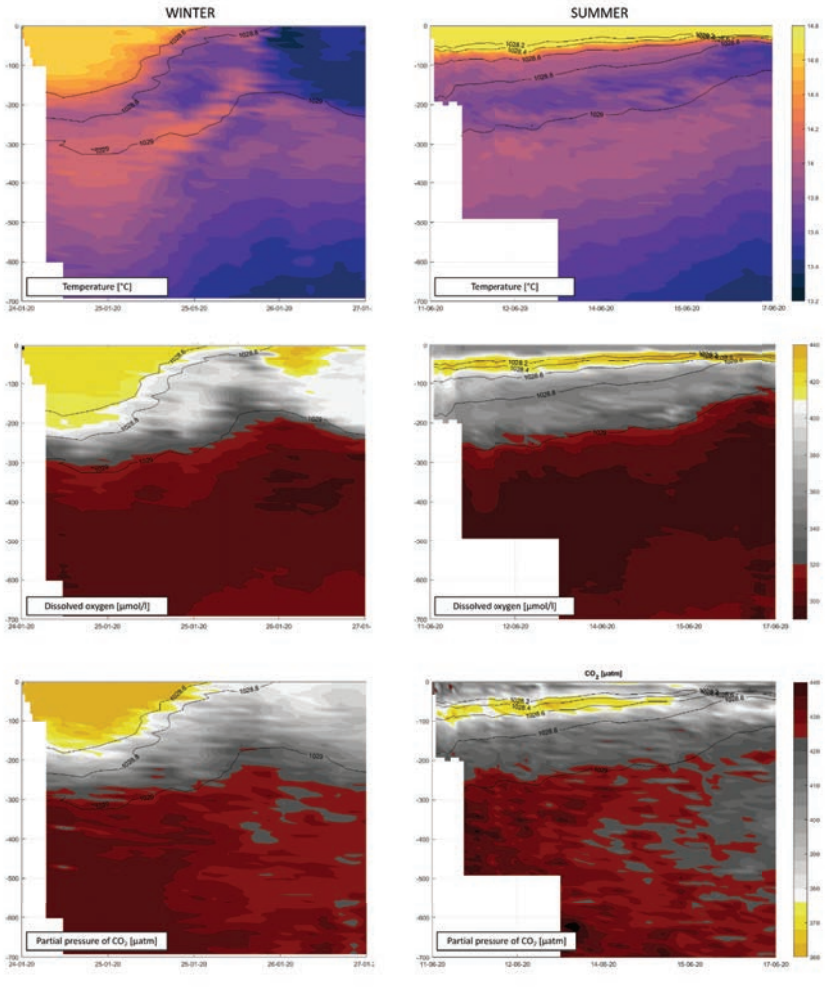

Image: Alseamar

Figure 2. **Data acquired by the SeaExplorer during the two deployments**

Case Studies

Innovative technologies @ work

Tracking Cables in a Muddy River

JW Fishers Mfg has designed and manufactured underwater search equipment for more than 50 years.

Commercial Diving & Marine Services, Inc., is one customer that has been in the spotlight recently for its underwater commercial applications. The Michigan based company has provided diving services for more than 40 years, and owner Keith Mear employs top-notch commercial divers that perform salvage operations, preconstruction surveys, endangered species investigations, sediment sampling, pipeline inspections, sonar surveys, water intake cleaning, and maintenance of industrial and municipal facilities throughout the Great Lakes. The company owns both the Pulse 8X and CT-1 Cable Tracker, and it was ecently tasked with two similar jobs that ultimately required two different pieces of equipment.

For the first project, the team was tasked with locating a 6-inch steel gas main that had been directionally bored, and JW Fishers' CT-1 Cable Tracker was the right tool for the job. The main was located on the shoreline of the river, but the exact location was unknown. With two separate construction operations taking place, both calling for cofferdams to be installed, the pipeline needed to be pinpointed before the projects could continue. Some pipelines are buried with a tracer wire alongside. The JW Fishers CT-1 Signal Injector can place a signal into this tracer wire, allowing the CT-1 Probe to trace the pipeline over great distances. The pipeline location and burial depth can then be pinpointed. Another key to tracking underground steel pipelines is that they are typically protected by corrosion coatings. Cathodic Shielding is a secondary protection system that uses a system of anodes and electrical currents to protect areas where the coating has been compromised. The JW Fishers CT-1 Signal Injector can be temporarily connected to the cathodic protection station to apply a signal and allow the probe to track the pipeline. Keith and his team ultimately located the pipe buried deep under the surface. "Using the CT-1 and the Pulse Injector, our team quickly located the line and had a survey team plot the coordinates. After locating the line our team measured for depth, in some areas the pipe was about 25 ft. under the river bottom." Divers Carl DeCaussin and Ryan Zohr were on the job and accomplished the work in quickly with the help of the CT-1 cable tracker. "Once we hooked up the pulse injector and got it working properly, we located the entire 200' run in about 15 minutes."

Commercial Diving & Marine Service, Inc. was subsequently contracted to locate another 6-inch steel gas main. This time, the general area of the pipe was known but the exact location was needed to allow for a bridge contractor to drive sheet pile. The pipeline was assumed to have over three feet of overburden in areas. "We needed the Pulse 8X to locate from shore to the middle of the bridge span where it was exposed. Another reason the 8X was necessary instead of just drawing a straight line was that drawings showed that the pipeline had two 90-degree elbows in it, however, they did not give the location of the elbows. Our diver was able to locate and buoy the elbow that was under the riverbed, it turned out the other elbow was under riprap on the shoreline." The diver located the pipe quickly and placed weighted buoys identifying the location for approximately 140 feet. Diver Carl DeCausin was on lead for this project.

Image: JW Fishers

Slocum Glider Completes "Epic Mission"

Teledyne Marine reports that its Slocum G2 Glider dubbed Silbo, manufactured by Teledyne Webb Research, completed a 4+-year journey that circumnavigated the Atlantic Ocean in four legs, a first for an autonomous underwater vehicle (AUV).

Silbo was named in honor of its 2011 maiden voyage from Teledyne Gavia in Iceland to the Canary Islands, a Spanish archipelago off the coast of northwestern Africa. Silbo Gomero is a language of the Canary Islands, used to communicate across the deep ravines and narrow valleys that extend across the island. Silbo then went on to complete a western crossing of the Atlantic Ocean.

In 2016, Silbo was updated at the Teledyne factory with an extended energy bay and thruster in preparation to circle the Atlantic Ocean. Launched in the early spring of 2016 from Cape Cod, Massachusetts, Silbo interacted with international science teams from several countries, collected scientific and critical engineering data along the way for a variety of programs, and returned to Cape Cod in late June of 2020. Other than a scratched hull repair, the only maintenance that Silbo received during the three stops was an external cleaning and a fresh set of batteries. For the first leg, from Cape Cod to Ireland, Silbo covered a distance of 6557 km in 330 days. While in Ireland, Silbo participated in a Glider Training session hosted by the Marine Institute and P&O Maritime Services, Galway. On the second leg, Silbo flew from Ireland to revisit the Canary Islands, covering 3695 km in 178 days, and participated in "glider school" at the research facility Oceanic Platform of the Canary Islands (PLOCAN) and the University of Las Palmas de Gran Canaria (ULPCG).

The third leg took 418 days (believed to be another autonomous glider record), where Silbo flew from the Canary Islands to St. Thomas, U.S. Virgin Islands, again crossing the Atlantic Ocean and gliding 6256 km. Supported by staff and students from University of the Virgin Islands (UVI), St. Thomas, Teledyne technicians recovered, re-batteried and re-deployed Silbo in less than 24 hours.

Silbo's fourth and final journey from St. Thomas began on July 18, 2019 and concluded on June 29, 2020 south of Martha's Vineyard completing the final 6236 km trek in 348 days. During this transit Silbo spent three months flying a butterfly pattern south of Bermuda contributing data to Bermuda Atlantic Time-series Study (BATS). Silbo then joined the Gulf Stream becoming the season's first storm glider as Tropical Storm Arthur passed directly over the glider. In all, Silbo covered 22,744 km and spent roughly 1,273 days at sea.

During Silbo's journey, it collected hurricane data, corrected current models, and provided close to 5000 CTD casts that aided metalogical forecasting. With partners from Rutgers University and its student base, UVI, PLOCAN, UGCLP, the Marine Institute, and others,

In all, Silbo covered 22,744 km and spent roughly 1,273 days at sea via four legs, starting in 2016 and concluding in June 2020.

Image: Teledyne Marine

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Blue Logic Wins Subsea Docking Innovation Award

Blue Logic won the Innovation Award 2020 from ONS, in the SME (small and medium-sized enterprises) category, for its development of an open-standard subsea docking station for underwater vehicles.

Blue Logic's seabed installed docking station is designed to enable underwater vehicles or drones to be permanently deployed subsea by providing access to power for charging and communications for upload/download of inspection and assignment data.

The ability to long-term or permanently deploy underwater drones is seen as a benefit for several underwater applications, enabling a reduction in risk to personnel, who can operate the vehicles from shore, a reduction in reduce the carbon footprint of subsea operations, by no longer requiring a support vessel on site.

A key component of the subsea docking station is Blue Logic's wireless connectors, which provide power and data transmission underwater. Development of the docking station also involved Blue Logic undertaking a significant amount of industry collaboration, with many companies and organisations contributing and participating towards the docking station's requirements and specifications in order to achieve a truly universal result.

"Equinor has been with us at the front throughout this process," said Stig Magnar Lura, GM, Blue Logic. "Together, we have jointly developed specifications and requirements. By working together in this completely new way, where the focus has been on developing open solutions with a common interface, we believe we have succeeded in a universal solution which all subsea vehicles will be able to utilize."

Helge Sverre Eide, Head of Business Development at Blue Logic, said "We have also worked closely with the drone suppliers – Eelume, SAAB, Oceaneering and Saipem – and held several full-day workshops in order to refine this solution to ensure its functional for the various players."

As a committee member of the American Petroleum Institute (API), Blue Logic has also worked toward API 17H and with the DeepStar programme in the U.S. to ensure that its open innovation falls within recognized industry standards. Designed and built close to Blue Logic's headquarters in Sandnes near Stavanger, multiple docking stations have already been tested, including at the Norwegian University of Science and Technology (NTNU) underwater test facility in Trondheimsfjorden, near Trondheim, as well as by SAAB in Sweden, Oceaneering at the Tau Autonomy Center near Stavanger. One is also due to go to Italy where Saipem will verify its functionality with its underwater vehicles.

The first underwater inductive product was introduced in 2005. Blue Logic has since developed several more products that can use and support the docking station, including inductive torque tools for valves, inductive fiber optic cable couplers, inductive couplers for drone tools and inductive subsea batteries.

Image: Blue Logic

Panther Wins GOM Pipeline Inspection Deal

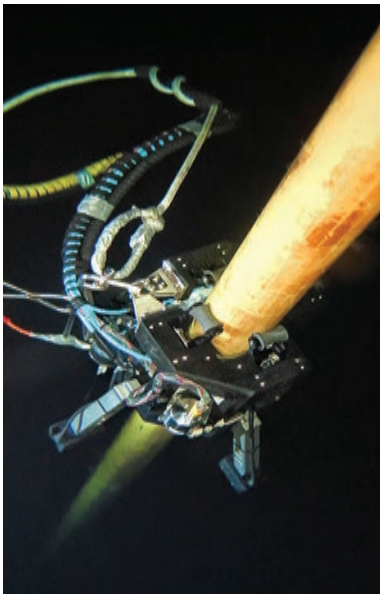
ACSM chose an electric Saab Seaeye Panther XT robotic vehicle for pipeline inspection in the Gulf of Mexico. The Panther inspected 261 pipelines totalling 2,340 km in four fields in the Gulf of Mexico (GOM), at depths ranging from 15 to 130 metres, in a less than 10 month project duration.

ACSM, a maritime, survey and ROV services operator, said that considerable savings come from deploying the 700 kg Panther system.

Rated for 1000 m, Panther's can accommodate a wide range of tooling with a 'plug and go' simplicity that makes it easy to change, maintain and repair systems.

The ROV's thruster power can handle the large array of equipment needed for full survey work - and provide the steadiness and agility needed to continue working even in strong currents.

The ACSM Panther XT is fitted with a Kongsberg HDTV camera, Norbit Dual Head MBES, ROVINS INS, Tritech Super SeaKing sonar, Blueview multibeam sonar, Teledyne Navigator DVL, TSS 440 pipe tracking system, CTD, Laser Line, CP and five-function manipulators and booms.



Welaptega

Riser Cleaning Technology

Welaptega innovated a cleaning system designed to safely and efficiently remove marine growth from risers.

Welaptega, owned by Ashtead Technology, delivered the Riser/Rope Cleaning and Inspection System (RCIS) to Ocean Installer AS for its inaugural deployment in May 2020.

The project saw riser cleaning operations carried out in Norwegian waters as part of the Balder X project.

Tyler de Gier, GM, Welaptega, said "This project with Ocean Installer marks the first occasion that a RCIS has been used in the field. Building on the decades of practical experience we have gleaned with our proven mooring rope cleaning and inspection Rope Measurement System, the RCIS cleans and inspects the surface of subsea tubular components such as flexible risers, marine power cables, umbilicals and fibre/wire moorings."

The RCIS frame is towed by an ROV at approximately 1m/s, efficiently cleaning both soft and hard marine growth. An optional module consisting of four cameras performs a full 360-degree close visual inspection of the riser or rope surface.

The RCIS, which can be used for unmanned operations, operates efficiently and requires no specialist offshore technicians to operate.

World First: Remote in-water Ship Surveys via ROV

As COVID-19 continues to challenge many business plans and practices, the advent of remote inspection techniques is growing in popularity. What is reported to be the world's first in-water remote ship surveys using a remotely operated vehicle (ROV) have been completed by DNV GL.

In-water bottom surveys using ROVs have now been carried out on three separate Wilson ASA-managed vessels with the first having been completed on the Wilson Fedje in December 2019 by a surveyor from Høvik.

The survey was performed earlier in July on another ASA Wilson-managed vessel in Bergen, Norway. Elias Triantafyllidis, the remote surveyor, attended the survey from the DNV GL DATE (Direct Access To Experts) hub in Piraeus, Greece. As with the two previous surveys, it was conducted in collaboration with VUVI AS, a Norwegian inspection company certified by DNV GL to perform underwater inspections for ships and offshore platforms using ROVs. "DNV GL has been carrying out remote surveys since 2018, so this service is an extension of a broad suite of remote services that are already available," said Knut Ørbeck-Nilssen, CEO of DNV GL - Maritime. "Naturally, the pandemic has pushed us to scale up the intensity of remote service delivery and we are fortunate that our longstanding commitment to digital advancement has meant we are well positioned to respond to the needs of our customers during this difficult time."

Survey planning and review of hull drawings were completed the day prior to the survey. During the inspection, the surveyor used VUVI's sonar technology to scan the vessel's bottom in order to locate the hull equipment, such as echo sounder sensors; speed log sensors and sea chests, while simultaneously assessing the general condition of the hull. The in-water survey was concluded in a similar timeframe to traditional surveys, approximately two-and-a-half hours, achieving the same level of assurance as an in-person survey. DNV GL's digital industry platform Veracity was used by VUVI AS, DNV GL and Wilson ASA to ensure secure data transfer when saving and sharing the video stream from the remote survey. "Working in a modern world, with technologies allowing us carry out a bottom-survey without deviation or off-hire, we are really enabling a huge potential for efficiency and environmentally friendly solutions," said Thorbjørn Dalsøren, General Director of Wilson Ship Management. "We trust this will be adapted to several more of our operations, taking advantage of digital solutions."

"VUVI AS has since the company was founded in 2013 focused on in-water survey of vessels as one of the company's core services," said VUVI CEO, Frode Rødølen. "We became DNV GL certified to perform in-water inspections in 2017, and re-audited earlier this year. We are proud to have become a trusted partner by DNV GL to perform inspections with our ROV teams, and we are inspired by the fact the we contribute in the shaping of the inspection-services for the future," said Rødølen.

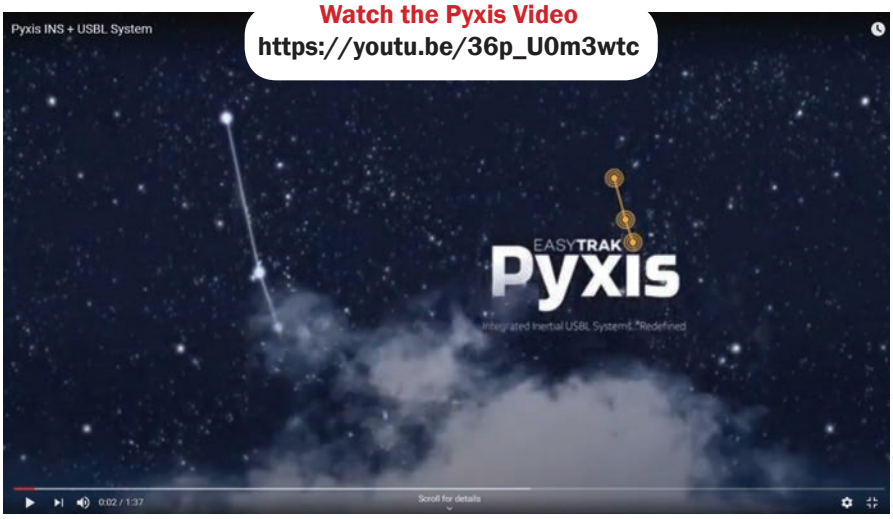
Image: DNV GL

New Products

Innovative new products, technologies and concepts

Pyxis

Applied Acoustic Launches Pyxis



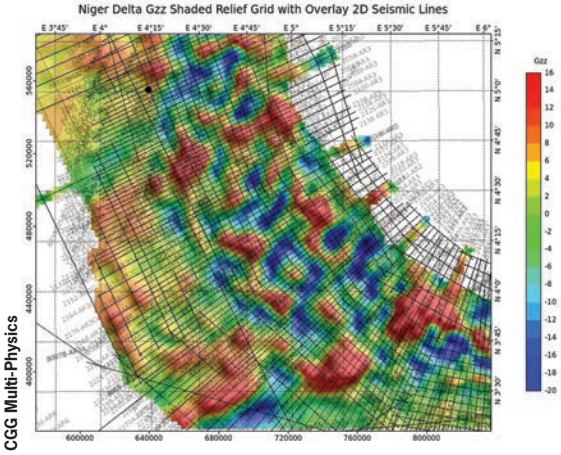
Applied Acoustic

Applied Acoustic Engineering (AAE) launched its next generation USBL system, Pyxis USBL. Taking its name from the constellation Pyxis Nautica, the mariner's compass, Pyxis USBL takes the best of AAE's subsea acoustic tracking technology with a highly advanced inertial navigation system (INS) to create a inertially aided Ultra Short Baseline system capable of accurate subsea tracking with survey grade performance.

The combination of AAE's Sigma 2 acoustic protocols and SBG Systems high precision Navsight Apogee Marine INS brings together two leaders, resulting in AAE's most accurate and long range positioning system to date, and in the process providing many time, cost and performance benefits to global survey operators.

As a tightly coupled, factory fitted package, Pyxis USBL is a portable, calibration free system able to immediately operate from any vessel as soon as the work site has been reached. The MEMS based INS does not fall under ITAR regulations, and the range restricted option means the whole system can be shipped unhindered and without export control to almost anywhere in the world. A feature of the Pyxis system is the ability for the operator to deactivate the range restriction in the field under an export-controlled regime.

Available with short range omnidirectional or long range directional transceiver options, the versatility of Pyxis USBL makes it ideal for very shallow operations such as diver monitoring, for deeper applications where ROV's and AUV's might be deployed, and for tracking short or long range towed sensors such as magnetometers and side scan sonars.



CGG Multi-Physics

CGG Multi-Physics: Imaging Updated

CGG Multi-Physics released an update to its LCT potential field software suite. Improved capabilities include enhancements to the software's workflows and improved ease-of-use.

Critical techniques required for comprehensive geological forward modeling, inversion, and management of potential field data have also been extended and enhanced to rapidly deliver an accurate model of the subsurface, for example the new LightTable module supports and integrates LCT's existing 3MOD and 2MOD modules for producing realistic geological models. Seamless integration of 2D and 3D gravity and magnetic modeling has never been easier.

Birns

Birns Brochure

BIRNS, Inc. launched a new resource for the subsea industry with its new BIRNS Millennium Interconnect Brochure. This detailed overview of the company's 6km rated BIRNS Millennium connector series and a wide range of relevant connectivity capabilities and options is expanded from its former revision of 18 pages to the new iteration of 49 pages. It includes interactive features like product selection and detailed part numbering guides, as well as configuration and specification tools to walk the user through the selection and ordering process **https://birns.com/**

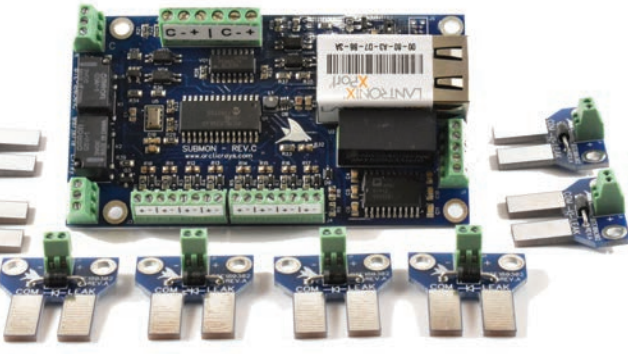
New South African Navy Survey Boat

Paramount Maritime, a Paramount Group company, said it has launched the first of three next-generation Survey Motor Boats (SMBs) to the South African Navy in continued support of its programs to enhance the capabilities and infrastructure of the South African Navy Hydrographic Office (SANHO).

In addition to the three Survey Motor Boats to be delivered to the South African Navy Hydrographic Office (SANHO), this program also provides for the delivery of a Hydrographic Survey Vessel and a Sea Boat as well as a third, fully operational inshore Survey Motor Boat, to remain ashore and in reserve. Veecraft Marine, a subsidiary of Paramount Maritime, had been tasked with the design and manufacture of the Survey Motor Boats, all of which having taken place within South Africa. The 11m length overall (LOA) Survey Motor Boat hosts two twin Volvo Penta duo-prop propellers, providing for greater fuel efficiency and effective and predictable handling alongside a Volvo Penta D3 joystick helm control system. The vessel's advanced survey equipment includes Multi-Beam and Single-Beam echo-sounders and Side-Scan Sonar and a Seabed Sampler to recover sample material from the sea-floor and underlying sub-strata for detailed analytical and testing purposes.

The vessel capabilities allow for near-shore shallow water surveys in depths of up to 300m. Training has additionally been provided for the Survey Motor Boat's multifaceted survey systems.

Paramount Maritime



Arctic Rays

Submersible Monitoring System

Arctic Rays released a compact Submersible Monitoring System for use in 1 atmosphere pressure housings. While designed specifically for manned submersible battery pods and electronics housings where immediate detection of leaks is critical, the monitoring system is ideal for all applications. The 90.5mm x 51mm x 19mm single-board system monitors for ground faults, leaks and includes on-board barometric pressure, temperature, and humidity sensors. The ground fault system monitors both poles of 2 independent DC busses up to 350V. The leak detection system can monitor up to 8 independent locations with the included remote self-checking water detection probes. The system has two on-board configurable alarm relays. It is electrically isolated and has ethernet and RS232 communications.

New Products

Innovative new products, technologies and concepts

GeoSpectrum

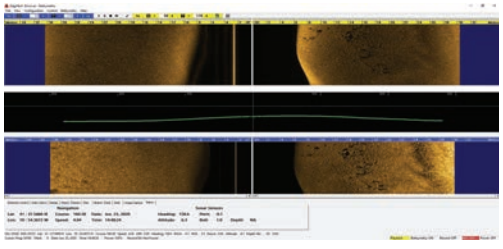
New LR Acoustic Effector

GeoSpectrum Technologies, an Elbit Systems' subsidiary, introduced the C-Bass family of compact Very Low Frequency (VLF) long-range acoustic underwater transducers. The GeoSpectrum patented C-BASS family of underwater transducers offers a deployable system that is small in size and weight but still maintains the high-power and frequency range (bandwidth) of legacy systems. Designed to be robust, affordable and easy to operate with, ranges exceeding 2500 km and capable to effectively operate under ice, the C-BASS family of transducers is suitable for a wide range of sub-sea applications including: communication/transmission from shore or surface units to submarines; divers' alert and communications; communication with Unmanned Underwater Vehicle (UUV) for control/positioning; mine sweeping, as well as augmentation of submarine signatures when transiting in or out of ports or narrow passages. C-BASS transducers are available in a variety of sizes and configurations from the 20 cm diameter configuration that can even fit in a medium UUV up to the 1.1 m diameter unit used in a multi-source high-power configuration for seismic exploration.

Edgetech: New Sonar Frequency Combo

EdgeTech introduced a new sonar frequency combination suited for shallow water USVs and UUVs. The new 850kHz and 1600kHz dual frequency combination provides high resolution side scan sonar imagery at both frequencies and optional bathymetry at 850kHz. The new frequency pair is available in EdgeTech's 2205 hosted platform product line of solutions. The EdgeTech 2205 is a compact, extremely flexible and configurable sonar system for integration on 3rd party underwater and surface vehicles. This modular unit can be configured, based on the customers' application, to collect side scan sonar imagery, sub-bottom profiles and bathymetric data, singly or in concert with one another. The system is provided as a complete package where the 2205 electronics are enclosed in a pressure vessel, or alternatively the core electronics can be provided as boards mounted onto a chassis so the customer can integrate the system into their vehicle's dry electronics area.

www.edgetech.com



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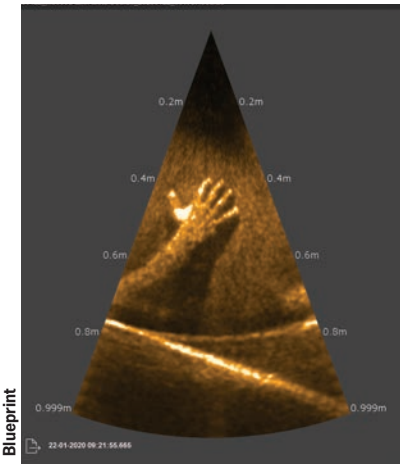


Blueprint

Ultra High Resolution Imaging Sonar

Blueprint have recently extended its sonar product range with the introduction of the M3000d dual frequency multibeam imaging sonar. For general purpose navigation and target detection the sonar is operated at 1.2MHz. This provides a maximum range capability of 30m and an acoustic aperture of 20 by 130 degrees. While the image quality at this frequency is impressive, it may be further improved by switching the sonar to 3MHz for target identification. At this frequency the sonar provides an exceptional acoustic angular resolution of 0.25 degrees and a beam spacing of better than 0.1 degrees. Near field focusing is performed digitally within the sonar and offers a minimum range capability of better than 10cm. All of this is done using the standard Oculus form factor, with a small space envelope and a weight in water of under 400g making it an ideal solution for small ROVs and diver handheld systems.

New Products

Manipulators & Tools

Robotic vehicles working underwater are only as good as their tools. *MTR* takes a look here are recent developments.

Saab Seaeye

What is reported to be the world's first seven-function all-electric work-class manipulator has been developed by Saab Seaeye. According to the manufacturer, this breakthrough heralds a significant advance in underwater robotic technology in the growing electric tooling and vehicle market. The all-electric work-class seven-function manipulator is designed to have equal power and more precision, delivering a 'more intelligent' in comparison to the hydraulic equivalent. Its control system enables both manual and automated control, with the potential for full autonomy in the future.

Oceaneering

Oceaneering has developed a completely new concept for its Freedom vehicle. It has designed a tooling interface that can either work inline of the vehicle, e.g. facing forward, or pointing down, by rotating it 90 degrees. All of the "smarts" for operating the tooling, including the motors, are on the vehicle so that the interchangeable tools (suites of which can be kept, ready to use, subsea) can be as simple and robust as possible. Designed for Freedom, the idea is for the interface to be compatible with the entire Oceaneering ROV fleet.

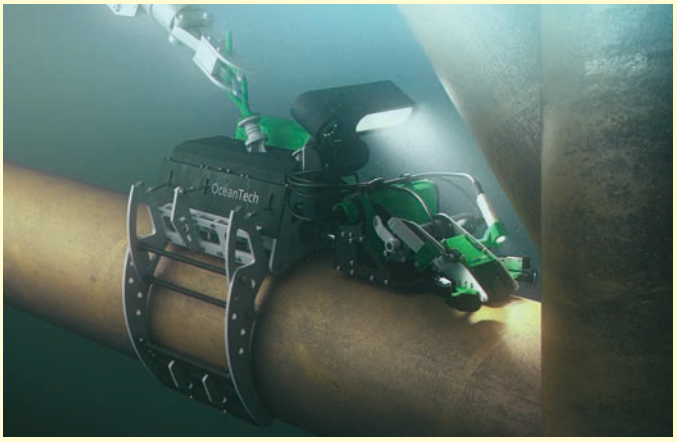
iCon Inspections

The new iCon, with its sensor package, could be decisive in an operator's bid to get a life-extension project approved. It can inspect for fatigue cracks using alternating current field measurement. For the first time, a degree of autonomous movement turned the iCon Deepwater Inspection Tool into a splash zone tool able to effect repairs below the waterline. It's crack-finding sensor — originally a handheld tool for divers — is affixed a probe carried by the robot, allowing it to trace subsea structures. Using machine vision and automated thrusts in six directions, the tool follows a weld right around a structure, staying just millimetres form item being studied.

Saab Seaeye Electric Manipulator

Saab Seaeye

iCon Inspection Robot



OceanTech

Oceaneering Tooling Package

Oceaneering

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