MARINE TECHNOLOGY REPORTER

May/June 2022
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AUV Extravaganza

Report on new, improved systems which made their debut @ Oi '22

Leadership Interview
Dawn Massa Stancavish

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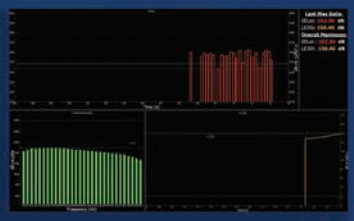

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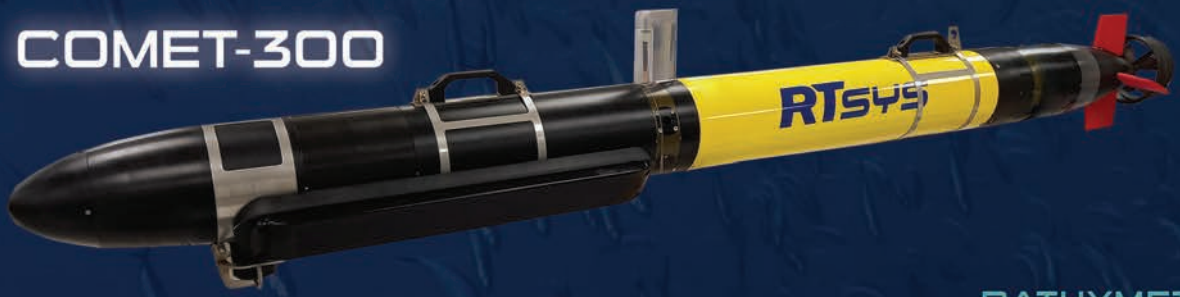

AUV

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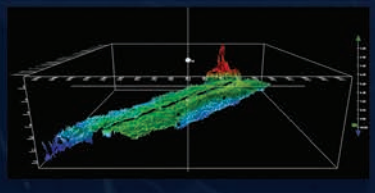

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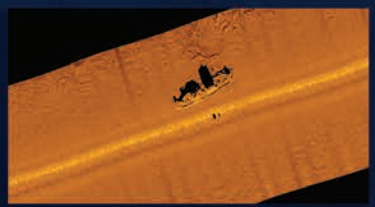

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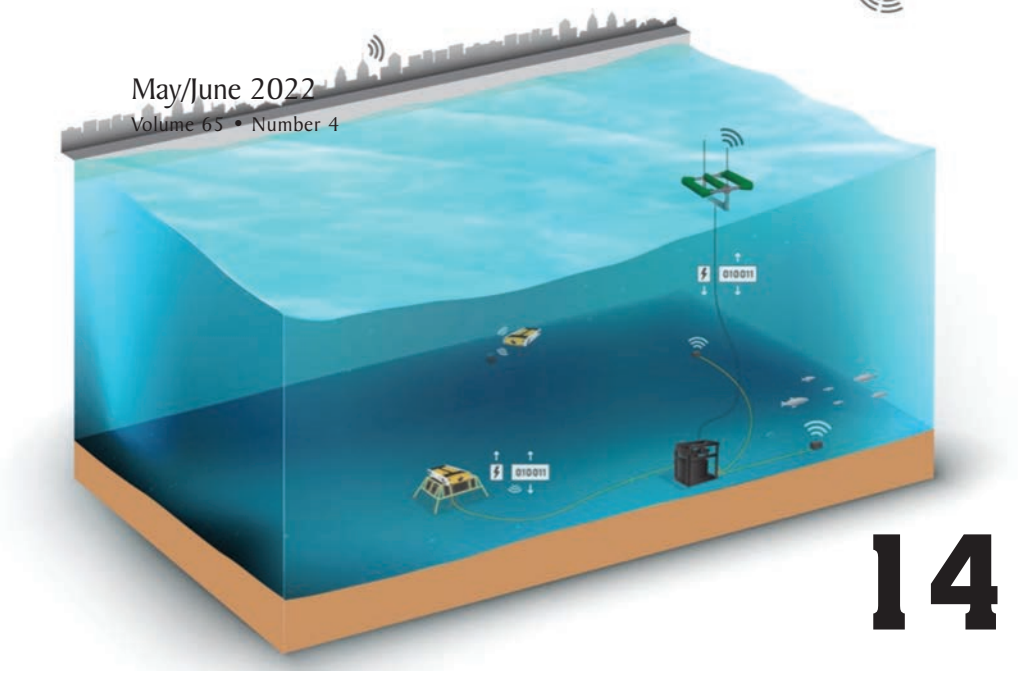

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Photo courtesy Massa Products Corporation

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Image courtesy Kongsberg

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Image courtesy Teledyne Gavia

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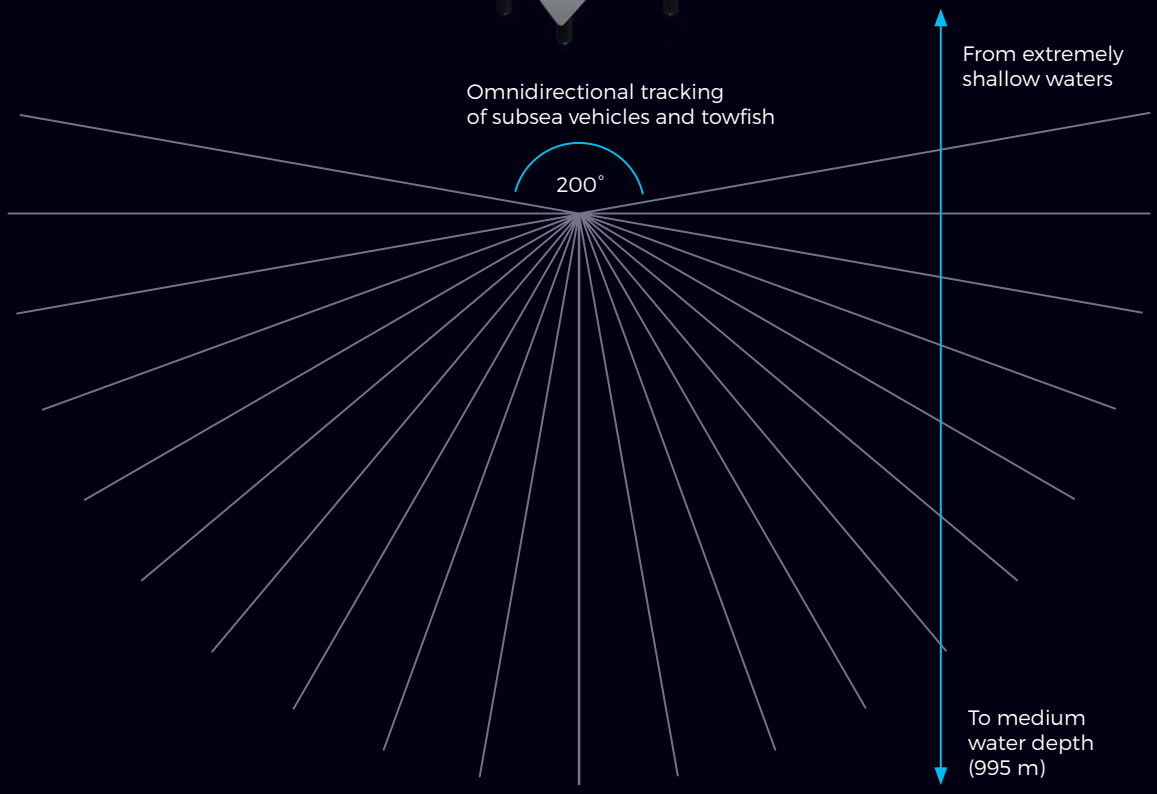

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Editorial

While I'm pleased to see the world starting to return to some semblance of 'normal' following a two-year hiatus from live events due to COVID, I must admit that regaining my 'travel / work balance' equilibrium has been somewhat of a chore, and is decidedly a work in progress. That said, our team has been out and about again with a vigor, internationally, as seemingly every show has decided to come back at once, meaning we've been splitting our team to maximize coverage across our subsea, maritime and offshore energy brands, and in the last six weeks alone we've been to London, Oslo, Tokyo, Miami and Atlantic City, to name a few.

All reports from London and Oceanology International indicate a raging success, and MTR's Elaine Maslin was on hand for the full three days of coverage. We went in with low to no expectations, and walked out with a load of stories and ideas that will sustain us through the summer.

Front and center in London were an amazing number of innovations in the AUV sector, a cumulative updated presented starting on page 44 in her cover feature entitled "AUV Extravaganza".

Closer to home, I had a great opportunity to engage with Dawn Massa Stancavish, the third-generation leader of this iconic sonar and ultrasonic products engineering company, for a soup-to-nuts interview on the company's colorful past and exciting future.

I must admit, having done this for now nearly 30 years, a personal favorite is to dig in on one topic, one technology, one company that has a long and winding track record, as you never know what you're going to find. What I found with Massa Products Corporation was an engineering solutions organization to the core … a company that has leveraged its technology from U.S. Navy nuclear submarines to AMF bowling score systems, and nearly everything in between. Following my interview with Stancavish for Marine Technology TV, I can safely say there is a lot more to come.

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Konowe

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ADVANCED NAVIGATION

U.S. Marine Sgt. Hadden Sherman, an explosive ordnance disposal (EOD) technician, assigned to 4th Platoon Littoral Explosive Ordnance Neutralization (LEON), 1st EOD Company, 7th Engineer Support Battalion, 1st Marine Logistical Group, works with an AMY unmanned surface vehicle used for sea floor mapping and mine hunting, as part of Baltic Operations (BALTOPS) 2021.

U.S. Marine Corps photo by Cpl. Robin Lewis

SONAR EMILY

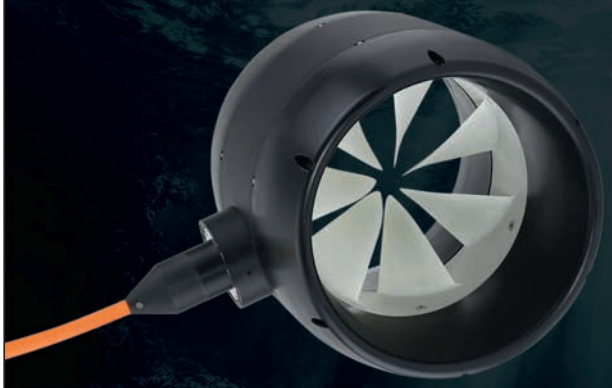
Affordable, easy-to-use underwater surveillance system

By Edward Lundquist

A surprisingly simple and affordable combination of technologies provides users with an affordable but highly effective underwater surveillance system. The Hydronalix Sonar EMILY Unmanned Surface Vessel (USV), equipped with a Johnson Outdoors Marine Electronics Humminbird sonar, and processing and displaying data with SAR Hawk software from Black Laser Learning, Inc. (BLL), safely and efficiently provides immediately usable data to support time-critical and underwater inspections and search and recovery operations.

According to BLL's Vince Capone, a side scan sonar subject matter (SME) expert an expert in marine technology, with over

NEW class of ROV Propulsion



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Images courtesy Hydronalix

30 years of worldwide hydrographic and underwater search and survey operations experience, the Humminbird was developed by Johnson Outboard for sportsmen. "There's a huge market for fishfinder systems. Fire and Rescue teams started using it to look for drowning victims, and then the science and engineering community. The resolution has been improved over the years. When you add processing like the SAR Hawk software, these systems have far more resolution in their data than is displayed on the small fisherman's screen," Capone said.

"It provides three types of data--depth; downward imagery and the sidescan imagery," said Capone. "We can take that and display it on a 4k monitor and really and deliver high resolution imagery in formats that that may be helpful to a lot of people"

"For depth, we get strings of data representing the depth below the surface of the water by means of an echo sounder, referenced to the movement of the vehicle," Capone said.

The data is compatible with the industry-standard ArcGIS data format in both directions. "You can take our data and put it into your own ArcGIS system, or bring data that's relevant to what we're viewing into SAR Hawk. If I have satellite imagery, topographic data or any geo referenced data, it can be brought in and layered in SAR Hawk, or the SAR Hawk data can be exported and be layered with the customer's system."

The Emergency Integrated Lifesaving Lanyard (EMILY) vehicle was developed for lifesaving, and represents a high technology solution with a low barrier to entry to acquire and deploy. It can carry payloads to conduct missions, such as the sonar version.

EMILY was launched from a series of Navy-sponsored Small Business Innovation Research (SBIR) investments starting as far back as 2001. Mulligan said the rescue version is used around the world. "It saves lives every day," he said.

Hurricane Dorian hit the Bahamas in 2019, severely damaging Great Abaco Island, and shutting down Marsh Harbor. "Our job was to make sure the shipping channel was open, so the rescue and supply ships could safely come in so they could reopen the airport and help the doctors, medical staff and administrators along with the medicines, equipment and supplies to come in so they could reopen the hospital and begin treating patient," Mulligan said. "All the ships that followed used the clear-passage map generated by the EMILY sonar."

The Swiftwater EMILY version comes with a bigger battery and a higher-power motor for use in fast current or very rough water conditions.

The Sonar EMILY system doesn't replace divers. But it can narrow down a search area or help determine the full the condition of underwater structures, giving divers much more information before entering the water, especially in situations

with extremely low water clarity and visibility. It can point out debris and objects that could entangle a diver, making the dive safer.

"Water clarity does not impair the imagery with Sonar EMILY," said Capone. "It's unaffected by turbidity. It provides clear imagery no matter how turbid the water."

The Michigan and Montana Departments of Transportation have procured Sonar EMILY to perform scheduled monitoring of underwater bridge foundations, as well as more urgent inspections following high-water events, such as heavy rain, snowmelt, or a dam breach.

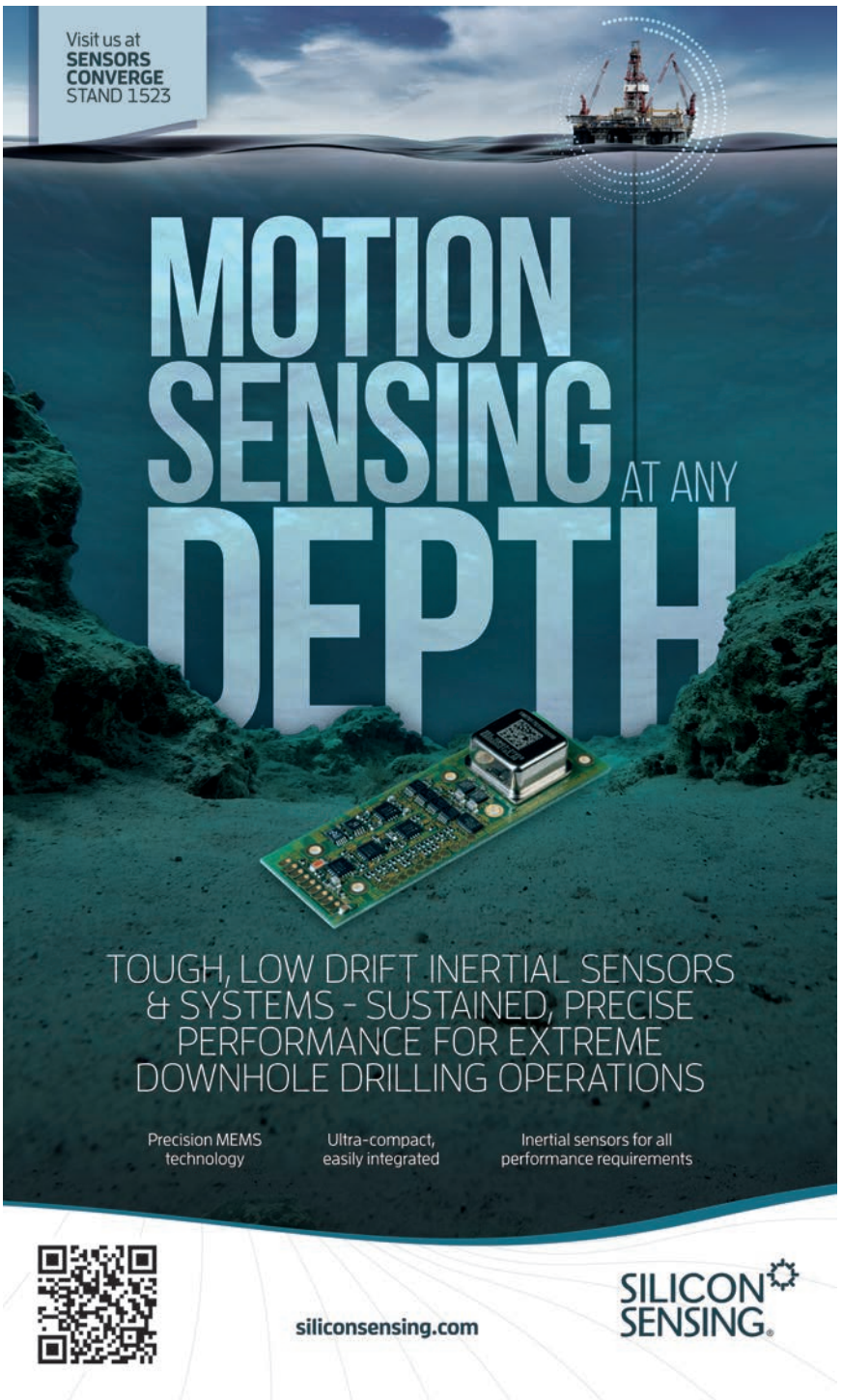
In May 2020, Michigan's heavy rain and flooding destroyed two dams and left a path of destruction. All downstream bridges were closed until they could be inspected. However, conducting those emergency inspections are usually when they are also more difficult and dangerous. While each bridge might take up to a day to survey under a traditional inspection requiring equipment to be transported and assembled on site, the Michigan DOT team was able to inspect around one bridge an hour using EMILY.

Casey Collings conducts underwater inspections for Great Lakes Engineering, and appreciates knowing what he'll find below before diving, especially in bad visibility. "Sometimes we can't see out of our mask, let alone see six inches ahead of us. With this system, we can deploy it easily and safely, and we'll know if we're going to encounter a tree trunk coming up, or a shopping cart, or, like last week, a toilet. It kind of gives us peace of mind."

Sahuarita, Ariz.-based Hydronalix CEO Tony Mulligan said the company is looking at installing the new Humminbird APEX sonars on Sonar EMILY. "One advantages of the APEX system is we can connect it through a small portable radio with your smart tablet, or your phone or even your Smart TV. You don't even have to have a ground station."

Capone said most towed sidescan sonars are quite expensive, and they take quite a bit of skill to operate properly.

"Like Sonar EMILY, we designed SAR Hawk to be simple and easy to use," said Capone. "You can buy professional-grade software at 20 to 30 times the cost that will require weeks to become proficient."



Acoustic remote sensing for underwater archaeology

High resolution multibeam mapping of the submerged city of Baia, Italy

The greatest archaeological treasures are not only hidden below the ground but many of them remain below water, on the seabed and beneath. This is the case of the submerged city of Baia located in the Gulf of Pozzuoli in the western part of the Bay of Naples (Italy). It was a famous and fashionable resort city in Roman times, with luxury villas and baths with hot springs. Mostly of the city was submerged between the 3rd and 8th century AD due to vertical ground movements induced by a local volcanic phenomena known as "Bradydeism". To protect this, in 2002 the underwater site of Baia was designated as Marine Archaeological Park and Marine Protected Area with an incomparable cultural and natural value. There are several underwater archaeological assets ranging from 5 to 13m of depth. One of them is Villa dei Pisoni (Fig. 1), which was owned by very wealthy Roman patricians but was later sized by imperial authority following a failed conspiracy against Nero.

In November 2021, Norbit Subsea and 2BControl, in collaboration with Institute of Heritage Science of the Italian National Research Council (ISPC_CNR, Naples) have conducted a very successful demonstration in the Baia submerged Park. Recent developments in high frequency acoustic mapping allow for detailed reconstruction of submerged objects providing a valuable tool for recognizing and describing archaeological resources at the seabed (Figs 2 and 3). Surface imaging with centimetric resolution using multibeam sonar gives a wide and comprehensive picture of underwater sites of cultural interest.

The survey carried out on 8 m long motorboat r/v ULISSE during two days of data acquisition, using the WINGHEAD i77h, the new high-resolution multibeam sonar system from Norbit.

A 10 cm DTM is the first result of the high data density and resolution acquired, a primary record of the current state of the submerged archaeological features. The extreme details and accuracy obtained will help to refine the overall mapping and measurements of the villas, supporting the Park monitoring and preservation. Moreover, thanks to the ultra-high resolution of the xyz real data detected (centimetric resolution) the 3D shape point clouds views are an adding and meaningful value for the interpretation of the secondary features mapped inside the villas, great support to the deep understanding of the ancient use of the areas present in this spectacular submerged site.

The WINGHEAD is a part of Norbit curved array, bathymetric integrated systems family with 1024 true beams (0.5°x0.9°), frequency range of 200kHz to 700kHz and high-end navigation. Its portable and light construction allows fast mobilization on almost every boat. Friendly user interface with easy-to-follow setup steps makes it very easy and quick

Fig.1. General view of mapped bathymetry in the Baia Marine Protected Area.

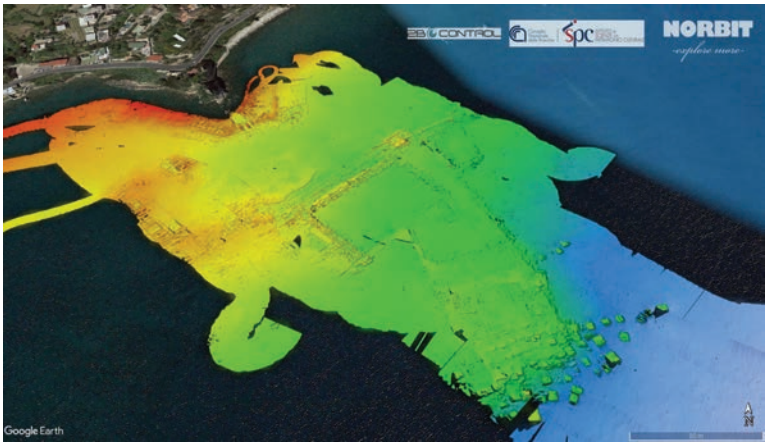
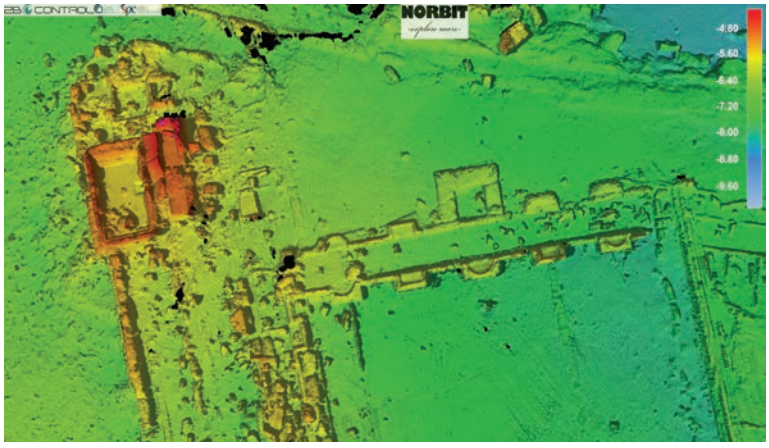
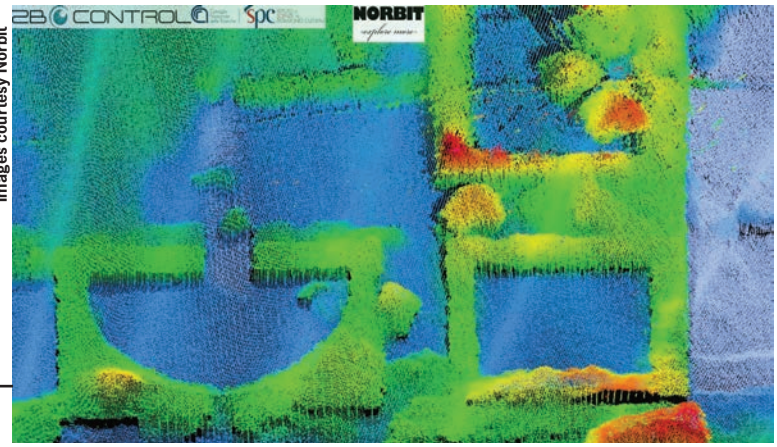


Fig.2. Submerged site of the Pisoni's villa and surroundings.



Images courtesy Norbit



Images courtesy Norbit

Fig.3. Zoomed point cloud view of the north-west side of the Pisoni's villa based on multibeam data.

to learn. Most of the parameters can be left as default and provide precise bathymetry even for an unexperienced operator.

Even though archaeological research in the Baia area started in XIX century, the Gulf of Pozzuoli still has many secrets to reveal. Remote sensing methods based on underwater acoustics have a big advantage over diver's work. As they can provide a full picture of extensive areas with high resolution images helping to understand their current state and past function. With these innovative tools new discoveries are within reach.

About the Authors:

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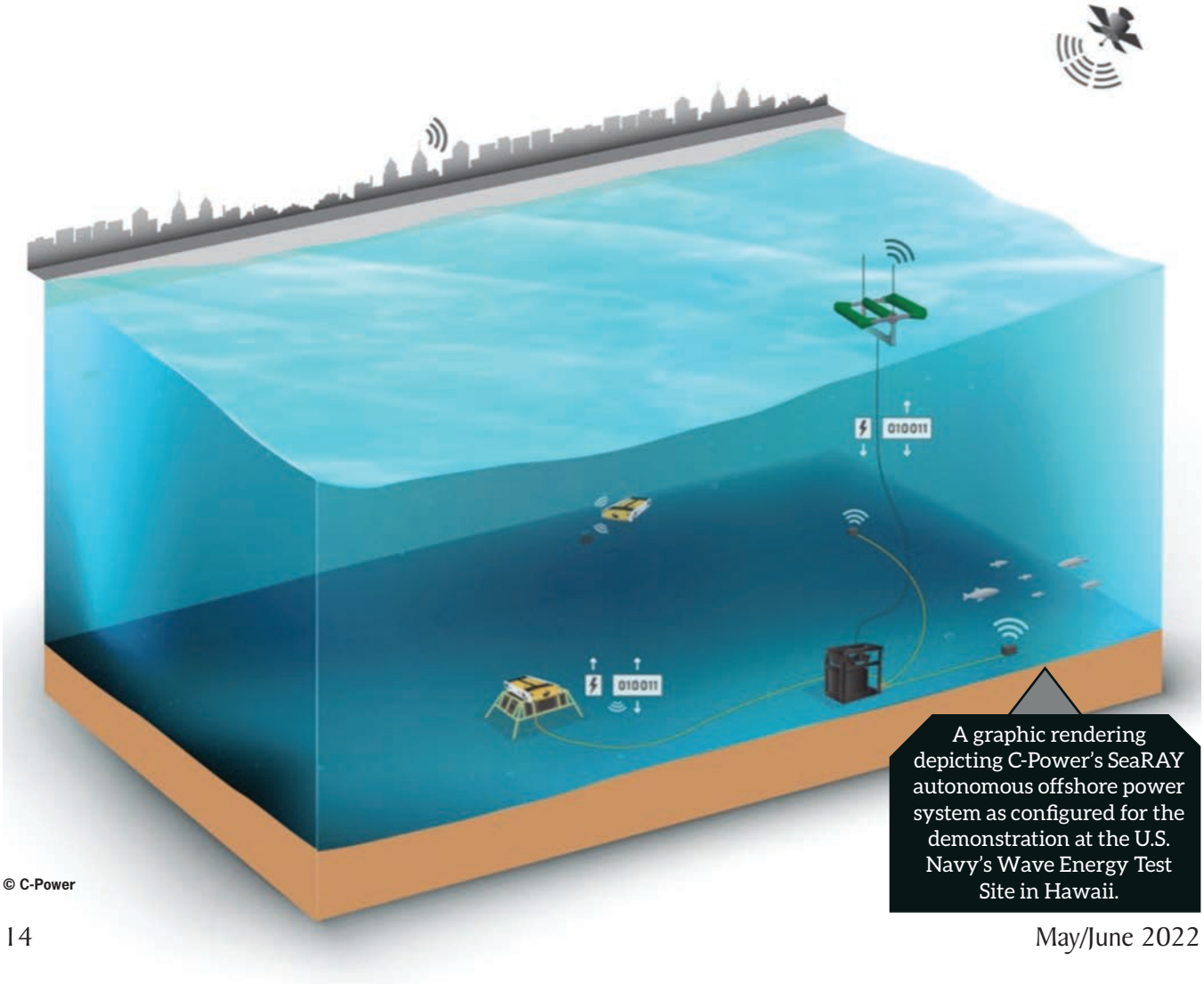
- Dr Aleksandra Kruss, benthic habitat mapping specialist, surveyor and scientific expert of NORBIT Subsea

A Blue Desert

By Celia Konowe

Last year marked the beginning of the United Nations Decade of Ocean Science for Sustainable Development, lasting from 2021 until 2030. With 10 years comes 10 challenges—goals for regional, national and global participants to work towards for positive, collective impact on our oceans. Included in the 10 are ocean-based solutions for climate change, expanding the Global Ocean Observing System, creating a digital representation of the sea, and access to data and technology across all marine stakeholders. These and others on the list depend on collecting increasingly more ocean data. While technology to monitor marine systems is rapidly adapting and expanding, it surfaces new issues such as offshore energy generation and storage to support sensors, operating equipment, subsea vehicles and wind farms. What's necessary, therefore, is a way to not only store energy onsite underwater, but to also replenish those systems in a renewable and sustainable way — TE Connectivity, a multi-industry connector and sensor engineering company, points to grid stability and compensating for times of low production. Different power sources added to the grid can cause fluctuation and having power available, short-term, can help compensate. In times of low power production — when the sun isn't out or the wind is calm, energy storage is crucial to meet demands. Across the industry, technology companies and research institutes are racing to fill the gaps, providing solutions from offshore power systems to underwater batteries.



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A graphic rendering depicting C-Power's SeaRAY autonomous offshore power system as configured for the demonstration at the U.S. Navy's Wave Energy Test Site in Hawaii.

EVs electrify the way

Underwater energy storage can be likened to the recent boom in electric vehicles (EVs), according to Reenst Lesemann, the CEO of C-Power. EVs have been a compelling alternative for years, but if owners were limited to only charging their cars in their garages, they would never reap the full benefits of the technology.

"The same can be said at sea. It's not enough to have the best electric ship. Underwater vehicles, surface vessels, operating equipment and data sensors at sea need that electricity to be delivered to them when they need it and how they need it. That means there needs to be a network of charging stations, such as C-Power's Autonomous Offshore Power Systems (AOPS) that can enable those systems to be truly autonomous, connected and resident," he said.

There are two primary uses for energy storage in marine environments, said Lesemann. The first is utility-scale renewables, like wind and wave energy, that connect to terrestrial electric grids. Storage is needed to save energy when produced in excess so that it can be delivered during periods of peak demand. At the low-power end of the spectrum are the systems that require in-situ energy. "Today, the ocean is a power desert. There are no resident sources of renewable energy generation or storage for the ocean economy. To operate equipment, sensors, underwater vehicles or unmanned surface vessels at sea, it currently requires people-, capital- and carbon-intensive solutions such as sending manned vessels to recharge systems from diesel-fueled generators."

C-Power's solution is AOPS—a series of systems to capture available wave energy and deliver it as electricity to batteries or storage units. The system further connects the sea to the cloud, granting the ability to upload and download data with ease. Specifically, its SeaRAY AOPS is "a moored configuration consisting of a surface wave power system; a single, combined mooring, data, communications and power cable; and a seafloor base unit that provides 55 kWh of energy storage for payload operation." Altogether, C-Power aims to advance the marine economy through the realization of autonomous, connected and resident technologies. The SeaRAY will also soon participate in a demonstration in partnership with the U.S. Navy and the Department of Energy in Hawai'i. The energy storage unit to be used will be a Halo underwater battery provided by Verlume, a provider of energy management and storage technologies. The AOPS will be deployed from the Navy's

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The first commercially sold SeaRAY AOPS, nicknamed the TigerRAY, went in the water this spring, where its owners tested its capabilities on Lake Washington near Seattle.

© C-Power

Wave Energy Test Site, and its generation and storage capabilities will support several technologies, including data sensors and a Saab Sabertooth autonomous underwater vehicle.

The BEST system?

Also tackling renewable underwater energy is the International Institute for Applied Systems Analysis (IIASA), a research body that aims, among many things, to enhance the resilience of natural systems and achieve the UN Sustainable Development Goals. The challenges poised by underwater energy production and storage include increasing pressure at depth—but IIASA sees this as an opportunity to be harnessed instead. Research scholar Julian David Hunt explained the Buoyancy Energy Storage Technology (BEST), which can be used to store intermittent energy.

The concept is based on pumped energy storage systems, which usually consist of floating platforms near wind farms and a motor/generator on the sea floor. "BEST consists of anchoring a cube made of a series of segmented pipelines with air or hydrogen inside to the deep sea (between 3,000 to 6,000 meters deep)," Hunt explained. "The buoyancy force pushes the cube upwards to the surface, but cables attached to the bottom holds it in place. The cube moves up and down slowly (with speeds of 0.1 m/s to increase overall efficiency), storing energy by isothermally compressing the gas inside the pipelines. The motor/generator pulls the cube to the bottom of the sea as it stores energy and controls the ascend of the cube as it generates electricity."

Inspiration from this work comes from Hunt's background—he's been working with hydropower for more than a decade and with gravity energy storage for more than five years. "An important variable for estimating the electricity potential of these technologies is the height difference between the upper and lower storage sites. After brainstorming practical locations that have a high height difference, I thought of the deep sea," he said.

Full speed ahead

Underwater energy capacities don't end there—many companies are working to create the batteries and storage systems necessary for these larger systems to run. Ocean Grazer, a Dutch startup incubated by the University of Groningen, is piloting the Ocean Battery, a modular solution for utility-scale storage, according to their website. The Battery is a pumped hydro system, based on dam technology. To store energy, the system pumps water to be stored under high pressure as potential energy. As demand for power increases, the water flows into low-pressure reservoirs, turning turbines to generate electricity. On top of the Ocean Battery, Ocean Grazer also boasts Ocean Energy Consultancy for renewable offshore energy solutions and Ocean Power, which converts waves into electricity. Another player in this market is Seatrec, whose technology can harvest energy from differing ocean temperatures. According to the company's website, many substances expand as they're heated and change phase, also known as Phase Change Materials (PCMs). PCMs are often used to release or absorb energy. In the warming phase, these substances transition from solid to liquid and change volume while in transition, moving a motor through pressurized fluid to convert hydraulic energy into electricity.

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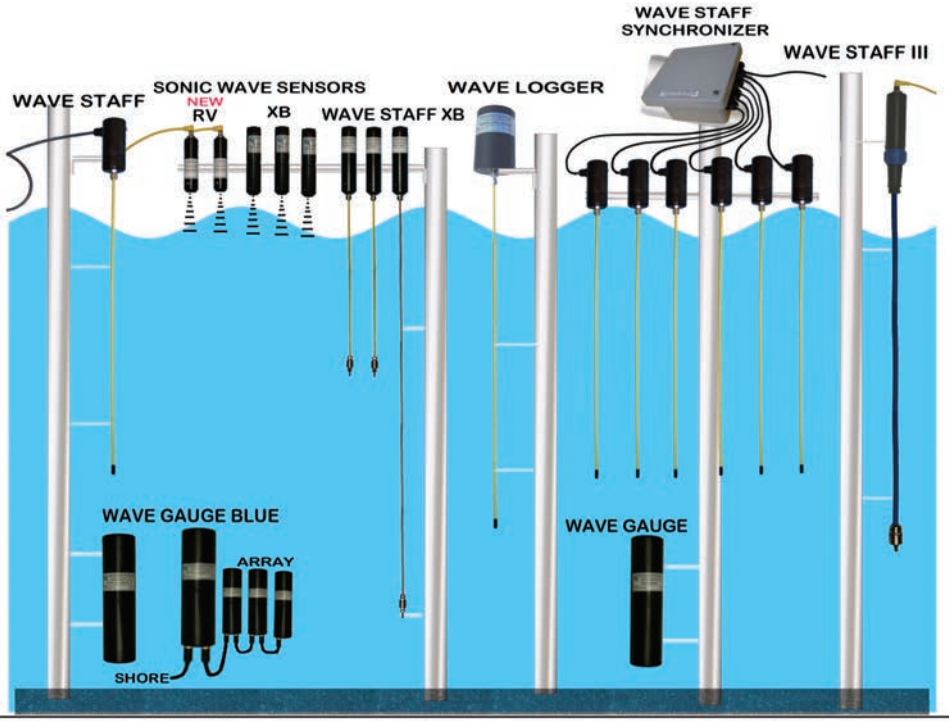

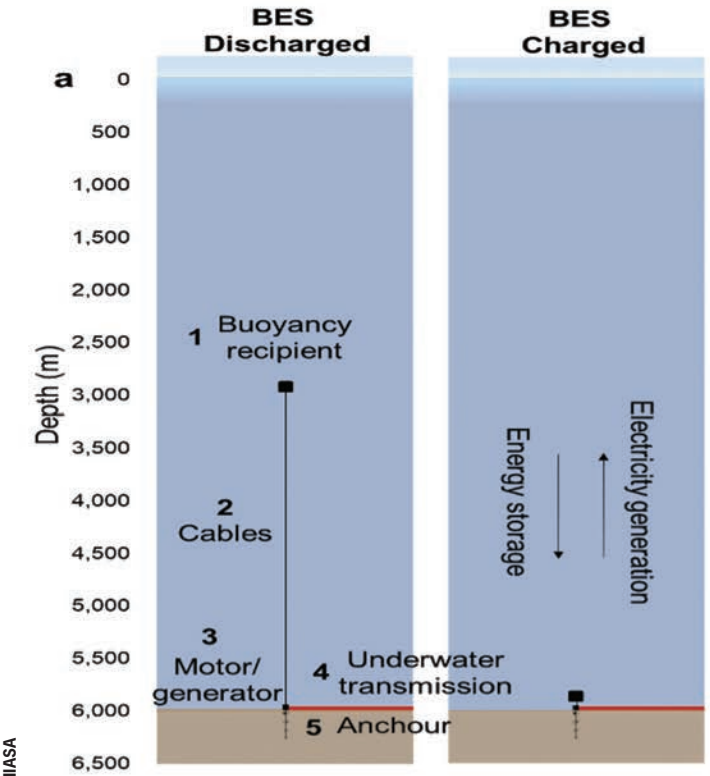

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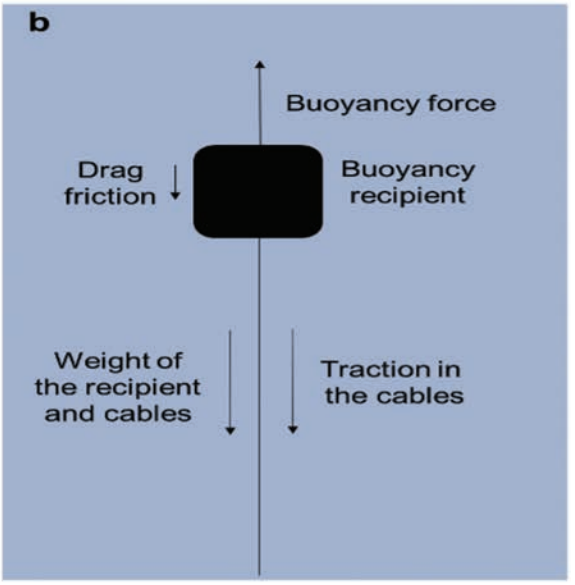

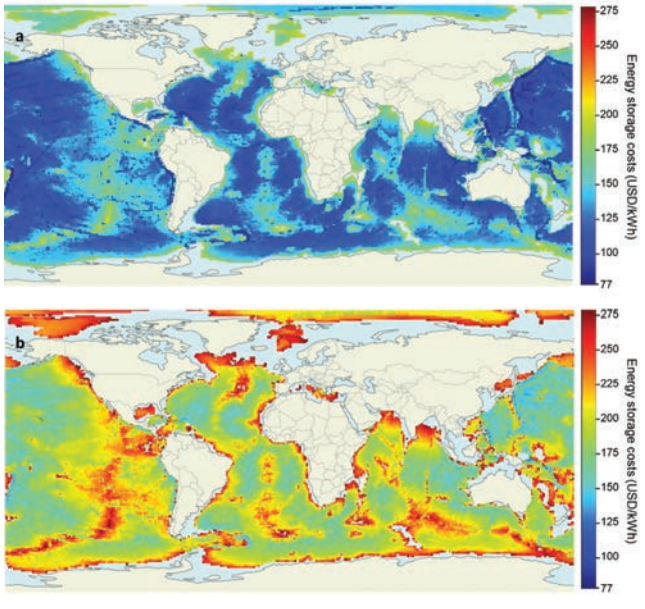

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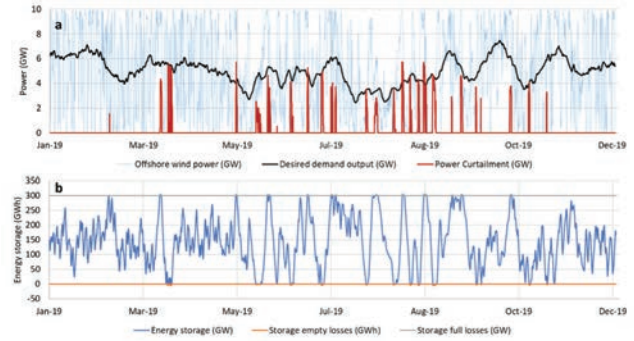

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Above: Buoyancy Energy Storage, (a) the sketch of the system and the main components, (b) presents the forces exerted in the buoyancy recipient.

Middle Left: World potential of BEST with (a) air and (b) hydrogen as the storage medium. The greater the depth, the higher the BEST potential.

Bottom Right: Proposed operational scenario for BEST to store offshore wind power near Tokyo, Japan. (a) wind power, electricity demand and energy losses (GW), (b) energy storage (GWh).

Images on this page: © Julian David Hunt, Behnam Zakeri, Alexandre Giulietti de Barros, Walter Leal Filho, Augusto Delavald Marques, Paulo Sérgio Franco Barbosa, Paulo Smith Schneider, "Buoyancy Energy Storage Technology: an energy storage solution for islands, coastal regions, offshore wind power and hydrogen compression." Journal of Energy Storage, Volume 40, 2, August 2021.

Charging forward

Although the future of offshore and underwater renewables and energy storage isn't quite as clear as other parts of the marine industry, abundant technological development and advancement portend an exciting era to come. And that's just as well, given that ocean energy systems have their fair share of catching up to do compared with terrestrial ones.

"There are more than 35 billion connected devices creating an Internet of Things on land. There are fewer than 10,000 in the ocean. Why is that?" Lesemann posed. "We all know the ocean is a difficult, expensive and complex work environment. Every time you want to do anything, you have to take people and power offshore. This begs for autonomous solutions; it begs for the Internet of Ocean Things." The ocean, unsurprisingly, is a power desert. Where there is no power, there's no energy or data. C-Power believes that once power is supplied to the seas, everything else will fall into line: "All of the trends toward digitization, AI, robotics and electrification that have proliferated on land and driven huge value to economy the economy will finally take hold at sea."

IIASA's BEST technology is attacking the ocean desert from two other angles: innovative and affordable energy storage (BEST claims an installed capacity of $50-100/kW as opposed to more pricey batteries) and an alternative option to compress hydrogen to be stored long term and transported through deep-sea pipelines. "The deep ocean will play an integral part in the future of renewable energy," Hunt explained. "Its role will include generating tidal and wave power, energy storage with BEST systems, transporting hydrogen between continents, and providing cooling services in coastal areas."

The 10 goals presented as part of the Decade of Ocean Science for Sustainable Development are widescale and all-inclusive—they're challenges that cannot be completed in isolation or rapidly. Their success heavily relies on increased and enduring ocean research, technology and exploration. While initial efforts to increase and advance these activities are underway, the ocean remains without easy, affordable, widespread and sustainable power.

Until renewable energy can be stored underwater and self-sufficient systems ensured, these goals remain more lofty than attainable. However, if the EV industry is any indication for how ideation, innovation, maturation and adoption can be accelerated, then it's only a matter of time until this blue desert gets flooded with power.

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BUOYANCY

Figure 1

An eye-catching demonstration of Buoyant Force!

Photo courtesy of Teledyne Benthos, 2010

By Kevin Hardy, Global Ocean Design LLC, MTR columnist

There is a palatable excitement when an ocean lander is released to explore the deep sea. The checklists and endless tests all come down to this moment. Our optimism is high because none of this is new. Still, we realize the risks. Davy Jones is a crafty soul, and tries to keep what he covets. Looking down, the lander dissolves into flickering scraps of color that fade to blue. And it's gone. One imagines the dry and safe environment inside the top command sphere. The clocks are running. As the lander descends towards the seafloor, the ocean outside shifts to darker hues of violet, then black.

A safe return relies on Archimedes' principal of buoyant force: any object immersed in a fluid is buoyed up by a force equal to the weight of the fluid displaced. If our vehicle is heavier than an equal volume of seawater, it sinks. If it's lighter, it floats. That's how we go down and back up again. A descent weight makes the lander negatively buoyant and it sinks. Releasing the weight makes the lander positively buoyant and it floats.

The weight of the displaced fluid may vary with salinity, temperature, and depth. Surprisingly, a vehicle can actually gain buoyancy as it travels deeper.

We strive to make the vehicle strong enough to work, but light enough in air to be managed by a small crew on deck. It's elegance of design.We have a strict buoyancy budget to work with, and strategies to stay within that.

Buoyancy Budget refers to the amount of flotation available to lift the lander with payload. Subtract half the buoyancy of the upper sphere as that portion will be above water on recovery. The remainder is the flotation available for everything else.

There are three buoyancy states of materials and components: positive, negative, and neutral. We can combine these to solve both the flotation and stability problems.

Specific gravity: One of the first techniques to stay within the buoyancy budget is the use of a material selected for its specific gravity, strength and bulk modulus. All things being equal, select the lighter material. For example: Fiberglass (FRP) has a specific gravity of 1.7, whereas aluminum is 2.7. Steel is about 8. Lead is 11.3. Marine grade HDPE is 0.96, which means it floats. We don't use HDPE for flotation, but it subtracts zero from the buoyancy budget. Most plastics are not prone to corrosion, though some are hygroscopic and absorb some percentage of water over time. A great reference is Steven Dexter's text, "Handbook of Oceanographic Engineering Materials". An earlier copy is available for free through WHOI @ **https://darchive.mblwhoilibrary.org/handle/1912/3194**.

Design tip: Subtract the air weight from the buoyancy budget of an item placed inside a sealed pressure case. Subtract the water weight of an object placed on the frame and exposed to the sea.

Sizing flotation: It is possible to have too much positive buoyancy. That requires a much larger anchor, and a heavier frame to hold all of that. As a vehicle gets larger, it gets more expensive and unwieldy. You can sense when the design spiral is turning in the wrong direction. A lander should have means to add positive and negative buoyancy. Like a spar buoy, the part of the lander above the water line after ascent should be no more than 20% of the overall length. I trim the vehicle for just half of the top sphere to be out-of-water.

Stability: A simple design rule: Flotation high, weight low. This provides the vehicle its stability on descent, on the bottom, on ascent, and at the surface. Recall that when the lander returns to the surface, we want to have ½ of the upper sphere out of the water. This is so our satellite beacons can see the sky, the strobe is clearly visible, and our flag stands proudly above the vehicle on the surface. The portion of the lander out of water is now

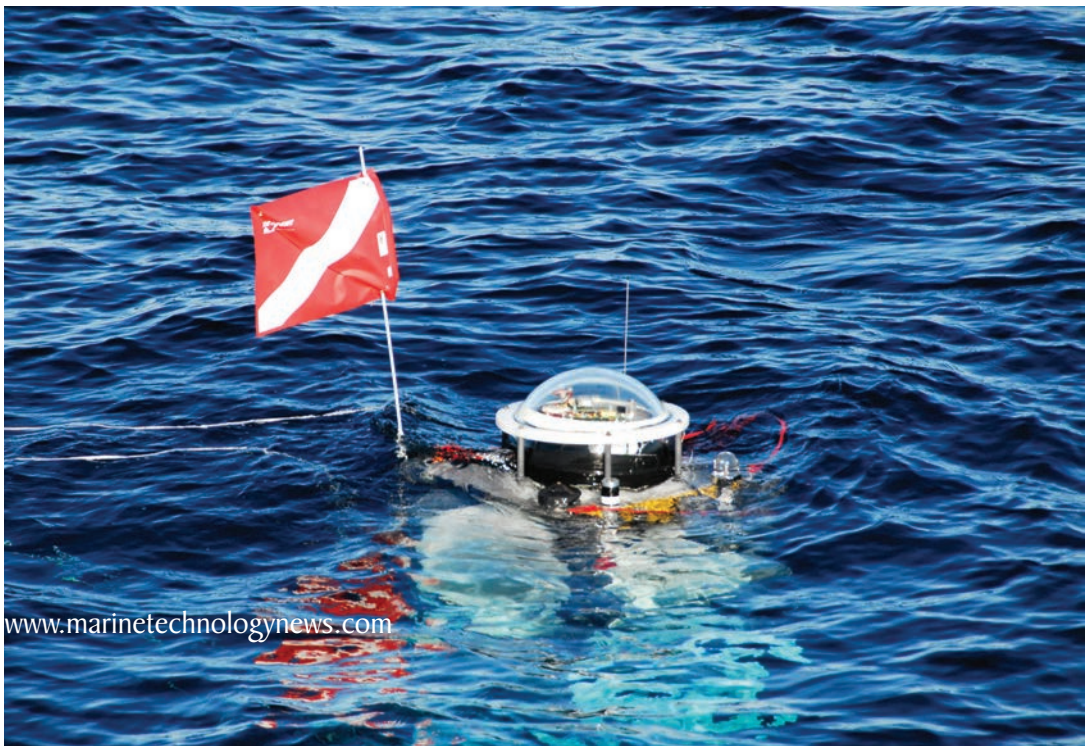

Figure 2

A Global Ocean Design Alpha Lander floats with its upper sphere half out of water. The remainder of the 8-ft lander resides safely below water.

Photo courtesy Kevin Hardy

negative weight lifted by the vehicle from below. Too much of the lander lifted from the water may turn the lander into a log, floating horizontally.

Stability of a lander is easier to establish than a glider or AUV as the separation of the center of flotation and the center of gravity can be a significant distance. The lander can be tall and slender, like a spar buoy, with minimal frontal projected area in the direction of travel that causes drag. The long vertical length enhances the intrinsic stability of the lander in all modes of operation.

Auxiliary buoyancy: These are side flotation pods added to increase net positive buoyancy for heavy payloads. These are added in equal measure to both sides to maintain uniform trim. In our landers, we place the top of the side pods below the centerline of the top sphere. This aids in lifting the upper hemisphere out of the water for recovery. We have to add flotation in minimum increments of the spheres we have. If that adds too much flotation, and the lander is sitting too high in the water, we add additional counterweight to the bottom, also in equal measure to each side.

Auxiliary side pods also provide space for additional batteries for lights, or instrumentation from research colleagues hitching a ride on your lander. Placing the pods on the sides also reduces the height under the A-frame, if that's a consideration.

• **Trim:** An axis of symmetry runs through the centerline of the lander, top-to-bottom. The centerline points the way to the seafloor and surface. Distribute positive and negative buoyancy uniformly around this axis. Position trim weights to balance as needed. A 2-lb transducer on one side, gets a 2-lb trim weight on the other side. Too much weight on one side will tip the lander and force a glide angle away from the drop point, both down and back, in some undetermined compass direction. We'll discuss recovery beacons in another issue.

• **Water float test:** Begin where you want to end: the descent anchor gone, and the lander floating upright and stable on the surface, flag high, and the upper sphere half out of the water. A dunk test off the stern of the boat before you leave the dock is a better place to find a problem than on-station with everyone on deck and the weather window closing.

• **A design tip:** Keep the upper hemisphere of the top sphere as empty as possible. Restrict contents to recovery beacons that need to see or be seen. This limits the amount of weight that needs to be lifted above the water line on recovery. If heavier elements are required, such as an acoustic release system, place

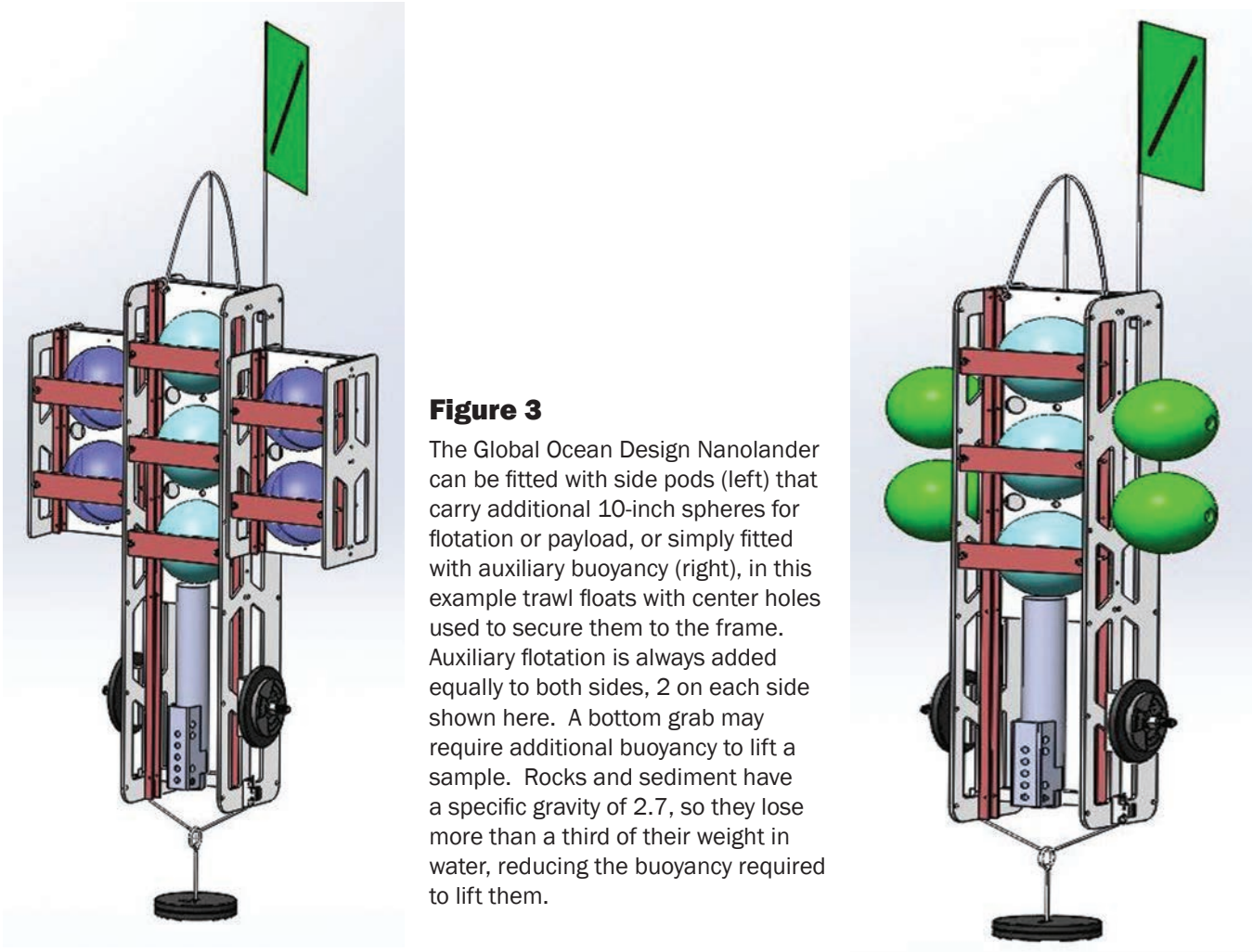

Figure 3

The Global Ocean Design Nanolander can be fitted with side pods (left) that carry additional 10-inch spheres for flotation or payload, or simply fitted with auxiliary buoyancy (right), in this example trawl floats with center holes used to secure them to the frame. Auxiliary flotation is always added equally to both sides, 2 on each side shown here. A bottom grab may require additional buoyancy to lift a sample. Rocks and sediment have a specific gravity of 2.7, so they lose more than a third of their weight in water, reducing the buoyancy required to lift them.

Illustrations by Mario Mitic, Global Ocean Design

those parts in the lower part of the top sphere. An acoustic release board or countdown timer release with their batteries could also be in a sphere further down the stack, with just the transducer placed in an unobstructed position to see upwards. It could also occupy one of the spheres in one of the Auxiliary Side Pods.

• **Sizing the descent weight:** Fixed counterweights, lead or steel, are added to position the upper half of the top sphere out of the water. The water weight of the descent weight, most often a stack of iron barbell weights, is approximately equal to the positive buoyancy of the full upper sphere.

Water weight of a solid material is calculated as:

Water weight = Material weight x ((Material Specific Gravity-1.03)/(Material Specific Gravity).

If iron has a specific gravity of 7.9, and seawater is 1.03, a 10-lb iron anchor in air will weigh 8.7-lbs underwater.

Alternately, to calculate the air weight of an iron anchor of a desired water weight:

Desired iron anchor air weight = Desired iron anchor water weight x (7.9/(7.9-1.03)), or approximately:

Desired iron anchor air weight = Desired iron anchor water weight x 8/7

Thus, if a desired iron anchor water weight is 10-lbs:

10-lbs (water weight) = 10-lbs x (8/7) = 11.4-lbs air weights

This provides the same force pulling the lander to the seafloor as it will have coming back up. A first approximation: a 10" sphere is 9-lbs positive, so a minimum 11.5-lb air weight iron descent weight should be enough if half of the top 10" sphere is above water. A thirteen-inch sphere is 24-lbs positive. A minimum 28.5-lb air weight iron descent weight should be enough if half of the top 13" sphere is out of the water. A 17-inch sphere is 57-lbs positive. A 65-lb air weight iron descent weight should be sufficient if half of the top 17" sphere is out of the water. If bottom currents are suspected, an additional 20% weight could be added to keep the lander from hopping across the seafloor.

We discussed ferrocement anchors in the January 2022 *MTR*,

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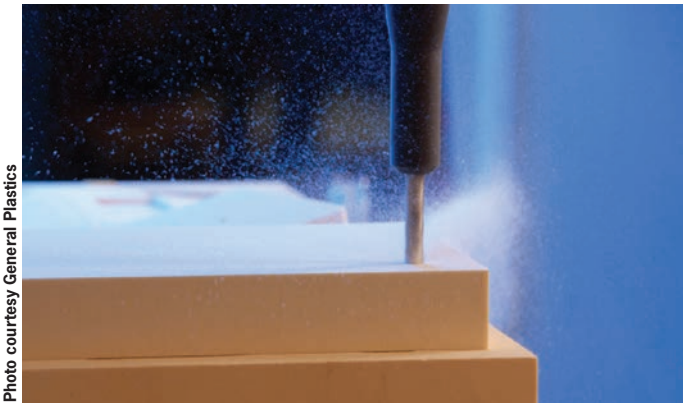


Photo courtesy General Plastics

Figure 4

Closed cell rigid polyurethane foam is dimensionally stable and easy to machine, with some densities rated for 1200-ft depth.

Photo Niels Martin Lundsgaard, Atlantic Floats

Figure 5

Trawl floats come in a variety of sizes, shapes, colors, and depth ratings.

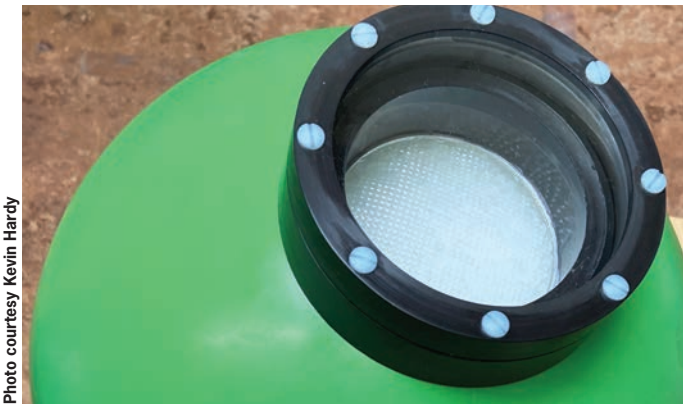


Photo courtesy Kevin Hardy

Figure 6

A 10-inch trawl float modified to serve as a camera housing. An o-ring groove makes the seal at the equator of the sphere. Connectors are on the back side.

cheap and heavy, using steel stampings for the coarse gravel in a concrete mix. You'll need to do the air weight/water weight measurement yourself to determine what specific gravity you're getting. Because it's a composite of cement and iron, you'll likely hit around 5, about twice as dense as straight concrete.

Air weight/water weight three-ring binder: to facilitate flexibility of operations and future mission planning, some seagoing teams record measurements of component air and water weights in a 3-ring binder to refer to when reconfiguring a lander. This helps work through the buoyancy budget, and is also useful for shipping, and shipboard operations planning.

Flotation Materials:

While petroleum oils were the primary flotation material in prior years, such as for bathyscaphes, today oils are mainly used for pressure balanced oil-filed (PBOF) applications. Depending on depth, there are several current material choices to consider.

The bulk modulus of the material, its ability to resist change of its volume with pressure, is an important characteristic. We all love the shrunken Styrofoam cups, but that just shows the poor bulk modulus of Styrofoam.

Closed cell rigid polyurethane foams: General Plastics (Tacoma, WA) [**www.generalplastics.com**] offers marine grade rigid foams in a range of densities and depth ratings, engineered for shallow to mid-water subsea buoyancy systems. Densities range from 12-lbs/ft3 with test depth of 300-ft (92m), up to 25-lbs/ft3 with a maximum test depth of 1,200-ft (366m). The material has high impact resistance, and is biologically inert. Standard sheet sizes are 10" x 24" x 100", and 14" x 18" x 100". The material is easy to machine, coat, and paint, is dimensionally stable, and compatible with many types of adhesives.

Trawl floats: Atlantic Floats, (Vordingborg, Denmark) [**www.atlanticfloats.com**] (U.S. distributor: Trawlworks, (Narragansett, RI), [**http://trawlworks.com/>**] are made in many styles, sizes, and depth ratings. The material is injection molded, thermally fused glass-filled polyamide (nylon). Most are spherical, some are plain spheres, while others have a center pass through (the 8" spheres have a ¾" center hole), while others have "lug" attachments that look like pierced ears. Working depths range from 400-2,000m (1,312 – 6,560-ft), with buoyancy ranging from 1.9-38.7 lb (840gms-17.60 Kgs)

Global Ocean Design has also made trawl floats into instrument and camera housings.

Glass: Nautilus Marine Service (Buxtehude, Germany) [**https://www.vitrovex.com/**] wide product offerings of size and depth rating to 12km, in borosilicate and BK-5. McLane Labs [**mclanelabs.com**] (East Falmouth, MA) has inventory of 12" borosilicate spheres for both flotation and instrument housings. Okamoto Glass Co (Kashiwa, Chiba, Japan) [**https://ogc-jp.com/en/productinfo/glassball/**] makes a line of glass spheres (10-inch, 13-inch, 17-inch) with depth ranges of 4-12km. JAMSTEC's Edokko Mark-1 lander program uti-

Photo Steffen Pausch, Nautilus Marine Service

Figure 7 Precision glass spheres by Nautilus Marine Service.

lizes their glass. Glass provides great compressive strength, is easily formed of readily available materials, can be drilled and even polished to be a camera housing. Bonding to glass with adhesives is easily done. Equipment mounts can be internal or external, providing some design choices. Work is still being done on creating a metal flange to protect the finely polished glass sealing surfaces and provide an o-ring seal. Random surface spalling may be due to residual stresses of the casting and forming operation. Rubber bumpers over the polished glass edge is crutial when the sphere is open to prevent inadvertent damage from impact to the glass.

Syntactic Foam: Engineered Syntactic Systems (Attleboro, MA) [**www. esyntactic.com/**], Trelleborg/Eccofloat (Boston, MA), DeepWater Buoyancy, (Biddeford, ME) [**deepwaterbuoyancy.com**], SynFoam (Livingston, NJ).

Syntactic foam embeds hollow glass microspheres in a rigid epoxy matrix. This allows machining to a particular shape. The microspheres have diameters ranging from 10 to 300 micrometers, providing the compressive strength. While the spheres are buoyant, the epoxy is not. A 1mm sphere in a 1mm cube takes up 0.52mm3 volume. The remaining 0.48mm3 interstitial space is filled with epoxy. It has a specific gravity of 1.1. Filled with 30% microspheres, a syntactic block has a specific gravity of 0.85.

Macroballoons can be used to cut the weight, filling the interstitial areas with smaller and smaller microspheres, but at the cost of reduced depth rating.

Syntactic foams can cause excessive wear of machining bits due to the glass microsphere fillers. Dust control is important.

Mixing too large a mass of syntactic is challenging as the resin is exothermic, and can get hot enough to crack the block.

Like thick cake batter, free pouring the thick resin can pull in inclusions of air, which can be a problem at depth. Vacuum degassing is one technique used to control this.

To maximize microspheres in a structure, some companies cast the parts, allowed the microspheres to float to the top, let it cure, then flip the part over and machine off the resin rich layer.

The resin is hygroscopic, and will absorbed moisture over time. That won't affect the buoyancy of the microspheres. Painting or

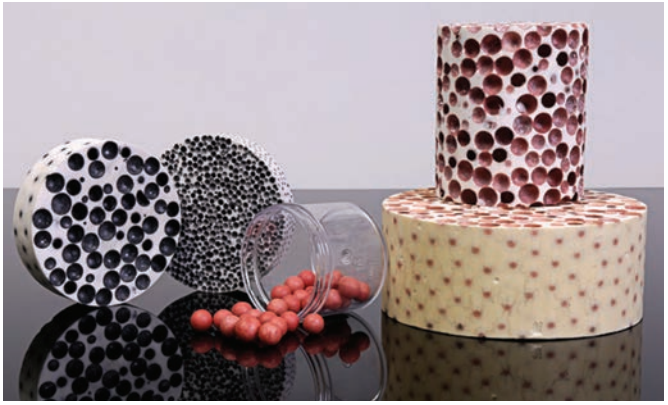


Photo Noel Tessier, Engineered Syntactic Systems

Figure 8

Examples of different compositions of syntactic foam. Larger spheres provide more buoyancy, but have depth limits. The material is formulated for the application.

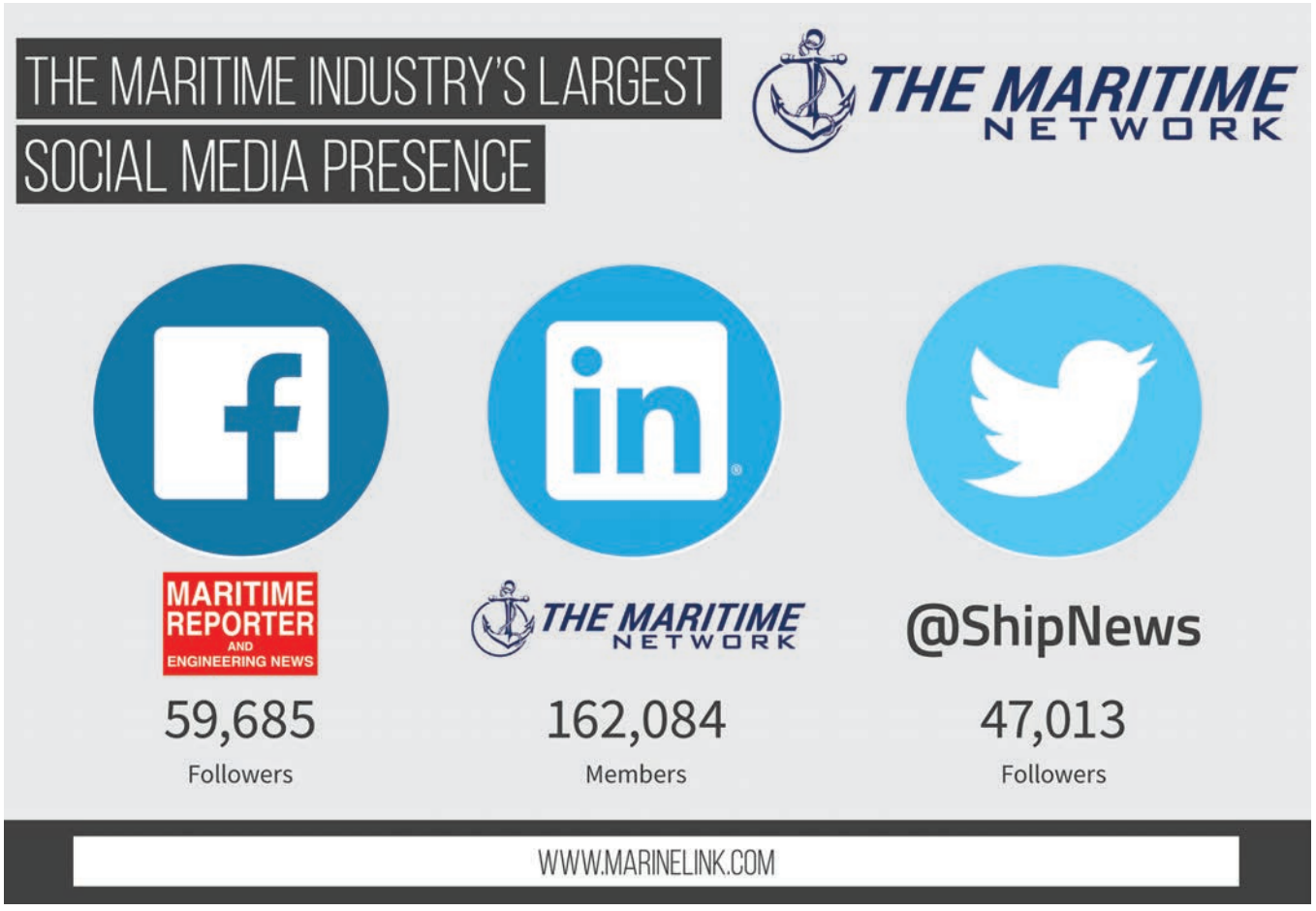
fiber glassing the exterior of the syntactic part will substantially reduce the potential for water absorption.

You can try your hand at it for not much money. Polymer Composites (Ontario, CA) [**https://theepoxyexperts.com/high-strength-hollow-glass-microspheres-1-5-pounds/**] sells a 1.5-lb/1-gallon kit, with instructions, and training videos.

Rather than locking glass microspheres in hard epoxy, it may be possible to suspended them in oil, filing the interstitial space with a positively buoyant fluid, then use that mixture to fill a soft plastic polyethylene bottle. The hollow microspheres are buoyant, the oil is buoyant (mineral oil has a specific gravity of around 0.88). No chance of inclusions, any captured air will be compressed to nothing. I haven't tried this yet, but it seems like it will work.

« Le petit baigneur »

A young French student, Jonah Royer, has written me with some ideas he has been thinking about. We are crafting a small lander using a trawl float, a 1-kg counterweight, and a center shaft. A GoPro camera in a housing is the payload. The release is a dissolvable Life Saver, the descent/expendable weight is a cotton sock full of sand. All the parts are there, in all the right order. IFREMER might have an up-and-comer in this young fellow.



Acknowledgements: This column is meant to serve the ocean community in the manner of *Make Magazine*, **Forrest Mims**' Engineer's Mini-Notebooks, or other DIY communities. I hope it will promote creative thinking and curiosity to try new things, as I have benefitted over time from members of the marine community who shared their expertise and enthusiasm with me. From earlier days at Benthos, **Sam Raymond** and **Robert Catalano** stand out in my memory. I learned so much working with the TR-6000. **Jim Teague**, then at Emerson-Cuming/Grace Syntactics, who knows everything there is about syntactic foam, has been a great friend. I have recollection of a paper by **Cliff Goudey** at MIT/WHOI, who first used plastic trawl floats as shallow water instrument housings. **Gerald Albich**, then with Nautilus Marine Service in Germany, who was intrigued by an idea to make their Vitrovex glass spheres with a little thicker wall so they would go deeper. The horizon keeps calling us onward.

Figure 9

Photo courtesy Kevin Hardy

Le petit baigneur, the little bather, a name from a popular 1960's French film. This little lander is a tool of discovery for a young student in the south of France. The flag mast has since gotten its flag.

Neptune Energy's Q13a-A platform.

Photo courtesy Neptune Energy

Carbon Capture & Storage

A New Lease of Life for Submarine Pipelines?

Since 2019, hydrogen and carbon capture and storage (CCS) have risen up the political agenda, globally, offering a route to decarbonization, as well as (more recently), increased energy security. Many are eying use of existing pipeline to make both happen. **Elaine Maslin takes a look.**

Hydrogen production and CCS offers a more or less "green" decarbonization options for oil and gas companies, alongside carbon capture and storage (CCS), especially if existing offshore infrastructure could be reused to make it happen. Instead of bringing natural gas onshore from offshore reservoirs, existing pipelines could be connected with offshore wind parks that produce hydrogen, when there's excess wind power. Alternatively, they could be used to export sequestered CO_2 from onshore power production facilities or industrial areas to be stored underground out at sea.

A North Sea Hydrogen Opportunity

Pauline Innes, Head of Decommissioning at UK regulator the North Sea Transition Authority (NSTA, formerly the Oil & Gas Authority), said analysis by NSTA has highlighted about 100 pipelines of particular interest for reuse in the UK sector. "If a pipeline were to be used for CCS or hydrogen (or indeed any other use) it has the effect of saving the new owner the time, effort and cost of installing a new pipeline," she says. "That's not only good from an environmental perspective it's also good from a cost perspective. Money saved from installing infrastructure can be used elsewhere in the business."

If half of those 100 identified pipelines were to find a life beyond oil and gas, the cost saving of not building new pipelines would be about £7 billion, she says. It's a big opportunity, but it does come with a health warning, she says. "The truth is that further work is required to determine exactly how many of those pipelines are suitable for repurposing."

Graeme Rogerson, Senior Project Manager at the Net Zero Technology Centre (NZTC, formerly the Oil & Gas Technology Centre), agrees. He said that offshore submarine pipelines haven't got up to speed when it comes to design codes for reuse for hydrogen, but that there is a longer history for reuse and transportation of CO_2.

That's not stopping companies working up ideas. Among others, Mitsubishi Corp and Shell have pledged to produce 400,000 tons of green hydrogen from a European offshore wind project by 2030, while the Longship project in Norway is looking at, among other things, producing and transporting blue hydrogen via

existing pipelines, with the associated CO_2 also sequestered and then stored offshore.

Offshore Hydrogen Production

Neptune Energy is busy in this space with its PosHYdon and H2opZee projects. The first is a pilot aimed at gaining experience in integrating energy systems offshore. It will see a 1MW offshore wind powered electrolyzer installed on the Q13a-A platform offshore the Netherlands sometime next year. Hydrogen produced will be fed into an existing natural gas pipeline into the national grid, mixed in with the natural gas.

Learnings from this project will feed into green hydrogen production further offshore, says Neptune, which is already planning the H2opZee demonstration project (an initiative of TKI Wind op Zee, which is supported by the Dutch government). This aims to have a 300-500MW electrolyser capacity in 2029.

The H2opZee could feed into the NOGAT (in use since 1992) and the Noordgastransport (in use since the 1970s) pipelines (24-in. and 36-in. respectively). "There're made of the same steel the offshore pipelines are made of which are now converted into hydrogen backbone," said Neptune. "A few years ago, studies showed it can be used for gas molecules, hydrogen molecules or a blend. Recertification is needed and now in process [to do that] for valves etc."

Opportunities and Brittle Challenges

Phil Cooper, Subsea and Pipelines Manager, Petrofac, says his company is involved in various projects looking at repurposing pipelines for CO_2 and hydrogen reuse.

"The North Sea is really one of many mature basins where we have a lot of infrastructure in place that's coming to the end of its life for hydrocarbons," he said. "The fields they service have depleted, but there might be a great opportunity there to pivot those basins into carbon sinks rather than carbon sources as we can store CO_2 in the depleted reservoirs."

Cooper said transport of hydrogen in pipelines isn't new. But it comes with some considerations, such as embrittle-

Neptune Energy's PosHYdon Pilot Project

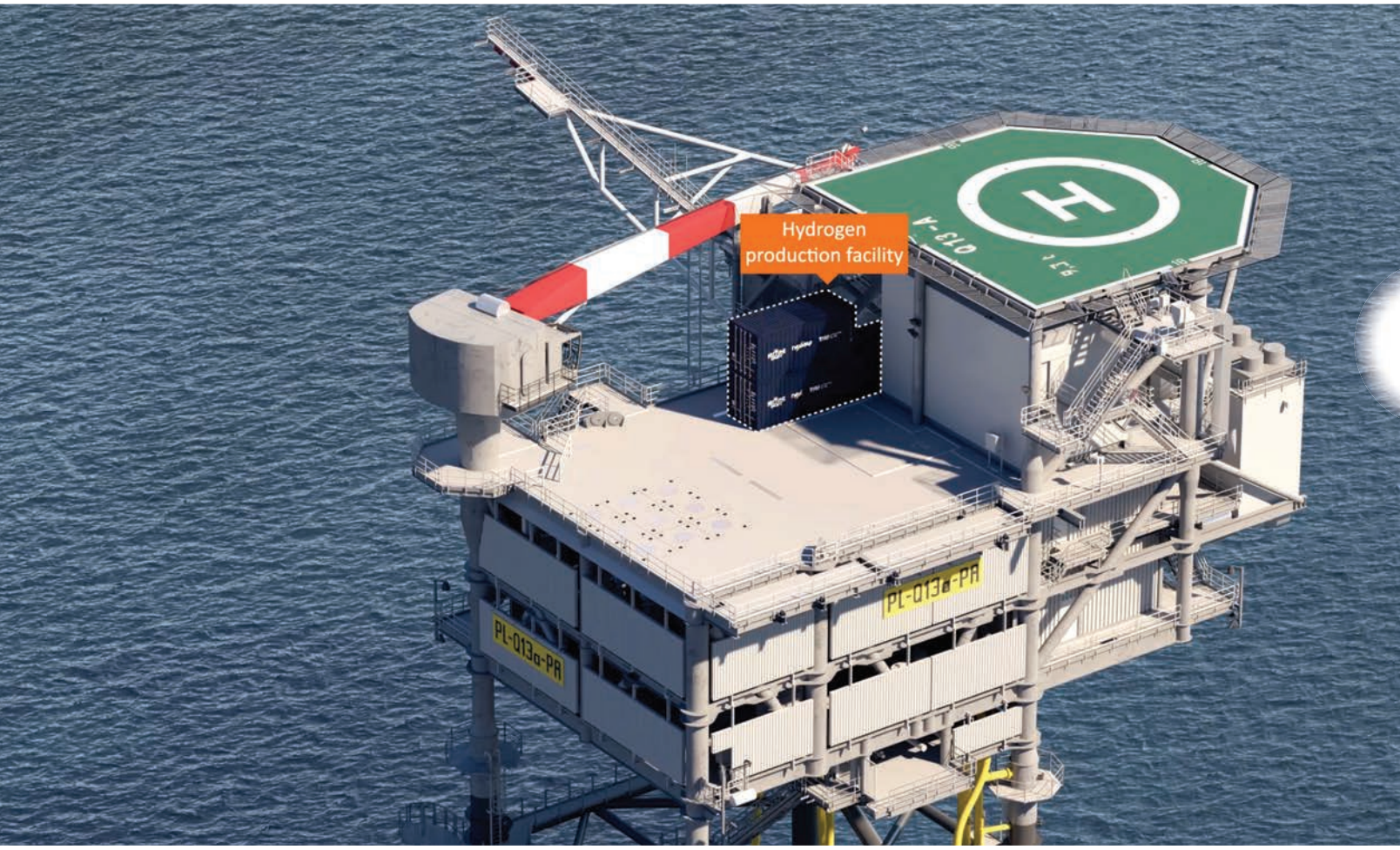


Photo courtesy Neptune Energy

ment, which causes a drop in fatigue resistance, loss of toughness and sulphide stress cracking. "Hydrogen induced cracking, as well, can be associated with hydrogen," he said. Some of these issues are similar to issues the upstream industry is used to, for example is sour gas or fluid service. However, they're a "bigger deal" with hydrogen.

The established design code for hydrogen service is ASME B.31 12 and the usual mitigation for embrittlement is to stay with quite a low strength steel, e.g. X52, said Cooper. However, damage like a gouge or a dent could be relatively more of a concern with hydrogen with other fluids.

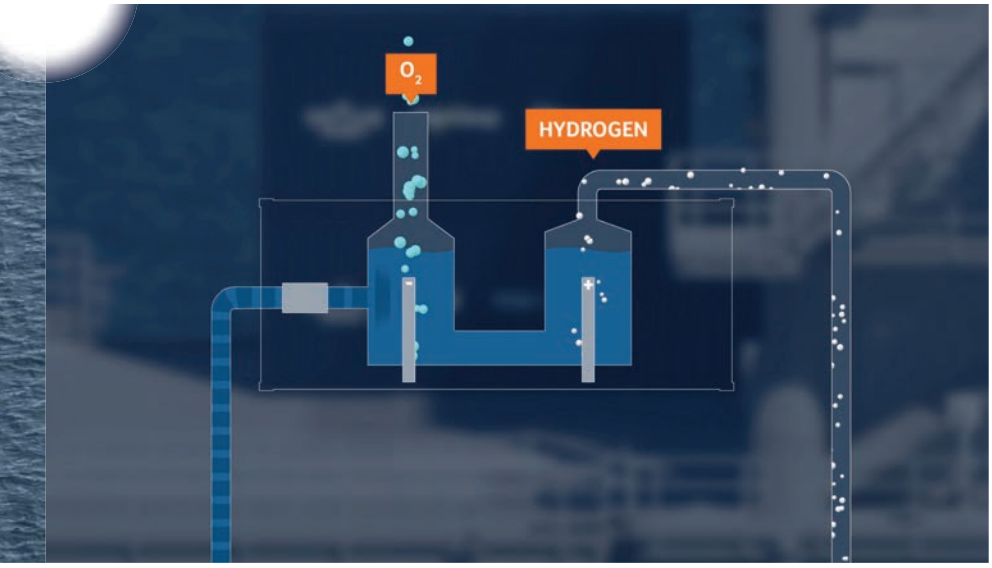
Revising standards

There is work underway to develop a design standard for offshore hydrogen pipelines. Last year, DNV launched a joint industry project, H2Pipe. An existing DNV standard for submarine pipelines (DNV-ST-F101) includes hydrogen as a transport product, but it's felt additional considerations are needed to meet a target safety level now required.

H2Pipe is focusing on blended and pure hydrogen transport in 16-48-in. pipelines, installed or for installation via J-lay, S-lay and reel-lay, with the goal of developing a recommended practice (RP) as a supplement to the existing offshore pipeline standard (DNV-ST-F101), similar to an RP for CO_2 pipelines.

"The objective of the JIP is to develop a Guideline for Design, Construction and Operation of hydrogen Pipelines which will be a supplement to the DNV Pipeline Standard," said Jan Fredrik Helgaker, project manager on the project. "For C-Mn steel pipelines, components and associated welds, it is well recognized that hydrogen may promote hydrogen embrittlement which could have an adverse effect on the pipeline system integrity, and hence impacting both the design and operation of such pipeline systems. There are still uncertainties related to how hydrogen gas or blends may affect the mechanical properties of these materials."

A first revision was shared in December 2021, but there are still uncertainties around how hydrogen gas or gas blends may affect mechanical properties of pipelines, so experimental test programs are being run to further develop the guidance with an RP expected to be published in 2023.



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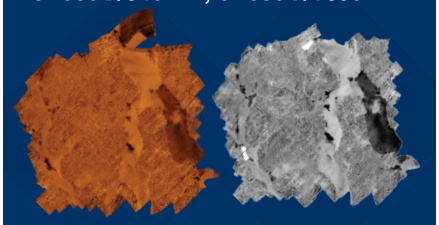

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What about CCS?

Neptune also has plans for large-scale CCS in the Dutch North Sea. There's some experience in the area, such as the Snohvit project offshore Norway. Over 14 years, Neptune has been reinjecting CO_2 into a gas field from its K12-B platform offshore the Netherlands. Now, it's conducting a study, assessing the feasibility of injecting between 5 and 8 million tonnes of CO_2 annually into the depleted gas fields around our operated L10-A, L10-B and L10-E areas.

Speaking at a Subsea Pipeline Technology webinar, Cooper said CO_2 is a more "pipeline friendly" gas, without the embrittlement problem and flows nicely when in the right condition, i.e. into the dense phase. However, the tiniest of impurities impact where phase transitions occur and very specific compressors need to be used. While these two issues are "very solvable", there are "other complications", he said. One is sudden depressurization of a pipeline packed with dense phase CO_2, which could result in a blocked line.

Another is corrosion, if water gets into the mix, which means ensuring no water gets in. Running ductile fracture is also an issue, said Cooper. "This is the tendency of a longitudinal defect, to open up and leak and then run along a very long length very fast in the direction of the internal pressure." While this is a familiar issue that's dealt with for dry gas,

The proposed H2opZee process.

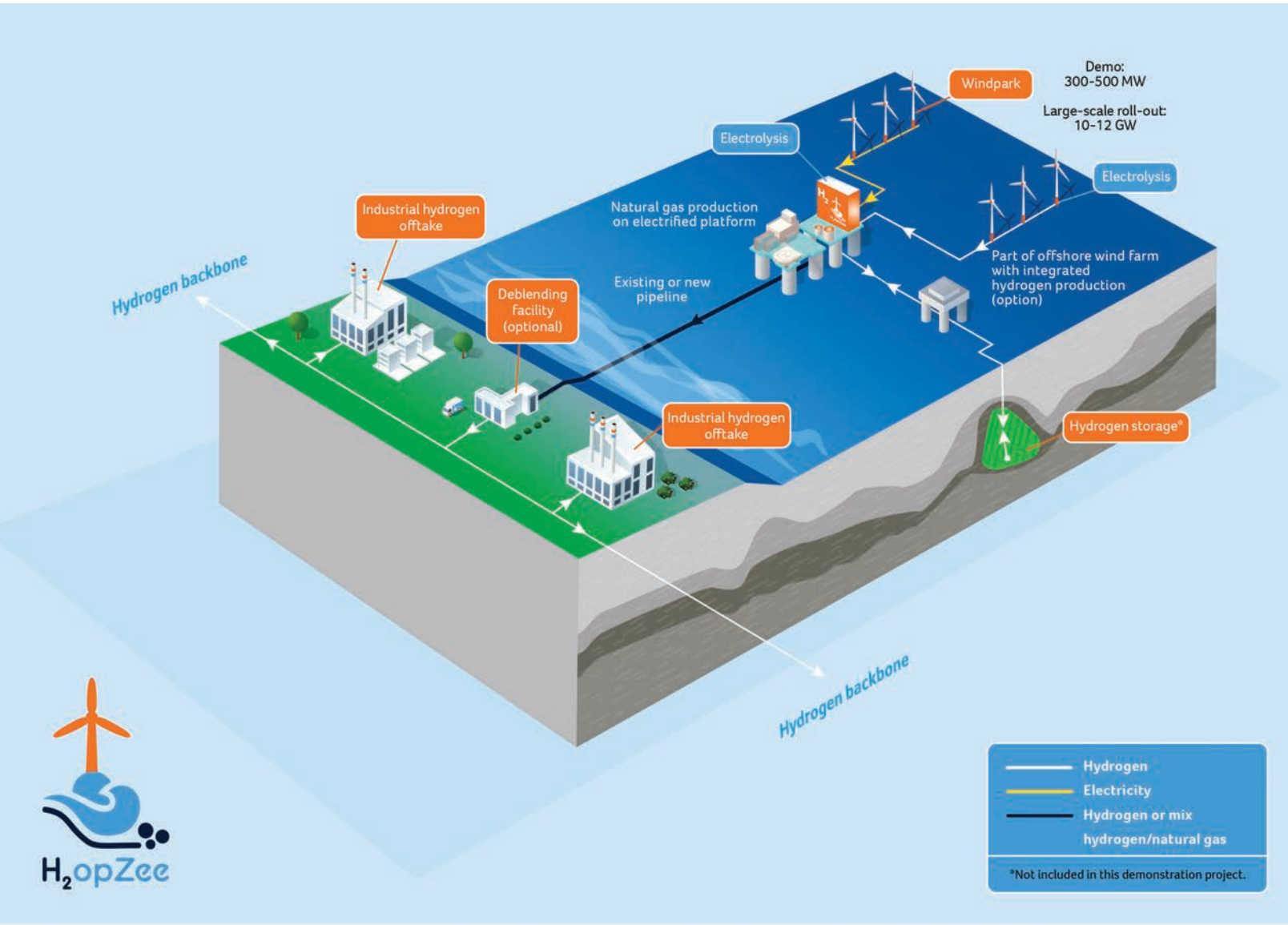


Photo courtesy Neptune Energy

"CO_2 is a bit more demanding", because of its properties as a dense phase, when it depressurizes, maintains an evaporation pressure for a very long period, so cracks continue to grow. That drives a requirement for increased toughness, "which is fine if you're building a new pipeline; not so easy if you have an existing pipeline so we have to be a bit careful about that one."

CO_2 also likes to dissolve polymers, so traditional pipeline inspection gauges could be a problem, but this is being looked at by the likes of Rosen and others, said Cooper.

Monetizing CO_2

Marc MacDonald Head of Clean Fuels at TÜV SÜD National Engineering Laboratory in Scotland also raises another challenge – being able to measure CO_2 as a fluid, particularly as it's subject to phase changes, which could lead to measurement inaccuracies. That's important, he said. "Whether through taxation, carbon credits or some other means, CCS schemes will be monetized; we already have an accuracy requirement ±1.5% of mass from the EU ETS.

"In the future, flow meters will likely act as 'cash registers' for CCS schemes, as they do currently for the oil and gas sector. Of course, measurement inaccuracy undermines the technical and economic viability of these schemes." For these reasons, TUV SUD National Engineering Laboratory is researching how measurement practices for CO_2 can be improved.

There are many questions, but it's still an opportunity, says Rogerson. "No one has written the book on this yet and it's all to play for." He says pilot projects onshore currently make more sense, but that "reuse, repurposing of existing assets will happen. It will be on a case by case basis. If we are talking about pipelines, the larger diameter and longer pipelines get, the more critical they are and that means they have been looked after better. They are the ones most likely to be reused repurposed."

MASSA

Innovation Inside its DNA

Dawn Massa Stancavish standing in front of a display at the Reagan National Library's "Secrets of WWII" exhibit honoring her grandfather, **Frank Massa**.

Photo courtesy Massa Products Corporation

From designing the world's largest transducer; to lobster-like surf crawling robots to detect and destroy mines; to creating a new bowling score system; to designing, building and delivering sonar systems used by the most powerful navy on the planet, Massa Products Corporation represents nearly eight decades of invention and innovation. **Dawn Massa Stancavish** shares her insights and experience as a female, third generation leader of this innovative sonar and ultrasonic products engineering company.

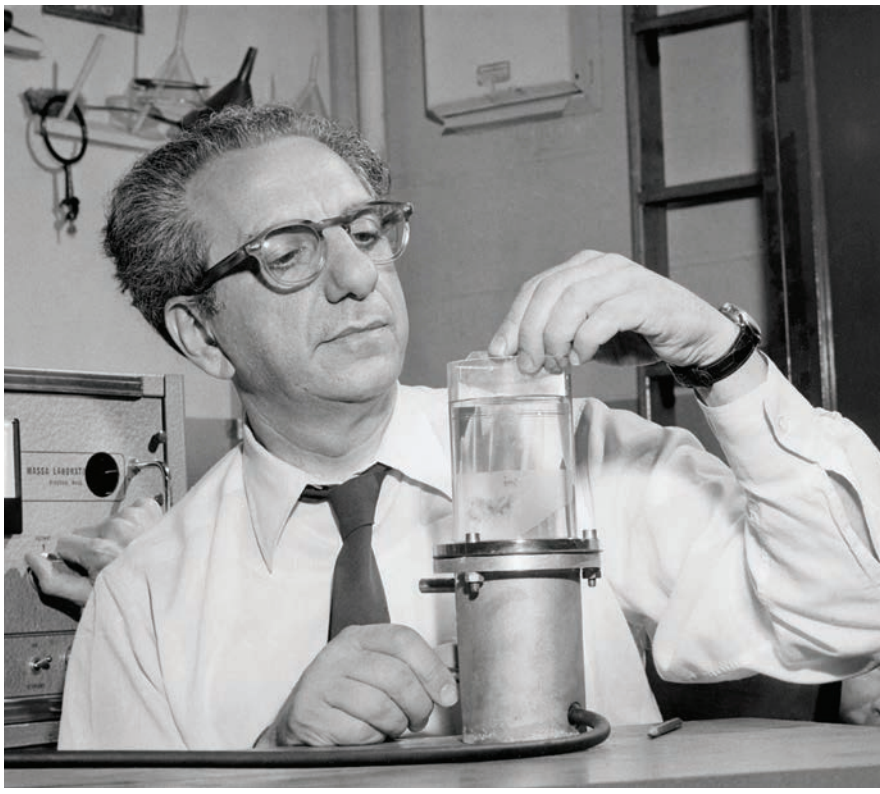
By Greg Trauthwein

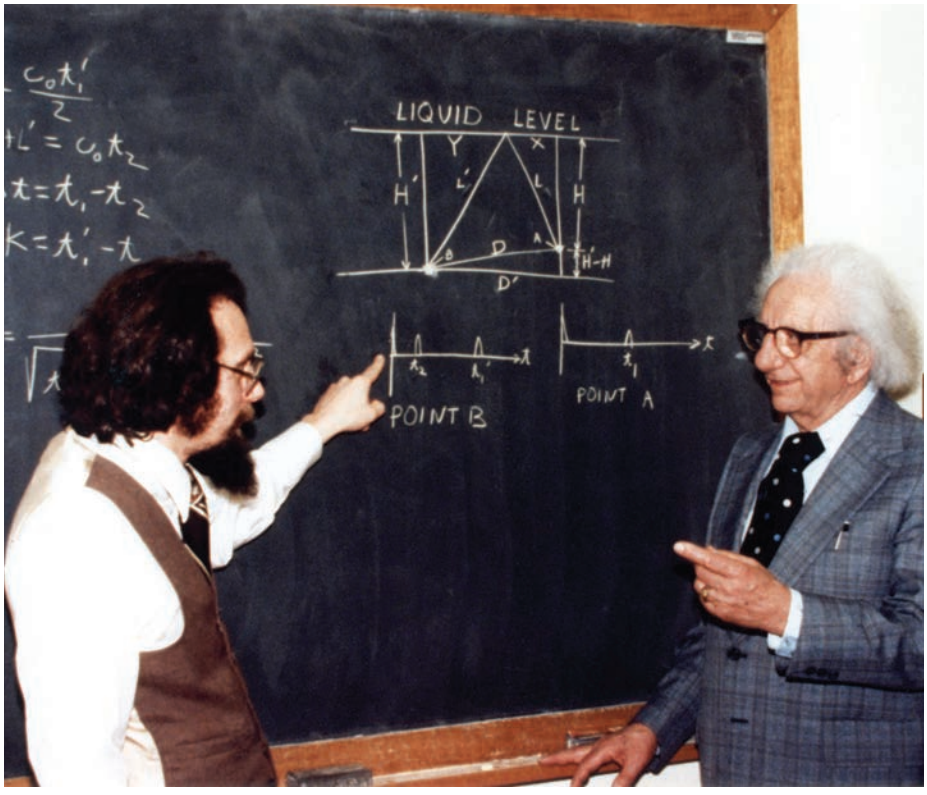
Following in the footsteps of an invention and engineering pioneer is neither straight nor easy. Following in the footsteps of your grandfather and father, taking the helm of a 77-year-old iconic company in the midst of a global pandemic, as a female leader in a male-dominated business, makes the path a bit more perilous.

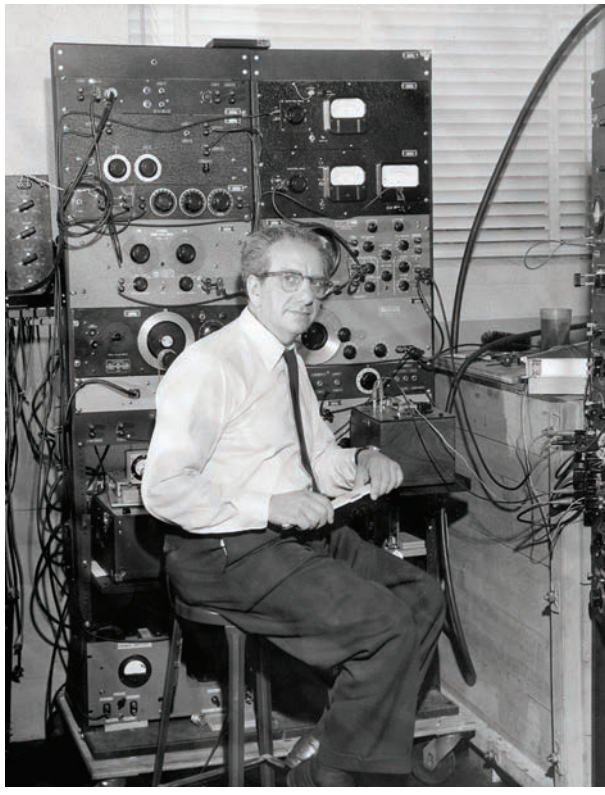
But through it all, Dawn Massa Stancavish has fallen back on her broad business acumen, as well as her long-tenured experience in and love of the family business to prepare Massa for another generation of growth.

Massa Products Corporation is self-proclaimed as "the eyes and ears for naval ships and submarines," founded by Frank Massa, who pioneered the field of electroacoustics. Today Massa engineers and manufactures sonar and ultrasonic products for use in the water and air, selling to commercial, industrial and military markets.

At a glance, Massa is an engineering and invention company to its core. But once you dig deeper, it is far more, with the ability







All photos courtesy Massa Products Corporation

to discuss, design and manufacture products for disparate industries, cradle to grave, all centered on using an electroacoustical solution. Massa designs, develops, and manufactures new and modified products, hundreds of transducers and systems that operate in fluid and gas at different frequencies spanning from 5 Hz to 500 kHz; used in various environments and applications including anti-collision, measurement, liquid level (C1D1 Hazardous and not), flow, anti-theft, web break, bowling scoring systems, active and passive sonars, to name a few.

"When I was younger, I had a conception that to be in this family business, you had to be an engineer," said Stancavish. So when she entered college she took some engineering classes. "I can do it, it takes a lot of work, I understand it; but I found that it really isn't my natural calling."

She ended with a Master's degree in Psychology and entered the workforce outside of the family business, brought into Massa at the board level, which gave her insight not only on the company, its processes and technologies, but also on how her specific talents were aligned with the company.

"I knew that I always wanted do something important, I always wanted to make sure that this company did well, but how I fit into it was discovered later on," said Stancavish.

A Different Perspective

Following in the footsteps of any legacy leader is difficult, following "Frank Massa, 'the Father of Modern Electroacoustics' and her own technically accomplished father, Don, takes the challenge to the next level. At a young age, Stancavish became keenly aware that complex technology, albeit a major part, is still just one part of the equation, with the ability to clearly communicate that technology to both technical and non-technical audiences a distinct and important skill, too.

"My dad and my grandfather were very technical, but they both also understood how to communicate to people that aren't technical," said Stancavish. "I was able to pick up because they always brought me into the conversations, even at a young age. I learned from them how important is to be clear in your communication. So I learned a lot about how things work and how to explain something that's a little more complicated to somebody who might not have that type of background."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Cleveland District Section

ASSOCIATION OF IRON AND STEEL ENGINEERS

APPLICATION OF SOUND TO INDUSTRY

By FRANK MASSA, Director

Massa Laboratories, Inc., Hingham, Mass.

Cleveland, Ohio

Monday, November 19, 1951

Allerton Hotel, 13th and Chester

Meeting 8:00 p. m.

Youngstown, Ohio

Tuesday, November 20, 1951

El Rio Club, Youngstown-Warren Road

Route 422

Meeting 8:00 p. m.

Clear communication with Stancavish starts in-house. "Everyone who's employed here is a person to us; it's not just a job, not just a title, not just a number," she said. "We care a lot about making sure that everyone is feeling satisfaction from their job, and that they understand how important each job here is." As a certified small, family business, that means everyone does lots of different things and everything that they do is important to the big picture.

While Stancavish is mindful of the company's legacy leadership, she aims to bring her skillset to the fore in the manner in which she leads. "Communicating internally is something that was important to both my father and my grandfather, but I think I do it a little bit differently, I just have a different nature," she said. "They were very technical leaders where I'm more of a holistic leader."

"The other piece that is really important is that I've embraced fully the founder's mentality," said Stancavish. "Innovation is critical in this business. A lot of businesses that do sonar in the ocean don't do the ultrasonics for air. And a lot of our competitors that do the ultrasonics in air don't have the underwater experience, longevity or capability that we have. Embracing all of that and embracing the science of sound itself has been very important. A lot of people focus more on the electronic or the signal processing side; we focus on design and the construction of the transducers."

Frank Massa, *The Father of Modern Electroacoustics*, was the founder of Massa Products Corporation. His list of innovations and achievements is long; with his son **Don** and granddaughter **Dawn** carrying on the company's mantra of engineering solution excellence, his legacy is longer.

All photos courtesy Massa Products Corporation

Holistic is also an apt description for the way in which Massa helps to engineer solutions for its client's needs, as it's far more than simply developing technology for the sake of technology. "We also do the software and signal processing to different degrees and different applications. But understanding not just what the application is and what the desired results are, but to design the actual transducer to be able to achieve those results while minimizing the need for extra expensive or overly complicated electronics and software," said Stancavish. "So we have a design system for new products – from transducers through electronics through software – designed to do what the customer really wants."

This approach has helped Massa maintain its competitive technological edge while helping it expand its own footprint in industries and applications where electroacoustics is not traditionally applied. "I haven't run into a lot of other companies that have focused on the electroacoustics and the science of sound to advance the products. And the fact that we design, engineer and manufacturer all in-house, we're not focused just on the innovation itself, but also how to make it so it's mass producible."

Women in Leadership

Taking over your family high-tech business without a formal technical education is one challenge, taking leadership of a technical business as a woman in a male-dominated industry another challenge altogether.

"I've enjoyed over the last few months meeting a lot of other women in leadership. What I've found is that for the pioneers, it's merit-based, everyone has earned their place," said Stancavish. "I hope that it continues along that path where women are considered, but they're not given a job just because they're women. It's important that every job is considered based on qualifications, capability and merit."

The path for Stancavish has had its fair share of ups and downs, too. "It's been interesting going to different shows because I'm received in different ways. I've been in groups where I've been with male colleagues and sometimes people automatically start speaking to the men instead of to me. One particular interaction stood out. "When I introduced myself as being third-generation leader of this technical business, he said 'Geez, you must be disappointed, you could have been a dress maker or something like that. I bet you're really upset." While this interaction left her in disbelief, she said it's is more the exception than the rule.

"Most of all, I've found that (being a female leader) doesn't stand in the way of something that's important or worthwhile. There have been situations where I've been underestimated, but that's also worked to my advantage. Most of the time it's just been normal, and that's the best. It's exciting to be the third generation here in a technical field, being the granddaughter that took it over."

Technology Development: Cradle to Grave

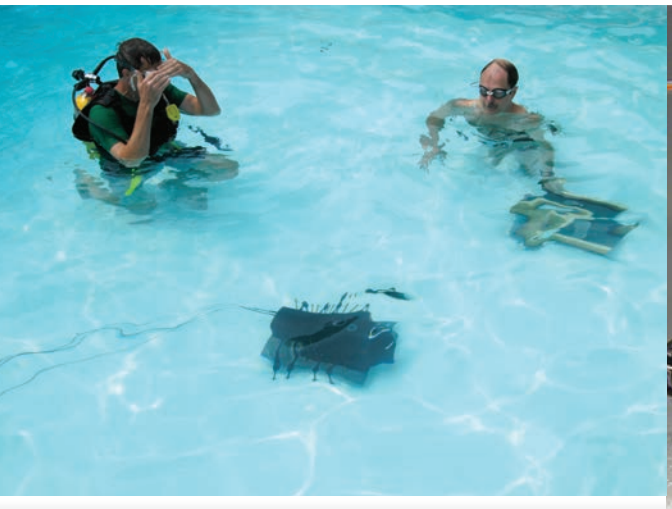
Frank Massa (1906-1990), MIT Swope Fellow Graduate, began involvement in the sound industry since the early days of the Victrola, working for Victor Talking Machine, RCA Victor, and later Brush Development Company. He developed new designs and patents throughout his career. He worked on everything from the development of sound for motion pictures when silent films were being replaced by "talkies", to the perfection of the hydrophone. Some of Frank Massa's early designs even became iconic symbols, such as the ribbon microphone used for NBC.

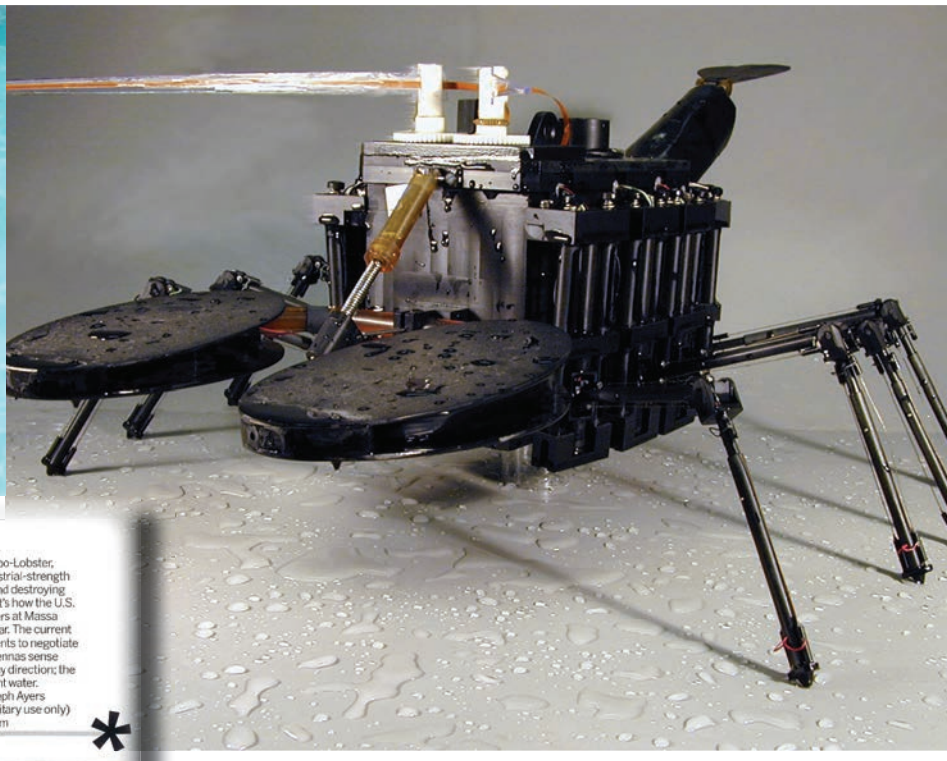
The legacy of Frank Massa's innovative spirit lives on in his namesake company today, as the company serves commercial and government clientele with a family of off-the-shelf products to original engineered solutions.

"(My grandfather) trained all of his people with the idea of design through production," said Stancavish, with an eye always on designing, manufacturing and delivering a solution that is high-quality yet affordable. "Being that we're one facility, we have a strong engineering department. We have production engineers that work with the design engineers and a full-blown production line too, with quality control in-house."

So everything from design through products is monitored, ensuring the kinks are worked out at the prototype level, with an

Frank's son, **Don Massa**, and Don's daughter, **Dawn Massa Stancavish**, have carried on and expanded the vision of the innovative founder. Today Massa employees design, develop, and manufacture new, and modified products. Hundreds of transducers and systems that operate in fluid and gas at different frequencies spanning from 5 Hz to 500 kHz have been designed and manufactured by Massa.



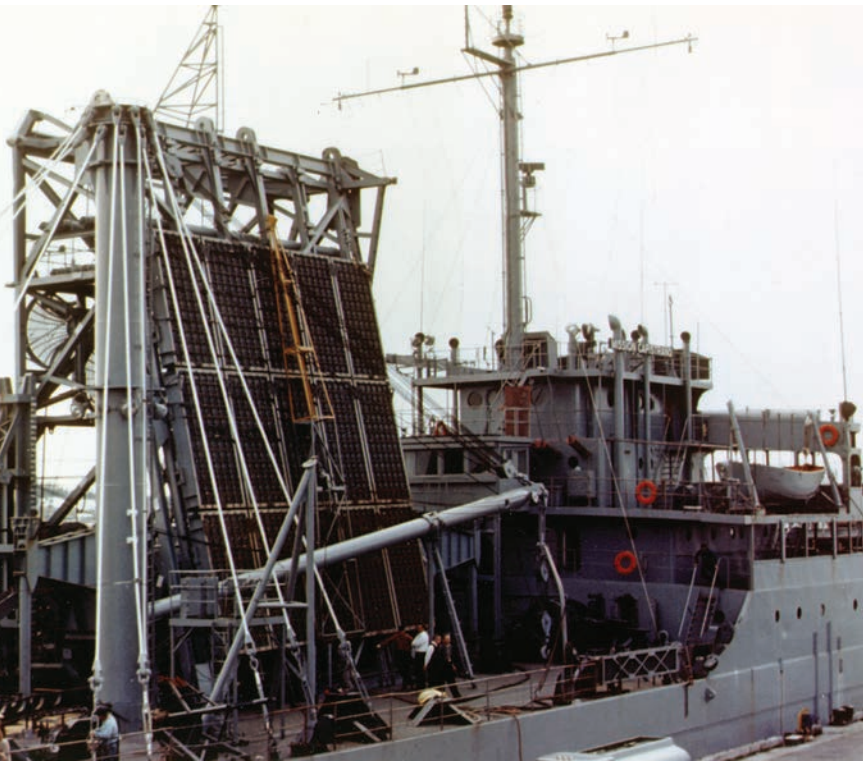


MINE SWEEPER

No, it's not a pet you take to the beach. Robo-Lobster, a 7-lb., 2-ft.-long crustacean made of industrial-strength plastic, has a bigger job to do: detecting and destroying mines buried in the surf zone. At least, that's how the U.S. Navy plans to use the robot once developers at Massa Products deliver their final version next year. The current prototype mimics a real lobster's movements to negotiate all types of coastal terrain. The plastic antennas sense obstacles; the eight legs can propel it in any direction; the two claws and tail keep it stable in turbulent water.

INVENTOR Don Massa and Joseph Ayers
AVAILABILITY Late 2004 (military use only)
TO LEARN MORE massa.com

TIME, NOVEMBER 17, 2003



All photos courtesy Massa Products Corporation

eye on making it both affordable and high-quality for mass production.

Working in such a proprietary field, with clients like the U.S. Navy, it's understandable that many current and future – and in some case past – technical innovations are kept under tight wraps

With more than 165 U.S. patents under its belt and more on the way, Massa is currently engaged in a number of projects and product development, both for itself and in partnership with outside organizations with the aim of delivering co-branded products.

Some of the product developments over the years have not been so secretive, and Stancavish remembers with a laugh one solution – a bowling score system developed in the late 1970s – that highlight Massa's out-of-the-box thinking in finding applications for its core competencies outside of the markets it normally serves.

"We've done everything over our history from innovations for the military to the bowling scoring systems for AMF," she said, noting that before the latter invention, the bowling leagues had to have a pin counter, an actual person who would count the pins tabulate the score. Massa came to the table with an air ultrasonics solution that spots the pins, counts them and gives the score automatically, which helped to speed up the rate of play and the ability to service more leagues in a shorter period.

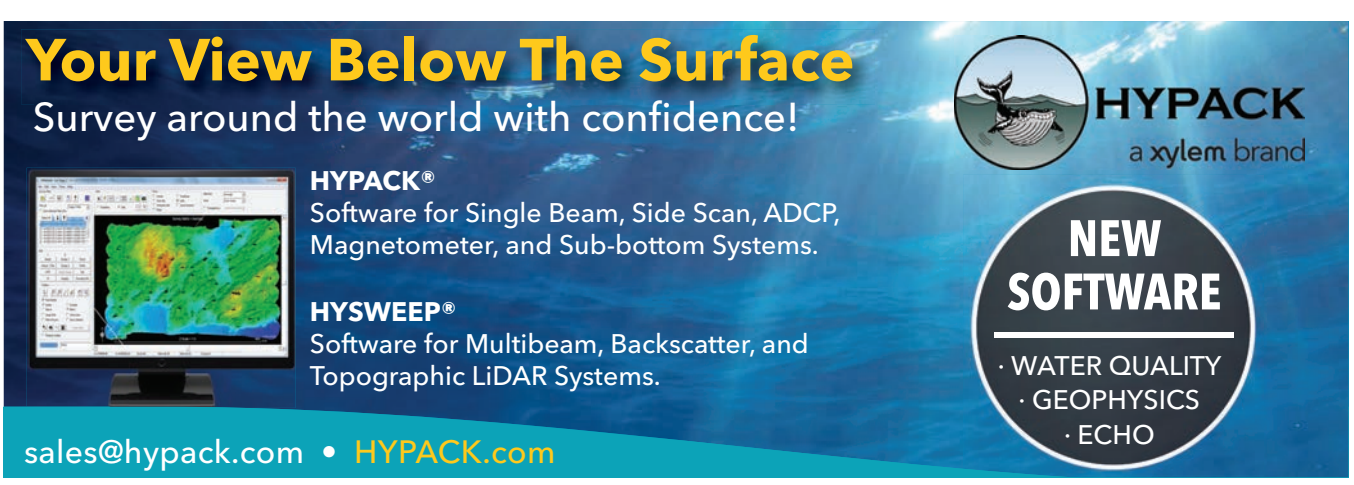
"It was kind of funny, because I was a little girl when that was happening. I came in and I saw all the engineers bowling, because we made a small half lane and they were testing it," remembers Stancavish. "And I said 'I thought you were working Dad. Can I have my birthday party here?'"

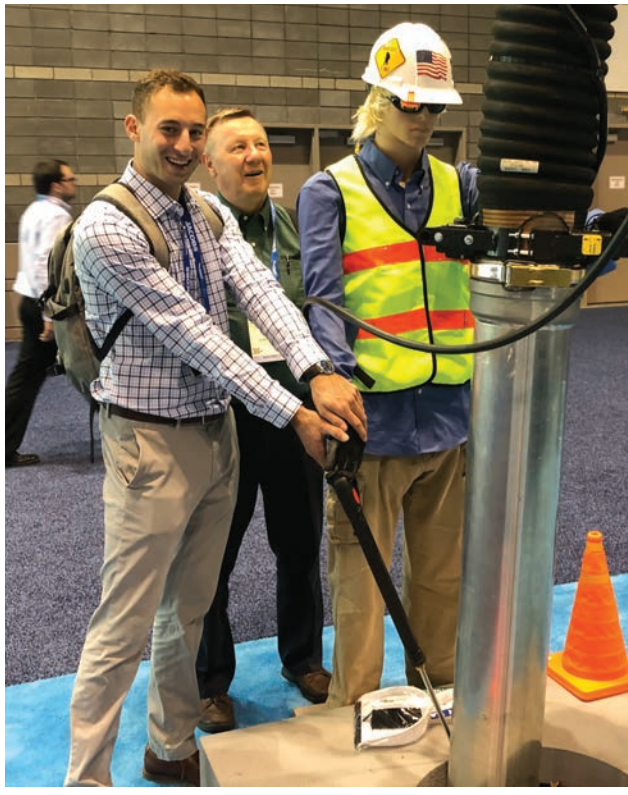
But the experience left an indelible mark on the company's future leader. "The bowling scoring thing wasn't something that we went out and said, 'let's use our technology to score bowling.' They came to us with a problem and we were able to say, 'Let's see what we can do to solve that problem,'" said Stancavish.

What she also learned, in retrospect, was the importance of enjoying your work. "I learned that this is a fun place to work. You can create amazing solutions and new products that make people happy, and you can have fun doing it."

With a solid history and present, Stancavish now has her eyes trained on the future of her family's company and the unique solutions it delivers. While unable to give explicit details of what's in the works, she said "What I can say is that we're pushing the boundaries of what's possible with our technology. We're creating some new designs for use in water, for use in air and in new

From designing the world's largest transducer; to lobster-like surf crawling robots to detect and destroy mines; to creating a new bowling score system; to designing, building and delivering sonar systems used by the most powerful navy on the planet, Massa Products Corporation represents nearly eight decades of invention and innovation.





All photos courtesy Massa Products Corporation

applications where our technology isn't currently seen. So over the next 10 to 20 years, it's my goal to continue to grow the markets where our technology is possible and considered. Because right now there are a few known spaces that everybody is in, but we've been learning about some other spaces" where Massa can introduce or further expand its solutions.

Part of the future is looking to the past; past innovations, some dating as much as 50 years ago, that were perhaps innovations before their time. "To be able to go back and revisit some of the older things that we started – but that might not have gone all the way through production – we've been finding that some of those things are applicable today."

While she found it nearly impossible to select her favorite Massa innovation of all time, she noted two – both military products – that were featured nationally in *TIME* magazine.

The first was the design and manufacture of the world's largest transducer in the 1960s for the Mission Capistrano, Project Artemis. This was interesting because – despite not winning the contract to supply the transducer – Massa made the investment of time and resources to develop a prototype … just in case. As luck may have it the winning bidder's system failed to deliver according to Stancavish, so the Navy turned to Massa.

"That is such an important story for our business, even though it happened a long time ago, because that's what we still do today," said Stancavish. "If there is a need to do something well, to do it right, to apply our technology in a way that others might not be able to, we will do it if there's enough of a need. If we're sure of what the application is and what the solution is, we'll do it on our own to prove it and then negotiate."

The second feature in *TIME* – named one of the "Best Inventions of 2003" – was for Massa's Robo-Lobster (Invented by Don Massa and Joseph Ayers), a 7-lb., 2-ft.-long crustacean -like robot made of industrial-strength plastic, tasked with detecting and destroying mines buried in the surf zone. The prototype mimicked real lobster movements to negotiate all types of coastal terrain. The plastic antennas sensed obstacles; the eight legs propelled it in any direction; the two claws and tail kept it stable in turbulent water.

"It's the same philosophies as with the Artemis story, and with the lobster story, and with the bowling alley story: we listen and understand the problem, we determine if there's enough of a business case for us to go for it, and then we can usually find a solution that's more affordable to our customer."

Massa Employees

"I learned that this is a fun place to work. You can create amazing solutions and new products that make people happy, and you can have fun doing it," said Dawn Massa Stancavish.

auv advances run the FULL SPECTRUM

Modularity, flexibility and intelligence *are the buzzwords of some of the next-gen autonomous underwater vehicles (AUVs), but not for all. Some are taking a more industrial mass production approach and/or going for a more fixed payload offering, to bring slimmer, lighter but still highly capable vehicles to the market.* **Elaine Maslin takes a look.**

Duane Fotheringham with Remus 300 at Oceanology International 2022 in London.

Photo by Elaine Maslin

The range of colors – pink, grey, yellow, orange – not to mention shape and size of AUVs on show at this year's Oceanology reflected more than just their different physical characteristics. For a market that's still growing and evolving, vehicle manufacturers are continuously looking for their edge.

Kongsberg is looking for just that with the HUGIN Edge. The Norwegian company is hoping to re-open the 1,000 m-rated AUV market with its new "autonomous by design" HUGIN Edge. The 4m-long vehicle, weighing just 300 kg and designed to work at 2-5 knots, is targeting those who want to go deep for up to 24-hours, but don't need to go 3,000m deep and don't necessarily want to have to be AUV experts to run it.

It's been designed to be operated with goal-based adaptive mission planning using AI and for ease of use from uncrewed surface vehicles (USVs), including autonomous launch and recovery and charging and data offload. Kongsberg hopes to deliver the first systems to customers by the end of 2023.

A nod to the past

The most distinctive feature is its design. This harks back to the first HUGIN design from the 1990s, which had a more Rankine-Carmichael hydrodynamic style, said Richard Mills, VP, Marine Robotics Sales, Kongsberg, while also drawing on work Kongsberg is doing on naval strike missiles.

The early vehicle was very low drag and "super high efficiency," but that efficiency was lost as soon as holes were cut in it for sensors or modular sections, he says. The new design, which has also had input from industrial designers (in a first for Kongsberg on the HUGIN), to give it its modern look, goes back to that hydrodynamic focus. To do this, it's had to go for a more fixed configuration.

"Unlike all our other products, this is a fixed configuration out of the factory, there are very few options on it," said Mills. "This means we don't have to have holes for bigger sonars, for example, which means we can integrate them and have them nice and flush."

Bringing back 1,000 m vehicles

A 1,000 m-rated vehicle is not new to Kongsberg. The first HUGINs were 1,000m-rated and it had one up until only a few years ago. But it was almost the same size as its deeper twin and weighed about a ton, so it needed the LARS and vessel support. It was also only 2% lower in price than a 3,000 m-rated version, so most would pay the extra 2% for that extra depth capability, he said.

However, many don't go below that 1,000 m mark and when they polled customers and their sales team, they found that most needs, across defense and the commercial sphere, could be met with a common payload. That meant size, weight and cost could be reduced. The low-drag form factor, enabled by the fixed payload, has also meant power consumption has been cut by a third to a half.

Instead of the 120 kg EM240 multibeam echosounder, it's getting a 700-1400 kHz, survey grade Kongsberg Mesotech M3. It's getting a new Kongsberg synthetic aperture sonar, due to be released later this year and which Mills says "will outperform any sonar of a similar size on a similar vehicle" (but couldn't say more, yet). It'll also have a magnetometer and in the back of the vehicle there's a swappable sub-bottom profiler or camera.

"Again, we found that people rarely need to do both (sub-bottom profiling and imagery) at the same time," says Mills. "So to keep the size down, we designed this payload module that simply plugs into the same BUS that everything else is on." This is also fixed, however, with a choice of EdgeTech or potentially GeoAcoustics GeoPulse Compact sub-bottom profiler and a CathX still image camera. The result is a price tag starting at just under $2 million, compared with $3 million and up for a 3,000m-rated HUGIN.

The HUGIN Edge is also getting a new Kongsberg forward looking sonar (FLS), which will also roll out across the HUGIN family of AUVs over time. This has wider horizontal coverage, out to 30 degrees, than the previous 7.5 degrees system used. This helps with contour smoothing and trajectory planning, including when traversing a slope or "crabbing", to reduce the risk of heavy pitching that can cause gaps or smearing in data.

Goal-based mission planning

To make life easier for operators and reduce entry requirements, Kongsberg has also focused on goal-based mission planning. Instead of programming a mission, "we draw a box, select an activity and set the performance requirements for that activity". Then the vehicle goes off and does it in the most efficient way it can. "You launch the vehicle and then in mission we have some performance metrics to compare what it's achieving to the plan and it will then adjust accordingly," says Mills. "It's a smarter approach to survey so you can do things in a single dive that previously would have taken two or three dives and even with people in the water in the defence community," says Mills.

Teledyne Gavia's SeaRaptor

More targeted towards the traditional HUGIN's deepwater space is Teledyne Gavia's "survey-grade" SeaRaptor. This max 4 knot, 3,000m or 6,000m depth capable vehicle, with 50-60-hour range at 3 knots, was first unveiled in 2019, when a first delivery was made, Teledyne said at the time, with longer duration options now available.

The flooded hull design vehicle is 6.8m-long and weighs 1.6 Mt. The modular design, with multiple pressure vessels for its control, navigation and electronics systems, etc., mean it's flexible in terms of sensor and (Kraken) battery configuration ("field-swappable"). The payload included EdgeTech side scan sonar or Kraken 120 MinSAS synthetic aperture

sonar, Teledyne Reson T-50 multibeam and Benthos Chirp 3 sub bottom profiler, as well as CathX high resolution camera and laser and Teledyne BlueViewM450 Obstacle avoidance sonar. It can also be air-shipped in its component parts. Navigation includes INS and DVL, with acoustic aiding from Teledyne and third-party, with tracking using an acoustic modem out to 10km, and USBL or LBL.

Stefan Reynisson, Teledyne Gavia, General Manager, Iceland, says modularity is important. "People don't want to be stuck with a certain configuration for lifetime of the vehicle. Modularity means options in the first phase but also throughout life span. Vehicles that been out there 10-20 years can be upgraded to the latest standards. It helps one vehicle to add capability and modernise throughout its life."

Doing more for longer

But increasing autonomy, endurance and capability, "staying out for longer and doing more", is another key trend. "Customers want more reactive behaviour, more real-time processing, based on actual detection without human intervention," says Reynisson. "By adding higher sensitivity sensors, you get better data quality, autonomous reactions will be more sophisticated, because they can rely on the detection probability using SAS and high frequency multi beam. Better resolution means better grounded decisions and making the vehicle react to those."

Norway's Argeo ordered two, 6,000m SeaRaptor's last year, with the first delivered early March this year and the second due to be delivered at the end of April. Argeo is one of a number of companies that Reynisson notes is targeting a new business model; data as a service, alongside TerraDepth, which has Gavia's in its fleet. Looking further ahead, we are going to be seeing even fewer people in the field, says Reynisson. "Put the vehicle out in the harbour, send it out for 10-12 days to do a mission, have it pop up occasionally to say what it's doing. There's a lot more trust in autonomous and robustness in vehicle to do what it needs to do.

Hydroid's Remus 300

In the shallower water domain, but targeting similar modularity, flexibility and intelligence is HII's REMUS 300. First unveiled by Hydroid in 2020 (before its acquisition by HII), with a prototype for the U.S. Navy, HII's REMUS 300 is being delivered to customers, mostly in the military domain.

Kongsberg's Richard Mills with HUGIN Edge at Oceanology International 2022 in London.

Photo by Elaine Maslin

The 2.5m-long, 19cm-diameter dry hull-design vehicle is designed for work at up to 5 knots down to 300 m, with modular battery options allowing up to 10, 20 or 30 hours endurance. It has iXblue Phins C3 INS, Teledyne DVL and acoustic LBL aiding for navigation, plus side scan sonar, with a raft of optional payloads. It has a common operating system for interoperability with all other REMUS vehicles and an open-architecture and modularity to enable easy integration of hardware and software, with optional development kits to enable third-party integration, said Duane Fotheringham, president of the Unmanned Systems business group in HII's Mission Technologies division. It has sealed replaceable, modular sections that can be changed in damp environments in the field. "We can pull it on deck and in 10 minutes put in a new battery pack and send it on another mission," he says. The navigation and electronics systems, once in the same pressure housing, are now so compact they have been split into separate modules, increasing modularity and the open architecture, while a data distribution system means new payloads can communicate with each other via a single BUS.

Advanced autonomy

But, in addition to modularity and flexibility, it's all about advanced autonomy. "We can now put a lot more processing power into the vehicles, which allows us to do edge processing, increasing the autonomous capabilities," said Fotheringham. "Some of the things we are working on include health monitoring and how to understand, in mission, something is not working properly and then complete that mission using ML to solve those problems. If the side scan sonar fails, how to re-plan the mission to still get data. Automatic target detection and in mission sonar processing are the biggest changes we're seeing. Longer missions without a person in the loop and increasing the odds of mission success."

More broadly, HII's direction of travel is about autonomy and multidomain operations. HII recently announced Odyssey, "a suite of advanced autonomy solutions that can turn any ship or vehicle in any domain into an intelligent, robotic platform". This includes multi-vehicle collaborative autonomy, from remote control to fully autonomous capability, aligned with industry open architecture standards.

In-roads with national navies

Back to the REMUS 300; last year, the Royal New Zealand Navy was the first to place an international order, ordering four REMUS 300s. Late March, the vehicle was also selected as U.S. Navy's next generation small UUV (SUUV) program of record (dubbed Lionfish), following a two-year rapid prototyping and refining of the REMUS 300 design.

Read more in MTR; The Remus legacy https://ntf.maritimemagazines.com/marine-technology/202112/the-remus-legacy/?fbclid=IwAR31Yxt-MfANqB9Yrn6UerExjofQmSH8KFI_TWJx08eDYSvhMjIvl14Y7Lc

Seaber

Shallower and simpler by far is the YUCO range of Micro AUVs from French firm Seaber. Co-founder and CEO Vidal Teixero says a problem for those in ocean science has been that AUVs cost hundreds of thousands and they can be difficult to use – experts are needed "and that's a real barrier". So Seaber was launched in 2020 to address those needs in an industrial way, with offshore the shelf AUVs.

Seaber's range is 12m diameter and 98cm to 123cm long, weighing up to 10.5kg and operable down to 300m water depth for 8-10 hours at 2-6 knots. They come in passive acoustic monitoring, CTD, AML multi-parameter and side scan variants and are designed to be used by anyone via a simple web user interface (SEAPLAN) and handheld UHF relocator (SEACOMM) with a 'home' button which triggers the vehicle to home in on that signal. For navigation, with vehicles use Seaber's INX (Intuitive Navigation eXperience) software that the company says works without needing externing sensors, but can be used with a DVL to more accurate positioning.

Side scan sonar for a song

YUCO-SCAN, the firm's side scan sonar variant with Deepvision 680 kHz side scan sonar and a Water Linked DVL costs under $65,000, he said, "changing the game in side scan sonar. We are changing the rules."

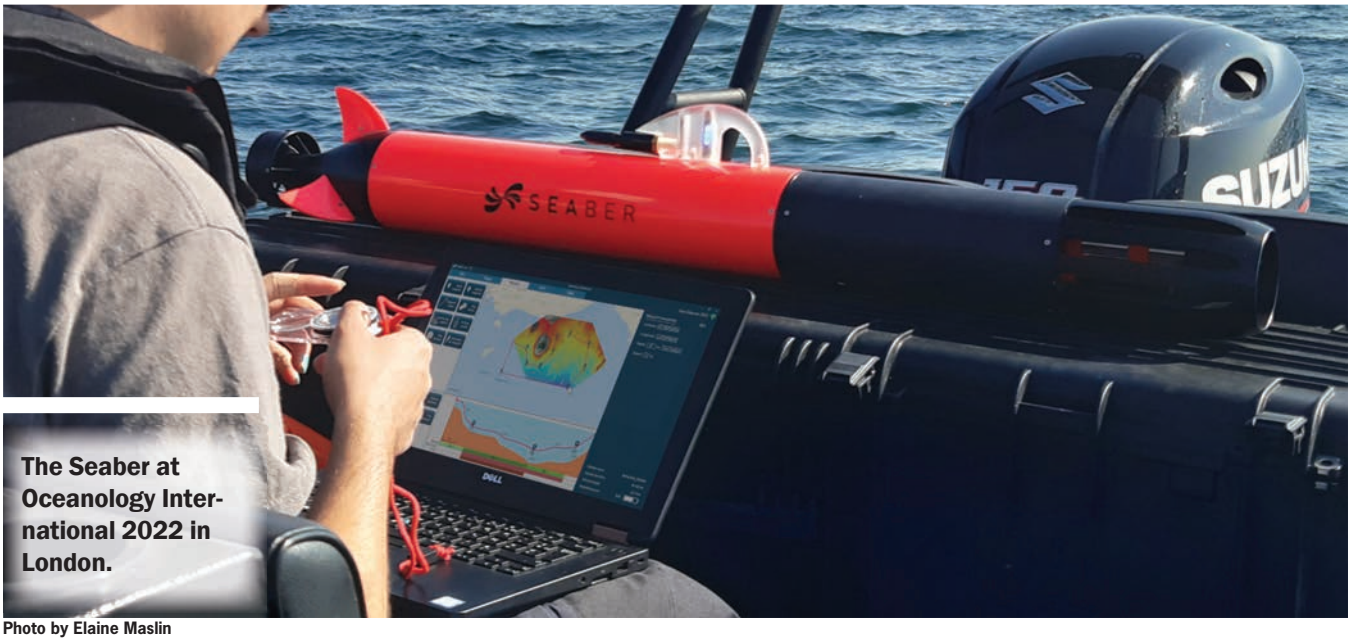
They're not designed to need to work with acoustic positioning systems, which can add expense for institutes, says Teixero.

Likewise, complex swarm operations can be avoided, simply by planning missions with the vehicles operating side by side, without any need to communicate, he says. The company got an initial break via the Jerico program, to develop a simple AUV that meets science users' needs. Since then its seen its AUVs deployed in all five oceans, says Teixero, mostly for ocean science or survey related operations.

One project, with Dalhousie University, saw the YUCO-PHYSICO AML multi-parameter probe model used in the St. Lawrence River estuary in Canada. The vehicle had an AML 3 sonde with fluorimeter, CTD and SVP and chased and ran a corkscrew or helix style pattern with a 30m radius (Seaber says 15m is possible) through a Rhodamine tracer cloud, enabling scientists to map concentrations through the water column (as a study to model the spread of pollutants in the water), where previously it only had a single stationary sensor for monitoring.

Stefan Reynisson, Teledyne Marine, with SeaRaptor at Oceanology International 2022 in London.

Photo by Elaine Maslin



The Seaber at Oceanology International 2022 in London.

Photo by Elaine Maslin

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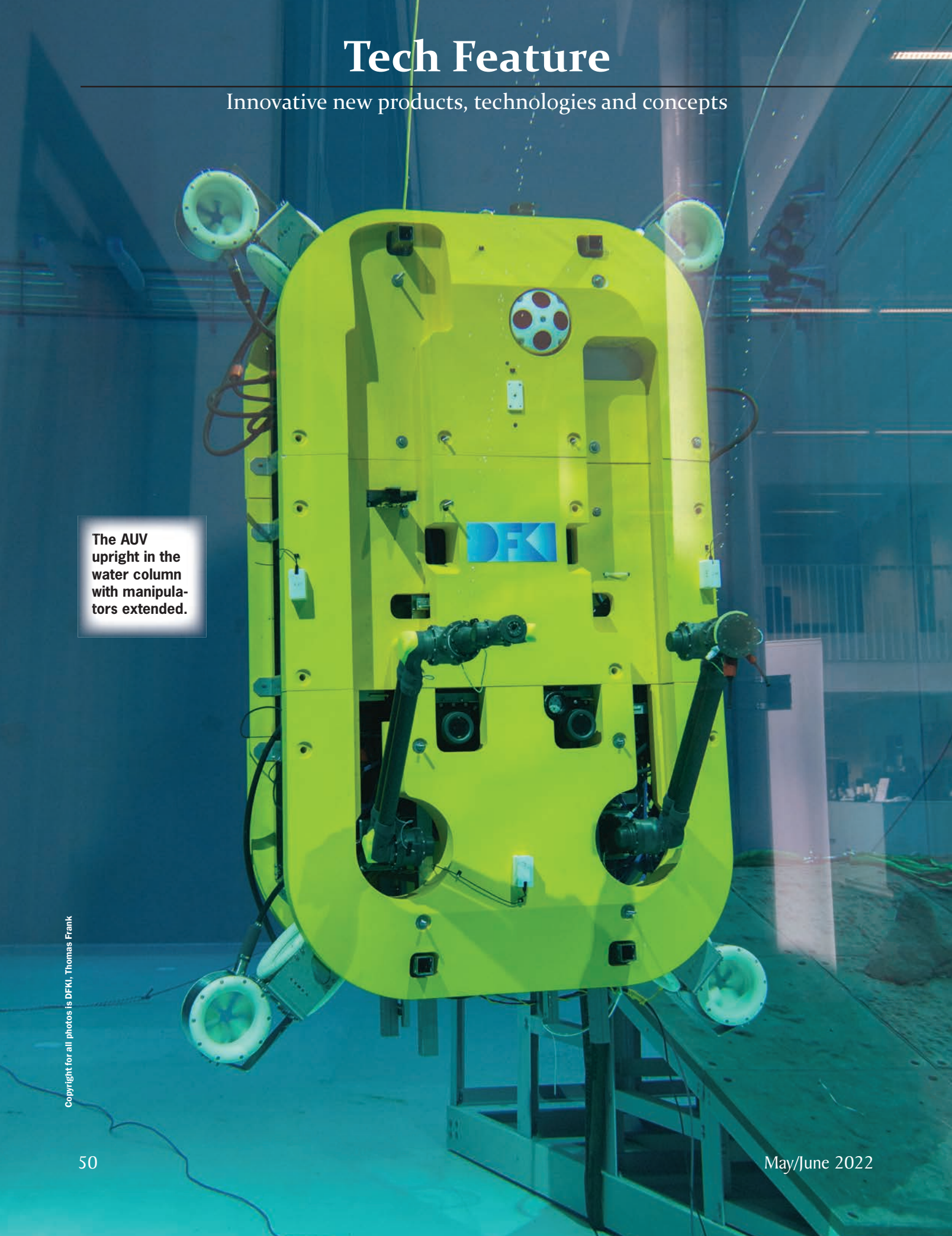
Tech Feature

Innovative new products, technologies and concepts



The AUV upright in the water column with manipulators extended.

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AUV "Cuttlefish"

Dual-Arm AUV Launched in Germany

A consortium led by the German Research Center for Artificial Intelligence (DFKI) developed a holistic AUV solution in the Mare-IT project: an innovative, two-armed AUV for complex inspection and maintenance tasks, embedded in a powerful IT infrastructure that enables both intuitive control and monitoring of the system and effective information flow with the plant operator. The project was funded by the German Federal Ministry of Education and Research (BMBF).

The development is aiming first at the routine maintenance in offshore energy infrastructure, as the industry increasingly eye systems that are not only autonomous but that also have longer persistence courtesy of in water residency capabilities.

An important step in this direction has been taken by a consortium of leading companies and research institutions from the fields of IT, robotics, drive technology and offshore under the leadership of the DFKI Robotics Innovation Center in the Mare-IT project. At the end of the project, the partners, including the DFKI research departments Cognitive Assistance Systems and Embedded Intelligence as well as WITTENSTEIN cyber motor GmbH, SAP SE and ROSEN Technology and Research Center GmbH, presented a holistic solution.

The proposed solution comprises a novel two-arm AUV that can operate both autonomously and remotely and, thanks to two integrated manipulators, can be used for maintenance work and repairs on underwater structures. In addition, the partners are providing a powerful IT infrastructure that not only enables intuitive control and monitoring of the robot underwater but also ensures the smooth bidirectional flow of information with the plant operators and allows integration into existing business processes.

"With Mare-IT, we were once again able to demonstrate that the development of autonomous robots for complex underwater applications cannot be implemented without machine learning and artificial intelligence methods," said Prof. Dr. Dr. h.c. Frank Kirchner, Director of the DFKI Robotics Innovation Center. "Our research represents an important building block in making the vision of practical autonomous underwater vehicles in the offshore industry a reality."

The DFKI Robotics Innovation Center has successfully designed and built the AUV "Cuttlefish" in Mare-IT as an intervention AUV that can be freely positioned in the water column. The AUV has two deep-sea gripping systems attached to its ventral side that allow it to manipulate objects underwater. In doing so, thanks to its special design and AI-based control, it is possible to change the center of gravity and buoyancy during a dive and to adopt and maintain any orientation in a stable manner. In addition to fully autonomous operations, the vehicle can be operated in a hybrid mode – so-called supervised autonomy – using a fiber optic cable. The hybrid mode allows humans to intervene and remotely control the AUV during critical operations on underwater structures. For this purpose, in addition to the manipulators, the system is equipped with many sensors for environmental perception, e.g., sonar sensors, cameras, laser scanners and magnetometers. To effectively process the large amount of sensor data, the researchers developed a special architecture concept that enables the decentralized analysis of data streams directly on board the robot. The researchers in Bremen were also responsible for implementing mission planning to carry out inspection or maintenance tasks. In addition, they developed a standard interface that enables bidirectional data exchange between the AUV, the control station and the internal business infrastructure.

Virtual Co-pilot

A virtual co-pilot developed at DFKI's Cognitive Assistance Systems research department supports human personnel in the control station during teleoperation tasks. For this purpose, it is equipped with a Microsoft HoloLens, which can be used either in combination with the control station or as a lightweight separate interaction medium, e.g., on board a ship. Thanks to a holographic 3D representation on the display, the operator is always informed about the status of the AUV and the underwater structure. Sensor information and measured values can be displayed and warnings configured via natural voice interaction. In The AUV and its cameras can also be controlled via voice commands and, in combination with eye tracking, information can be retrieved on elements of the infrastructure that the person is currently looking at. Furthermore, tt is also possible to define own voice terms during the mission and to use them as alias, e.g., for camera or docking positions.

In order to complement the innovative interaction technologies, the DFKI Embedded Intelligence research department in Mare-IT has developed a web application that allows the AUV to be controlled and change parameter settings via mobile devices such as smartphones or tablets. In addition, the researchers investigated the possible use of artificial, oscillat-

ing magnetic fields for localizing the underwater robot.

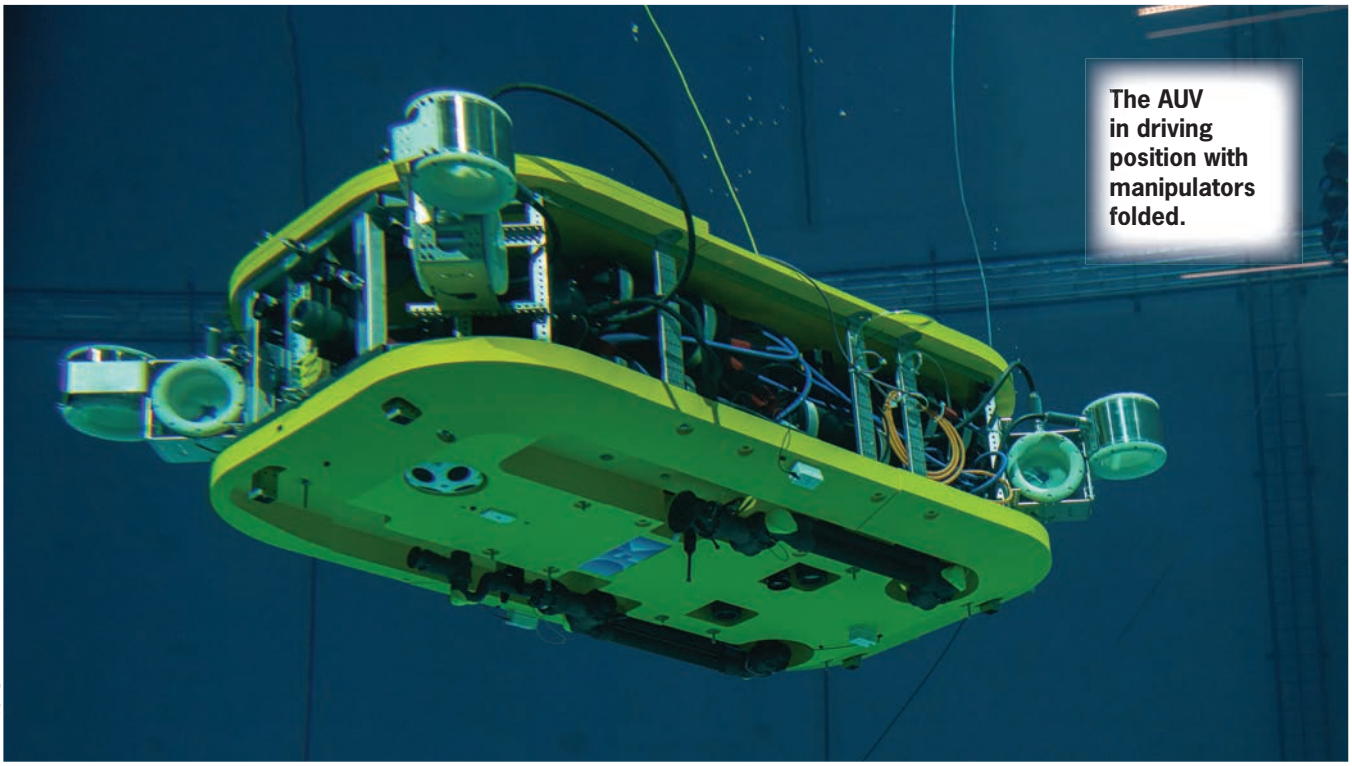
Robust Thrusters

WITTENSTEIN cyber motor GmbH developed and produced the highly robust thruster drives for the AUV's locomotion. These have a thrust of up to 500 newtons, are protected against seawater and are suitable for water depths of up to 6000 meters. No liquid fillers were used in the manufacturing process, which employed special potting technologies to avert chemical hazards to the environment. The servo inverters that go with the thrusters include sensorless control specifically matched to the thruster motor, providing accurate, highly dynamic speed control over the entire speed range up to standstill in both directions of rotation. The AUV is equipped with eight such thruster drives, which in the overall network enable highly precise movements as required for docking with underwater structures. The real-time communication required for this is carried out within the AUV using EtherNet/IP.

In Mare-IT, SAP investigated how and under what conditions autonomous systems such as AUVs can be integrated into IT infrastructures such as cloud systems. For this purpose, a vendor-independent integration of digital twins into business applications was realized by developing the management shell, a central component of the Industry 4.0 reference architecture. The management shell ensures interoperability across solutions from any manufacturer. It reduces integration costs and efforts, especially if several organizations are to access data of digital twins. SAP prototyped the management shell for planned and unplanned maintenance processes, such as the isolation valve of a subsea structure. The SAP Intelligent Asset Management cloud application can now initiate such maintenance via the isolation valve's management shell and receive execution status back from the underwater robot. Thanks to the management shell, any other systems from other parties can be added or replaced by others without much integration effort.

In the project, the ROSEN Group, a leading global provider of integrity management solutions for large-scale industrial plants in the energy industry, developed four different measurement technologies for AUVs to check the condition of various subsea structures: Magnetic field sensors to detect ferromagnetic structures, sensors to measure electric fields of cathodic protection systems, and ultrasonic and eddy current sensors to measure local wall thicknesses using manipulators on the AUV. In addition, a communication buoy was developed to ensure data transmission from the robot through the water column to the central control station. ROSEN has successfully completed all four measurement technologies for use on the AUV, making an important contribution to autonomous underwater applications of complex sensor systems.

The Mare-IT project was funded from August 1, 2018, to November 30, 2021, by the Project Management Agency for Software Systems and Knowledge Technologies of the German Aerospace Center (DLR) with funding from the Federal Ministry of Education and Research (BMBF) of around 5.5 million euros.



The AUV in driving position with manipulators folded.

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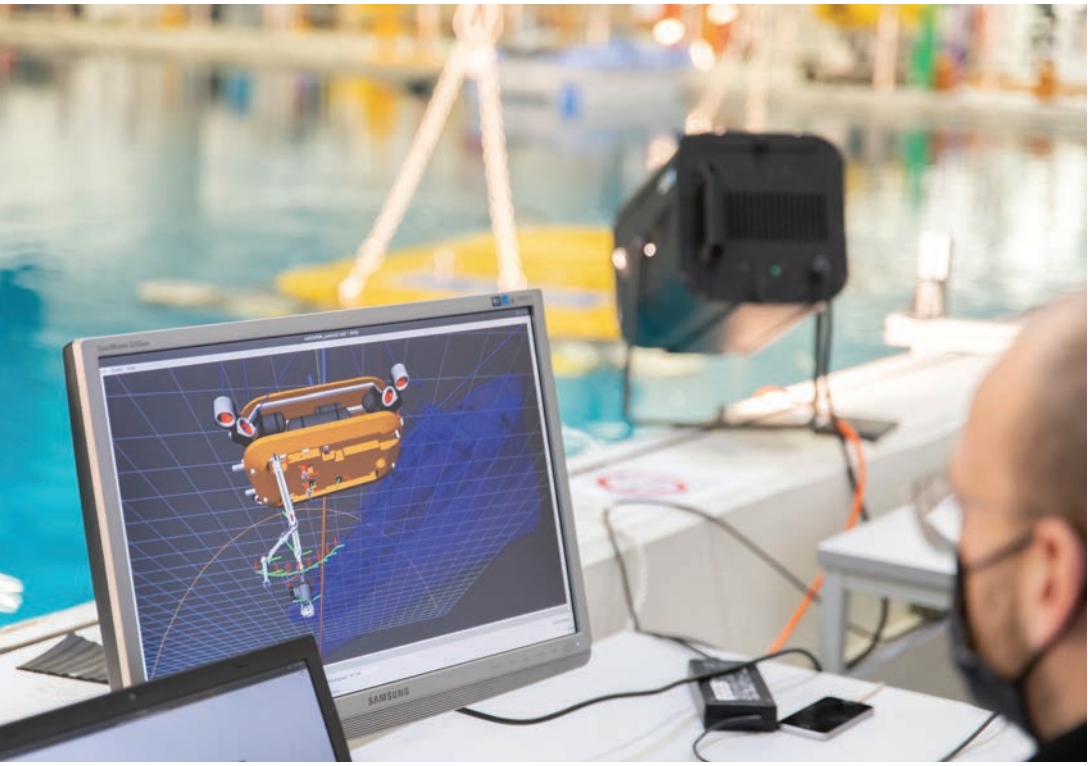

ABOVE
The dual-arm AUV Cuttlefish is launched in the DFKI's Maritime Exploration Hall in Bremen.

LEFT
A researcher monitors the AUV's collision avoidance in dual-arm mode from the edge of the pool.

Navy, Offshore Markets give Vestdavit a Lift

Vestdavit made a big splash at the live return Nor-Shipping in Oslo in April by showcasing a full-size PLR-5000 davit on its stand. Normally mounted on the decks of naval or coast-guard vessels for launch of smaller craft, the davit sports a 5000kg lifting capacity. The year 2021 was a strong sales year for the company, including a pair of signature orders. Vestdavit booked an order with the Norwegian Coast Guard (NCG) for a total of six PLR-5003KV systems being supplied for a series of three Jan Mayen-class polar patrol vessels now under construction at Norway's Vard Langsten yard, of which the first is due for delivery this year.

Each of the newbuild will have two specially designed PLR systems intended to meet the NCG's requirement for 330 days a year of operational availability in up to Sea State 5 and temperatures as low as -25C.

In addition, Vestdavit is delivering a TDB-10000L boat-handling system as well as a wagon-based boat transfer system, based on its MissionEase concept, for each of the newbuilds.

Vestdavit also won its first order with the Finnish shipyard Rauma Marine Constructions (RMC) to supply davits for a series of the Finnish Navy's four newbuild multi-role combat vessels, thereby bolstering its position in the wider Nordic naval market. The 114 x 16m Pohjanmaa-class corvettes will sport ice-strengthened hulls and are to be built at RMC's shipyard in Rauma, Finland as part of the navy's $1.36B Squadron 2020 project. We caught up with **Rolf Andreas Wingard**, Managing Director, Vestdavit, in Oslo for his insights on the technology and the market drivers moving forward.

Photo: Greg Trauthwein

Rolf Andreas Wingard, Managing Director, Vestdavit in front of the PLR-5000 davit @ NorShipping.

Rolf, we're coming off of two years of pandemic. Can you give insight on how it impacted Vestdavit and, specifically, what did you find to be the biggest challenges?

The biggest change was, in the middle of all this, we purchased our biggest manufacturing supplier, a facility in Poland, a company with 70 employees. That was a good thing because we secured the supply chain and we ensured that we had capacity to produce what we had sold. We learned that our new colleagues in Poland were very capable of running the business and ensuring proper quality of everything they built.

Do you see any positives that came out of COVID, from a business standpoint?

I think the positive thing is that we saw that we don't have to travel as much as we have previously done. We saw this with our colleagues in Poland. Normally we had been travelling to attend and perform testing.

Is there anything new with Vestdavit?

We see everything is getting bigger and more advanced. I think we've been loyal to our strat-

egy, which is to focus on the customers that are looking for a davit and boat handling systems that enables you to launch boats in adverse weather conditions. We are coming from a market where we've been delivering a lot of davits in the size range of five, six, seven tons for using fast rescue craft and now to bigger davits with dual lifting points for bigger boats, to 11 meters and from 10 to 15 tons.

We see that for the Navy applications, there are tougher and tougher specifications when it comes to shock and vibration requirements. So we have decided we want to have those competencies in-house, and we have invested quite a bit in building up competence and also in the software and hardware to deliver those services.

Can you give an overview of Vestdavit today using the metrics of your choice?

We are close to 120 people, including the factory in Poland. In 2021 our revenue was 175 million Norwegian krone ($19.7m). Last year we made approximately 50 davits, or about one a week on average. But we see that the systems are getting bigger (to help provide) a safe working load to handle bigger boats (or) multi-handling of small and big boats with in the same system. They also need to be able to handle unmanned boats, (which presents its own challenges when there isn't anyone onboard to connect a wire) and for this we have several systems available.

When you look at the markets you serve, where do you see the brightest opportunities?

I see after sales is becoming more important to make sure that things are operating and in good order. We see more customers appreciating and understanding that using the OEM to perform service and having proper spare parts is important, as up time is the key. So we are building up a bigger service network with own personnel, and also service partners close to the customer. That is one thing. And then we also see that, given how the world has been turning that there is a need for more patrol ships. This is to protect fishery rights, to control territorial waters, to catch smugglers and terrorists. So we see more navies building patrol crafts, and in those type of ships you need boat handling. We see this as a big opportunity for Vestdavit.

Nabrico Debuts New Line of Steel Davit Cranes

Nabrico has always offered a davit style crane primarily for hose handling on barges, but its newest lineup of steel davit cranes— available in 500-, 1,000- and 2,500-pound lift capacities—is designed to be used for a wider range of lifting applications. "Nabrico's new davit cranes are designed for multi-purpose use—a portable, inexpensive lifting tool for a wide range of applications," said Brad Jarnagin, industrial market manager at Nabrico. "Their applications are all across the board, from pulling pumps, motors, hose handling, miscellaneous engine parts, lifting generators and other equipment onto barges, to lifting tools and equipment up onto catwalks and mezzanines." Jarnagin noted the cranes can handle very long lifts, unlike chain hoists that become unwieldy due to all the chain. But, according to Jarnagin, "Their biggest advantage is that they are lightweight and portable. Multiple bases can be placed in various locations, and one crane can easily be moved from base to base." Jarnagin noted the bases come in three configurations: pedestal, flush mount and wall mount. The flush mount base is embedded so no structure sits up above ground level. In addition, the Nabrico davit cranes can easily be broken down and put into storage when not in use. These cranes are zinc plated, and all Nabrico cranes are made in the U.S. and come individually tested and certified.

GreyHawk 500 Davit

Gyrfalcon 2500 Davit

Images courtesy Nabrico

Tech Files

Innovative new products, technologies and concepts

Impact Subsea Launches seaView V3

Impact Subsea launched the third generation of seaView software to support its range of Altimeters, Attitude and Heading Reference Systems, Depth Sensors and Sonars.

seaView V3 provides a cutting-edge user interface for the setup and operation of Impact Subsea sensors. The launch of seaView V3 is accompanied by the release of a third generation of sensor firmware. V3 is an entirely new software development and intends to provide a powerful platform for existing Impact Subsea sensors and future sensor developments.

"To support our existing and new generation of underwater sensors, we have redeveloped seaView together with our sensor firmware from the ground up," said Alastair Mclennan-Murray, Technical Director, Impact Subsea,. "This provides new capabilities to the user and a strong software and firmware base for future product development."

V3 allows a single or multiple Impact Subsea sensors to operate simultaneously from a single application. This is ideal for operations with a single sensor to ROV operations where Sonar, Altitude, Depth, Heading, Pitch & Roll can all be displayed on screen at the same time. With V3 comes the ability to automatically detect any sensor that has been physically connected to the computer. The user no longer needs to deal with communication port allocation or configuration of required baud rate – this is handled automatically by the software. Sensors are physically connected then automatically displayed on screen. This is a great time-saver for applications where multiple sensors are in operation. All sensors are fully software configurable, with seaView V3 providing a clear process to set up and configure sensors to suit specific requirements. For example, V3 allows for custom output strings to be created, where users can add new formats of ASCII output strings to a sensor's firmware. This enables quick integration of sensors into existing platforms and software applications by the user, without the need to redevelop systems or request additional support from Impact Subsea.

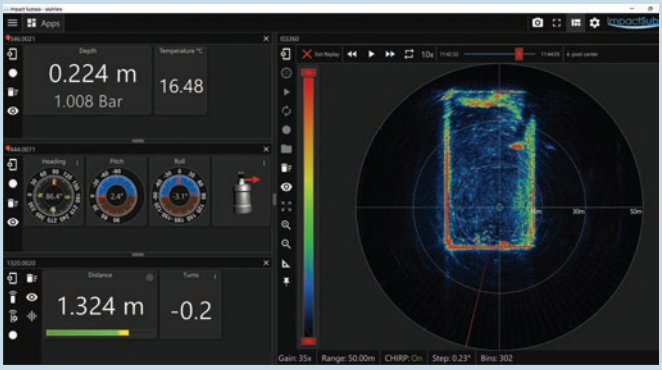

Photo courtesy Impact Subsea

The 'inversion reset' capability in Impact Subsea sensors has been further enhanced: Three inversions within 10 seconds of power on sets the sensors to RS232; Six inversions, sets it to RS485.

This allows sensors to quickly be configured to suit the required communications interface.

Nauticus Fleet Launched

Houston-based Nauticus Robotics Inc. announced the initial production run of Nauticus Fleet, a robotic navy of 20 Hydronaut - Aquanaut pairs. These tandem pairs will be deployed in multiple offshore industries serving applications ranging from subsea maintenance and intervention to data collection activities. These first sets of robots will be delivered in Q4 2022, with the remainder being fulfilled by the end of 2024.

Nauticus is currently planning regional operations within the Gulf of Mexico, Norway, the United Kingdom, and Brazil.

The surface aspect of the fleet is Hydronaut, an 18-m optionally crewed autonomous surface vessel (ASV) that supports the launch, recovery and real-time operations of Aquanaut, its undersea robotic counterpart. Hydronaut ferries Aquanaut to and from the worksite and supports battery recharges and the communications link from the local remote operations center for supervised autonomous operations. Additional technical and operational support can be provided from Nauticus' Houston-based global remote operations center.

Aquanaut is a fully electric, free-swimming subsea robot, controlled through acoustic communication networking and can perform a wide range of data collection, inspection, and manipulation tasks. Aquanaut's defining capability is operating in two separate modes: actively transforming itself between the excursion and intervention configurations. Excursion mode involves the usage of data collection and perception sensors during transit, while intervention mode uses two electric work-class manipulators (Nauticus' Olympic Arms) to perform work in the subsea environment.

Image courtesy Nauticus Robotics

MARINE TECHNOLOGY REPORTER

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Marine Technology Reporter's annual MTR100 awards edition is the industry's most awaited annual ranking of the leading companies serving the global underwater and subsea industry. Participants annually come from every corner of the globe and every sector of the industry.

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Tech Files

Innovative new products, technologies and concepts

Linden Photonics

Linden Photonics said it supplied the critical fiber optic link transmitting pictures and videos seen around the world from the mission to find the wreckage of polar explorer Ernest Shackleton's ship Endurance lost 10,000 feet under Antarctic ice. The Endurance22 expedition team came to Linden to build the best possible cable for the job, Linden said. Thin yet strong, rugged yet light, the patented design provided a dedicated link to the ROV providing real time data. Not wanting to risk a lost AUV, the Endurance22 team decided a reliable link was needed.

Linden said it supplied this cable in a single continuous length 25km long.

Tritech's Gemini Imaging Sonar

Tritech released the Micron Gemini, which the company claims is the smallest multibeam sonar on the market. With improved image quality, a 90-degree horizontal field of view and 50 m range, the Micron Gemini is designed to offer cost effective obstacle avoidance and navigation for small ROVs and AUVs, as well as utilization with Tritech's Diver Mounted Display system (DMD). Alongside improved image quality, the Micron Gemini now includes a built-in pressure sensor, temperature sensor, depth reading and optional AHRS (Attitude Heading and Reference System). The Micron Gemini operates at 720kHz.

Valeport Instruments

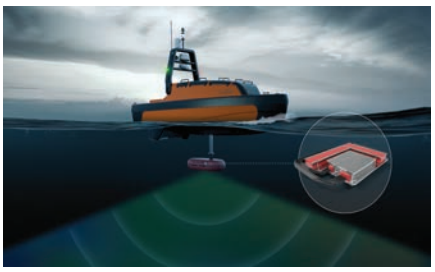
Valeport introduced several new technologies at Oceanology International held earlier this year, including:

- **Bathy2** (pictured) – an enhanced, robust integrated instrument to provide reliable and accurate density corrected depth data up to 6000m
- **miniIPS2 and uvSVX** – with unique interchangeable pressure heads, these next-gen sensors benefit users who work at different depths
- **SWiFT CTD and SWiFT CTDplus** – designed for a seamless workflow, these user-friendly profilers deliver improved accuracy and versatility to those requiring CTD measurements.

3D at Depth Expands

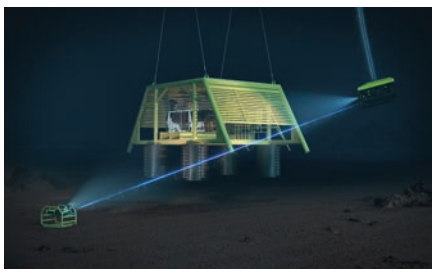
3D at Depth expands with a marine robotics solution, launching Cuvier DEEP, an automated underwater solution that combines sensors and system performance with operational efficiency and data quality in one solution — leveraging 3D at Depth's SL4 technology.

Neil Manning, COO, said: "We have developed the new service delivery and application by evolving the hovering unmanned 3,000m deep-water dual-hull SAAB Sabertooth Underwater System, modified to enable greater endurance and more diverse sensor payload integration, meaning both greater in water operational time and higher data capture accuracy."



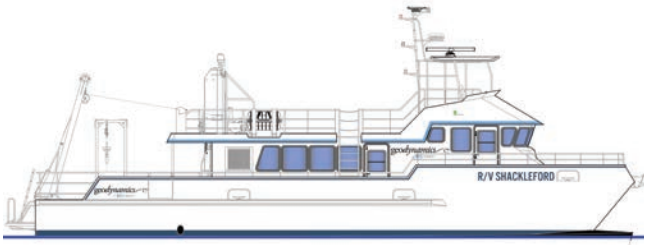
USV Multibeam Echosounder

Kongsberg Maritime launched the EM 712 USV, a multibeam echosounder for use with Unmanned Surface Vehicles (USVs). The EM 712 USV has been designed to be easily integrated with and operated from any USV. It features a subsea container housing redesigned electronics, which would normally be located on the topside of a standard EM 712. The container fits inside the same footprint as the transducers and can be installed in a gondola. It is fully frequency-agile between 40 and 100 kHz, allowing for long-range and swath coverages by utilizing CW and FM chirp pulses, in combination with being a high-resolution sonar.



KM Wireless Video Solution

Kongsberg Maritime launched its cNODE Mantis – a new addition to the cNODE product range of acoustic modems which introduces the new capability to stream a live video feed. The live video it streams is transmitted to a receiver installed either on the ROV's TMS (Tether Management System) or on the vessel itself, at ranges of up to 500m. As the wireless video transfer works on a high-speed acoustics link it will function in both murky and clear water conditions and is unaffected by background light. With a bit-rate of up to 70 kbit/s, it allows for the transfer of live video with a typical quality of 420 x 380p at four frames per second.



All American Marine inks deal to build Wind Survey Vessel

All American Marine (AAM) won a contract to build a research and hydrographic survey vessel for Geodynamics, an NV5 company. R/V Shackleford is a 73 x 26.7-ft. semi-displacement aluminum catamaran hull that was developed by Nic de Waal of Teknicraft Design in Auckland, New Zealand.

The vessel will have the fundamental, and primary design elements of the Duke University Marine Lab's R/V Shearwater and Blue Tide Puerto Rico's R/V Blue Manta that were both recently commissioned. R/V Shackleford is named after the southernmost barrier island in the Cape Lookout National Seashore chain, a region rich in maritime history. The vessel will be built to USCG Subchapter T standards and will primarily operate off the eastern seaboard of the U.S.

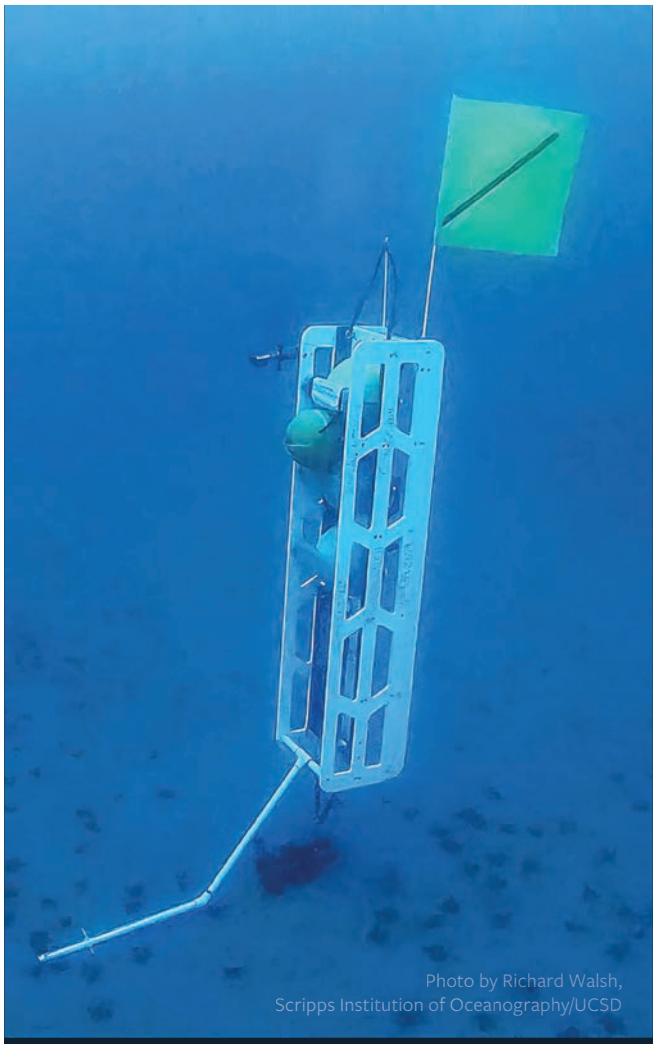
"Our continued focus is meeting the most stringent offshore survey specifications in the world, whether that is for nautical charting or for subsea exploration to support offshore wind development. A larger, more stable and customized vessel will not only help us maintain our high standards of quality, but it will also help with our real-time data acquisition and processing transparency objectives by comfortably accommodating our client reps," said Chris Freeman, General Manager & Sr. Marine Geologist.

The R/V Shackleford integrates the signature Teknicraft Design symmetrical and asymmetrical combined hull shape, bow wave piercer, and a patented hydrofoil-assisted hull design. The hull and hull components are designed to break up wave action and ensure reduced drag while enhancing passenger comfort. This design is proven to have both low-wake wash energy and increased fuel economy.

For the operator, the most valuable feature is the fuel economy, consuming approximately the same gallons per nautical mile throughout the estimated cruising speed of 18-24 knots, with a fuel-efficient survey operation speed of 4-8 knots, fully laden.

With a large fuel capacity of 1500 gallons, this fuel-efficient design will be able to hold up to 16-day passengers / 8 live-aboard plus 3 crew. The propulsion package includes 2x fixed pitch propellers, powered by twin CAT C18 "D" ACERT, Tier 3 engines, rated at 803 bhp @ 2100 RPM driving ZF 665V remote mounted gearboxes.

GLOBAL OCEAN DESIGN



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Funds Secured for Cal Maritime's Training Ship

By Eric Haun

U.S. President Joe Biden signed the $1.5 billion Fiscal Year 2022 (FY22) omnibus appropriations package that includes a funding provision for the California State University Maritime Academy's new state-of-the-art training ship.

The newly funded ship, which has yet to be named, is the fifth in a series of 524.5-foot-long National Security Multi-Mission Vessels (NSMV) designed specifically for America's state maritime academies. It will replace Cal Maritime's aging training ship Golden Bear and is expected to be delivered within the next three to five years.

"We are grateful for the funding of this new ship," said Cal Maritime president Tom Cropper. "This moment is remarkable – it culminates eight years of work by the Consortium of State Maritime Academies and for the first time, provides brand new training vessels for our cadets."

The new highly capable, modern and versatile NSMVs will be a major upgrade from the retired and retrofitted naval vessels currently used to train state maritime academy cadets. "The training ship Golden Bear is a former oceanographic research vessel within the Navy fleet and has been retrofitted for cadet training. The ship requires continuous repairs, remodeling, upgrading, and improvements to best serve those aboard," Cropper said.

According to Cropper, a key advantage of the NSMV is that it is purpose built with brand new and current technology, similar to what is found on modern merchant fleets. He noted the ships will feature diesel electric engines and diesel generators.

"The new NSMV will feature numerous instructional spaces, a full training bridge and accommodations for up to 600 cadets to train in a first-rate maritime academic environment at sea," Cropper said. "In addition to providing additional billet space to educate our cadets the NSMV will provide them the opportunity to train on a state-of-the-art vessel."

As an added benefit, the ships are also designed to support humanitarian assistance and disaster relief missions globally when needed. "The NSMV will have a helicopter deck and will have space to provide as a hotel service ship for first responders and medical trailers for humanitarian purposes. Upgrades for the ship also include thrusters, which reduces the need for a tug as well as roll on/roll off capability. The versatility of this ship is boundless," Cropper said.

The new series of vessels is ultimately the result efforts made by U.S. Maritime Administration (MARAD) administrators, state maritime academy presidents and legislators—all recognizing the critical need for excellence in maritime education, and specifically the need for updated training ships.

"The bipartisan support of the new vessel underscores the support of Cal Maritime and the other state maritime academies," Cropper said. "I send a special thank you to the delegates in the House of Representative and Senate from Alaska, California, Hawaii, Oregon and Washington in backing the

new training ship and sharing in the value and mission of our academy."

The current training ships and the new NSMVs are owned by the federal government and part of MARAD's National Defense Reserve Fleet, on custodial loan to the state maritime academies. "On behalf of the Maritime Administration, Transportation Secretary Pete Buttigieg and the Biden-Harris Administration, we are extremely pleased to receive funding for the fifth National Security Multi-Mission Vessel," said Acting MARAD Administrator Lucinda Lessley. "This investment represents a steadfast commitment to our maritime workforce development and our national security. The construction and delivery of these vessels also demonstrates a highly innovative and cost-effective shipbuilding program that has enabled government to draw on industry best practices." In May 2019, MARAD selected TOTE Services to be the vessel construction manager (VCM) for the NSMV program, and in April 2020, TOTE Services awarded Philly Shipyard a contract to construct up to five NSMVs.

The first vessel is currently under construction and scheduled to be delivered to SUNY Maritime College in 2023. The next three ships are designated for Massachusetts Maritime Academy, Maine Maritime Academy and Texas A&M Maritime Academy, respectively.

Image courtesy MARAD

MARINE TECHNOLOGY REPORTER

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January/February 2022

Underwater Vehicle Annual

- Underwater Defense
- Manipulator Arms and Tools
- Autonomous Navigation GNSS MEMS
- Unmanned Vehicle Propulsion
- IMR: Offshore Inspection, Maintenance & Repair

Event Distribution:
Subsea Expo
February 22-24 Aberdeen, Scotland

Digital Edition

MTR E-Magazine Edition: Oceanographic

Special Report on
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March/April 2022

Oceanographic Instrumentation & Sensors

- Fiber Optic Cables, Connectors & Slip Rings
- Buoyancy Technology
- Environmental Testing Equipment
- Underwater Communications
- Underwater Battery Technology

Event Distribution:
Oceanology International:
March 15-17, London, UK
IPF:
April 26-28, Atlantic City, NJ

May/June 2022

Offshore Energy: O&G & Renewables

- Hydrographic Survey Sonar
- Sonar, Telemetry & Data Processing Software
- USV, ROV & AUV Platforms
- GPS, Gyro Compasses & MEMS Motion Tracking
- Interconnect: Underwater Cables & Connectors

Event Distribution:
OTC:
May 2-5, Houston, TX

July/August 2022

Autonomous Vehicle Operations

- ROV Technology: Work Class to Micro Systems
- Thruster Tech: Underwater Propulsion
- Underwater Tools & Manipulators
- Scientific Deck Machinery

Event Distribution:
MATE ROV Competition:
July 2022

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Special Report on
Offshore Wind Field Surveys

September/October 2022

MTR100: Focus on 100 Leading Companies, People and Innovations in the Subsea Space

Event Distribution:
Oceans 2022:
October 17-21, Hampton Roads, VA

November 2022

Ocean Observation: Gliders, Buoys & Sub-Surface Networks

- Acoustic Doppler Sonar Technologies ADCPs and DVLs
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