MARINE TECHNOLOGY REPORTER

October 2017

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Paul G. Allen & the successful quest to

Find Indianapolis

The Promise and Peril of Subsea Mining

Autonomous Fleets and Unmanned Forces

Harsh Environments 'Roomba' in the Arctic

Volume 60 Number 8

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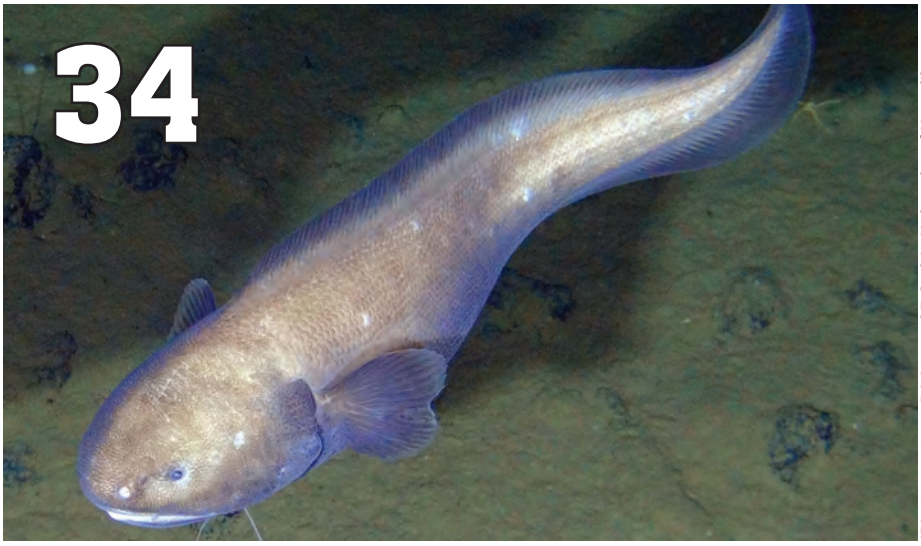

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Editorial

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I try not to play favorites, but human nature occasionally overrules. **Eric Haun's** cover story of this edition on the successful quest to find the USS Indianapolis is one of my favorites for sure. For me the story starts – as I'm sure it did and has for generations of movie watchers – with the ubiquitous movie *Jaws* and Captain Quint's (actor Robert Shaw's) three and a half minute speech on the sinking of the USS Indianapolis; a scene-stealing speech which gives breadth and depth to the character's obsession with finding and killing the ornery 25-ft. great white shark. But my interest in the story exceeds Hollywood, as it neatly ties together many of the themes we discuss in our pages regularly: collaboration, technology and history. The most recent hunt for USS Indianapolis was led by Microsoft co-founder **Paul G. Allen** and his Seattle-based company Vulcan Inc., a journey on board RV Petrel that deployed a full arsenal of the latest vehicle, sensor and software technology in the quest to find a ship that sank more than 70 years ago and came to rest in waters more than 5,000 meters deep. The full story starts on page 20, and on pages 24 and 25 you will find a list of the technology deployed to finally explore this historic wreck.

The story of technology and autonomy continues on page 26 with the feature: *Unmanned Forces: Building a Multi-Domain Autonomous Fleet.* Autonomy is obviously a recurring theme in our pages, and here we examine the tools and performance multi-agency, multi-asset exercise to push autonomy to its limits.

Looking at subsea technology from a different angle this month is **Kira Coley**, who examines in her feature starting on page 34 the promise and the peril of subsea mining. As we increasingly build the tools and technique to operate under the waves more efficiently and effectively, in tandem there is increasing industrial activity on the world's seafloors. In this edition Coley takes a look inside the ABYSSLINE project, which is undertaking benthic biological baseline studies to evaluate subsea structure and biodiversity, and is intent on playing a role in determining the environmental cost of subsea mining.

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NOAA teams with Paul Allen for Deep Ocean Observation

NOAA partners with Paul G. Allen Philanthropies; new Deep Argo buoys to probe ocean currents that drive weather and climate

Microsoft co-founder and philanthropist Paul G. Allen and NOAA's Pacific Marine Environmental Laboratory will deploy a large array of new deep ocean floats to expand ocean observations in a key area of the western South Atlantic Ocean.

Image: NOAA

www.marinetechnologynews.com/news/teams-allen-ocean-observation-552250

Black Sea MAP

Final Cruise Sets Sail

One of the largest maritime archaeological projects ever staged was launched in 2015 to investigate the changes in the ancient environment of the Black Sea region, including the impact of sea level change during the last glacial cycle. On August 25, 2017 the Black Sea MAP (Maritime Archaeological Project) team set sail from the Bulgarian port of Burgas for the final phase of the project aboard the R/V Havila Subsea.

Photo: Students study the secrets of the Black Sea.

Image : Martin Hartley

https://www.marinetechnologynews.com/news/final-cruise-black-551887

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Image courtesy of Mingxi Zhou / AOSL

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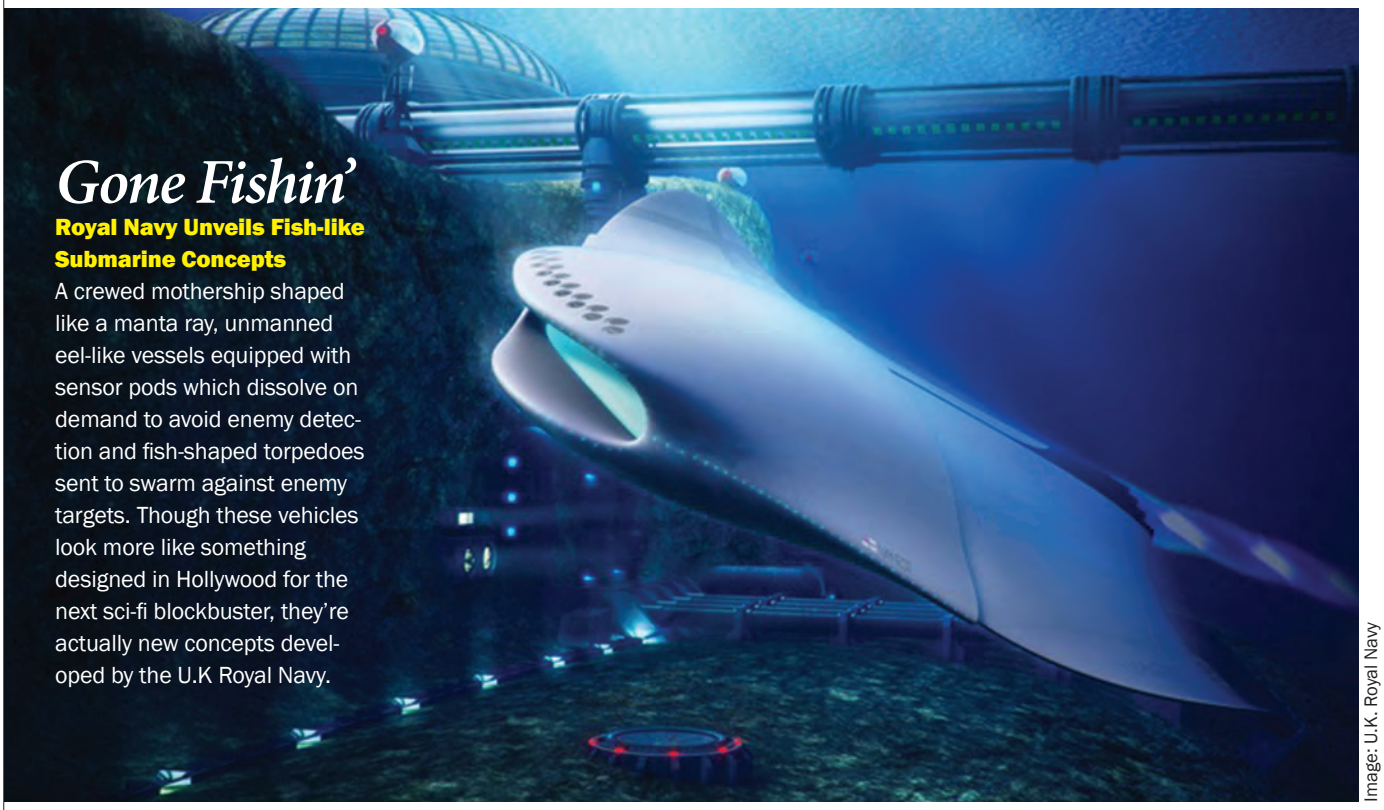


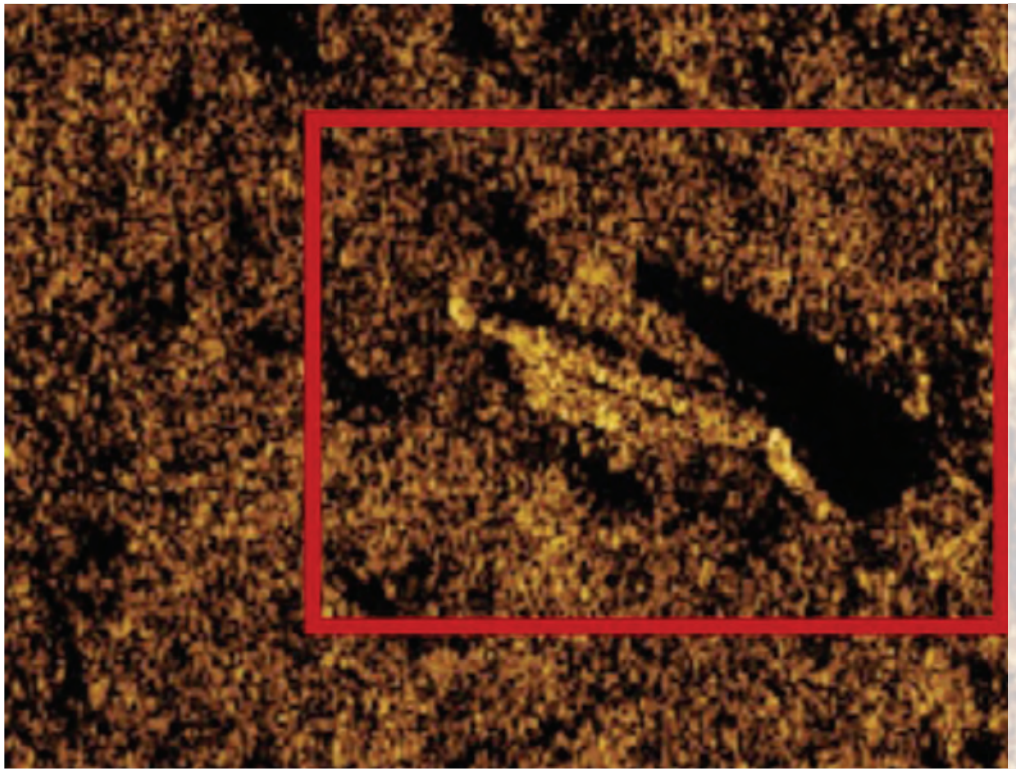
Gone Fishin'

Royal Navy Unveils Fish-like Submarine Concepts

A crewed mothership shaped like a manta ray, unmanned eel-like vessels equipped with sensor pods which dissolve on demand to avoid enemy detection and fish-shaped torpedoes sent to swarm against enemy targets. Though these vehicles look more like something designed in Hollywood for the next sci-fi blockbuster, they're actually new concepts developed by the U.K Royal Navy.

Image: U.K. Royal Navy

www.marinetechnologynews.com/news/royal-unveils-submarine-concepts-551934



Avro Arrow

A search team has recently unveiled images that show the first of nine Avro Arrow free-flight models believed to be sitting at the bottom of Lake Ontario.

Search program organizers OEX Recovery Group held a press conference in Toronto last Friday to unveil sonar and underwater camera images that showcase a free-flight Avro Arrow model launched in a series of tests from 1954 to 1957 as part of the Avro Arrow design program

https://www.marinetechnologynews.com/news/sonar-images-historic-arrow-552331

Image: Kraken

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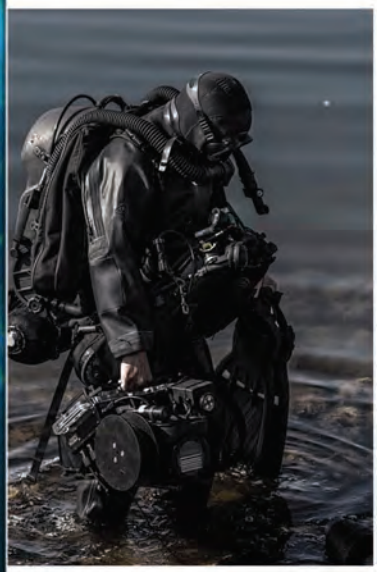

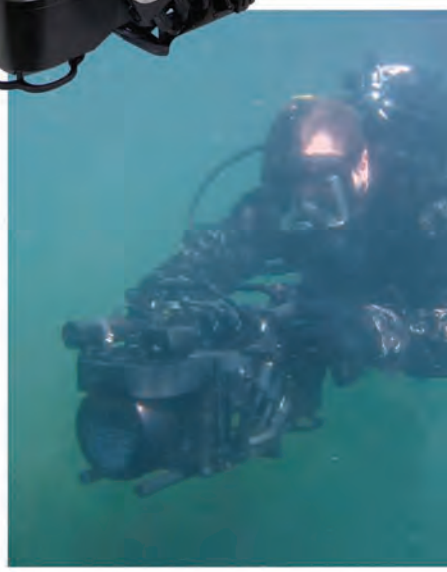

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A Unified Voice

for Ocean Science and Technology Companies in Washington, DC

By Richard Lawson

It is well established that associations play a vital role in the success and growth of companies in a particular industry. Associations are an industry's public relations arm; providing advertising, education, conferences, lobbying, publishing and, ultimately, fostering collaboration between companies and enhancing business opportunities. An association is a collection of companies, many of which may be competitors, but work and prosper in the same trade and business space.

These companies recognize that – to steal a phrase from President John F. Kennedy – "a rising tide lifts all boats." What is in the common good for the industry is an ultimate benefit to each company.

And so, these associations serve to better professional networking and business development by providing an atmosphere and the tools that benefit each company.

Associations also act as an advocacy effort for the industry, providing the legislative and executive branches of government with a 30,000-foot snap shot of the federal issues and matters confronting the industry, and working with these various government institutions to find solutions to these matters. And this is where individual, and topic-specific, industry associations are invaluable to the public policy process.

Associations provide the high-level and granular information that elected and appointed officials need in order to make on-the-spot, informed decisions on often tedious and difficult to understand matters.

And this is why every industry has an association; from the mighty U.S. Chamber of Commerce to the smaller Surf Industry Manufacturers Association – and all industries in between.

Except one.

To rectify this oversight, earlier this month, the new "International Ocean Science and Technology Industry Association (IOSTIA)" was launched in Washington, D.C.

Until now, companies in the ocean science and technology space; those "blue tech" sectors whose companies explore, and commercially and sustainably utilize the Earth's oceans, did not have an industry association to call home. These companies were scattered among various other industry associations, if they found an affiliation at all.

For instance, an ocean technology company, with no serious connection with offshore oil and gas, may find itself squeezed into a traditional oil and gas association because it was the "closest" option for them. But just like a shoe that doesn't quite fit, their membership in that association doesn't quite fit. Companies in the ocean science and technology space shouldn't have to settle. They needed an association where the shoe finally fit.

IOSTIA (pronounced IO-sha) is an association for businesses in the ocean science and technology community that share the same business interests and public policy goals. Its mission is to advance the business interests of its members and represent the industry as a unified voice in Washington on matters associated with ocean science and technology.

With as many as two-thirds of IOSTIA-related companies overseas, this industry association will also be international in scope and substance. That means we'll be engaging the foreign embassies located in Washington to assist international companies with entering the U.S. market, and playing a central role in business development and professional networking opportunities.

IOSTIA's member companies cover the waterfront of ocean science and technology that include notable sectors such as marine renewable energy, environmental monitoring protection, fisheries and aquaculture, maritime security, marine

telecommunications, maritime vehicles, oceanography and hydrography, mineral resources, sensors and imaging, marine spatial planning, ocean observing systems, ports and infrastructure, and diving and manned exploration.

The new association will provide key benefits and services to its member companies including venture capital promotion, member marketing initiatives, business savings programs, trade missions, and will host the Capitol Hill Ocean Tech Expo to showcase member's technologies directly to Congress and the regulatory agencies.

And while there are many outstanding ocean-related nonprofit organizations, foundations, think tanks, scientific societies, and centers of learning – all with which we hope to collaborate, IOSTIA is different. As a 501(c)(6) industry associations, IOSTIA and its member companies can directly lobby Capitol Hill and the Administration on key legislative and regulatory matters critical to the ocean science and technology industry.

As such, IOSTIA will develop a serious, substantive and unified voice on Capitol Hill and in the regulatory agencies on issues that matter exclusively to ocean science and technology companies – unencumbered by mixed messages coming out of unrelated associations.

IOSTIA will be a power on Capitol Hill and in the regulatory agencies on such matters.

But at the end of the day, the biggest benefit to these companies will be the common interest, the unified voice, the singular message and the business development and professional networking opportunities.

Backed by the strength of one unified industry association, it is our belief that significant progress grow the impact of these crucial, but all too often disparate industry sectors.

With IOSTIA, the shoe finally fits for ocean science and technology companies.

Figure 1:
UAS programs are ideal for visually inspecting remote assets, such as rig components or sub-components in difficult-to-reach areas.

Credit: Oceaneering

UAS Programs

Improving Safety and Effectiveness for Offshore Asset Inspection and Surveying

By Todd Chase

Oil and gas companies are using unmanned aircraft system (UAS) technology to improve safety and efficiency in a growing range of applications, from infrastructure and maintenance inspection to security, emergency response and environmental and regulatory compliance. Today's UAS programs are supported by payloads including high-definition video equipment, high-resolution still cameras, thermal imaging cameras and emission sensors – and there are many ways, operationally and financially, to incorporate them into business processes. Numerous oil companies have demonstrated how UAS programs can improve safety while augmenting existing operations, and have also shown the value of supporting these programs with a comprehensive range of processes, procedures and management systems.

Examples of Successful Programs

One of the most popular applications for UAS programs includes visual inspections of remote assets such as oil rigs. In one example, a major oil company set up a UAS program to identify the presence or absence of rig components or sub-components – as well as any gross damage or deformation, including visible cracks, the extent of coating breakdown and variations from structural drawings. The unmanned, eight-pile production and compressor platform included a boat landing connected by a bridge, and featured two decks and elevation depths ranging from -97 feet to 10 feet (Figure 1). Many of the areas of interest were in hard-to-reach locations, as the image shows.

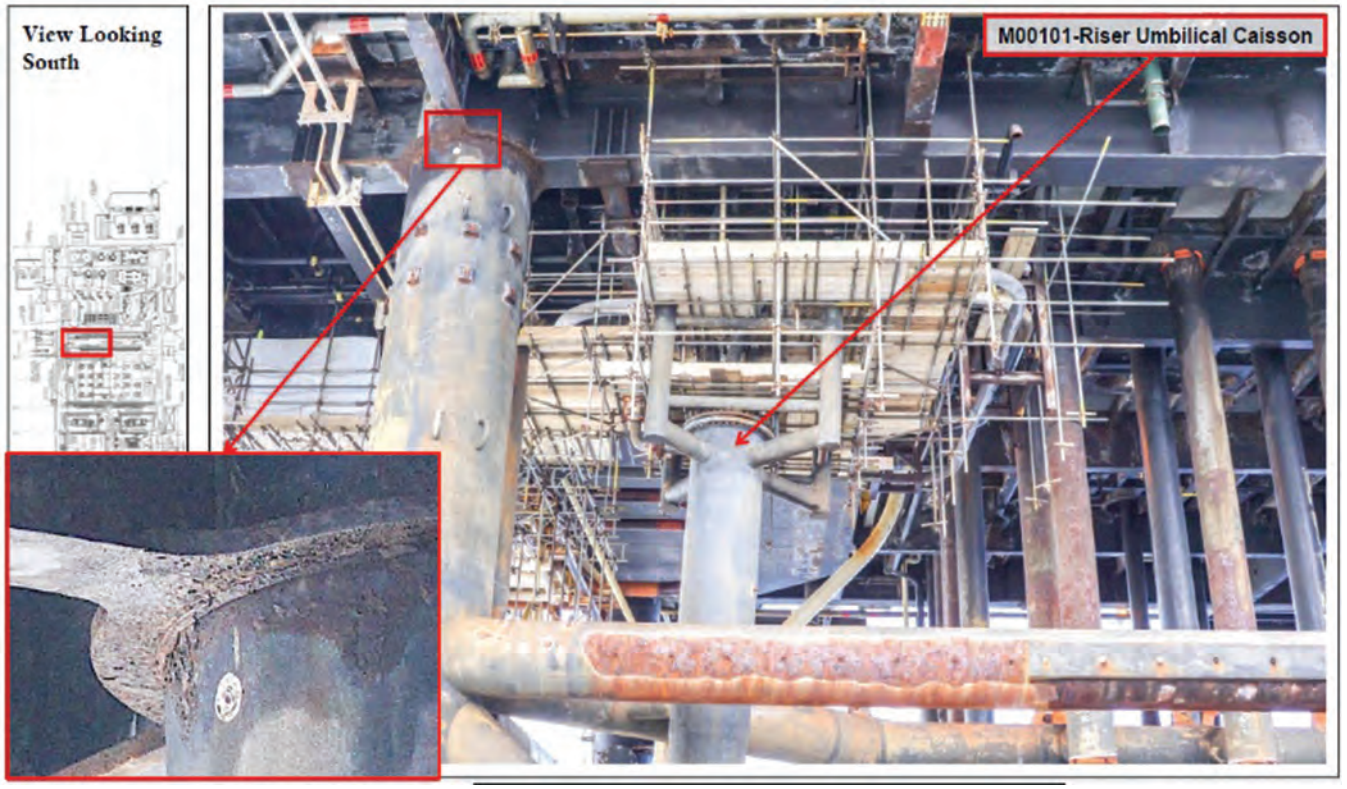
Clearly, manual inspection of these rig elements would be both difficult and dangerous if it required sending someone down a ladder or out onto scaffolding. With a UAS program, people are removed from these dangerous situations. Additionally, inspections can be performed while the asset is live, thus reducing the length of costly shutdowns. A study of UAS use at one leading international exploration and production (E&P) company showed that these programs enable inspec-

Figure 2: **A typical video log, with links to the relevant inspection clips.**

Video Log	Platform	Structure No.	Inspection No.
	BB-202-C	BB202C	BB202C T20162
	DVD/Cloud ID Number: D504	Media Type: Cloud	

Start	End	Caption	Action
01:00:00:01	01:00:00:14	Introduction to UAS inspection of flare boom.	Watch Video
01:00:00:16	01:00:00:29	General visual inspection of upper flare boom attachment point.	Watch Video
01:00:00:40	01:00:01:15	Close visual inspection of Section #4 members of flare boom.	Watch Video
01:00:01:16	01:00:01:36	Close visual inspection of Section #5 members of flare boom.	Watch Video
01:00:01:41	01:00:02:18	General visual inspection of flare boom end members.	Watch Video
01:00:02:19	01:00:03:18	UAS moving to launch/recovery point.	Watch Video
01:00:03:19	01:00:03:48	UAS on deck, end of inspection.	Watch Video

Figure 3: **Difficult-to-reach locations, such as this riser umbilical caisson access platform, can be surveyed by using a UAS. Access to the platform had been restricted after it was damaged.**



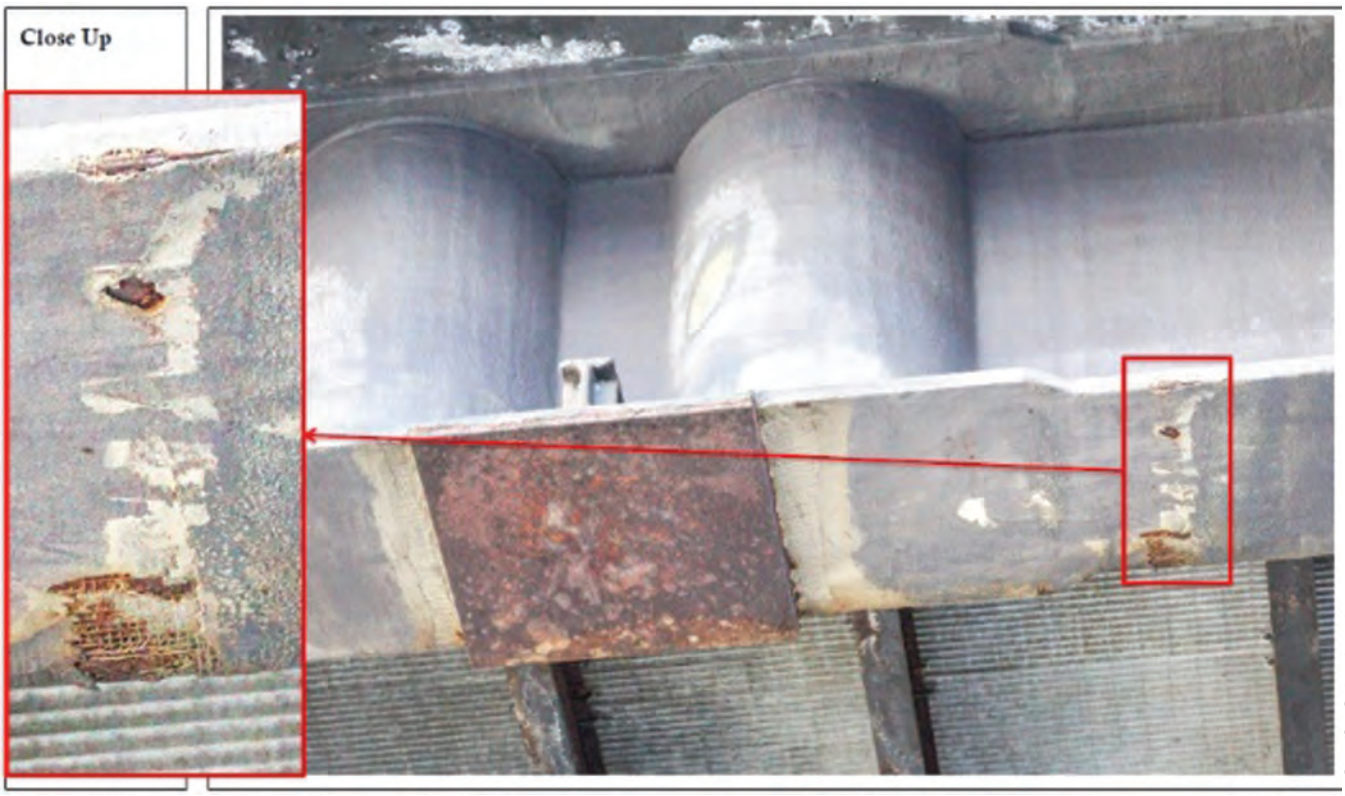
Credit: Cyberhawk

tions to be completed 20 times more quickly than traditional rope-access techniques, which can take an average of eight weeks to complete when using human inspection teams. The direct costs of UAS programs are half those of human inspections – and UAS programs also eliminate other indirect costs associated with offshore bed space, standby boats and the transport of personnel to and from the rig by air or sea. The costs of helicopters, alone, can average as much as $2,500 an hour and up to $60,000 per flight.

When UAVs are used for all initial visual and thermal inspections, personnel are only deployed for contact inspection and other advanced investigations, if required. This can sharply reduce the risk of death and injury in a workplace environment that, according to the Occupational Safety and Health Administration (OSHA), has a fatality rate seven times greater than that for professionals in other sectors. One rig operator that implemented a UAS program reported a reduction in injuries of greater than 10 percent as compared to the same period a year earlier when it used human inspections. The other benefit of removing humans from these inspections is that it is no longer necessary to shut down rig operations, which can cost an operator millions of dollars in lost production. Assuming a typical five-day shutdown during a traditional inspection, the operator might possibly lose 100,000 barrels in lost production at a cost of $40 to $50 per barrel.

In a typical rig survey example, a UAS could capture visual images of key elements including cellar underdecks, emergency shutdown valve (ESDV) platforms, conductors and guides, caissons and jacket legs. Coverage of a cellar underdeck would be enhanced by having the UAS aerially inspect it from several different angles, taking both close-up and standoff photos. An interim inspection report is generally provided midway through a project, highlighting immediate issues and general conditions, and a final report is submitted at the project's completion. A typical inspection report encompasses all key elements across multiple elevation depths. In the example of an unmanned, eight-pile production and compressor platform, this would include performing topside, hull and structural critical inspection point (SCIP) surveys. A UAS would be used to take topside photos of the structure, along with video footage throughout the inspection. The UAS would also be used to image the structural and coating condition on the hull exterior and associated components, along with the coating condition and surface corrosion on all columns and other SCIPs. Figure 2 shows the video log of a typical report.

The images in Figure 3 are among 1,900 visual images that were captured



Credit: Cyberhawk

Figure 4: This UAS survey image shows 100% coating breakdown and surface corrosion in the primary member between two grid points, along with exposed reinforcing mesh in the insert.

during a survey of a typical rig's components and subcomponents. It shows a riser umbilical caisson platform to which access had been restricted because of storm damage. The images in Figure 3 show an 80 percent coating breakdown on the deck support leg, with surface rusting shown in the inset image.

The UAS survey identified numerous other issues, ranging from missing gratings and handrails to areas of moderate to heavy corrosion on jacket legs, horizontal bracing, conductors and the welded connections in the areas between jacket legs and the underdeck and near discharge pipes. In the cellar underdeck steelwork, the survey showed that the primary member between two grid points displayed complete coating breakdown and surface corrosion, with exposed reinforcing mesh shown in the inset. This area would have been extremely difficult for a person to survey (Figure 4).

One of the most difficult locations for human surveyors to observe is the flare and its supporting structure, a location relatively easy for a UAS to survey. In this example, liquid staining has occurred, providing evidence of process fluid that may have been discharged during a blowdown or process interruption.

Developing a Program

One of the biggest decisions that organizations must make is whether to subcontract services from a third-party provider or to build and deploy a solution themselves. It often makes better sense, economically, to subcontract a UAS program to a third-party service provider rather than to invest in the staff, equipment and resources that would be required to develop a program. Those that choose to outsource their UAS programs are often better positioned to take advantage of new technologies while keeping up with industry developments. This isn't always an option, though, for organizations that need more control over how their data is collected. In other cases, an organization may have a sound business case for staffing and equipping an in-house team. For those that develop their own UAS programs, it is critical to allocate sufficient resources and attention to the latest technology developments and to support evolving safety guidelines. There will also be a learning curve in terms of selecting equipment and pilots for maximum safety, performance and environmental protection, and knowing how to implement industry guidelines and best practices. These have been established by the International Association

of Oil & Gas Producers (IOGP), the Helicopter Safety Advisory Conference (HSAC) and Oil & Gas UK, among others. These and other organizations have played a key role in focusing attention on best practices for UAS safety.

For instance, the collaboration that HSAC has facilitated between major oil and gas companies has resulted in a set of IOGP recommendations for safe UAS operation. This living document was the first to provide high-level, industrywide guidance for recommended UAS practices. The IOGP has published its Aircraft Management Guidelines for the industry, providing the basis for aviation safety expectations and guidelines for aviation in the oil and gas industry. IOGP has also released a similar set of Unmanned Aerial Systems Guidelines to provide a framework of guidance and expectations for UAS operations, with input from HSAC and other groups. UAS programs provide numerous data-gathering advantages as compared to alternative approaches, and offer benefits across a growing range of applications. Sending a person onto scaffolding to inspect a flare tip is far more dangerous and inefficient than deploying a UAS. Plus, the UAS can perform its task while the flare tip is still operating, at a cost that is generally lower than dispatching a helicopter. UAS programs create new opportunities to gather essential data.

Launching a successful UAS program requires a thorough commitment to industry best practices for operational excellence. This means adopting guidelines set by an oil and gas industry that views UAS operations in much the same way as it does manned operations – with an emphasis on quality, safety and risk management. Organizations that embrace these industry guidelines will augment their existing processes to improve data-gathering capabilities and safety with maximum cost efficiency and flawless execution.

The Quest to find the USS Indian

By Eric Haun

Sunk by Japanese torpedoes near the end of World War II, heavy cruiser USS Indianapolis disappeared to the darkest depths of the Philippine Sea, where it remained undiscovered for more than 70 years. Recently a team of civilian researchers led by Microsoft co-founder Paul G. Allen set out equipped with an arsenal of high-tech search equipment on a mission to locate the historic vessel last seen on July 30, 1945. The story of the USS Indianapolis is one of military

Photo courtesy of Paul G. Allen

USS Indianapolis (CA 35) off the Mare Island Navy Yard in California, July 10, 1945.

(U.S. Navy file photo)

napolis

might, heroism, tragedy, controversy and mystery. Built by New York Shipbuilding Corporation in Camden, N.J., the 623-ft., 9,800-ton Portland Class heavy cruiser USS Indianapolis (CA-35) entered service in November 1932, serving through campaigns that earned the ship 10 battle stars over the course of World War II.

But after much success in battle, the fate of the Indianapolis eventually turned tragic as World War II neared its end. In the early hours of July 30, 1945, having just completed a secret mission to deliver materials from California for the first operational atomic bomb, "Little Boy" to a naval base on the Pacific island Tinian, Indianapolis was en route from Guam to Leyte when it was torpedoed by Japanese submarine I-58.

Indianapolis sank quickly – reportedly in just 12 minutes – leaving little time for the crew to deploy lifeboats or for an emergency signal to be sent. It is estimated that 800 of the nearly 1,200 Sailors and Marines on board survived the sinking, but a communication error prevented Navy command from having any knowledge of the sinking, and rescuers were not immediately dispatched. This left survivors to battle exposure, dehydration, drowning and shark attacks for a grueling four to five days at sea until help finally arrived. In the end, only 316 were rescued in what remains the largest loss of life at sea in U.S. naval history.

Due to the ship's rapid sinking and lack of a distress call, the ship's location had long remained a mystery – until recently.

Microsoft co-founder, philanthropist and entrepreneur Paul G. Allen is fascinated with World War II history. Combining this passion with a spirit of technological innovation, Mr. Allen and his Seattle-based company Vulcan Inc. set out to hunt for the Indianapolis. The team embarked with several high-profile marine archaeology projects already under their belt, including the discovery of Japanese battleship Musashi in March 2015 and Italian WWII destroyer Artigliere in March 2017, as well as the recovery of the bell from the HMS Hood for presentation to the British Navy.

Other search missions to locate Indianapolis have been undertaken by various groups over the years, but all have come up short – partly due to a lack of sufficient technology. For the Indianapolis search, Mr. Allen deployed an exploration team outfitted with the latest state-of-the-art deep search and exploration equipment aboard the newly acquired 76-meter-long DP2 vessel RV Petrel. Vulcan Inc. purchased the offshore service vessel in 2016 from subsea engineering, construction and services company Subsea 7. The ship was converted into a bonafide deep submergence research vessel in 2017, and now sails as one of the select few ships worldwide equipped to explore 6,000 meters below the ocean's surface.

For the Indianapolis search, the Vulcan team conducted a significant amount of research, leveraging a combination of historical records, detailed undersea topographical data and advanced technology to explore a 400 square nautical mile search area between Guam and Palau in the Philippine Sea. A key data point came from a discovery by Dr. Richard Hulver, a historian with the Naval History and Heritage Command, who identified a naval landing craft that had recorded sighting the USS Indianapolis hours before it was torpedoed. All this research led to a new estimated position west of where previous searches have been conducted.

But even with the new insight, finding a ship that has been missing for over seven decades is no easy task, especially at depths greater than 5,000 meters. Aiding Vulcan's team is a 6,000-meter-rated autonomous underwater vehicle (AUV), the REMUS 6000, manufactured by Kongsberg Maritime subsidiary Hydroid Inc., which gathered sonar data to locate the USS Indianapolis.

Used regularly in commercial, research and defense applications, the REMUS 6000 AUV has been labeled a "deep-water workhorse" by Hydroid. The vehicle can be configured to include a wide variety of payloads to meet diverse mission requirements and is capable of navigating for 20-22 hours of high speed search operations during a single dive, providing efficient coverage of wide areas. "Outfitted with a payload equipped with the tools to optimize the wreckage search, the REMUS 6000 vehicle was an ideal, versatile solution for this mission. This is one of the many reasons why the vehicle is in a league of its own; we are able to design it to meet individual operational requirements," a Hydroid representative said. "The REMUS 6000 has proven time and time again that it is a reliable, field-proven solution. Specifically, it was used in the discovery of Air France Flight 447, a passenger flight that crashed in June 2009, and to explore the site of the Titanic sinking in July 2010."

To find the long-lost Indianapolis, the REMUS 6000 AUV was equipped with long range, high resolution side scan sonar and bathymetry equipment for scanning the seafloor to detect and classify anomalies. The EdgeTech dual frequency 2205 75kHz / 230kHz side scan with interferometric bathymetry was mounted on the AUV to acoustically image a large 1 km range (in low frequency mode) from each side of the vehicle while flying preprogrammed deepwater searches in a mowing pattern.

Once a search grid was completed, the AUV surfaced at a preset location for retrieval to the Petrel. On board the team downloaded stored survey data for review and swapped batteries for redeployment. Data analysis revealed seabed anomalies such as geology features or manmade objects/debris that could potentially point out the location of the missing warship. Once targets of interest were identified and mapped at closer range and higher resolution at 230 kHz, the Petrel team deployed a newly built, class-leading remotely operated vehicle (ROV) system for positive identification.

For design, build and commissioning of the specialty ROV, Mr. Allen's team contracted 3U Technologies LLC to manage overall system design and integration. Vulcan had initially contracted 3U in 2012 to investigate 6,000-meter rated ROV solutions to extend its exploration and archeology capabilities to a majority of the world's ocean depths. 3U worked under

the direction of Robert Kraft, Vulcan's Director of Subsea Operations, to engineer what Kraft called "arguably one of the most technologically advanced and capable deep diving ROV systems in the world today."

"Vulcan's project team consists of experienced diving systems professionals and was expressly determined to push the boundaries and capabilities in the deep submergence realm," said Carl Barrett, 3U Project Manager. "The goal was to extend the present industry state-of-the-art to a full 6,000 meter depth capability."

3U and Vulcan sourced, specified and designed all key systems/subsystems and managed equipment manufacturing, testing and integration from a worldwide supplier base. The result, Barrett said, is a powerful 100 kW ROV system (90 kW at ROV) which is well outfitted for deep ocean exploration. Key features include:

- An integrated surface control and data management suite with intuitive interfaces;
- Dual interchangeable pilot and navigation control stations with ergonomic Cyber chairs;
- INS and DVL Based Automation: Waypoint navigation and station keeping; sonar target tracking and station keeping;
- Powerful all-electric propulsion with 550 kg horizontal and 780 kg vertical thrust capacity;
- 4500 VAC, 17mm diameter umbilical;
- 5 kW LED lighting system;
- Broadcast quality HDTV video cameras;
- Scanning and multi-beam sonar systems;
- Fiber optic MUX featuring multiple high bandwidth data channels: Gigabit Ethernet; Serial Data;
- Dual Titan 4 manipulators: Isolated hydraulic supply; and
- 18 kW tooling hydraulic system: Operator adjustable flow and pressure

Barrett explained that the Petrel ROV serves primarily as a camera and survey sensor platform that must maintain a no-touch policy out of respect for the hallowed wreck sites it typically explores. "The vehicle system must provide a stable platform with excellent station keeping capabilities for close proximity video work, have a powerful propulsion system to combat currents impacting both the ROV and the entire 6,000 meter umbilical length, provide the operators with outstanding situational awareness and operate reliably and efficiently for extended durations," he said.

Also instrumental to the mission was the OPENSEA operating platform from Greensea, which "provided a stable, automated operating platform for acquisition of stunning video sequences, created operational efficiencies which minimized operator task loading and dramatically simplified integration of a large suite of camera and sensor packages into a coherent and intuitive operator interface," Barrett said. "Greensea's

data management and archival system provides ease of access to a wealth of data (past and present) such that operators can maintain situational awareness and monitor vehicle health with minimum effort to maintain focus on mission goals."

Synchronized pilot and co-pilot chairs allowed vehicle control and navigation to be switched between pilots, complete with touchscreen displays to support simultaneous operation of lights, cameras, positioning and hydraulics. The system even included an automated ascent and descent for the umbilical winch that enabled pilots to automatically synchronize ROV depths.

"Greensea's OPENSEA control system is crucial to our success for extreme deep diving operations. Never before have I experienced an ROV control environment as unified, configurable or integrated as this one," Kraft said.

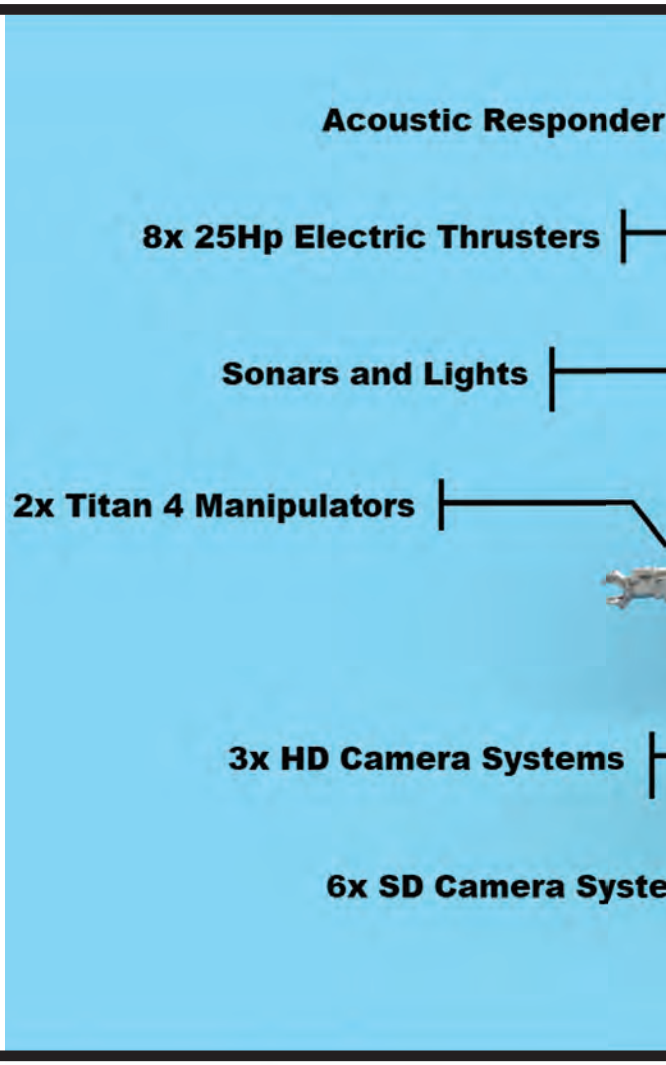
With help from some of the most capable and advanced equipment available, the Vulcan team located the wreckage of the USS Indianapolis on August 19, resting 5,500 meters below the surface in the Philippine Sea where it will remain undisturbed as a naval war grave. The wreck's exact location was provided to the U.S. Navy exclusively, as the wreck is property of the U.S. Navy.

"To be able to honor the brave men of the USS Indianapolis and their families through the discovery of a ship that played such a significant role during World War II is truly humbling," Mr. Allen said in a press release announcing the discovery. "As Americans, we all owe a debt of gratitude to the crew for their courage, persistence and sacrifice in the face of horrendous circumstances. While our search for the rest of the wreckage will continue, I hope everyone connected to this historic ship will feel some measure of closure at this discovery so long in coming."

Acknowledgements
Special thanks to Carl Barrett and the team at 3U Technologies, LLC.

Making of a Modern ROV

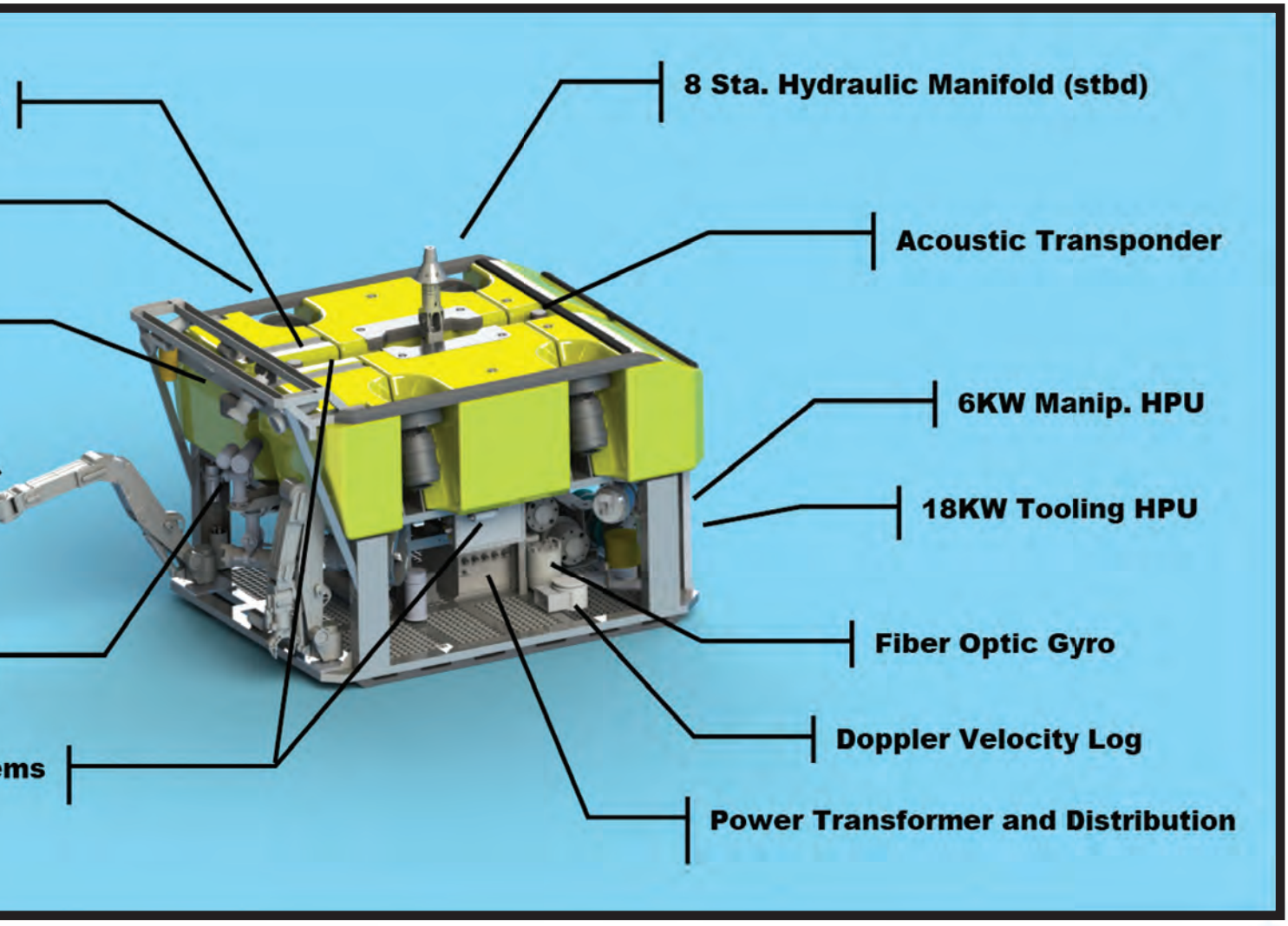
Title	Manufacturer	Model	Interface	#
ROV Assembly	Argus Remote Systems	BXL79		1
Electric Propulsion	Argus Remote Systems		230 VAC	8
8 Station Hydraulic Manifold	Sub-Atlantic		Serial	1
18 kW Tooling HPU	Innova		440 VAC	1
6 kW Manipulator HPU	Argus Remote Systems		230 VAC	1
Water Removal Hydraulic Filtration	Cardev			2
Fiber Optic Multiplexer	Focal	907		1
Umbilical	Cortland Cable	Custom 17 mm		1
Automation & Datalogging	Greensea	OpenSea	Network	1
Manipulator	Schilling Robotics	Titan 4	Serial	2
HD-3G Broadcast Quality Video Camera	Insite	Mini Zeus MkII	Fiber	1
HD-SDI Video Camera	Argus Remote Systems		HD-SDI	1
Scale Reference Red Spot Laser	Cathex		24 VDC	2
SD Video	Insite	Sculpin	NTSC - SMB	6
LED Spot Light	Cathx	Aphos	Serial	4
LED Flood Light	Argus Remote Systems		Serial	8
Electric Pan & Tilt	Remote Ocean Systems	P15	Serial	3
Fiber Optic Gyro	iXblue	Phins	Serial	1
Doppler Velocity Log	Rowe	Seapilot	Serial	1
USBL Positioning System	Kongsberg	HiPAP 102	Serial	1
Acoustic Transponder	Kongsberg	cNode LF	Acoustic	1
Acoustic Responder	Kongsberg	cNode LF	Serial	1
Mechanical Scanning Sonar	Tritech	Seaking	Serial	1
Multi Beam Sonar	Blueview	M450	Ethernet	1
Future Multi Beam Sonal	R2Sonic	2024	Gigabit Ethernet	1
Sound Velocity Profiler	Valeport	MiniSVP	Serial	1
Digital Depth Sensor	SAIV AS	TD301	Serial	1



(Photos courtesy of Paul G. Allen)

The AUV returns to the R/V Petrel. The autonomous underwater vehicle can operate on a submerged run for up to 20 hours.

ROV pilots aboard RV Petrel. Greensea's OPENSEA enabled the use of synchronized pilot and co-pilot chairs



AUVs

Unmanned Forces

Building a Multi-Domain Autonomous Fleet

Photo Courtesy SeeByte

By Katie Rittoo, SeeByte

Success on the frontline relies largely upon harmonious operations between all sectors of the armed forces, whether that is Army, Navy, Air Force or Amphibious units. Naturally, each unit is assigned operations according the capabilities it brings to the battlefield and together bring the best of each domain. While this concept seems a clear choice for manned operations, multi-domain collaboration is rarely seen in unmanned operations. While unmanned systems are increasingly being used in the military domain across air, ground and sea in their own right, they are rarely used in tandem.

Key questions inevitably arise regarding the ethics and practicalities of deploying unmanned systems into an active military operational environment. Can you send a system into enemy territory with a list of objectives and trust it to do "the right thing"? Can you program to react rapidly to changes in a volatile environment? These are just some of the questions facing lawmakers, policy makers and the Executive Branch. As a result today's fielded unmanned assets have very limited levels of decision making. They can act as a data gathering tool, but not as a force multiplying

Figure 1:
Hell Bay 4 demonstrated collaboration using robots from different manufacturers. 10 systems networked together through a central command station.

and enabling tool.

With an increasing number of unmanned vehicle manufacturers bringing products to market, it is essential to discuss the challenges of compiling an unmanned fleet comprised of the best vehicles the market has to offer, regardless of manufacturer or domain. Rather than one specialist manufacturer building a cross-domain fleet from the ground up, the key to this approach is to use existing offerings and tackle the challenges from an after-market software perspective.

There are several hurdles that need to be overcome in order to achieve seamless multi-domain operations where the benefits of unmanned operations are not outweighed by prohibitively heavy implementation costs. Issues such as proprietary standards that are incapable of communicating cross platform and challenges intrinsic to autonomous unmanned operations have limited the potential of unmanned vehicles. Another block in the road toward collaborative autonomy is that manufacturers of unmanned systems may be specialists in autonomy for their own particular domain whether that be land, air or maritime.

Each domain comes with its own challenges. To date, autonomous systems have seen the most development and traction in air. The air domain in itself presents very challenging obstacles such as creating an aerodynamic system capable of successful landing and take-offs, as well as maintaining airborne flight unaided by a pilot. There are also legal challenges such as airspace restrictions and increasingly tight regulations. However, the value that aerial drones have proven to add to operations, for example in Iraq and Afghanistan, means that there has been substantial investment and R&D despite the challenging environment. Investment has been such that unmanned aerial vehicles have branched out from their early roots in the military domain out into commercial markets where they are commonly used for surveillance, survey and

Figure 2: **Mission Control at Unmanned Warrior. Each Royal Navy operator is monitoring a Neptune squad of multiple robots.**

(U.S. Navy photo by John F. Williams)

At the event Neptune was present on the Royal Navy's two Hydroid REMUS 100 AUV systems, two OceanServer Iver AUVs and one ASV C-Worker 5 USV; it was also used with the U.S. Office of Naval Research, NSWC PCD operated Hydroid REMUS 100 AUV systems; and Defense Research Development Canada's OceanServer Iver AUV and SeaRobotics USV.

delivery tasks. In maritime, autonomy is progressing to sectors outside of the early adopter mine countermeasures (MCM) domain, such as oceanography and oil and gas. Unmanned systems have cropped up in various marine industries whether that is assisting warfighters in MCM operations, marine researchers and projects in the commercial maritime industry. However the MCM community is by far the biggest end user of unmanned maritime systems which are equipped with varying levels of autonomy. While several steps have been taken to develop fully autonomous systems, there is still a long way to go before solutions gain widespread market traction.

While unmanned systems are not currently being put to use at their full potential, there are two key areas which if invested in could take unmanned systems from auxiliary assets to full blown multi-domain squads carrying out over-the-horizon autonomous operations; firstly developing a system that allows for real-time communication between vehicles to facilitate collaboration, and, secondly, the development of software to allow for true autonomous operations where the fleet is able to adapt, respond and react in real-time.

Moving from Waypoints to Autonomy

The term autonomy is often applied as a sweeping term to a broad range of technology and covers a wide range of levels of autonomy.

True autonomy is a leap beyond the automation of basic functions, such as waypoint navigation. Autonomy implies independence and a degree of intelligence – the ability to sense, interpret, decide and act without external control.

There are three main threads to autonomy: true adaptive autonomy, where the vehicle is able to adjust its behavior in response to feedback from the environment; collaborative autonomy which enables unmanned systems to work as part of an adaptive fleet with each asset communicating continuously

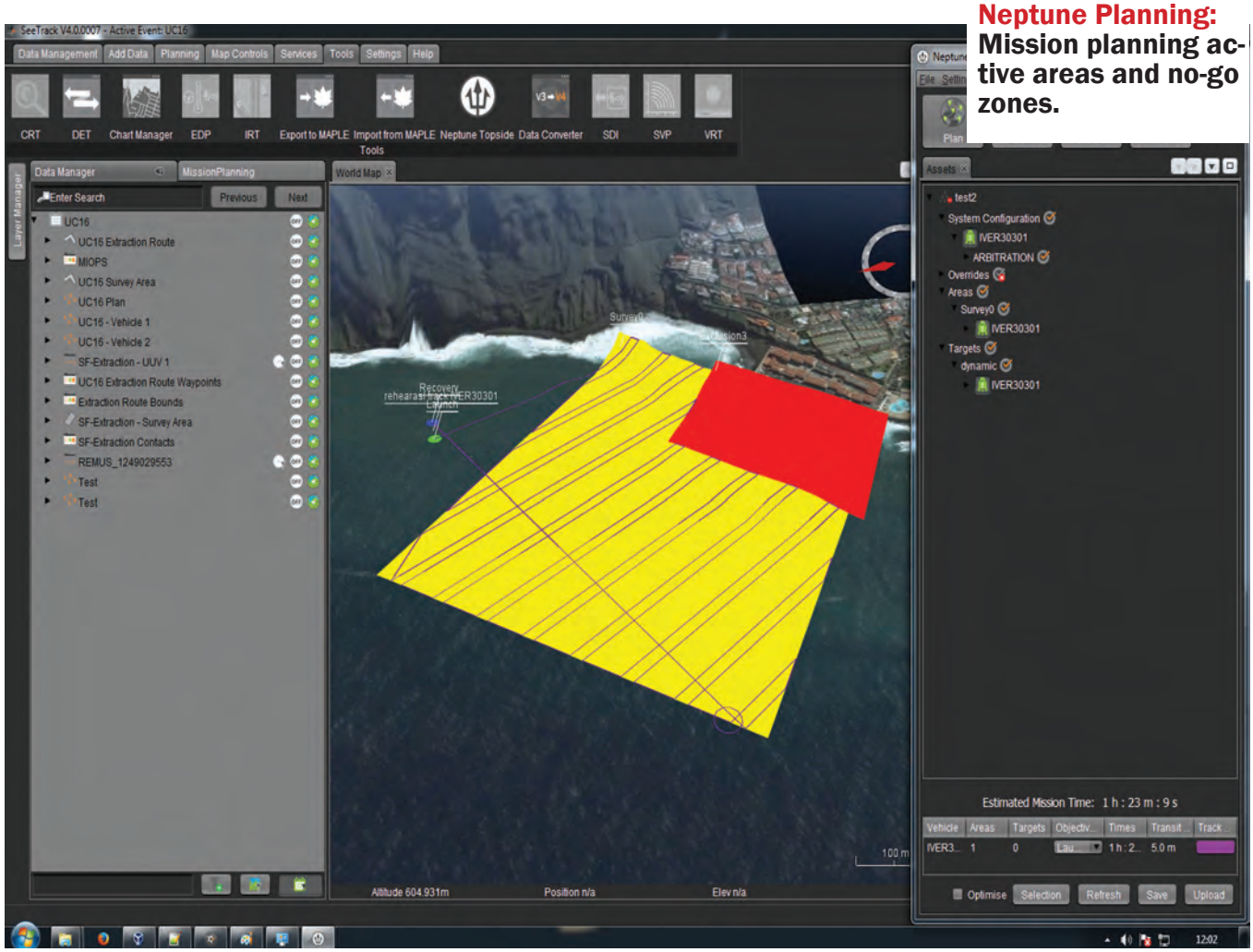
with the others in the fleet to achieve a common goal; and thirdly over-the-horizon operations where the fleet is able to perform tasks autonomously supported only by a launch and recovery team.

In essence, true adaptive autonomy is goal-based planning means telling robots what to do rather than how to do it. With a goal-based architecture the user provides the vehicle with a set of goals, examples of which may be to survey an area or to look for certain objects. The vehicle and its software engine compute what waypoints are necessary in order to accomplish those goals while staying out of identified hazardous areas. Goal-based autonomy simplifies human machine interaction in that the human just states what they want to accomplish. The software engine using goal based autonomy does the mission planning and is able to leverage from all the available expertise programmed into it and learned from previous missions to generate optimal plans.

Secondly, to create an autonomous fleet of vehicles, it is essential that they are able to communicate with each other through a shared 'language', regardless of vehicle make or model. This can be achieved by integrating the vehicles onto a shared command station which providing a central control capability.

This gives rise to the third and final thread of autonomy: over-the-horizon operations. The crux of this approach relies on goal-based mission planning; the fleet is assigned a task or tasks to accomplish by the operator pre-deployment but software decides the optimal approach based on the feedback from the vehicle payloads. The technologies developed provide the first major steps toward a paradigm shift: a move away from men on the frontline operations towards unmanned over-the-horizon multi-squad operations supported by a shore-side team.

But how do we go from an unmanned system that follows waypoints to a team of vehicles that make and communicate decisions? First and foremost, autonomy relies on the software underpinning the vehicles. Limited software design which is only designed to work with one particular system will inevitably lead to limited autonomy. Ideally the most success is found using a goal-based, open, modular, scalable architec-



Neptune Planning: **Mission planning active areas and no-go zones.**

Photo Courtesy SeeByte

ture which acts like a central brain for a fleet of unmanned systems– in other words, a software engine, upon which industry and government laboratories can collaborate and contribute to new robotic capabilities.

Open means the system can easily be extended to work with new systems, new sensors and new programmers and hardware manufacturers – the goal should always be best-of-breed. An improvement in code, sensing or industrial applications is something that we should be able to take advantage of, without building a whole new system. By generating waypoints that dynamically stay ahead of the vehicle, the vehicle can adapt the mission in real-time as it senses new stimuli. Since all autonomous underwater vehicle (AUV) and unmanned surface vehicle (USV) systems to date have been designed to follow waypoints, this simple concept enables dynamic control of the vehicles in the maritime domain. In other words, the autonomy engine acts as a backseat driver that doesn't interfere with the vehicle manufacturers' proprietary operating software.

Modularity is required to help developers to choose best-of-breed capability. As new autonomous behaviors are developed to enable unmanned systems to react to the environment, including the actions of other unmanned systems or threats to the fleet, additional modules can be integrated, or existing ones can be replaced, to provide new capability to the systems. The developer is therefore able to design solutions to evolving requirements without having to rebuild the entire system.

Scalability is required to help the system work with any number of vehicles. The architecture needs to be able to work with a single system but enable multiple vehicles to share the mission goals and updates to enable full collaborative missions where unmanned systems tackle tasks as part of a dynamically cooperating team.

SeeByte has made steps toward rising to this challenge with Neptune, an autonomy engine which been designed and developed to be goal-based, open, modular and scalable.

Pedro Patron, Engineering Manager at SeeByte describes the scenario, "Originally when SeeByte looked at the state-of-the-art of autonomous systems in the maritime domain it was faced with a stark reality: they have been designed to fol-

low predetermined waypoints. There often there wasn't even the payload processing power on-board to do anything else beyond following waypoints. The crucial paradigm shift was to move away from waypoints and into autonomy. Autonomy means that the success or the failure of the entire fleet relies on the software underpinning it. While this is a daunting task, it appears this is a realistic and achievable method of extending the capabilities of the robots that users already have access to, without resorting to redesigned robot fleets equipped with autonomous capabilities from scratch."

With Neptune the vehicles employ user designed behaviors to accomplish goals. These behaviors provide the vehicles with sets of waypoints that adapt on the fly to suit the sensed environment, as it is balanced against the user defined goals. The design of Neptune allows for third parties to develop their own behaviors and implement them within the Neptune Autonomy Engine. This means that the behaviors can be developed and chosen to suit different mission profiles. The same is the case for the sensors on board that sense the environment and the algorithms that tell the vehicle where it is, both in relation to where it is supposed to be in the world, and where it is relative to other vehicles.

SeeByte's next challenge was to develop a common framework for all the surface and underwater vehicle to share the mission objectives. This was achieved by enabling each system to keep a model of what the world looks like, how it is changing as new data is gathered, and the progress that has been made against each of the human defined objectives. It is pursuant upon the system to share the latest information, or worldview, with all the other vehicles in the fleet. The use of high-level metadata to describe the world and mission progress through it, makes it possible to share the information using low bandwidth applications. This can be done opportunistically. Each vehicle therefore keeps an up to date view of its own progress and the progress of all the other vehicles in the fleet. This view can be shared with the operator to ensure that they monitor the operations as they happen, things happen as they expected, and when they don't, Neptune describes what did happen and why.

To date Neptune has been made to work with AUVs, gliders and USVs from different manufacturers and with significantly different payloads. Neptune has been optimized for missions encompassing mine countermeasures, reconnaissance, and oceanography. However, a significant milestone was reached in October of 2016 with Unmanned Warrior.

Unmanned Warrior: Autonomy in Action

Unmanned Warrior was a real test. This demonstration was organized by the U.K.'s Royal Navy to showcase never-seen-before capabilities in the field of autonomy and unmanned systems and gathered over 50 vehicles, sensors and systems from different nations, different vendors and different government sponsored laboratories.

Hell Bay 4 was run in conjunction with The Technical Cooperation Program and became a big part of the Unmanned Warrior demonstration. TTCP is an international organization that collaborates in a number of areas: defense scientific and technical information exchange, program harmonization and alignment, and shared research activities for the governments of United States, United Kingdom, Canada, Australia and New Zealand.

In Hell Bay 4 SeeByte supported the U.S. Navy Labs from Naval Surface Warfare Center Panama City Division (NSWC-PCD) and Space & Naval Warfare Systems Center, Pacific (SPAWAR-SSCPAC), Defense Research and Development Canada (DRDC) and the U.K.'s Defense Science and Technology Lab (Dstl). SeeByte's Neptune software formed the basis of the autonomy engine in the U.K.'s Maritime Architecture Framework (MAF) to facilitate autonomous collaboration between unmanned assets from multiple nations. The U.K. MAF provides advanced autonomous capabilities and allows fleets of unmanned systems, both surface and subsurface, to be managed from a single command station. The main focus was on over-the-horizon multi-squad, collaborative autonomous and automatic operations, allowing subsea and surface autonomous marine assets to communicate and report on shore via an unmanned aerial vehicle communications repeater.

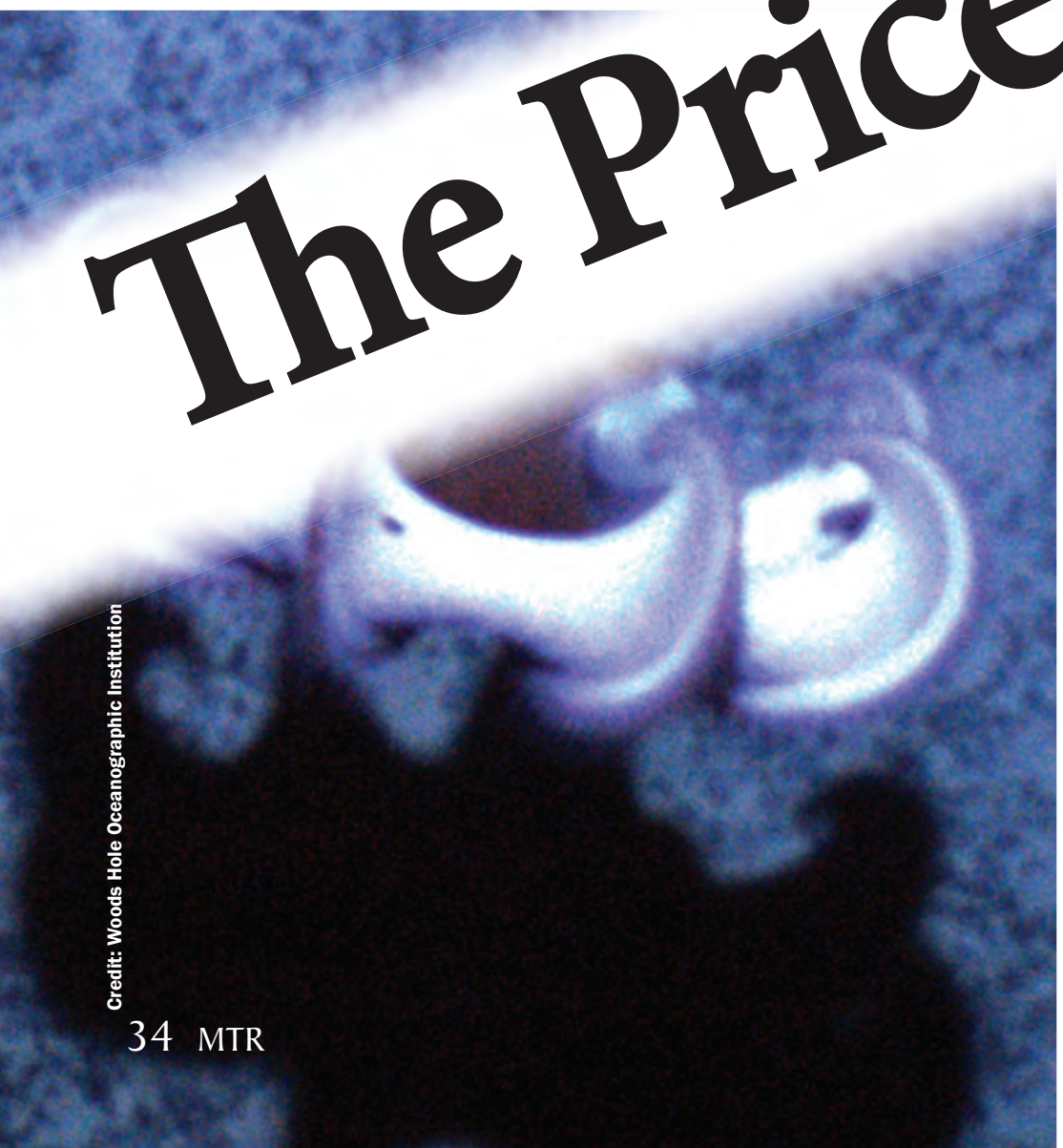
At the event Neptune was present on the Royal Navy's two Hydroid REMUS 100 AUV systems, two OceanServer Iver AUVs and one ASV C-Worker 5 USV; it was also used with the U.S.© Office of Naval Research, NSWC PCD operated Hydroid REMUS 100 AUV systems; and Defense Research Development Canada's OceanServer Iver AUV and SeaRobotics USV. The USVs communicated with BlueBear's aerial drone which acted as communications relay. A total of 10 robots working together across all three domains: subsea, sea surface and air.

What's Next?

Going forward, there are several hurdles that must be overcome before these advancements in technology become viable solutions for modern warfare. Trial and testing is key to building robust systems capable of withstanding unpredictable environments. Taking heed of lessons learnt in these early trials will be key to achieving this. There are clearly benefits to be enjoyed from deploying over-the-horizon autonomous fleets, namely putting a layer between the front line and the operators. To reach a stage where these systems can be reliably deployed there has to be not only investment into the core technology itself, but extensive testing of the system in real-world environments.

Credit: DJ Amon & CR Smith, University of Hawai'i

The Price of Su



Credit: Woods Hole Oceanographic Institution

ubsea Mining

(Credit: A Leitner and J Drazen, University of Hawai'i)

(Credit: A Leitner and J Drazen, University of Hawai'i)

IMAGES

Top Left
Dorsal view of cf. Coryphaenoides morphospecies swimming above the seafloor

Top Right
Hymenopenaeus nereus after collection via baited trap from the UK-1 exploration contract area

Bottom Left
Cirroteuthidae morphospecies swimming above the seafloor

Bottom Right
Coryphaenoides armatus after collection via baited trap from the UK-1 exploration contract area

By Kira Coley

Over millions of years, metal particles accrete onto sediment grains slowly forming lumps of commercially-valuable metallic ores in deep aphotic basins three miles underwater. As resources dwindle, mining companies are increasingly looking to the ocean to provide the metals and minerals we need. But environmental concerns hang heavy over the deep-sea mining industries. Before we venture into places untouched by humankind, the ABYSSLINE project sought to discover what animals wait in the path of destruction and, more importantly, what fate has in store for those communities when mining begins.

Polymetallic nodules, sometimes known as manganese nodules, are found in vast deep-sea basins at depths of 3,500 to 6,500 meters across the world's oceans. The most profitable fields, however, are found in the Pacific and Indian Oceans. Within the Pacific, an area around the size of Europe called the Clarion-Clipperton Zone (CCZ), extends from the west coast of Mexico to Hawaii. This region has the world's largest and most valuable beds, hosting around 21 billion metric tons of nodules, that form at a sluggish rate of a few millimeters every million years.

As the CCZ is in international waters, it falls under the mandate of the International Seabed Authority (ISA). So far, there have been 16 mining exploration areas allocated, each roughly the size of Panama (up to 75,000 km2). Nodules can be harvested relatively easily from the seafloor with underwater vehicles similar to potato harvesters. The mining process will harvest huge quantities of metal that will benefit mankind, but at what environmental cost?

"Let's be honest; nodule mining is going to do some damage. Removing nodules will result in local extinctions of the many animals – corals, sponges, bryozoans, polychaetes, nematodes and more – that call these nodules home. There will be no possibility for their reestablishment in the future. Machines, like combine harvesters, will disturb and compact large swathes of sediment, kicking up sediment plumes, which will travel for kilometers before depositing elsewhere. Further entombment of the seafloor will occur when they discharge tailings into the water column. Not to mention other possible impacts that include light and noise pollution from machinery, and major changes to the geochemistry of the sediment, food webs and carbon sequestration pathways. The cumulative impacts of these operations aren't yet understood but will likely be long-standing and ocean-wide," said Dr. Diva Amon, a deep-sea biologist and expert in deep-sea mining who took part in the ABYSSLINE project.

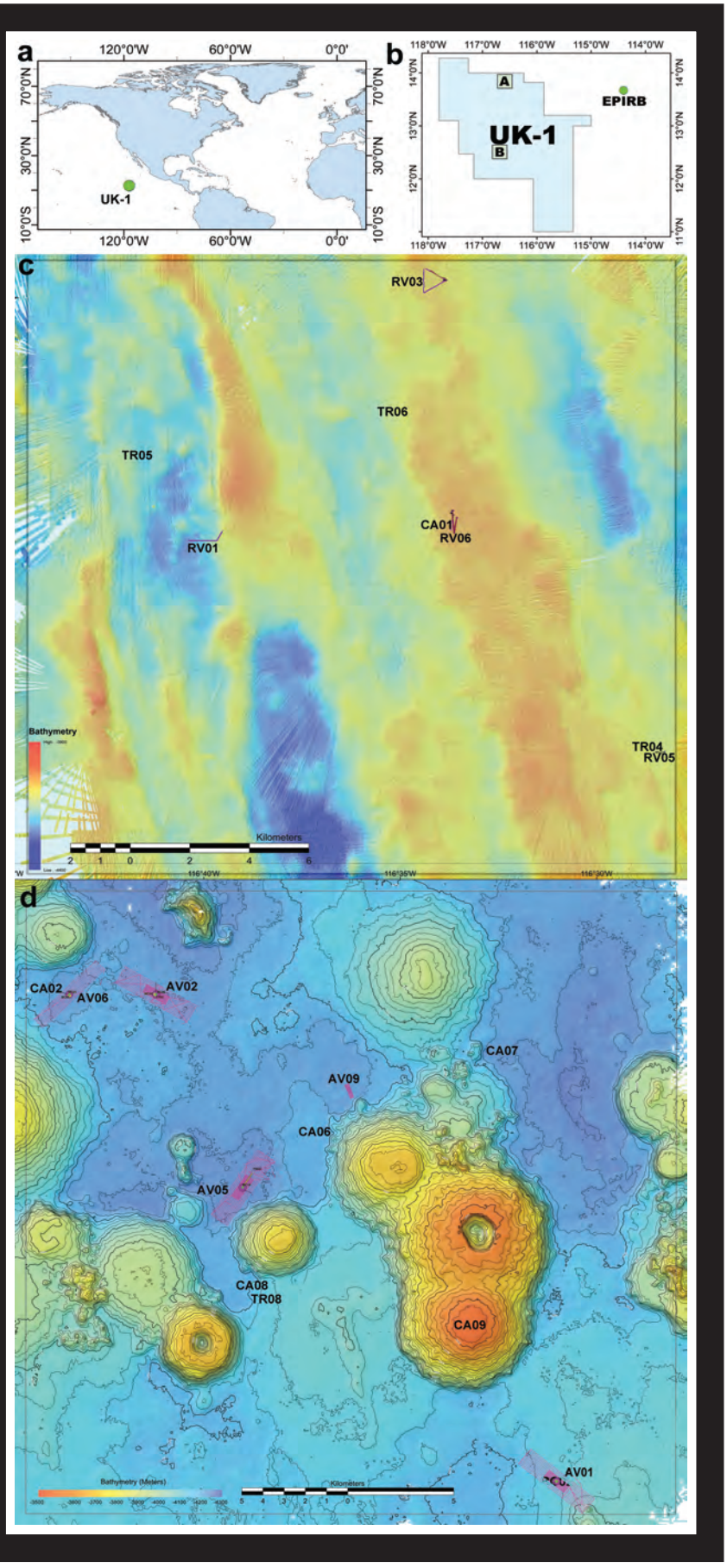
Despite this looming threat, the CCZ is critically underexplored and little is known of the animals that live in this relatively remote and undisturbed region of the deep ocean.

It is mandatory that contractors undertake baseline studies of the biology living at the seafloor before mining can begin, and the ABYSSLINE Project has been doing just that. Amon is part of a team of international researchers that recently undertook benthic biological baseline studies within the exploration contract area leased to U.K. Seabed Resources Ltd (UKSRL) in the CCZ, where deep-sea mining of polymetallic nodules will take place shortly.

Their goals were to evaluate baseline conditions of community structure and biodiversity of all living creatures in the region. They also gathered information to begin to establish how community structure, biodiversity and benthic carbon cycling vary across the UKSRL contract area especially with regards to environmental parameters such as nodule abundance.

Amon explained, "My component of this project was to study the megafauna – the awesome charismatic animals over 2 centimeters in size – in collaboration with Professor Craig Smith at the University of Hawaii. We wanted to answer fundamental questions such as: What species live in this area? Do they show variation in where they live? If so, why? How does their distribution relate to that of the nodules that will be mined? Do animals seen in the UKSRL contract area occur across the region? Studying the megafauna is important because they play significant roles in deep-sea ecosystem function - such as eating organic particulate matter and mixing

Locations of megafaunal surveys during the ABYSSLINE cruises, AB01 and AB02, in the Clarion-Clipperton Zone. (a) The location of the UK Seabed Resources Ltd exploration contract area (UK-1) in the eastern Pacific Ocean. (b) The locations of the 30x30-km survey areas, UK-1 Stratum A and UK-1 Stratum B, in relation to the UK-1 exploration contract area and the AB01 ROV dive site, EPIRB, which was approximately 250 km east of the UK-1 contract area. (c) The locations of ROV dives within UK-1 Stratum A, indicated by purple tracklines labelled with the dive number (e.g. RV01). Stations where imagery was collected with a baited camera (CA01) and samples collected with a baited trap (TR04, TR05, TR06) are also indicated. (d) The locations of AUV dives within UK-1 Stratum B, indicated by purple tracklines labelled with the dive number (e.g. AV01). Stations where imagery was collected with a baited camera (CA02, CA06, CA07, CA08, CA09) and samples collected with a baited trap (TR08) are also indicated. All maps were created by Seafloor Investigations Ltd for the ABYSSLINE Project using ArcGIS software.



sediments. They are also the most conspicuous animals in the area, and are particularly vulnerable to deep-sea mining."

Over two years, ABYSSLINE scientists have spent more than two months out in the middle of the Pacific Ocean sampling the seafloor with a menagerie of oceanographic equipment. Researchers collected imagery using a remotely operated vehicle (ROV) Remora III, operated by Phoenix International Holdings, Inc., and autonomous underwater vehicle (AUV) REMUS 6000, operated by Woods Hole Oceanographic Institution. A baited camera was occasionally used to look at the scavenger community, and the team collected megafauna samples using the ROV, baited trap, megacorer, box corer and Brenke epibenthic sled.

"By using all of this technology, we were able to make the first estimates of abundance and diversity," Amon said. "So far, results show that the UKSRL contract area is rich, not only in metals but also in life. At first glance, the seabed seemed almost void of life. Taking a closer look, we realized that there were small animals everywhere: tiny white corals, pink and purple sea cucumbers, bright red shrimp and strange unicellular animals that create sediment homes the size of your fist. During our two expeditions, we sampled an area smaller than Hong Kong and found around 213 species of megafauna!"

The animals discovered by the team include everything from deposit-feeding echinoderms (such as sea stars) that cycles nutrients and mixes the sediment, to deep-sea corals and worms that filter feed particles out of the water.

"We also saw large scavenging fish, shrimp and crabs. There were purple sea cucumbers with sails, bright pink sea stars, dumbo octopuses, a Relicanthus cnidarian [resembling a sea anemone] with 8-foot tentacles, eel-like fish and giant amphipods. It was really amazing how much life was down there. And even more amazingly, this is only the megafauna and doesn't include the hundreds to thousands of smaller animals living in this area."

These levels of biodiversity are currently the highest in the CCZ and many other abyssal regions worldwide. Researchers also collected 12 megafauna species during the first expedition, over half of which were new to science, echoing how little is known of the abyssal life in this region. But among the excitement of discovery are also huge concerns: approximately half of the megafauna species found so far live only on polymetallic nodules – the resource targeted for removal by mining industries.

Amon and the team are also publishing photo atlases of all the megafauna species seen in hope it will be useful to other scientists and stakeholders researching the CCZ in the future.

Amon commented, "Working in the deep ocean is always difficult, but out in the Clarion-Clipperton Zone was even less easy. It is extremely remote – it took us close to a week to get there from San Diego, Calif. That meant we stayed out for 5-7 weeks at a time, which is a long time to be on a small research vessel with limited internet and no escape! The sea was quite rough at times – we had to outrun several hurricanes. And some critical pieces of equipment didn't work as well as we were expecting, but we repaired them to the best of our abilities and carried on. Overall both cruises went pretty smoothly, and we accomplished our main objectives despite a few hiccups."

Amon hopes that the mining industry, the ISA and other stakeholders will be able to use the data from the ABYSSLINE project, as well as the other projects working in the area, to mitigate the environmental impacts of deep-sea mining. Comprehensive baseline surveys are crucial for effective spatial management, including the designation of protected areas. It's also critical to ensure that Environmental Impact Assessments, which will occur before, during and after mining provide real results.

Amon said, "Deep-sea mining in international waters is a nascent industry. There should be applause given to the process thus far, especially concerning the adoption of an environmental management plan for the CCZ by the ISA as well as the stipulation that before exploitation, benthic biological baseline studies must be undertaken for each contract area. But there are still many outstanding issues and unknowns. These include that the Areas of Particular Environmental Interest (APEIs), currently off-limits to mining, are unsurveyed and unknown when these APEIs should harbor similar species and environments to allow recolonization and preservation. The APEIs also need to be far away enough to be unimpacted by mining, but currently, there is not enough known about plumes, noise pollution, etc. from deep-sea mining to confirm that."

Further unknowns with the environmental plan include whether it will be enforced, and if so, whether the standard to which surveys will be undertaken will be high enough. These discussions are ongoing, but one thing that can be said for certain is that deep-sea mining will result in a great loss of biodiversity, will be on a large-scale and will have long-lasting effects on our oceans.

"It was incredibly eye opening to realize how little we know about the largest ecosystem on our planet and exciting to be amongst the first people to ever see certain areas of the Pacific seafloor and many new species. The majority of our world's deep ocean has never been explored by humans because it's difficult to do so. It is expensive, inhospitable to humans and is usually in a remote part of the planet. This area of the CCZ is no different. In fact, it is only because of the resources in this area that it is currently being explored and studied. But the most overwhelming emotion for me was sadness, knowing that these areas and animals are already vulnerable, places we barely know anything about and do not yet understand. It's difficult for a deep-sea biologist working in a region that may be forever changed within the next decade."

The ABYSSLINE teams continue to publish results that will help us understand and manage our oceans before deep-sea mining irreparably alters it. From next March, Amon will continue research into megafaunal communities that may be impacted by deep-sea mining at the Natural History Museum, London, thanks to a Marie Sklodowska-Curie fellowship.

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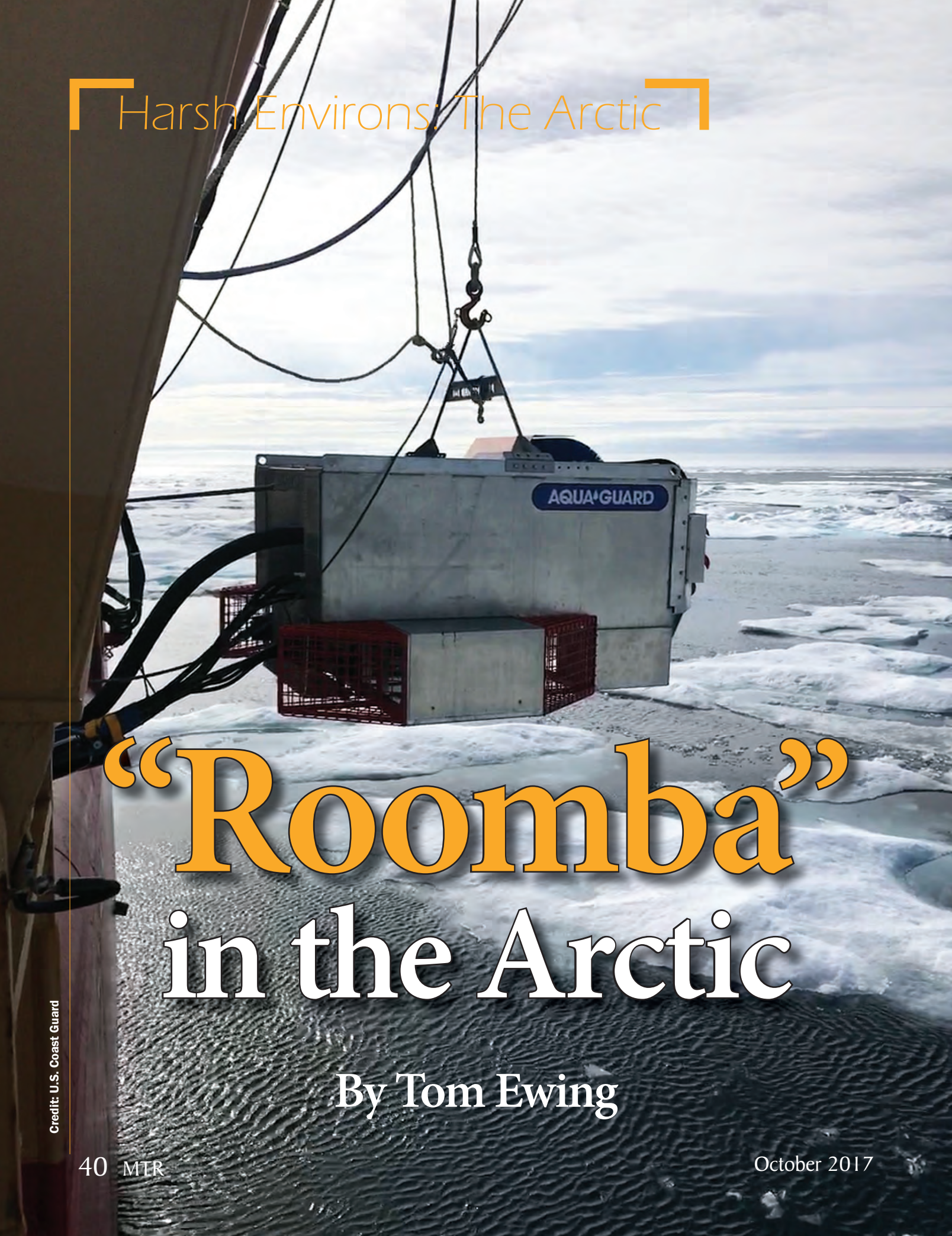


"Roomba" in the Arctic

By Tom Ewing

Credit: U.S. Coast Guard

The pace and quality of oil spill research in the United States typically ebbs and flows as a function of two, if not three important variables. First, after the 1989 Exxon Valdez grounding, there was a flurry of activity to ramp up oil spill research because it had been dormant for so long. The need was recognized, with plenty of money made available. Primarily, this research centered on conventional spill remediation techniques – for example, a tanker or barge spilling oil – and not much else. Predictably, when memory of the spill faded, so did interest in research and funding.

A new era of heightened focus on spill response research and testing started with the so-called Deepwater Macondo spill. Stakeholders quickly lamented the dearth of recent research. Even those who could point to what had been done since the Exxon Valdez, also couldn't deny that much of this work was not well aligned with events and situations then happening in the U.S. Gulf of Mexico. Research had largely stopped a decade before. A new call went out for robust research, and this new commitment is delivering results.

Today, the chances of oil spills become more likely as previously permanent sea ice diminishes in the Arctic and as maritime activity in the region increases.

To be ready, the U.S. Coast Guard places a high priority on developing options for recovering oil in the Arctic. To that end, an important research project took place this August during the Coast Guard's annual science patrol aboard the cutter Healy, the United States' newest and most technologically advanced polar icebreaker.

Arctic West Summer 1701

'Arctic West Summer 1701' started July 20 and concluded August 17 when the Healy returned to Seward, Alaska. The research agenda was extensive, including autonomous surface, underwater and aerial vehicles, an electrically powered shore transfer craft and a passive millimeter wave camera.

Critically, in addition, the research agenda included testing the capabilities of a self-propelled oil skimmer – the Aqua-Guard Triton RotoX – designed and built by Aqua-Guard, based in Vancouver. The Healy team wanted to evaluate the skimmer's maneuverability, buoyancy and ability to move among broken ice. Ice floes present a fragmented and scattered seascape, adding a dangerous variable to an already challenging environment. In these conditions, oil that could otherwise be recovered may be inaccessible to crews and equipment.

"Recovering oil in broken ice is the challenging part," Chief Petty Officer Angela Vallier, a member of the strike force team, said in a CG report. "We have proven technology in open water and proven technology in packed ice, but those technologies would be inefficient in broken ice."

During the trials, the skimmer easily propelled itself through the ice floes and its thrusters provided ample power, the CG reported. However, ice-

Harsh Environs: The Arctic

Credit: U.S. Coast Guard

"Recovering oil in broken ice is the challenging part. We have proven technology in open water and proven technology in packed ice, but those technologies would be inefficient in broken ice."

USCG Chief Petty Officer Angela Vallier

cutting teeth, designed to chop the ice into small pieces, did not work as well as expected.

"The testing of these technologies is extremely important to ensure the capability to deal with an incident is available in the future should one occur," said Scot Tripp, the chief scientist aboard the Healy during the skimmer trials. "Each time we test a technology, we get a better handle on its capabilities and its limitations."

The testing was a joint effort between Coast Guard RDC, Coast Guard National Strike Force, Navy Supervisor of Salvage and Diving, the Oil Spill Recovery Institute of Cordova, Alaska, and Coast Guard Cutter Healy.

The Aqua-Guard RotoX Skimmer

Importantly, Aqua-Guard's RotoX skimmer was not originally designed for Arctic operations. The Arctic equipment was a modification; an advancement of Aqua-Guard's RBS-TRITON, or rotating brush skimmer, technology. The RotoX is designed to macerate (soften or separate a mixture); in this case, large oil solids, into constituent elements, then recovering the slurry and pumping it out of the water. Company co-founder and principal, Nigel Bennett, explained that the system is designed to break up and recover ultra-heavy oil/sludge floating islands.

Bennett said that his company became part of the Arctic West Summer 1701 expedition after Coast Guard staff from the Research & Development Center (RDC) viewed a video of the RotoX, operating in ultra-heavy oil. That video was presented at the International Oil Spill Conference in Long Beach, last May.

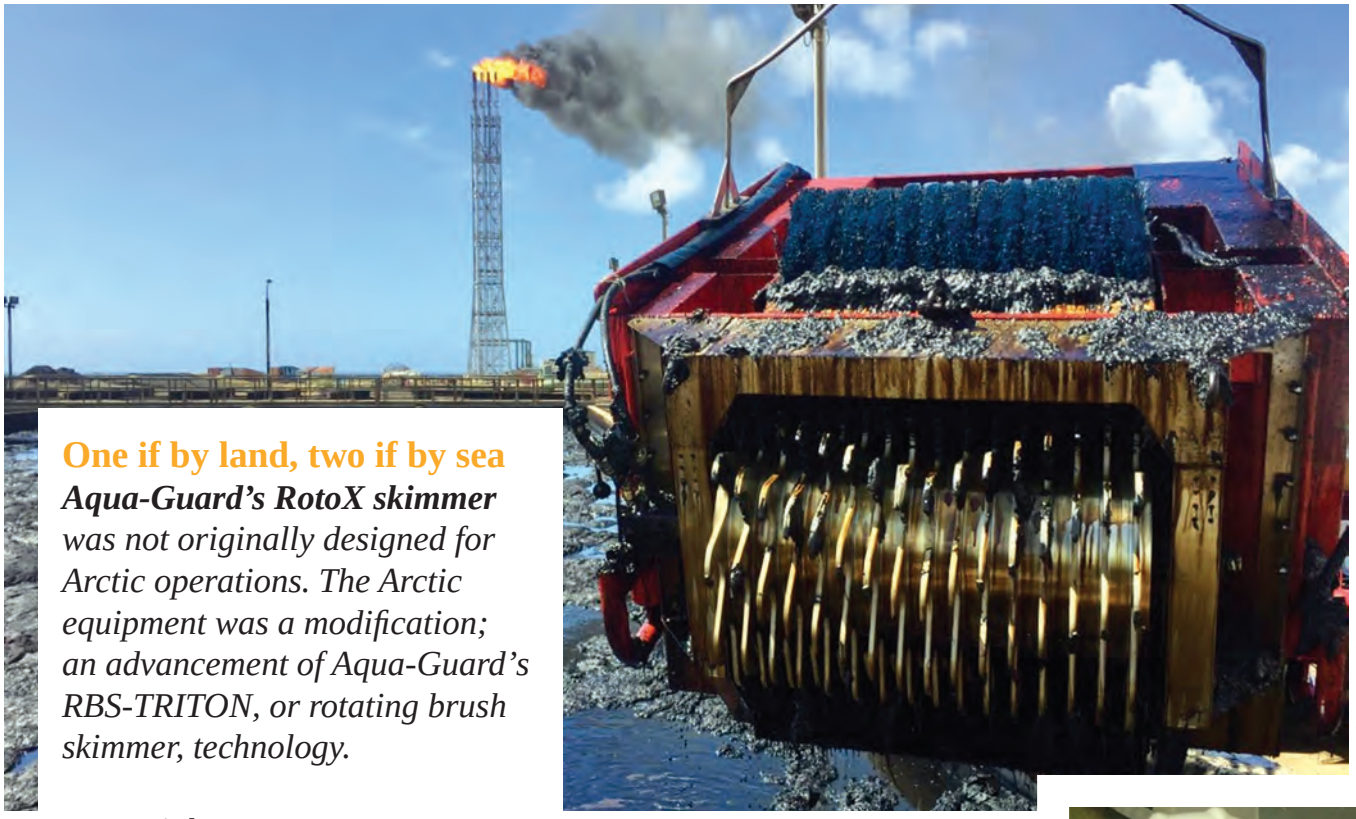
"RDC had solicited companies," Bennett explained, "with the request to get an operational skimming system with thrusters to Alaska by mid-July for the 2017 Arctic Technology Evaluations, but no entity was able to fulfill the deadline request."

Subsequently, Coast Guard personal contacted the Aqua-Guard team in Vancouver. Bennett said Aqua-Guard's team "jumped on the opportunity to have a RotoX tested in ice" and they built and tested a skimmer modified for Arctic operations in time for the Healy's departure. He said that given the machine's history of successful operations in heavy oil, the next step was testing in ice. Regarding operations, company officials said "as long as it is safe for operation crews to be on deck, then our skimming system can be used." RotoX recovers a complete range of oils, from light diesels to ultra-heavy crude. The system can be deployed from a trailer, skid or from a ship or barge.

Coast Guard Research

To be fair, this is not the Coast Guard's only ongoing ice-oil research. Other projects include a cage-management system that separates ice from oily water. Work is also ongoing in the Great Lakes, started in 2010.

Harsh Environs: The Arctic



Credit: Aqua-Guard / RotoX

One if by land, two if by sea

Aqua-Guard's RotoX skimmer *was not originally designed for Arctic operations. The Arctic equipment was a modification; an advancement of Aqua-Guard's RBS-TRITON, or rotating brush skimmer, technology.*

Inset Right:
Nigel Bennett*, co-founder, Principal at Aqua-Guard*

Credit: U.S. Coast Guard

Coast Guard staff said that tests by the Bureau of Safety and Environmental Enforcement (BSEE), in a controlled facility, indicate that skimmers can be effective in up to about 30-40% ice if the system can get to the oil. After that, performance declines quickly with 60-70% of ice, again due to accessibility to the oil. Mobility – getting to the pollution – is critical.

As most mariners likely know, in the United States, oil cannot be deliberately spilled or discharged into open waters even for research and testing and, accordingly, the AWS 1701 expedition did not include actual oil recovery. And, the Healy's 2017 expedition was in U.S. waters. (Norway, reportedly, is the only country that allows such tests, but under strict controls.)

For this mission, the primary goal was to demonstrate the ability of the skimmer to (1) maneuver around larger icebergs and (2) using the dual onboard thrusters to displace smaller icebergs. Indeed, this up-close navigation worked as the skimmer moved itself into small pockets of water where oil would pool in the event of a spill. Actually, and to demonstrate how closely this natural environment was reviewed, the Healy team did find a tiny sheen of oil. They concluded it came from a hydraulic fitting. Quantity: a few drops only.

In an ice-strewn environment, the independent mobility of the oil recovery equipment is critical, so the cutter or icebreaker does not need to move, reposition or otherwise control the skimmer. When the icebreaker moves it changes the seascape, pushing the surrounding ice and potentially eliminating the chance to recover pockets of oil. Similarly, by remaining stationary, an icebreaker does not move itself into contamination. A remote skimmer can keep the icebreaker farther away from oil so the ship's propellers or bow thrusters do not pull oil into the water column.

Summing Up & Looking Ahead

The initial Arctic RotoX mobility tests were encouraging. A Coast Guard news release on the project reports that "during the trials, the team discovered that the skimmer easily propelled itself through the ice floes and the thrusters provided ample power." Aqua-Guard personnel were not aboard the Healy for the 30-day voyage. However, a technician did participate in installing the RotoX on the Healy and for training CG operators. Bennett said the RotoX system "met and exceeded expectations" regarding tests for maneuverability.

Coast Guard personnel prepared an "After Action Report" detailing the RotoX's strengths and weaknesses, but the full text is not yet available. Initial reports noted some problems with the ice-cutting teeth designed to chop ice into small pieces. This part of the equipment requires further work. But in the Arctic, this could be a challenge of scale. Bennett noted that the "ice cutting mechanism is not intended to macerate icebergs." Rather, current equipment is intended to "chop up smaller ice chunks into slush with the intention of positioning the skimmer into pockets of spilled oil."

In the meantime, Bennett said that R&D continues, focusing on improving the ice cutting functionality. He said the data collected during the Arctic tests is invaluable for further development. Without saying when, Bennett predicted that "the system, with a few minor adjustments, will be ready for market with regards to arctic oil spill response as the standard RotoX is already on the market."

Today, as in the post-Exxon Valdez and post-Macondo eras, there is a heightened state of awareness about environmental contamination in the undisturbed Arctic. This new awareness has propelled a quicker pace of research into better and more site-specific spill response techniques. Stakeholders understand that a spill in the Arctic would be catastrophic unless the tools are available to combat such an unwelcome crisis, should it come.

To that end, efforts are underway in many sectors to ensure that spill equipment is viable, available and – critically – proven to work.

The Hybrid AUV/ROV

How a multi-mission vehicle can transform underwater exploration and inspection

By Durval Tavares, CEO, Aquabotix

On their own, autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs) possess unique capabilities for users across multiple industries. Yet, while both are unmanned underwater vehicles, they feature significant differences in their design, function and use.

AUVs operate autonomously; once programmed, they can move independently, carrying out missions for hours, or in some instances, days. While being untethered enables AUVs to have a greater operational radius, they can only maneuver in certain directions and change depths. ROVs, on the other hand, are tethered to human operators, who pilot or "fly" the vehicle using a computer console, either on shore or on a boat or ship. In other words, they always need a guiding hand, leading to increased cost in manpower. Despite this, ROVs are traditionally more maneuverable than AUVs, considering human pilots still outperform robots in field conditions.

Enter the Hybrid AUV/ROV

The evolving demand for underwater exploration and inspection missions requires a multi-mission vehicle that offers users both automation and control. The solution that best addresses these needs is a hybrid AUV/ROV, an underwater vehicle that is changing the way underwater surveys are performed. For broad range searches, the hybrid can be easily programmed to conduct grid or linear searches in AUV mode. For more thorough analysis of conditions, operators can attach the tether and maneuver the ROV to capture detailed images and data readings.

The impact of hybrid capabilities for multi-mission purposes is apparent across a wide range of industries, including military/defense, security, infrastructure, energy and aquaculture. In the infrastructure industry, for example, these vehicles are prime for bridge and dam inspections as they can conduct a wide mapping of bridge and dam structures in AUV mode and then perform more in-depth inspections upon transitioning to ROV mode. Hybrid AUVs/ROVs can also assist the navies of the world in addressing increased underwater threats, which often occur in hazardous environments that are difficult and dangerous for divers themselves to explore. Hybrid AUVs/ROVs can augment and even replace divers in situations, including explosive ordinance disposal (EOD), mine countermeasures (MCM), port security and intelligence, and surveillance and reconnaissance (ISP), as they are quick and easy to launch and are intuitively piloted.

Hybrids can also remove potential perils for divers when it comes to the policing, surveillance and security of oceanic and inland waterways, as they safely and economically inspect, surveil and monitor what lies beneath the ocean's surface.

Hybrid and Connectivity: Going Beyond the Dive

While hybrid AUVs/ROVs prove more than capable of exploring the depths of the world's bodies of water, technological advancements like cloud computing promote greater interactivity and connectivity during missions both below and above the sea. Previously, long-term storage, analysis and report generation were left up to end users. Now, the cloud, when properly accessed and utilized by underwater vehicles, has become the future of data collection and storage. For example, where it used to take operators three hours to conduct an underwater inspection, and analysts another three months to generate a report, the cloud now provides easy access to data, which can be properly archived, managed and viewed in-action during missions. In addition, users don't have to be on-site to monitor missions—cloud connectivity brings all crucial data points together in a convenient and easy way, in real-time.

With oceans covering 70 percent of the Earth's surface, it remains largely unexplored from a subsea perspective, making research and data collection challenging. Add the burden of needing two separate types of vehicles—and essentially two separate crews—for different exploration and inspection missions, and you're presented with a significant barrier to both cost and efficiency. With the hybrid AUV/ROV, you not only have a digital framework for autonomy, but also the ability to quickly take control. It is a multi-mission vehicle that is poised to be a game-changer for the underwater robotics industry.

Photos: Aquabotix

Image: Blueye Robotics

Underwater Drones Join the burgeoning business of

Exploration Cruising

Norway-based Hurtigruten is a leader in the niche exploration cruise market, in part for its capacity to entertain travelers in fresh new ways such as virtual parachute descents and indoor snow, among many others. Now the company which sails to some of the most remote Arctic and Antarctica destinations is set to roll out another offering: underwater drones capable of exploring cold water locales.

Through a partnership with Blueye Robotics, Hurtigruten will offer underwater vehicles for use on board two of its new hybrid-powered cruise ships, MS Roald Amundsen and MS Fridtjof Nansen. The vessels are being built the Kleven Yard in Norway for delivery in 2018 and 2019.

According to Hurtigruten, the collaboration with Blueye Robotics aims to make the mysterious realm of these intriguing waters accessible to guests on board. Blueye's Pioneer drones will share video and images of each guest's underwater adventure, as Blueeye and Hurtigruten implore travelers to take exploring into their own hands, with all relevant content being stored and made available to scientists.

Earlier this year, representatives from Blueye Robotics set out aboard Hurtigruten expedition ship MS Fram for a test run along the coast of Norway. During the voyage, the Blueye team and Hurtigruten crew members were able to explore seldom seen underwater scenery at locations such as Vega, Træna and Stamsund, and as far north as Tromsø. The captain of the ship even joined the Blueye team as they used the Pioneer to inspect the vessel's hull. The Blueye Pioneer will be available for purchase from 2018, with pricing starting at $3,550.

Blueye Pioneer

- Hull design: Hydrodynamic and hydrobalanced hull for stability and performance in ocean conditions. Engineering plastic and rubber protections that withstand impact
- Pressure rating: 150 m
- Weight: Less than 8 kg
- Speed: At least 2 m/s (4 knots)
- Run-time: At least 2 hrs normal operation
- Thrusters: 4 x 350 W; plus 2 rear, 1 vertical center, 1 lateral
- Automation: Auto heading, auto depth
- Camera: Full HD 1080p/30fps, wide angle lens
- Search Light: Powerful LED below camera, with fittings for extra lights as payload
- Sensors: Inertial Measurement Unit (IMU) with 3-axis gyro and 3-axis accelerometer; depth sensor; magnetometer; temperature (inside and outside)
- Payload: Standard fittings for payload on both top and bottom side of drone
- Software: Remote update of drone software
- Wireless transmitter: WiFi router for wireless connection to smartphones or tablets; multiple smartphones may connect for a shared live experience
- Wireless range: At least 30 m
- Cable length: 75 m
- Wireless drone controller for iOS and Android smartphones and tablets
- Blueye App for android/iOS smartphone/tablet
- Quick charger for charging drone, WSU and drone controller

People & Companies


Ashtead Technology

Lestrange


Aqueos

Palmer


Phoenix International Holdings

Torgersen

Ashtead Hires Lestrange

Ashtead Technology hired Brett Lestrange as its new U.K. regional director, responsible for leading the company's U.K. sales and technical teams. He will be based in Aberdeen.

Aqueos Appoints Palmer

Aqueos Corp. appointed Allan Palmer to the position of Project Manager-Special Projects. "[Palmer's] 43 years of industry experience complements our existing team of strong project managers, and it increases our technical sales capabilities to our client base in Houston," said Ted Roche, Aqueos President and CEO.

Torgersen, Long, Turner Join Phoenix International

Phoenix International Holdings, Inc. announced that John Torgersen has joined the company as its new Quality Management Systems (QMS) Lead, Matthew Long has joined the company as General Manager (GM) of its Largo, Md. headquarters office, and Troy Turner has been appointed as Area Manager for our Bayou Vista, La. Location.

• Torgersen will oversee elements in all aspects required to achieve and maintain registration and certification in commercial and military quality standards and certification programs. His initial focus will be spearheading the effort to transition Phoenix to the ISO 9001:2015 standard.

• Long will oversee all aspects of Phoenix's government and commercial deep ocean search and recovery service lines, as well as the company's engineering and R&D work.

• Turner will be responsible for overseeing and directing the day-to-day activities of the Bayou Vista office, and actively pursuing growth opportunities for all Phoenix services in the area.

Stetkiewicz Joins FarSounder

FarSounder has hired Cassie Stetkiewicz as its new marketing, communications and relationship manager. She will work closely with the CEO and director of global sales playing an integral role in marketing, advertising, trade show organization, public relations and the development of client relationships.

Well-Safe Hires Jenkins

Well-Safe Solutions has appointed Matt Jenkins as director of well abandonment, in charge of leading the technical team to design safe and efficient well P&A operations. Jenkins joins Well-Safe from Conoco and brings to the position 15 years' experience in a variety of North Sea projects through drilling, completion, intervention and abandonment. He has a Masters Degree in Mechanical Engineering from Heriot-Watt University and is a Chartered Engineer with the IMechE.

Norsafe, Kongsberg to Develop USV

Norsafe and Kongsberg have been working to develop a USV to act as a combined autonomous and data collection platform with different sensors. Engineered for military and commercial maritime use, the USV has been designed to be robust and durable with easy servicing and the flexibility to allow for fast equipment changeovers. Norsafe said it has designed a vessel that is stable on the water with minimal vibration and optimized for low air disturbance under the hull. These features are essential in providing nominal disturbance to the sensitive sensor equipment on board. The USV has been designed for simple transportation either by road trailer or containerized on deck.

Phoenix Celebrates 20

This September, Phoenix International Holdings, Inc. celebrates two decades as a provider of underwater solutions worldwide. Formed in 1997 with six underwater operations experts dedicated to the waterborne repair of U.S. Navy

Phoenix International Holdings

Long

Phoenix International Holdings

Turner

FarSounder

Stetkiewicz

ships, the company has evolved into an international underwater solutions provider with a staff of almost 250 personnel and multiple service lines including offshore oil and gas IRM, ship repair, engineering, submarine rescue and deep ocean search, survey and recovery operations.

Kraken Sonar Renamed Kraken Robotics

Kraken Sonar Inc. has changed its name from Kraken Sonar Inc. to Kraken Robotics Inc., and its Canadian operating subsidiary Kraken Sonar Systems Inc. has been renamed Kraken Robotics Systems Inc. "Our new name reflects the company's broader commitment and expertise in driving the innovations needed to shape the future of unmanned maritime systems," said Karl Kenny, president and CEO. "We expect that the [unmanned maritime systems] market will soon evolve from research, develop and testing programs into significantly larger procurement opportunities for Kraken."

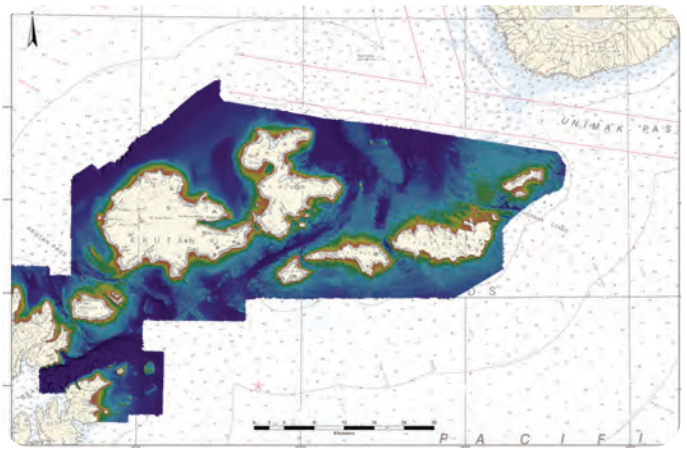
Fugro: Hydrography Center of Excellence

Fugro will establish a Houston-based Hydrography Center of Excellence for the Americas, to handle a wide range of hydrographic project types, including nautical charting, cable routing and law of the sea boundary claims, Fugro said it is formalizing its coastal zone mapping services using complimentary geophysical and geotechnical techniques to benefit a wide range of applications including resource development, infrastructure siting, coastal management and emergency response. To support these efforts, David Millar has been appointed to serve as government accounts director for the region. Filling Millar's former post as the regional hydrography service line director in San Diego is Mark MacDonald.

M2 Opens ROV Test Tank

M2 Subsea commissioned a purpose-built tank for testing ROVs and ancillary equipment at its existing workshop in Westhill, Aberdeenshire. M2 Subsea will use the facility for its own asset testing purposes and has also made it commercially available for subsea manufacturers and service providers to

People & Companies



Fugro

Fugro: Hydrography Center of Excellence

M2 Subsea

M2 Subsea ROV test tank

rent, along with or without M2 Subsea's ROV fleet. The facility has already been used by Acteon Group for product testing. The indoor fresh water test tank can accommodate both work-class and observation ROVs. It can hold 73,600 liters of water and measures 8 x 4 x 2.3 meters. It features a gantry crane which has a S.W.L 15t and an independent 415v three phase 200a power supply to accommodate testing equipment. 2t and 16t forklifts are also onsite at all times for any unloading and loading requirements.

Ashtead Subsea Tech Showcased

Ashtead Technology put the spotlight on the latest subsea technology at its annual Technology Showcase event in Aberdeenshire. The event welcomed more than 140 industry peers to highlight the latest tools, products and services from leading subsea manufacturers. Present were representatives from manufacturers such as iXblue, Kongsberg, Sonardyne and Teledyne Marine.

Global Marine Group Extends U.K. Footprint

Global Marine Group (GMG) has expanded its operations base in the U.K. to include the Port of Blyth, Northumberland. Operating from the Port of Blyth, both of GMG's two business units, CWind, which provides services to the offshore wind industry, and Global Marine, which provides fiber optic cable solutions to multiple sectors, will be able to offer regionally-focused support for customers. Beginning in August, Blyth will serve as a regional base for strategic asset management and modular equipment storage, as well as a mobilization and deployment site for the GMG fleet. A number of GMG assets, including vessels C.S. Sovereign and CS Recorder, will operate out of Blyth.

Saab Seaeye Joins NOC Robotics Innovation Center

Saab Seaeye joined the National Oceanography Center's (NOC) Marine Robotics Innovation Center, as an Associate Member. The membership will further enable Saab Seaeye to collaborate with other strategic partners in the advancement of underwater robotic systems.

Submarine Colorado Delivered

General Dynamics Electric Boat delivered the nuclear-powered attack submarine Colorado (SSN 788) to the U.S. Navy. The 15th ship of the Virginia Class, Colorado is the fifth of the eight-ship group known as Block III. Virginia-class submarines displace 7,835 tons, with a hull length of 377 feet and a diameter of 34 feet. They are capable of speeds in excess of 25 knots and can dive to a depth greater than 800 feet,

Shell, Petrobras Expand Partnership

Royal Dutch Shell and Petrobras signed a Memorandum of Understanding (MoU) to establish a long-term mutual collaboration in developing pre-salt fields in Brazil. The MoU, valid for five years and eligible for renewal, involves sharing best practices and learnings on technical and operational solutions, cost efficiency initiatives, safety and governance management, contract management, logistics, wells construction and transportation safety.

Teledyne CARIS Distributor

Teledyne CARIS selected Codevintec as its new software distributor for Italy, the Adriatic countries, Greece and Lebanon.

Aquabotix Adds Distributors

UUV Aquabotix Ltd. has added Deekay Marine Services, Pvt. Ltd as an exclusive representative in India. Deekay is the fourth distributor added to Aquabotix's global network in the recent month, under the guidance of

Ashteadd Technology

Ashtead Subsea Tech Showcased

Ashteadd Technology

The Port of Blyth

the new Chief Development Officer Ted Curley. Other new distributors: Sadaret Ltd (nonexclusive representative in the U.K. and Ireland), Seafloor Systems (nonexclusive representative in California, Washington, Oregon and Alaska) and A2 Marine Solution (nonexclusive representative in Brazil).

Polarcus Wins 3D Project

Polarcus Limited received a Letter of Award for a broadband 3D marine seismic project in Asia Pacific. The project is due to commence in Q4 2017 and will run for approximately one month.

Oceanscan Invests in Multibeam and INS

Swathe Services announced that Oceanscan has invested in R2Sonic 2022 digital wideband multibeam system with integrated I2NS (POS MV Wavemaster) INS. The Sonic 2022 is portable, the compact form factor making it suited for integration into AUV, ROV or small boat operations with a range up to 400m of water. The 3,000m-rated Sonic 2022 unit is fitted with the 700 kHz UHR Option, Truepix backscatter and raw water column detect. When UHR is selected, the beam width is 0.6° x 0.6° providing narrow beam widths. User-selectable frequencies from 170 to 450kHz and swath coverage from 10° to 160° are selectable on the fly, during survey operations.

NASA Orders an ROV

NASA's Jet Propulsion Laboratory has ordered a 300-meter depth-rated Endura 300 commercial-grade ROV from Aquabotix Technology Corporation, the wholly-owned U.S. subsidiary UUV Aquabotix Ltd. Integrated with a range of specialist sensors, the ROV will used to create multidimensional maps of oceanic environs as part of its Ocean Worlds exploration program, which is undertaking ocean exploration on Earth, in order to, among other things, assist NASA with its search for the best-known candidates for life in the solar system.

Sonardyne for MBARI ROVs

Sonardyne INS was selected by the Monterey Bay Aquarium Research Institute (MBARI), for its deep-rated remotely operated vehicles (ROVs), Ventana and Doc Ricketts. The SPRINT systems will be used in conjunction with MBARI's existing Sonardyne Ranger 2 acoustic tracking systems to improve the accuracy, precision and integrity of subsea vehicle positioning in water depths up to 13,000 feet. The SPRINT for Ventana has already been installed and commissioned, while the unit for Doc Ricketts is scheduled to be delivered soon.

Winch Systems for U.S. Navy Sonar

Curtiss-Wright's Defense Solutions division has been selected by Raytheon Integrated Defense Systems to provide its winch system technology for use in a new Variable Depth Sonar (VDS) for the U.S. Navy Littoral Combat Ship (LCS) class. Curtiss-Wright will manufacture the products covered by this agreement at its INDAL facility in Mississauga, Ontario.

FPROV Upgraded

Seatools completed the upgrade of the fall pipe ROV installed on Van Oord's flexible fall pipe vessel Stornes. The upgrade, which enables Van Oord to perform precision rock installation in water depths of up to 2,100 meters, required modification of both the ROV's electronic system as well as its software. Seatools initially delivered the fall pipe ROV in 2007, with a depth rating of 1,350 meters. Over the years, the 300 kW fall pipe ROV, executed with a range of dynamic positioning modes

People & Companies

Vard

KCS Orders Cable Layer

Bosch Rexroth

Wave Generators for Indonesian Lab

such as auto-heading, auto-track, and auto-swing, successfully performed precision rock installation operations in deep waters. The FPROV even set a world record in November 2014, when the Stornes installed rocks in water depths of up to 1,277 meters.

KCS Orders Cable Layer

A keel laying ceremony at Colombo Dockyard PLC in Sri Lanka signaled the start of construction on a new cable lay vessel for Japanese owner Kokusai Cable Ship Co. Ltd (KCS). The new vessel, a VARD 9 01 design tailor-made for installation and repair of subsea telecom cables, with a high capacity below-deck cable carousel, will feature diesel electric propulsion, DP2 positioning and large cable tanks combined with a 2,000 ton capacity carousel. The total cable carrying capacity is 5,000 tons. The outfitting also comprises a dual cable lay system, A-frame, hydro plough and trenching ROV.

Wave Generators for Indonesian Lab

Bosch Rexroth will install two electrical wave generator systems for Indonesian Hydrodynamic Laboratory (IHL), an advanced research laboratory of BPPT (The Agency for the Assessment and Application of Technology). The new system, which replaces the original supplied by Rexroth 25 years ago, is a multi-directional wave generator, with moveable flaps operated by AC servo drives.

ZipGrips Patented

Yale Cordage received a patent on ZipGrips, which were primarily developed for use in the offshore pipe lay and umbilical installation and maintenance arena. The Yale Cordage ZipGrip is a unique assembly of load bearing synthetic ropes, and has been designed to significantly reduce the time, length of material, and space needed to terminate a wide range of cylindrical equipment. A wide range of configurations have been evaluated, ranging in diameters from 25mm to 622mm, and from working capacities of 2,000kg to 40,800kg. Specialty grips have also been successfully installed on existing offshore oil platforms to contain large assemblies of multiple power and hydraulic lines and to support the weight of these cables as they are suspended between platform structures in spans exceeding 67m.

Non-contact Algae System

A new Algae-Station Non-Contact system come from water quality sensor designer Chelsea Technologies Group (CTG). The Algae-Station NC provides water process control operators with a unique monitoring system which reduces cleaning and maintenance requirements that are commonly associated with in situ sensors, reducing cost of ownership of these type of sensors, CTG said. These non-contact systems, up till now only available for such parameters as turbidity and flow, are now, with the Algae-Station NC, available for algae monitoring in water processing plants.

New MCM System

BAE Systems has unveiled NAUTIS 5, the latest version of its flagship Mine Counter Measures (MCM) system. BAE Systems' Naval Autonomy Tactical Information System (NAUTIS) is used to counter the ever present threat of naval mines. It is installed on board more than 65 ships from seven navies across the world, including the Royal Navy's Hunt and Sandown class Mine Counter Measure Vessels (MCMVs).

NAUTIS 5 is the result of BAE Systems' long term investment in MCM capabilities. It incorporates a number of new features including: improved command and control for autonomous and off-board systems, which can be easily integrated thanks to a new Open Architecture; a new and improved Human-Computer Interface (HCI) using the latest graphical technologies and embedded onboard training.

MARINE TECHNOLOGY REPORTER

EDITORIAL CALENDAR

JAN/FEB

Ad Close: Dec 21

Underwater Vehicle Annual: ROVs, AUVs and UUVs

Profile: Subsea Defense Technology
Market: Lights, Cameras and Sonar for Vehicles
Tech: Autonomous Navigation
Product: Scientific Deck Machinery

Ocean Sciences Meeting:
Feb 11-16, Portland, OR

FEBRUARY

Ad Close: Jan 22

MTR White Papers: Oceanographic 2018

Bonus Electronic Edition Publication Date: February 2018

MARCH

Ad Close: Feb 21

Oceanographic Instrumentation: Measurement, Process & Analysis

Market: Fiber Optic Cables, Connectors & Slip Rings
Tech: Oceanology International 2018 Technology Spotlight
Product: Hydrographic Sonar and Software

Oceanology International:
Mar 12-15, London, UK

APRIL

Ad Close: Mar 21

Offshore Geophysical

Profile: Workclass ROV
Market: Magnetometers & Streamers
Tech: Buoyancy Technology
Product: Marine Drones

OTC
Apr 30 – May 3, Houston, TX
Sea-Air Space:
Apr 9-11, National Harbor, MD
AUVSI Xponential:
Apr 30-May 5, Denver, CO

MAY

Ad Close: Apr 20

Hydrographic Survey: Single beam & Multibeam Sonar

Profile: Research Institutions
Market: Comms, Telemetry & Data Processing
Tech: GPS, Gyro Compasses & MEMS Motion Tracking
Product: Interconnect: Underwater Cables and Connectors

OCEANS'18 MTS/IEEE Kobe:
May 28-31, Kobe, Japan

JUNE

Ad Close: May 21

Underwater Defense

Profile: Underwater Lights & Cameras
Market: Offshore Renewable Energy: Wind, Wave & Tide
Tech: LARS: Launch and Recovery Systems
Product: Subsea Housings

SeaWork:
Jun 26-28, Southampton, UK
Clean Pacific:
Jun 19-21, Portland, OR

JULY

Ad Close: Jun 21

MTR White Papers: Hydrographic 2018

Bonus Electronic Edition Publication Date: July 2018

JULY/AUG

Ad Close: Jul 20

MTR100:

The 13th Annual Listing of 100 Leading Subsea Companies

MTR looks at 100 leading companies and executives in all subsea disciplines, defense, offshore energy and science.

SEPTEMBER

Ad Close: Aug 21

Autonomous Vehicle Operations

Profile: Subsea Engineering: Subsea Field Architecture
Market: ROV Technology: Work Class to Micro Systems
Tech: Thruster Tech: Underwater Propulsion
Product: Underwater Tools and Manipulators

OCTOBER

Ad Close: Sep 21

Ocean Observation: Gliders, Buoys & Sub-Surface Networks

Profile: Instrumentation: Profilers, Samplers and Sediment Corers
Market: Research Vessels
Tech: Harsh Environment Systems for Arctic Ops
Product: Geospatial Software Systems for Hydrography

OCEANS'18: Oct 22-25, Charleston,sc
EURONAVAL 2018: Oct 23-26, Paris
MAST : Nov 28-30, New Dehli, India
Clean Gulf : Dec 4-6 Houston, TX

NOVEMBER

Ad Close: Oct 22

MTR White Papers: Unmanned Marine and Subsea Vehicles 2018

Bonus Electronic Edition Publication Date: November, 2018

NOV/DEC

Ad Close: Nov 21

Acoustic Doppler Sonar Technologies ADCPs & DVLs

Market: Fresh Water Monitoring & Sensors
Tech: Offshore Inspection, Maintenance & Repair (IMR)
Product: Underwater Imaging: Lights, Cameras & Sonar
Special Report: The 2019 Subsea Market Planner

Underwater Intervention 2019:
New Orleans, LA

All information may be subject to change

Cable Gripper

The CRT200 Cable Retrieval Tool, developed by Webtool, is the first cable and umbilical retrieval tool to receive design verification approval from DNV GL for meeting the design codes and standards for marine operations, and offshore and platform lifting appliances. Designed to allow the safe and controlled recovery of damaged cable and umbilical, up to 8" (203 mm) diameter, the CRT200 meets the requirements of DNVGL-ST-N001 Marine Operations & Marine Warranty, June 2016 and DNVGL-ST-0378 Standard for Offshore & Platform Lifting Appliances, May 2016. The CRT200 cable gripper provides a streamlined cable recovery where the gripper, guided by an ROV, is lowered onto the end of the cable without requiring preliminary clearing of the soil around the cable. The mechanically locked gripping action ensures the umbilical cannot escape during retrieval; moreover, an internal clutch mechanism prevents damage from overtightening. By gripping the end of the cable, it makes subsequent handling much easier, enabling the cable to be recovered to a reeler or spooler on the surface vessel. The CRT200 weighs 600 kg and has a lifting capacity of 20 metric tons.

ww.allspeeds.co.uk

Cable Gripper

Image: Allspeeds

Electrical Manipulator Arm

The Ocean Innovation System 5 Function electric manipulator arm (BE5-500) is a high performance and cost-efficient skid-mounted electric manipulator arm. Intuitive programmable position controls, embedded controllers, an innovative modular system (plug and play) and three available additional connectors for optional cameras, projectors or lasers make operation of this manipulator easy, regardless of the operator's skill level, according to the manufacturer. The BE5-500 was specifically designed for a multitude of operations and can be retrofitted to most ROV systems.

www.oceaninnovationsystem.com

Electrical Manipulator Arm

Image: Ocean Innovation System

BluHaptics and J2 Subsea Partner

A recent agreement will see J2 Subsea perform sales, distribution, customer support and joint marketing of BluHaptics' software solution for underwater manipulator arms. Traditionally focused on subsea tooling (hardware), J2 Subsea is incorporating BluHaptics' software into its suite of offerings to provide customers with a higher level of control and precision in the operation of costly hardware. BluHaptics' engineers have integrated technologies – including real-time modeling, operator assistance and force feedback – into a unified platform for semi-automatic robotic control. Featuring a virtual interface and more user-friendly controls, this new system makes it easier for operators to interact with and more precisely control remote robots in fluid, unpredictable and dangerous environments. Several offshore trials are currently underway.

www.bluhaptics.com / www.j2subsea.com

BlueHaptics / J2

Image: J2 Subsea

Image: Kongsberg Maritime

Eelume

The snake-like Eelume underwater robot is essentially a self-propelled robotic arm designed to live permanently underwater and carry out underwater intervention, maintenance and repair (IMR) tasks. Its unique ability to change shape enables it to work in confined spaces not accessible by conventional vehicles and allows intricate interactions using a diverse toolset including torque tools, grippers and specialized maintenance equipment. The Eelume solution is a result of an agreement signed by Kongsberg Maritime and Statoil with Eelume, a NTNU spin-off company, to accelerate new technology that sets out to reduce costs related to subsea IMR.

www.kongsberg.com

CRD100 Seafloor Drill

Cellula Robotics' CRD100 is a fourth generation seafloor drill designed to operate in waters down to 3,000m for geotechnical surveys, mineral exploration and methane gas hydrates sampling. Designed on proven subsystems from previous projects, the CRD100 provides a level of automation that facilitates efficient core sampling and Cone Penetration Testing (CPT) measurements. A wireline tool system further enhances the speed of deep borehole drilling. CPT results are transmitted to the surface in real time, allowing sampling profiles to be optimized as the drill program progresses. The tool carousel supports standard Commercial off The Shelf (COTS) size H tooling providing ø60 mm core samples. Custom carousels can be supplied to support mission specific tools up to ø160 mm outside diameter. An integrated navigation, maneuvering and landing package allows the drill to be accurately deployed without any need for an external ROV. A suite of sensors including a precision depth sensor, altimeters and altitude sensors provide real time feedback to the surface operators during the landing of the drill. This is supplemented with landing cameras. Hydraulically adjustable legs allow the drill to be leveled on slopes up to 30°.

www.cellula.com

CRD100 Seafloor Drill

Image: Cellula Robotics

Next Gen Wave Glider

Liquid Robotics rolled out its next generation Wave Glider, featuring advancements to the platform's operational range, and performance for missions in high sea states and high latitudes. Other updates include advancements for expanded sensor payloads and increased energy and storage capacity required for long duration maritime surveillance, environmental monitoring and observation missions.

Wave Gliders are used for unmanned exploration and surveillance missions as well as for collecting an communicating data through a wide range of conditions and oceans around the world, including the Arctic (latitude of 78.76N) and Southern Ocean (latitude of 64.8S). The newest version builds on the current platform capabilities with the following innovations:

- Performance in high sea states (sea state 6 and greater)
- Advanced navigation in high latitudes (ex: Arctic and Antarctica)
- Supports 30% heavier payloads to enable new sensors and missions
- 15% greater power collection and 40% more battery storage extends operational range and support for larger sensor payloads
- Anti-biofouling copper coating improves system performance and simplifies maintenance

For existing customers, an upgrade kit has been developed to expand the capabilities of existing Wave Gliders to match those of the new platform. All sensor integration validated on the current platform is compatible with the new system without new certification. General availability for this new version is October 2017.

www.liquid-robotics.com

EIVA Cable Telemetry Kit

EIVA offers a cable telemetry kit based on the technology used in the company's range of ScanFish remotely operated towed vehicles (ROTVs) as an OEM product for integration with subsea sensor and sonar systems.

The ScanFish Cable Telemetry Kit comes in a standard version for equipment with a coax subsea cable. The standard kit includes:

- Topside (2U rack unit) with 300 W power supply, and Modem for Ethernet over power cable (4-5 Mbit/s via a single wire 4,000 m coax, with higher bandwidths – up to 7 Mbit/s – possible via shorter cables)
- 600 m-rated pressure bottle with subsea electronics with nine Teledyne Impulse interface connectors, with a mixture of Ethernet and serial ports; Modem for Ethernet over power cable; eight-port multiplexer, Ethernet to RS2323 or RS485; two DC output power modules each at 130 W (one is preconfigured to 24 V, the other is customizable, allowing for 12-48 V)

www.eiva.com

Wave Glider

Photo: Liquid Robotics, A Boeing Company

EIVA Cable Telemetry Kit

Image: EIVA

UUV for Mine Countermeasures

A Southeast Asian navy is changing how it performs mine hunting operations, opting for new unmanned systems instead of 50-m boats managed by a crew of 40. The new unmanned systems not only reduce the human risks involved with these operations, but are also controlled by three people, slashing operational costs. According to ECA Group, this unmanned solution for MCM operations is the first completely automated underwater robot demining system, including EMDS (Expandable Mine Disposal System) which can be remotely piloted and use a highly secured dedicated link for neutralization sequence. This ECA Group system completes the unmanned surface vessels (USV) built by a partner company. The USV is equipped with an inspection function using the K-STER I and a destruction one using K-STER C. All the vehicles are launched autonomously with an automated launch and recovery system (LARS), remotely piloted via a radio or satellite link. If a mine is found a Disposal vehicle KSTER C is deployed by a dedicated launching system, in order to destroy the mine. Sea acceptance tests of the first system is scheduled for September 2017.

www.ecagroup.com

Hi-Traq Trenching Vehicle

A Memorandum of Understanding between Royal IHC and Canyon Offshore, a U.K. subsidiary of Houston-based Helix Energy Solutions Group, will see that partners work toward an exclusive arrangement to jointly bring the Hi-Traq trenching vehicle to the market. Canyon would have the exclusive right to use the first Hi-Traq M1600, an asset built for both mechanical cutting and jetting operations. The modular asset would be available either as a standalone trenching spread on a client asset (vessel or barge for shallow water operations) or on board one of Canyon's construction and trenching support vessels. Following years of research and development, IHC built the Hi-Traq to bring forward the next generation of trenching vehicle to the market. The vehicle offers enhanced maneuverability and the powerful tooling will enable safe, efficient burial in a range of seabed conditions, the manufacturer said. The Hi-Traq vehicle has recently completed onshore cutter testing and is entering final commissioning prior to being mobilized for sea trials. With a strong track record in trenching, Canyon brings to the project engineering, design and build knowledge with operational expertise.

www.helixesg.com

MBES Mode Bathymetry Software

Aiming to raise the bar for shallow water mapping and imaging, Ping DSP has introduced its new MBES Bathymetry Engine. With a useable swath width of up to 14 times water depth, the 3DSS brings accurate, wide swath echo sounding to shallow water and provides the same operational and bathymetric performance benefits of Multibeam Echosounders but over the larger swath. Ping DSP said the new MBES Mode uses an advanced new seabed detection algorithm that takes advantage of the dual head nature of the 3DSS sonar and its high resolution 3D imaging capability to achieve swath widths far exceeding traditional beamsteering systems. The new MBES Mode introduces user control of sounding beamwidths as narrow as 0.25°, beam densities of up to 1024 beams, and sector sizes to 220°. Beams can be organized as equidistant, or equiangle, or in a new hybrid mode that preserves equidistant spacing over the widest possible swath while also providing full water column coverage of vertical structures and spurious hazards.

www.pingdsp.com

Mine Countermeasures

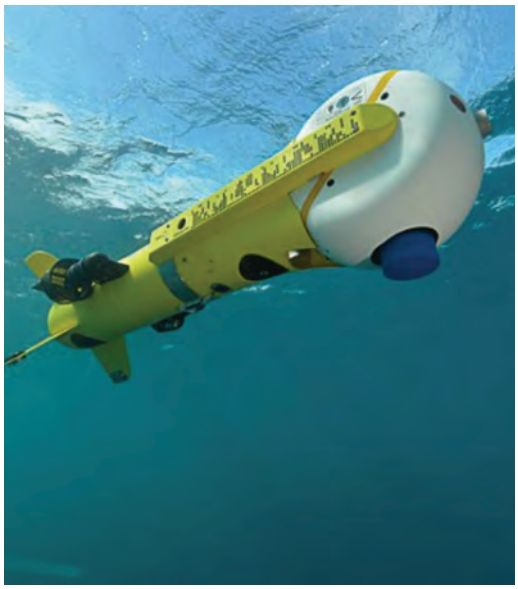


Image: ECA Group

Hi-Traq Trenching Vehicle

Image: Royal IHC

Bathymetry Software

Image: Ping DSP

BlueTech Week 2017

BlueTech Week 2017 aims to bring together industry, academia and government in sunny southern California. Now in its ninth year, the annual event has grown to encompass seven events in five days, scheduled for November 6-10, 2017. MTR *caught up with Michael Jones, president of The Maritime Alliance (TMA), to discuss 'what's new' at this year's event.*

By Eric Haun

How has BlueTech Week evolved over the years, and in what ways has it stayed the same?

The basic concepts are the same – to "Promote BlueTech & Blue Jobs", foster collaboration and international outreach. But there have been amazing developments over the years. As examples, we have grown from two events over two days to seven events over five days of BlueTech Week 2017 with a theme of "Smart Ocean, Smart Water." Attendance over the week has expanded from probably 100 in the first year to an expected 450 across the multiple events this year. Second, we became a membership organization in late 2013 and over the last four years have added over 80 corporate members starting in San Diego and increasingly across the U.S. and international with members in Brazil, Canada, Italy, Mexico, Norway, South Africa and the U.K., which means more members participate from around the world. Third, two years ago in 2015 we added a BlueTech Cluster Convening and had eight clusters from five countries participate sharing best practices and exploring ways to collaborate. For the third annual Cluster Convening this year, we expect 17-18 clusters and clusters-in-formation related to ocean and water technologies from at least eight countries and nine U.S. states to participate in the "by invitation" day. Fourth, there is not enough financing available to innovative SMEs, so last year we launched a BlueTech PitchFest day, which returns in 2017 with more presenting companies and more investors and channel partners expected. And finally, while TMA is best known for our ocean tech work, we are a cluster that covers both fresh and salt water. This year, for the first time, we are running multiple tracks for ocean and water technology providers and users – our member companies sell across both domains – including a dedicated water track with six panels. We will also have water clusters with us for the first time.

Photo: The Maritime Alliance

The event in San Diego has grown from two events over two days to seven events over five days of BlueTech Week 2017 with a theme of "Smart Ocean, Smart Water."

What makes BlueTech Week stand out from other conferences dedicated to the ocean science and marine technology communities?

TMA is a networking organization and everything that takes place during BlueTech Week relates to creating relationships between clusters and companies. BlueTech Week is not a trade show – there are great trade shows around the world that put technology and service companies in front of buyers. Our mission statement is "Promoting Sustainable, Science-Based Ocean & Water Industries" and our tag line is "Promoting BlueTech & Blue Jobs", so everything we do is designed to promote those goals. We create an intimate, networking environment with high level attendees from academia, industry and policy that results in academic and channel partnerships, funding opportunities, technology partnerships, workforce development and more during BlueTech Week. We like to say, "the right people, the right place, the right setting, the right time"… and San Diego is always a great place to visit, especially when it is winter in northern Europe.

Looking at the busy year that The Maritime Alliance has had so far, what are one or two highlights you most excited about?

Let me mention three. First, we have a growing number of examples of partnerships among TMA members internationally and with companies of our cluster partners – collaboration works. Second, our engagement with educational institutions and workforce development is critical. We care about developing the technical staff needed by our member companies and to inspire the entrepreneurial leaders of tomorrow. As two examples, we have recently begun working with the San Diego Unified School District – one of the largest school districts the U.S. – to create a Blue Economy Academy and

Networking with executives and officials from industry, academia and government is a central activity throughout BlueTech Week in San Diego.

Photo: The Maritime Alliance

workforce pathway…and, with some grant funding organized by one of our educational partners, we will launch a Blue Jobs website with career videos to inform and excite youth (and their parents) about the broad array of jobs in the fast-growing Blue Economy. And third, we are very excited to be working with a growing number of clusters and clusters in formation around the world to create win-win situations across the Triple Helix (academia, industry and policy makers) that will result in more Blue Job growth in sustainable, science-based ocean and water industries.

Please provide an update on The Maritime Alliance's efforts to engage with other similar clusters around the globe, as well as a look at plans for the next 12-18 months ahead.

In January 2017, TMA helped launch the BlueTech Cluster Alliance (BTCA), which is an association of nine of the leading BlueTech clusters in the world committed to collaborate. Most of us already have a history of working together and we are looking at ways to expand that collaboration. We have different sources of funding, we have different legal forms, we have different paths to the development of our various clusters…but we all want to promote sustainable, science-based ocean industries that create good-paying Blue Jobs while addressing the world's biggest challenges: food, water, energy, medicine, real estate, etc. As we like to say, it is our (collective) companies that are developing the technology and services to allow us understand the problems in the ocean…and it will be our companies that will help us solve them, which we can only do together. BTCA clusters are already active in locations around the world and now we are developing a more formalized cluster building capacity to help organize clusters in regions in Africa, Americas, Asia and the Pacific.

As Prof. Michael Porter wrote in his seminal article "Clusters and the New Economics of Competition" in the Harvard Business Review Nov-Dec 1998: Today's economic map of the world is dominated by what I call clusters: critical masses—in one place—of unusual competitive success in particular fields. The time has come for Blue Economy and BlueTech clusters to be recognized for their importance and we are working hard to raise their profile globally.

As examples, TMA co-organized a cluster event as part of the first ever UN Ocean conference in June 2017; we will promote clusters at the Our Ocean conference in Malta in October; BlueTech Week 2017 will focus on cluster collaboration; we are working with The Economist as its "World Ocean Summit" in Mexico in March 2018 will focus on Blue Economy Clusters for the first time; clusters will be active and visible at Oceanology Intl. in London in March 2018; and the effort will continue far beyond 2018.

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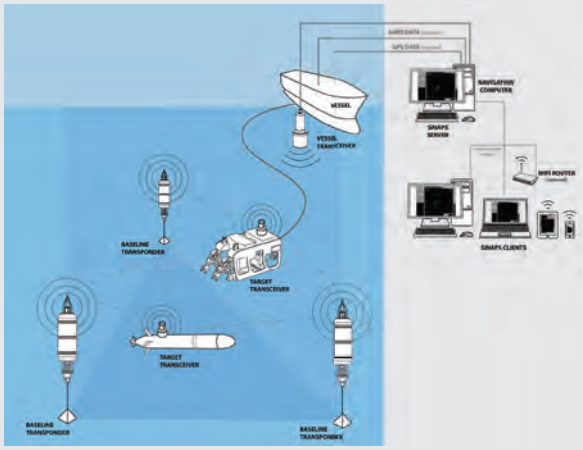

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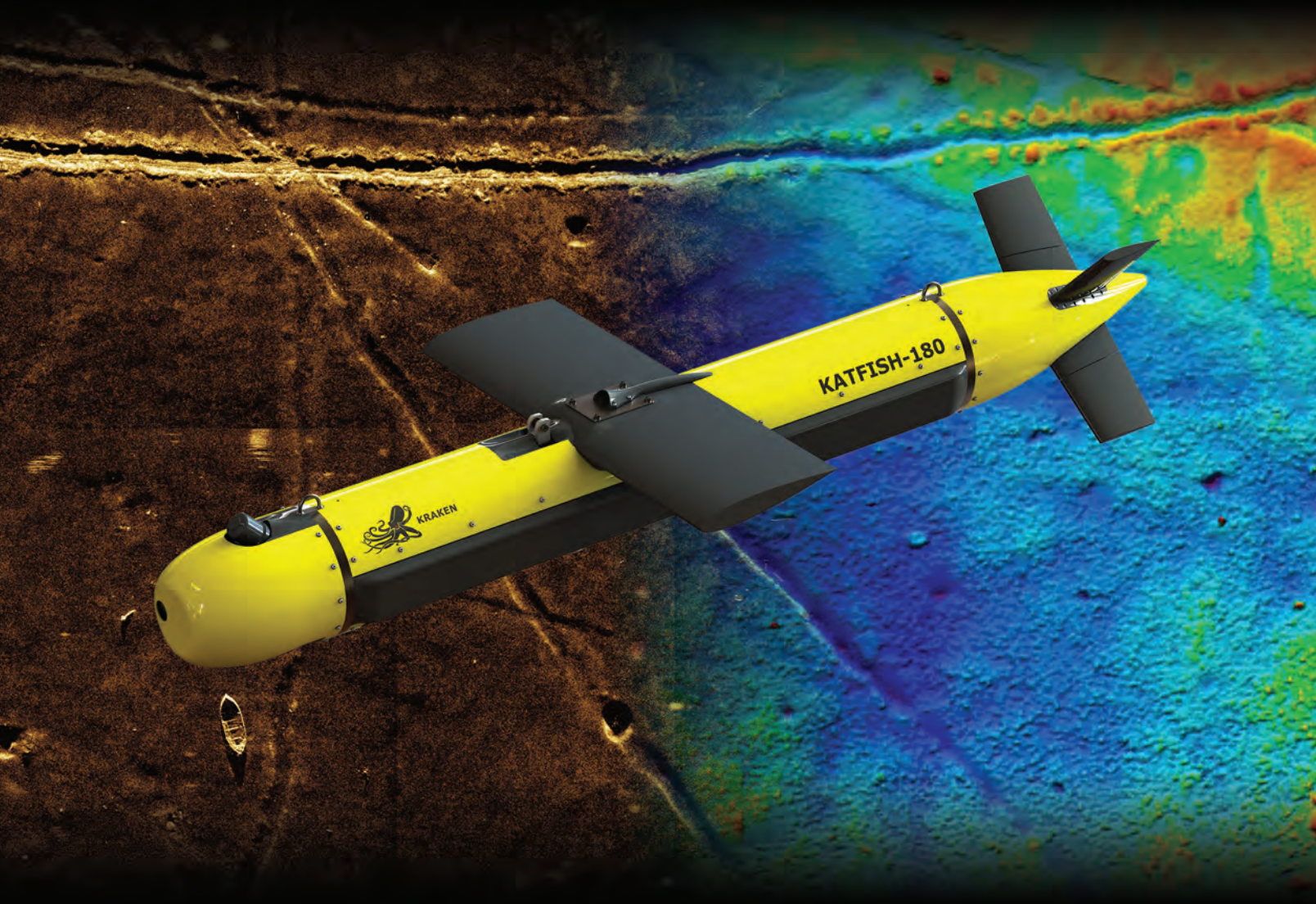

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