

SEA TECHNOLOGY®

www.sea-technology.com

NOVEMBER 2021

**Undersea Defense
Antisubmarine Warfare**

**FEATURING:
NATO and Maritime Autonomy
New Waveform Design for Sonar AI
Flying Ships**

TOTAL OCEAN MARKET COVERAGE

2022

JANUARY

Annual Review & Forecast

**EUROMARITIME, February 1-3, Marseille, France

**OCEANS 2022 Chennai, February 21-24, Chennai, India

FEBRUARY

Instrumentation: Measurement, Processing & Analysis

**Oceanology International, March 15-17, London, Excel, U.K.

MARCH

Electronic Charting/Vessel Management/
Ports & Harbors/Dredging/Homeland Security

**AUVSI XPONENTIAL 2022, April 25-28, Orlando, FL

APRIL

Offshore Technology/Alternative Energy & Ocean Engineering

**Offshore Technology Conference, May 2-5, Houston, TX

MAY

Communications, Telemetry, Data Processing

JUNE

Seafloor Mapping/Sonar Systems/Vessels

JULY

Deck Gear, Cable, Connectors, Power Systems & Salvage

AUGUST

Geophysical Exploration/Seafloor Engineering

**SEG 2022, September 11-16, Dallas, TX

SEPTEMBER

Ocean Resources Development & Coastal Zone Management

**OCEANS 2022 Hampton Roads, October 17-21, Virginia Beach, VA

**Offshore Energy 2022, dates TBD, Amsterdam, The Netherlands

OCTOBER

Environmental Monitoring, Remote Sensing & Pollution Control

NOVEMBER

Undersea Defense/Antisubmarine Warfare

DECEMBER

Diving, Underwater Vehicles & Imaging

**Sea Technology supports these shows via media partnerships.

SEA TECHNOLOGY®

WORLDWIDE INFORMATION LEADER FOR
MARINE BUSINESS, SCIENCE & ENGINEERING

The only magazine that addresses the total oceanographic field from undersea defense to offshore oil...globally

Recognized by tens of thousands as the authority for design, engineering, and application of equipment and services for government and industry.

...and most of all, IT SELLS!

**ADVERTISING CLOSES ON
THE 15TH OF THE MONTH
PRECEDING ISSUE DATE**

BONUS INFORMATION TO KEEP OUR READERS UP-TO-DATE

- Capital Report
- Company Profiles
- Contracts
- Environmental Monitoring
- International
- Marine Renewables
- Marine Resources
- Meetings
- Navy Currents
- Ocean Business
- Ocean Engineering
- Ocean Research
- People
- Product Development Reviews
- Soapbox

OTHER OPPORTUNITIES

- Advertisers
- Sea Technology Buyers Guide/Directory
- Sea Tech e-News
- Commercial Fisheries News
- Fish Farming News
- Fish Farmers Phone Book/Directory
- Commercial Marine Directory
- Direct mail list rentals
- Article reprints/PDFs
- Banner and skyscraper Web ads
- Sponsored e-blasts

EDITORIAL CONTACT

Aileen Torres-Bennett

ADVERTISING CONTACTS

C. Amos Bussmann
Sue Ingle Owen

Follow Us On:



Compass Publications, Inc.
4600 N. Fairfax Dr., Suite 304, Arlington, VA 22203-1553 • Tel: 703.524.3136 •
oceanbiz@sea-technology.com (editorial) • seatechads@sea-technology.com (

1963 – 2021 Celebrating More Than 50 Years of Serving the Global Ocean Community

MASSA

GENERATIONS AHEAD IN SONAR & ULTRASONIC TECHNOLOGY

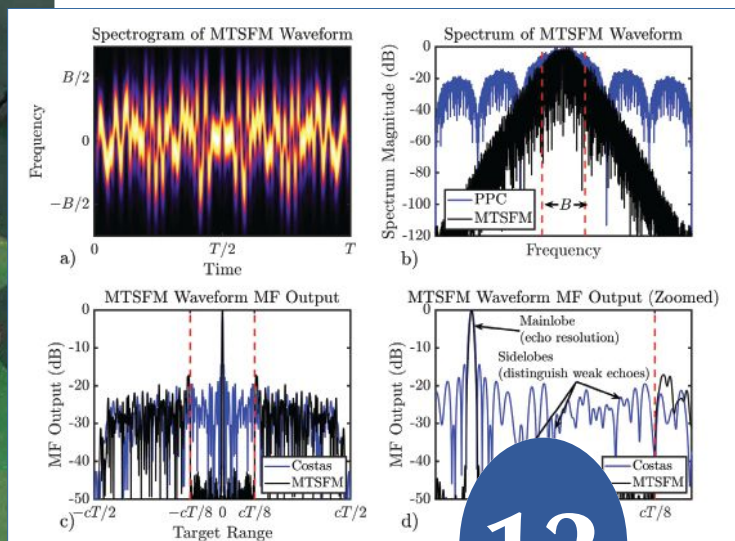
Protecting Our Shores, the Ocean & the Life Within One Name, One Family ~ MASSA

*When your heart seeks the ocean,
and your spirit seeks the sea
Quality tools put answers to motion, and
deliver the dependable answers you need
Oh brave ocean, oh brave sea
Run the ocean with MASSA, because
MASSA protects the seas*

**Talk to MASSA ~
We'll Hear You!**

sensors@massa.com
781-749-4800

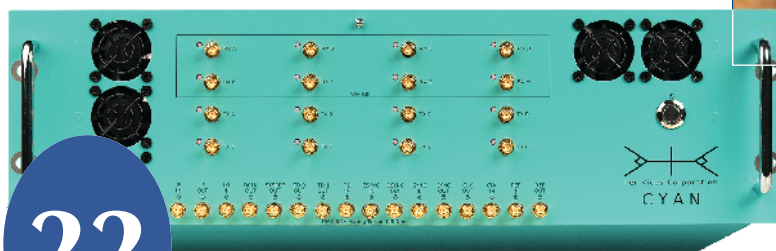
www.massa.com



12



17



22



27

FEATURES

- 8** **NATO AND 'AUTONOMY'**
Thomas Furfaro, Dr. Yan Pailhas and Dr. Sandro Carniel (*NATO STO CMRE*) present an overview of NATO CMRE's maritime autonomous systems developments in the last decade.
- 12** **ADAPTIVE TRANSMIT WAVEFORM DESIGN**
Dr. David A. Hague (*Naval Undersea Warfare Center, Newport, Rhode Island*) introduces a new waveform model that could enable cognitive active sonar.
- 17** **MULTICHANNEL MODEMS**
Manu Ignatius and Dr. Prasad Anjani (*Subnero*) detail the "Swiss Army Knife" of acoustic modems in the maritime domain.
- 22** **MODERN NAVAL RADAR**
Victor Wollesen (*Per Vices Corp.*) explains how software-defined radio supports maritime security.
- 27** **FLYING SHIPS**
Bill Peterson (*Flying Ship Technologies Corp.*), Gus Bateas (*Ground Effect Technologies Corp.*) and Capt. Steve Bomgardner (*Bahamas Maritime Authority*) discuss the development of the new autonomous wing-in-ground-effect vessels coming to market.

DEPARTMENTS

- | | |
|------------------------------------|--|
| 6 Soundings | 40 Offshore Oil & Ocean Engineering |
| 7 Editorial | 42 Contracts/Meetings |
| 31 International | 43 Navy Currents |
| 33 Capital Report | 44 Professional Services Directory |
| 34 Product Development | 45 Soapbox |
| 36 Marine Electronics | 46 Advertiser Index |
| 38 Environmental Monitoring | |

COVER IMAGE

Navy Divers assigned to Mobile Diving Salvage Unit (MDSU) 2 deploy a MK-18 Mod 1 UUV in Onslow Bay off the coast of North Carolina during Large-Scale Exercise (LSE 2021) in August 2021. LSE 2021 demonstrates the Navy's ability to employ precise, lethal, and overwhelming force globally across three naval component commands, five numbered fleets, and 17 time zones. (Credit: U.S. Navy, Arthurgwain L. Marquez)

NEXT MONTH

Autonomous tech becoming more affordable with low-cost components ... Creating data standards for AUV surveying ... AI in imaging, including 3D holograms ... SPACEWHALE: Detecting marine megafauna from space ... Hydrogen fuel cell for UUV.

Copyright 2021 by Compass Publications, Inc. *Sea Technology* (ISSN 0093-3651) is published monthly by Compass Publications, Inc., 4600 N. Fairfax Dr., Suite 304, Arlington, VA 22203; (703) 524-3136. All rights reserved. Neither this publication nor any part of it may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior permission of Compass Publications Inc. Periodicals postage paid at Arlington, Virginia, and additional mailing offices. Due to the COVID pandemic, printed issues will not be available in 2021. Digital subscriptions may be purchased for US 40 for one year. Printed back copies, where available, are US 6.00 each plus shipping and handling.



**Sea & Sun
Technology**

» CTD PROBES

» MSS PROBES

» SENSORS

» EQUIPMENT

» CALIBRATION

» SERVICE



up to 11.000 m



- » conductivity » turbidity
- » temperature » pH, Redox
- » pressure » fluorometers
- » oxygen » and much more



sales@sea-sun-tech.com
+49 4323 910 913

)) Winners of 2021 MTS Compass Awards. The Marine Technology Society (MTS) has announced its 2021 award winners, including the recipients of the Compass Awards, sponsored by Compass Publications Inc., the publisher of *Sea Technology*. Dr. Daniel Rudnick, director of the Instrument Development Group at Scripps Institute of Oceanography, has won the Compass Distinguished Achievement Award for outstanding contributions to physical oceanography, his many multidisciplinary collaborations, his dedication to ocean observing, and his astute understanding of stakeholder/community needs. Rudnick, a world leader in glider operations, has led climatology products development through his work with the U.S. Integrated Ocean Observing System - Southern California Coastal Ocean Observing System. Integrated Marine Observing System (IMOS) Australia has won the Compass International Award as a high-performing research infrastructure, both nationally and globally, that has made significant impacts in science excellence; technology innovation; training and education; economic benefit; and social responsibility. Kongsberg Maritime has won the Compass Industrial Award for outstanding contributions to marine science and technology. Kongsberg Maritime's history as part of leading Norwegian industrial powerhouse KONGSBERG stretches back over 200 years. Today, more than 18,000 merchant ships, fishing vessels, cruise liners, ferries and superyachts, as well as offshore support and research vessels, offshore installations and government craft, depend on Kongsberg Maritime technology. You can see the full list of 2021 MTS winners at: <https://tinyurl.com/n8h9ue8>.

)) Massive Redirection of Capital into Clean Energy Needed, DNV Says. An urgent change of mindset and a massive redirection of spending from carbon-heavy investment into clean energy is needed if an affordable transition that meets the Paris Agreement is to be achieved, says DNV in its special report: "Financing the Energy Transition" (<https://eto.dnv.com/2021/financing-energy-transition/about>). Emissions must fall by around half by 2030 for a 1.5° C future, but DNV forecasts they will fall by just 9 percent, and the world will already exhaust the 1.5° C budget in 2029. Financiers, bankers and governments have an essential role in ensuring a just and accelerated transition. Yet financiers also face significant challenges, particularly around how to price the risk of often multi-decade energy projects in a rapidly changing energy system and warming climate. This includes the potential for stranded assets, climate risk in infrastructure, and pressure on profitability and rates of return if too much capital chases a limited number of projects. Together with policy makers and energy companies, financiers also face the challenge of de-risking and improving the profitability of clean energy opportunities that are currently high-risk, low-return, long-term investments, which are often not considered bankable, but which are needed for an accelerated transition. "Financing the Energy Transition" focuses on the opportunities and challenges for financiers, policy makers, developers, and energy companies. The report, featuring contributions from global financial, policy and energy experts, shows there is a consensus that new short-term actions, alongside long-term commitments, must be agreed on by global leaders at COP26 in November.

)) Launch of Alliance for the Blue Economy. The University of North Carolina Wilmington (UNCW) Center for Innovation and Entrepreneurship has launched the Alliance for the Blue Economy, a multidisciplinary initiative to establish southeastern North Carolina as a national and global leader in the blue economy. The World Bank describes the blue economy as "the sustainable use of ocean resources for economic growth, improved livelihoods and jobs, while preserving the health of the ocean ecosystem." In the U.S., the blue economy delivered nearly \$400 billion to the GDP in 2019, according to a report from the U.S. Department of Commerce. The Alliance for the Blue Economy, also known as All Blue, will support blue economy entrepreneurs and innovators; promote the region as a blue economy innovation hub; assist in the creation of blue economy-ready infrastructure; and attract blue economy investment capital. To fulfill this vision, the alliance will work to obtain federal, state and regional grants with government agencies, educational institutions, nonprofit organizations and private sector partners. Led by an advisory board of science and business leaders from the region and UNCW, All Blue will focus on five strategic sectors: sustainable aquaculture and fisheries; marine biopharma; regenerative tourism; coastal resilience; and ocean engineering and marine robotics. With the launch of the alliance, southeastern North Carolina will join the ranks of a growing number of blue economy hubs in the U.S., including Boston, San Diego, Seattle and Gulfport, Mississippi.

)) Verification of World's Largest 3D-Printed Shipboard Fitting. Keppel Technology & Innovation (KTI) has received a verification certificate for a 3D-printed, deck-mounted type Panama Chock (SWL150Ton) from DNV's Global Additive Manufacturing Technology Centre of Excellence in Singapore. The component, which is intended for nonclass maritime applications, is the world's largest 3D-printed shipboard fitting. Panama Chocks are large shipboard fittings for towing and mooring, traditionally manufactured by casting, and are welded to a ship as a supporting hull structure. This component was manufactured by KTI's partner AML3D using the patented Wire Additive Manufacturing (WAM) process, employing medium-strength structural steel grade ER70S-6 wire feedstock. The verification by DNV follows extensive research, production and testing by KTI with end-user Keppel Offshore & Marine (Keppel O&M) and technology partner AML3D and confirms that the component has met all the primary test requirements in KTI's project material specification with satisfactory results. **ST**

**publisher
managing editor
production manager
assistant design/
website manager
advertising
service manager**

**C. Amos Bussmann
Aileen Torres-Bennett
Russell S. Conward
Joshua Ortega

Susan M. Ingle Owen**

ADVERTISING REPRESENTATIVES:

HEADQUARTERS

C. Amos Bussmann
4600 N. Fairfax Dr., Suite 304
Arlington, VA 22203-1553
Tel: (703) 524-3136
seatechads@sea-technology.com

EASTERN U.S.A. & CANADA/G.O.M.

Ray Mahr, Jr.
KRK Consultants Ltd.
17476 Slipper Shell Way, Ste. 6
Lewes, DE 19958
Tel: (302) 569-0019 (M)
rmahrjr@gmail.com

WESTERN U.S.A. & CANADA

John Sabo
Barbara Sabo
Gregory Sabo
John Sabo Associates
447 Herondo St. #305
Hermosa Beach, CA 90254
Tel: (310) 374-2301
bsabo@jsaboassoc.com

EUROPE

John Gold
John F. Gold & Associates
"Highview"
18a Aultone Way
Sutton, Surrey, SM1 3LE, England
Phone/FAX Nat'l: 020-8641-7717
Int'l: +44-20-8641-7717
johnfgold@gmail.com



Sea Technology back issues available on microform.

Contact: NA Publishing, Inc.
P.O. Box 998, Ann Arbor, MI 48106-0998
1-800-420-6272

COMPASS PUBLICATIONS, INC.

4600 N. Fairfax Dr., Suite 304
Arlington, VA 22203-1553
Tel: (703) 524-3136
oceanbiz@sea-technology.com
www.sea-technology.com

publishers of:
Sea Technology
Commercial Fisheries News
Fish Farming News
Commercial Marine Directory
Fish Farmers Phone Book/Directory
Sea Technology Buyers Guide/Directory
Sea Tech e-News

*Celebrating more than 58 years
of serving the global ocean community
- Since 1963 -*

Bruce Butler, Theseus Engineer, Author of "Into the Labyrinth"

25th Anniversary of Theseus Under-Ice AUV

This year marks the 25th anniversary of the record-breaking under-ice mission of Theseus, a watershed moment in AUV history. Theseus was not the first AUV to venture under the ice, but it was the first to perform extended under-ice operations.

Theseus was the star of Project Spinnaker, a joint Canada-U.S. defense research project conceived in the waning days of the Cold War. Spinnaker's purpose—classified at the time—was to provide Canada with the capability to monitor submarine activity in its Arctic waters by installing a prototype acoustic listening post on the seafloor. Theseus's role was to lay a communications trunk cable on the seabed from the northern shores of Ellesmere Island, Canada, out to the edge of the Continental Shelf, almost 200 km to the north.

Theseus was designed and built by International Submarine Engineering Ltd. (ISE), a Canadian company with a long history of subsea engineering innovation in ROVs, AUVs and robotic manipulator systems. Developing Theseus required pushing the boundaries of nascent subsea technologies such as navigation, launch and recovery through ice, energy storage, and fault tolerance. It was fortunate for the Project Spinnaker stakeholders that ISE engineers had the audacity to believe they could take on these challenges.

Vehicle design began in 1992; by late 1993 Theseus was taking shape, and by mid-1994 it underwent its first sea trials. In the spring of 1995, ISE took Theseus to Canada's High Arctic for a series of short (approximately 10 km) test dives, fine-tuning operational logistics and validating vehicle reliability and performance. The success of these under-ice trials was due in part to ISE engineers having already gained valuable Arctic experience through participation in Project Iceshelf, the Department of National Defence's annual Arctic field trials. Following a successful full mission-length trial in early 1996, Theseus was loaded into a C-130 Hercules for a 4,000-km flight to Canadian Forces Station Alert at the northern tip of Ellesmere Island. Theseus and its ISE designers then proved the many naysayers wrong by performing two back-to-back, 360-km, round-trip, under-ice missions, each lasting several days.

The performance of Theseus during Project Spinnaker showed the entire maritime community that long-duration autonomous under-ice missions were possible. This milestone soon led other institutions, governments and military agencies to begin developing AUVs for a multitude of under-ice applications.

The technologies, logistics and operational procedures developed for Theseus continue to bear fruit today. In the mid-2000s, ISE drew on its experience in Arctic subsea engineering to develop the Explorer-class AUVs. In 2010, an Explorer AUV performed a 10-day Arctic mapping mission in support of Canada's 2013 UNCLOS submission. More recently, an Explorer AUV made several ventures under both continental and fringing ice shelves in the Antarctic. In addition, ISE is currently developing an autonomous docking mechanism that will allow for submerged and underway battery charging and data transfer, enabling long-duration missions requiring persistent surveillance.

Many of the personnel involved in Theseus development continue to advance AUV technologies worldwide in maritime defense, commercial industry and academia. The most notable are ISE alumni at Cellula Robotics, who are developing a fuel cell-powered, long-range/duration AUV for Canada's All Domain Situational Awareness Science and Technology program.

A quarter century ago, the need for a mission-specific AUV drove the development of subsea technologies that laid the foundation for a new generation of vehicles, technologies and exciting opportunities. You can learn more about the story of Theseus at: www.theseusbook.com. **ST**

NATO and ‘Autonomy’

A Decadal Overview of CMRE’s Maritime Autonomous Systems

By Thomas Furfaro • Dr. Yan Pailhas • Dr. Sandro Carniel

NATO’s Science and Technology Organization (STO) recently developed a comprehensive assessment of emerging and disruptive technologies (EDTs) and their accompanying S&T ecosystem. The result is a kaleidoscopic breadth of technologies, such as artificial intelligence (AI), big data, quantum and space.

Following its mission of anticipating S&T trends, the STO Centre for Maritime Research and Experimentation (CMRE), located in La Spezia, Italy, has been devoting a considerable amount of research to the specific theme of “autonomy,” a disruptor identified by the report. Supported primarily by NATO Allied Command Transformation (ACT), CMRE tries to accelerate the bridge-gapping process, applying basic research outcomes in relevant maritime scenarios to understand quickly how such EDTs may be used in more realistic scenarios.

In this context, “autonomy” is the ability of a system to arbitrate decisions and courses of action depending on the self-contained awareness of a larger context. CMRE research in this area addresses challenges and issues brought along with the development and implementation of autonomous technologies and systems, with a specific focus on the maritime context.

The research, corroborated by other important pillars of the maritime technology sector, demonstrates that maritime autonomous systems offer wide-ranging near- and long-term benefits for enhancing Alliance capabilities, acting as a force multiplier across domains. This synthesis also presents potential new areas for future research and significant S&T challenges to better understand and tackle.

Background

Developments in robotics and autonomous systems (RAS) present the Alliance with a range of emerging and transformative opportunities for military and security capabilities. Moreover, as noted in “Science & Technology Trends 2020-2040: Exploring the S&T Edge,” RAS is a

key enabler and beneficiary of developments in other EDT areas.

Applying autonomy in the maritime environment is a challenging proposition that has particularities when compared to other primary domains (such as land, air, space and cyber). The maritime environment (below and above the surface), considered from the viewpoint of unmanned or autonomous robotic systems, can be harsh and isolating. The harshness arises from a myriad of factors, from weather and oceanographic conditions and the basics of chemistry. The isolation arises from a relative lack of stationary features in the observable space. An underwater vehicle operating in the water column has difficulty observing fixed points in its environment and can usually only measure depth and altitude intrinsically without other human-supported navigation aids.

This article provides an overview of more than a decade’s worth of CMRE research and analysis related to the autonomy theme, focusing on two areas: operations and systems; and interoperability, VV&A (verification, validation and accreditation), standards, and assurance. The themes of sensing, platforms and design, counter-measures, and human-machine teaming and sensing will also be discussed.

Operations and Systems

Research and analysis that considers how autonomous systems fit into larger systems of systems, or how autonomous applications could contribute to a particular operational domain, is referred to as “operations and systems.” Examples may include the integration of autonomous systems into existing or more expansive military systems, intelligent independent software (agents), small satellite constellations, and cyber-warfare agents. This core area is concerned with the “what and how” of autonomous systems: What are the systems to be employed, how would they be used and to what effect.

CMRE has conducted extensive research contributing



A glider fleet.

to this field in the maritime domain, examining the application of autonomy in naval mine warfare, anti-submarine warfare (ASW), harbor protection, oceanography, and modeling and simulation in the context of maritime unmanned systems (MUS). CMRE additionally has long-standing collaborations within the scope of European Union-funded projects, bringing cross-domain expertise to relevant civil and military applications.

In these applications, CMRE takes a systems engineering approach, combining elements that are commercial-off-the-shelf (COTS), proprietary, open, free, standardized or custom built to deliver relevant solutions to the task at

hand. In this way, the efficiency of the market can be leveraged while including innovative and state-of-the-art elements that multiply the overall capability. For example, in the mine countermeasures (MCM) projects that CMRE executes, a combination of COTS AUVs and sensors are augmented with custom configurations and software modules to produce an autonomous, collaborating MCM squad.

CMRE research indicates that integrating autonomous systems into military operations across the operational spectrum will continue, while further research will be needed to address specific system types and operational domains, together with stakeholders' engagement. Expected areas for future technology are: robotics and autonomous systems, enhancing data collection and situational awareness across different domains. Challenges include: barriers to and costs of integration, trust, cyber vulnerabilities, interoperability issues, operational validation and system reliability.

Interoperability, VV&A, Standards and Assurance

This section refers to research and analysis considering interoperability, VV&A (verification, validation and accreditation), standards, and assurance factors relating to technical applications of autonomy. For example, specific areas may include the development of new standards to enable interoperability of increasingly autonomous unmanned systems.

CMRE has been active in undertaking research relating to autonomous systems' interoperability and standardization issues.

CMRE occupies a particular area of the spectrum of applied research in the maritime environment, where the continuous improvement of interoperability among the members and partners of the Alliance cannot be carried solely by a single nation.

As part of the CMRE MUSE (Unmanned Systems Enablers) program, interoperability, standards and security for unmanned maritime systems are being investigated. Further ongoing research examines compliance for maritime robotic exploitation, while a research project on behalf of ACT explores trust issues between humans and autonomous systems. The topics of VV&A and assurance

are exceptionally important tools on the road to widespread maritime autonomous systems, as they focus on providing specific and concrete ways to describe the ability of a system to perform a certain kind of task in particular conditions.

As another example, CMRE is currently working with an EU project to enhance situational awareness in a maritime environment through the deployment and integration of unmanned systems. The focus is on improving interoperability between manned and unmanned systems and existing, multilateral EU defense systems and platforms.

CMRE research highlights the need to continue to address and raise awareness of issues such as trust and interoperability by harmonizing common and interoperable frameworks and standards for RAS technologies.

Sensing

Recalling the original definition of autonomy, i.e., the ability of a system to arbitrate decisions and

courses of action depending on the self-contained awareness of a larger context, one could argue that sensors and the capability of a system to sense and measure its environment are the primary enablers for autonomy. In that context, sensing refers to the “perception” layer of an autonomous system: the sensors, signal processing, data and algorithms that form a pipeline converting measurements of a system’s environment into actionable information. The level of autonomy of a system is then dictated by the quality and the relevance of the information fed to that system.

CMRE has a long history in understanding and exploiting the physics, particularly the physics of underwater acoustics, to design and build entirely new sensors to extract information of interest for a particular application. The development of the SAS (synthetic aperture sonar) in the early 2000s for MCM applications is an example of CMRE’s effort to build new sensing capabilities that have enabled auto-

my in MCM by drastically reducing the false alarm rate. CMRE ASW research is another example where physical knowledge exploitation of sound propagation in the oceans, developed originally in acoustical oceanography, led to smart antenna design for underwater surveillance.

Over the years, CMRE has been a pioneer in fundamental underwater acoustic research that has given access to new information, ultimately facilitating environmental awareness for autonomous systems.

Platforms and Design

Autonomous platforms and design refers to research and analysis that examines the design and development of military-relevant robotics and autonomous systems.

A relatively low number of CMRE activities have focused on the design and development of the system platform, onboard control systems and means of propulsion of specialized unmanned vehicles (UxVs) and swarms. However, CMRE has organized robotic competitions for research teams from academia and industry in different scenarios over the past decade.

Through the Student AUV Challenge Europe (SAUC-E) internal program at CMRE and EU-funded projects, these competitions aim to push the state of the art in autonomous platforms, enable cooperation, and support the development of multi-domain robotic systems. Areas for future research will be related to control systems, data reliability and resilience to cyber-physical attacks, particularly in the use of swarms.

Countermeasures

Countermeasures refer to research and analysis examining counter-UxV capabilities. The wide-ranging use of UxVs (and swarming) on the battlefield will require additional protection assets with explicit counter-UxV and counter-counter-UxV capabilities.

There has been some CMRE research focusing on maritime autonomous countermeasures. One project is led by Allied Command Transformation (ACT) with the Mul-

The Smart Solution
New & Retrofit
Naval Fleet Navigation

320N

KNUDSEN U.S. SALES: KNUDSENSYSTEMS.COM
INTERNATIONAL: KNUDSENENG.COM

***“Developments in robotics and autonomous systems (RAS)
present the Alliance with a range
of emerging and transformative opportunities
for military and security capabilities.”***

tinational Capability Development Campaign (MCDC), where CMRE provided expertise on issues related to countermeasures against unmanned autonomous systems.

Developing a better understanding of the protective aspects of autonomous systems is an active area of future research, and technology development will include decoy and jamming in relation to autonomous systems.

Human-Machine Teaming

Human-machine teaming (HUM-T) refers to research and analysis addressing challenges and opportunities of teaming between humans and autonomous systems.

CMRE has been investigating how to develop capabilities to support humans (i.e., operators and warfighters) working with complex systems, which make use of artificial intelligence and autonomy. CMRE has been focusing both on the advancement of the underlying technologies (i.e., AI algorithms) and advancements in terms of human-machine interaction. Specifically, cognitive support, situational awareness, explainability, uncertainty communication, semantic interoperability and trust are important constructs, which are currently under investigation in order to design advanced C2 (command and control) and decision-support tools.

Aspects specifically connected to human-likeness teammates have not been the focus of CMRE research due to the nature of operations (e.g., ASW and MCM) and consequent technologies that are at the core of CMRE activity. However, communication, language, cultural aspects, brain-computer interface and neuroscience-based technologies could be explored in future work. Finally, future work could expand on recent work to inform the doctrinal development of the use of mixed human-machine teams in autonomous ASW.

Conclusion

Over the last decade, CMRE has carried out a considerable amount of research and analysis on autonomous systems. Results have outlined how autonomous systems can offer wide-ranging near-term and longer-term benefits for enhancing Alliance capabilities, essentially acting as a force multiplier and enabling new capabilities. CMRE has and continues to contribute to the assessment of the operational value of maritime unmanned systems during exercises, where potential benefit to maritime mil-

itary scenarios and capability areas have been analyzed, including the enhancement of decision-making, crisis response and logistics capabilities.

However, there are still significant S&T challenges that must be understood and tackled if RAS can be fully, effectively and ethically employed in operations. The transition of autonomous capabilities from research to tech development entails challenges such as: integrating autonomous systems into operations, creating common frameworks and standards, the consideration of adversarial capabilities in the same domain, safety and control, and the construction of trusted and effective human-machine teams.

Most unmanned systems still need human operators, and, as a consequence, optimizing human-machine interaction is a critical challenge that is becoming increasingly relevant as operators are being further removed from the system.

Considering the challenges and concerns raised in the theme of “autonomy,” particularly evident in terms of interoperability, legal and ethical issues, it is mandatory to establish further collaborations within NATO.

CMRE’s expertise presents an excellent starting point to understand the current and potential future benefits of autonomous systems in the maritime context, as well as the associated challenges. In these areas, the role of CMRE is not merely to execute projects or provide products—it is also to leverage specific applications, experiments and results in the synthesis of broader lessons and rationale in the application of autonomy in operations and systems.

References

For a list of references, contact: Sandro.Carniel@cmre.nato.int. **ST**

Thomas Furfaro is a scientist at STO CMRE, working on autonomy for naval mine countermeasures, with a focus on software architectures, interoperability, collaborative autonomy and autonomous behaviors.

Dr. Yan Pailhas is a project leader at STO CMRE working on new sensors for mine countermeasure applications. He has been in the field of underwater acoustics and sonar design for more than 20 years.

Dr. Sandro Carniel is the head of the Research Division at STO CMRE and is directly engaged in climate and energy security themes. He is an oceanographer with a modeling background.

Adaptive Transmit Waveform Design

An Enabler for Cognitive Active Sonar

By Dr. David A. Hague

Recent research efforts in the anti-submarine warfare (ASW) community have focused on developing sonar systems that adapt to their acoustic environment, referred to as “cognitive” sonars. Cognitive active sonar systems utilize principles of the perception-action cycle of cognition to leverage information gathered from earlier sensing interactions with the underwater acoustic environment. This, in turn, informs the selection of system parameters to optimize target detection, classification, localization and tracking performance in that acoustic environment.

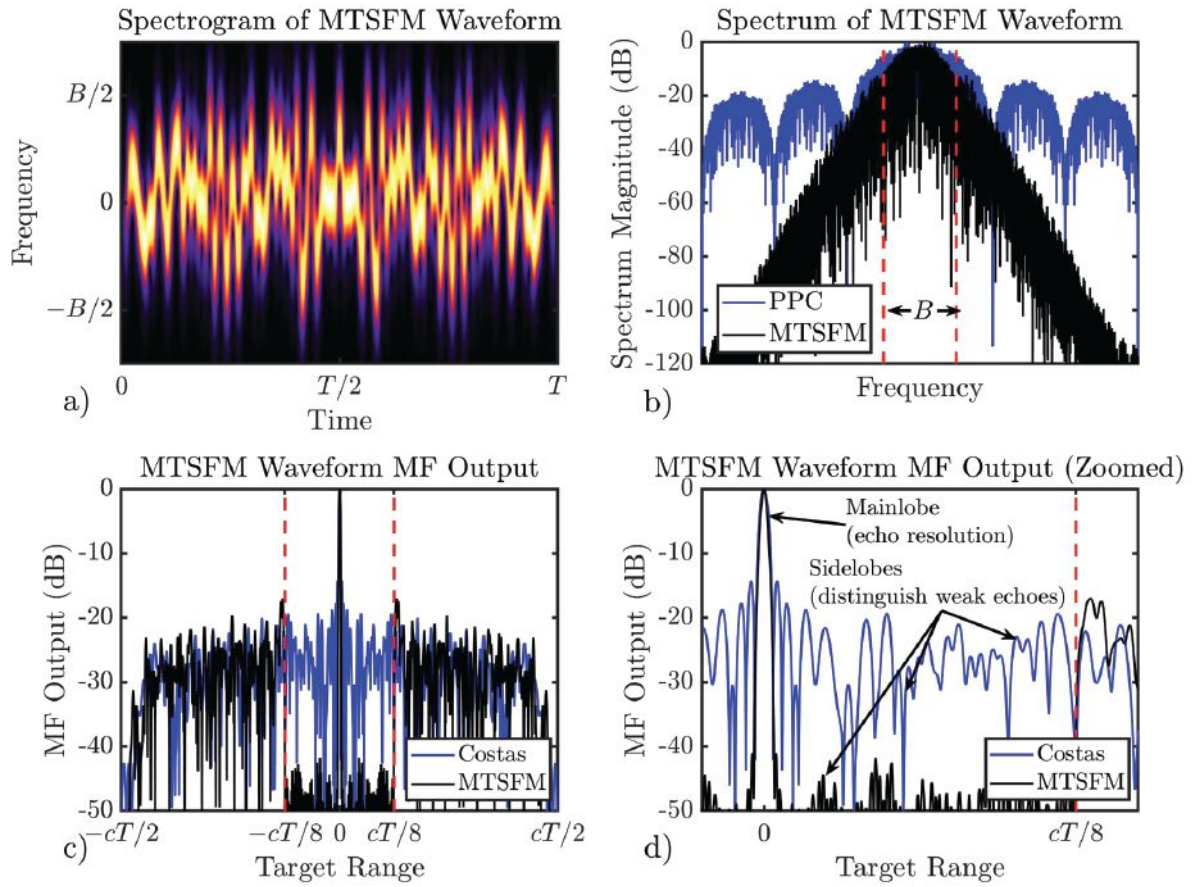
Of the many system parameters such a cognitive sonar system could potentially adapt, the acoustic signal transmitted into the medium, also known as the transmit waveform, has a profound impact on system performance. Many of the physical characteristics of the acoustic environment are contained in the return echo signal that is composed of amplitude-scaled (target strength), time-delayed (target range) and Doppler-shifted (target range-rate) echoes of the transmit waveform. The active sonar system then processes these echo signals typically with a bank of matched filters (MF) tuned to an array of potential target Doppler values. The output of such a receiver yields a range-Doppler map of the target scene.

Of the many transmit waveform parameters cognitive sonar systems could adapt, including pulse length, transmit source level and the operational band of frequencies, the type of phase or frequency modulation employed by the transmit waveform also fundamentally influences the type and quality of the information inferred about the target scene. Additionally, the waveform should facilitate efficient transmission on piezoelectric transducers and their driving electronics. It should possess a constant amplitude to minimize the distortion resulting from saturated power amplifiers, which drive the projector transducer. Constant amplitude also maximizes the energy transmitted into the medium for given duration and peak transmit power limits. Waveforms should also be

spectrally compact; the vast majority of the waveform’s energy should be concentrated densely in the operational band with very little energy elsewhere. This reduces mutual interference between systems operating in adjacent frequency bands and any distortion in the resulting transmitted acoustic signal from the frequency-dependent filtering of the projector transducer and its driving electronics.

Waveform Designs

There has been a wealth of research on waveform design dating back several decades. Continuous wave (CW) waveforms, perhaps the simplest of all sonar waveforms, possess a constant frequency throughout their duration and achieve high Doppler resolution but poor range resolution. The linear frequency-modulated (LFM) waveform, the first of the class of pulse compression waveforms, possesses both large bandwidth and long duration, resulting in a large time-bandwidth product (TBP). The large bandwidth provides improved target resolution and the long duration provides the necessary transmit energy for good target detection performance in noise-limited conditions. In the 1960s, the hyperbolic FM (HFM) was introduced as a large TBP counterpart to the LFM that was robust to Doppler mismatch and has found use in broadband active sonar applications. Also in the 1960s, John Costas developed a family of frequency-shift keying (FSK) waveforms that jointly resolved target range and Doppler in a single waveform. An FSK waveform is composed of equal length CW subpulses, known as chips, which are contiguous in time. Each chip possesses a different center frequency according to a particular “firing” code. Costas defined the basic necessary properties for these firing codes that now bear his name. Comb waveforms, whose spectral shape resembles the Dirac comb function, distinguish moving targets in stationary reverberation. All of these waveform types address a particular active sonar design problem and are rather diverse in



their characteristics. A cognitive sonar system may very well determine that the optimal waveform for a given scenario is one of the aforementioned waveform types.

New Waveform Model: MTSFM

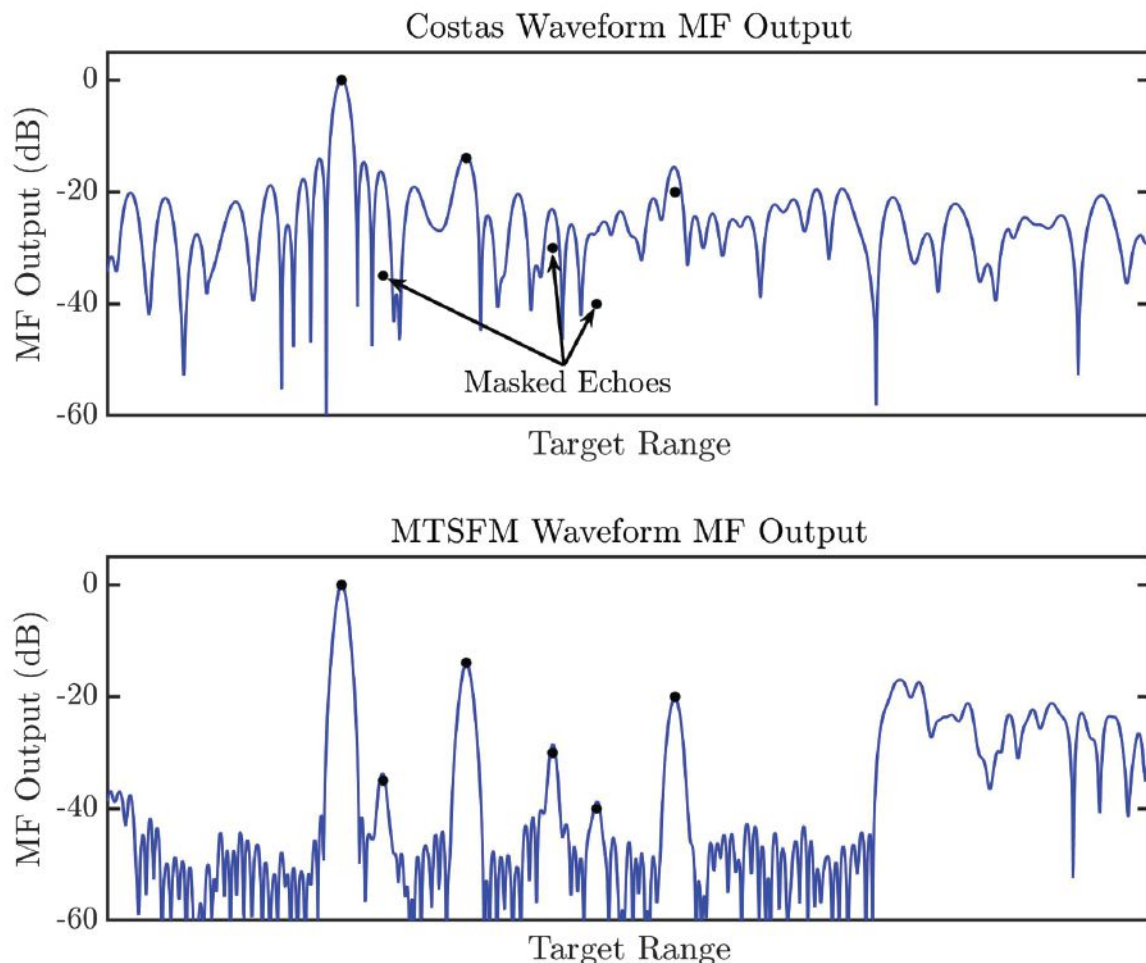
Fully leveraging the adaptive capability of a cognitive sonar system requires a waveform model that facilitates adaptation according to a set of system-defined goals and design metrics. The vast majority of adaptive transmit waveform design research has focused on poly-phase coded (PPC) waveforms from the radar literature. A PPC waveform is composed of a train of equal duration CW chips contiguous in time, all sharing a common center frequency. The phase of each chip is then assigned different values in a manner that generates a waveform with the desired characteristics. There exists a nearly endless combination of realizable poly-phase codes, making PPC waveforms far more versatile than their FM and FSK counterparts. While FM and FSK waveforms are limited in their versatility, they are readily implementable on practical systems due to their constant amplitude and spectral compactness properties. PPC waveforms, on the other hand, suffer from substantial spectral extent due to the nearly instantaneous phase transitions between chips. This has motivated the development of continuous phase modulation (CPM) techniques to improve upon their spectral characteristics by smoothing the phase transitions between chips. This phase smoothing essentially transforms PPC waveforms into constant amplitude,

Spectrogram (a), spectrum (b), and MF response (c & d) of an example MTSFM waveform with a TBP of 256. Also shown in (b) is the spectrum of an equivalent bandwidth PPC waveform and in (c & d) the range response of a Costas waveform with equivalent TBP. The waveform's range response is optimized to reduce sidelobe levels in the region denoted by the red dashed lines. This design allows for distinguishing several closely spaced echoes with varying strengths while possessing a spectrum whose energy is densely concentrated in the waveform's swept bandwidth B .

spectrally efficient parameterized FM waveforms. However, this smoothing also introduces perturbations to the waveform's characteristics, which then requires re-optimization of the original PPC waveform's phase code.

Inspired by these CPM efforts, I developed a spectrally compact adaptive FM waveform model using multi-tone sinusoidal frequency modulation (MTSFM). The MTSFM waveform's frequency and phase modulation functions are composed of a finite set of weighted sinusoidal harmonics. The weights for each harmonic are utilized as a discrete set of design coefficients. Adjusting these coefficients results in constant-amplitude, spectrally compact FM waveforms with unique characteristics.

The MTSFM's design parameters can be modified to finely tune the resulting waveform's characteristics. A certain design may also find use in certain scenarios. Real-world target returns are usually composed of multiple echoes from the acoustic highlights of the target, which



can vary greatly in strength. Distinguishing these echoes infers details about the physical makeup of that target. An MTSFM design can have advantages in distinguishing a collection of closely spaced echoes over a Costas waveform. The MF response from a Costas waveform can only pick out stronger echoes and not weaker ones near a strong echo, while the MTSFM can easily distinguish each echo when designed with much lower range sidelobes.

There are many waveform design problems where the MTSFM waveform model is applicable. The MTSFM model facilitates adjustable Doppler tolerance. In fact, it can smoothly transition from being ideally Doppler sensitive, like an FSK or CW waveform, to being ideally Doppler tolerant, like an LFM or HFM waveform. This ability offers the designer a trade-off between target Doppler resolution and receiver complexity (i.e., the number of required MFs to process the target scene). Additionally, other characteristics of the waveform, such as range and Doppler sidelobes, can also be further refined while maintaining the desired Doppler tolerance/sensitivity. The MTSFM can also synthesize comb waveforms for distinguishing moving targets in stationary reverberation. Comb waveform design typically focuses on ensuring strong reverberation suppression at specific target Doppler values while also possessing a constant

MF output for the Costas and MTSFM waveforms from the previous figure for a collection of closely spaced echoes (denoted by the black dots), with a 40-dB variation in echo strength. While the Costas waveform's sidelobe levels are too high to distinguish the weaker echoes, the MTSFM's suppressed sidelobes allow for distinguishing even the weakest echo in the presence of the strongest one.

amplitude and reasonably low range sidelobes. Generally, a waveform cannot achieve all three of these considerations simultaneously but can trade-off between them. Geometric comb waveforms have to date represented one of the best trade-off designs between these three considerations. The MTSFM model also can smoothly trade-off between these design considerations and, while not superior to the geometric comb waveform, is at least competitive in its design characteristics.

Lastly, another application of the MTSFM focuses on designing not just one waveform but families of MTSFM waveforms that occupy a common band of frequencies and also possess low cross-interference properties with one another. Such waveforms may be applicable for use in multi-static active sonar systems, where reducing the mutual interference between each waveform is para-

Real Time Communication Is Mission Critical



BIRNS Millennium™ pressure-rated, low-loss connectors provide advanced subsea RF connectivity for real time defense communication data transfer. They were developed for GPS-frequency systems up to SHF (centimetre wave) IEEE bands S and C.

Our exclusive 1C coax contacts withstand open-face pressure to depths of 1433m (mated to 6km), with UHF insertion loss $\leq 0.7\text{dB}$ and maximum UHF VSWR of 1.7:1 at signal frequencies to 3GHz. That's why BIRNS coax cable assemblies are trusted to provide strategic and tactical advantages for mission-critical subsea defense applications.

U.S. Military: ask about BIRNS 1B pressure-rated low-loss RF contacts for use to SHF band K (18GHz).



*High Performance . . .
Under Pressure®*

www.birns.com



BIRNS is NAVSEA PRO-020 Certified;
Our Quality Management System is
ISO 9001:2015 Certified by DNV GL

“The MTSFM’s design parameters can be modified to finely tune the resulting waveform’s characteristics. A certain design may also find use in certain scenarios.”

mount. The MTSFM closely approaches established performance bounds of such waveform families in a manner similar to that of FSK and PPC waveforms geared toward the same application. The adaptability of the MTSFM waveform model allows it to possess a wide variety of performance characteristics that in the past has required a diverse set of waveform designs to achieve.

Conclusion

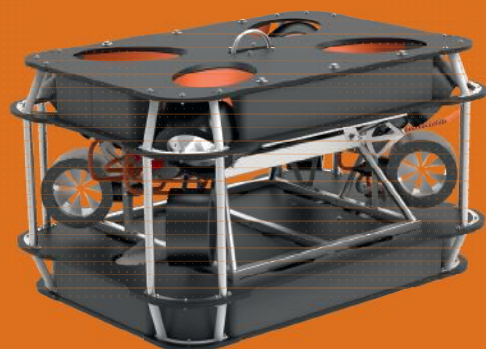
The MTSFM is an adaptive waveform that synthesizes constant amplitude, spectrally compact waveforms that can possess a wide variety of desirable properties. The adaptability of the MTSFM combined with its transmitter-friendly properties make it an attractive waveform type for a variety of active sonar applications. The intent of employing the MTSFM waveform model is not to outright replace the many waveform types used by current sonar systems. Rather, the intention is to provide a cognitive sonar system the ability to generate a complemen-

tary set of finely tuned waveforms for the novel scenarios and environments that it may encounter. In this sense, the MTSFM waveform may very well be an enabler for cognitive active sonar systems.

References

For a list of references, contact: david.a.hague@navy.mil. **ST**

Dr. David A. Hague received his Ph.D. in electrical engineering from the University of Massachusetts Dartmouth in 2015. Upon graduation, he joined the Naval Undersea Warfare Center in Newport, Rhode Island, conducting basic and applied research in radar/sonar signal processing with a focus on transmit waveform design.



Learn more www.copenhagensubsea.com

GORILLA ROV THE MOST RELIABLE ROV?

The thrusters are verified against our world leading test standard:



Endurance Test

1000 hours at full power.



Dynamic Stress Test

Full Power Direction shifts every second in 24 hours.

Don't settle for less - challenge your ROV provider to fulfill the highest standard.

**COPENHAGEN
SUBSEA**

Multichannel Modems

The ‘Swiss Army Knife’ of Acoustic Modems in the Maritime Domain

By Manu Ignatius • Dr. Prasad Anjangi

Adequate monitoring of coastal areas for potential threats from foreign and domestic actors is a must for any seafaring nation. This involves active and passive monitoring of large areas both above and under the water, employing a variety of cutting-edge technologies. A highly available, high-performance wireless communication network is required to connect the various monitoring solutions to provide a comprehensive picture to the end-user at all times. Advancements in various domains such as semiconductors (increasing compute power, reducing cost and size) and advanced manufacturing are making it possible for the underwater wireless domain to adopt several technologies from its terrestrial counterpart to raise the performance to the next level.

Spatial diversity techniques have been shown time and again to boost the performance of any communication system by improving a combination of reliability and robustness of a communication link, communication range or throughput. It is one of the key techniques used in modern terrestrial wireless communications (e.g., 5G, Wi-Fi). Usage of spatial diversity combining techniques and beamforming has also been used extensively in the case of towed-array systems to improve the diversity gain. However, the availability of commercial acoustic modems that utilize multiple receiving channels to leverage spatial diversity to boost performance is not that common today. Why is this the case?

Adding additional receiving channels to an underwater acoustic communication system increases the device's dimensions and complexity, and, most importantly, requires modifications to the processing techniques used for decoding incoming messages, all of which require a redesign of the entire device to support multiple receiving channels. Additionally, much of the literature that looks at spatial diversity exploitation uses a vertical placement of receiving elements. This may have led to the absence of acoustic modems with multiple receiving

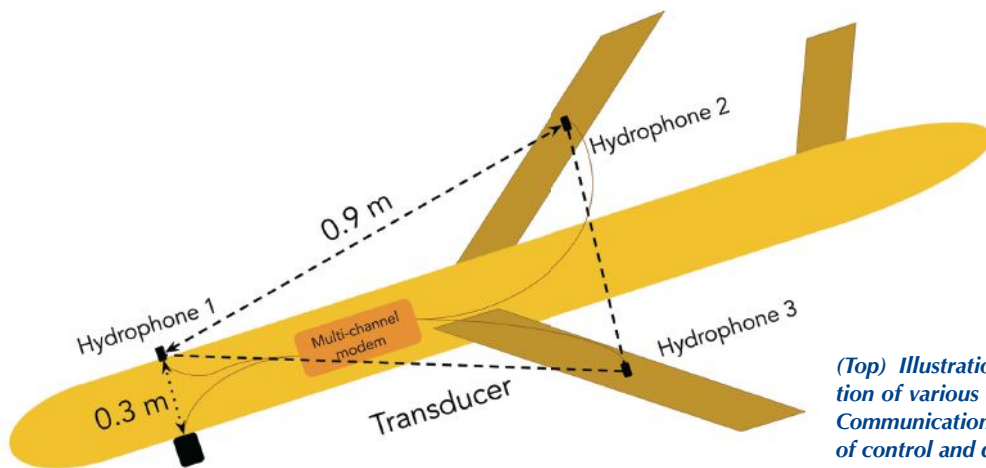


channels for practical applications since arranging the receiving elements vertically is not always practical (e.g., AUVs, underwater gliders).

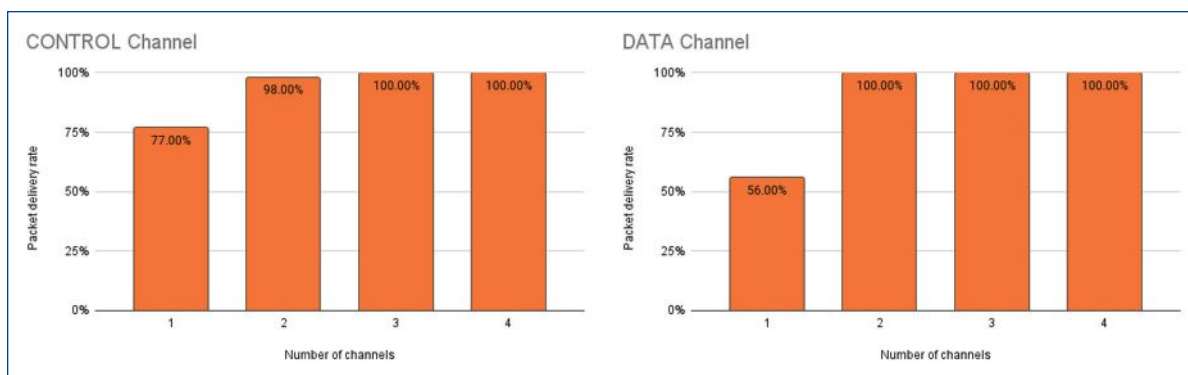
Subnero Multichannel Modems

Subnero introduced the new multichannel modems (WNC-M25MSS3-xCh) that run the UnetStack software framework (<https://unetstack.net>) in early 2021. These modems combine Subnero's silver edition M25M series modems (20-to-32-kHz band) with a multichannel acoustic recorder, thereby providing an acoustic modem with multiple synchronized receiving channels, without a significant change in the form factor. Configurable with up to four additional synchronous receiving channels, each channel can have a sampling rate of up to 256 kilo samples per second. Being truly software defined, the Subnero modems can add new processing techniques to support new features, as a firmware update to the modems, including user-defined ones.

Out of the box, the multichannel modems can be



(Top) Illustration of the intended installation of various receiving channels. (Bottom) Communication performance improvement of control and data channels.



used as a normal modem or a standalone acoustic recorder, or both at the same time. The data collected from the additional receiving channels can be either saved to the modem's internal storage or analyzed in real time with notification of users about specific acoustic events. This makes the multichannel modem an ideal candidate for applications such as rapid environment assessment.

These devices (with appropriate software upgrades) use spatial diversity combining techniques to decode the transmission from remote modems. This increases the effective communication range by acting as a spatial diversity receiver. Additionally, three-dimensional positioning and tracking of other acoustic sources using techniques such as time or phase difference of arrival are also available with the multichannel modems.

Performance Improvement vs. Traditional Modem

So, how much performance improvement is achievable with the multichannel modems as compared to a traditional single-channel modem? We conducted various experiments to find out. The main goal of the experiments was to explore the practicality of such a device for real-world applications.

One key application we considered is to extend the communication range for use with an underwater vehicle. In this case, we wanted to demonstrate the improvement in communication performance if we attach the multichannel modem with four receiving channels

(one transducer and three hydrophones) to an underwater glider. To test such a use case, we created a fixture that would let us simulate the attachment of the main transducer to the body of a glider, one hydrophone near the nose of the glider, and two hydrophones on each of the wings.

The three hydrophones were located at the corners of an equilateral triangular array with a spacing of 0.9 m. The transducer was spaced vertically 0.3 m below this triangle to mimic mounting at the bottom of the hull.

We then deployed this fixture underwater at a depth of 18 m and powered it using a battery pack. The transmitter node was deployed 0.4 km away from the multichannel modem. The transmitted signals include both FH-BFSK and OFDM communication signals as supported by Subnero modems (control and data channels). The signals were recorded using all four channels of the multichannel modem (similar to an acoustic recorder). The recordings were later processed, and the communication performance was compared between when a single channel and multiple channels were used.

To compare the communication performance when using a single receiving channel and up to three additional channels for reception, we compared the packet delivery rate (percentage of successful receptions) at the receiver in each case.

For the case of the control channel, the overall packet delivery rate was 77 percent with a single channel. With

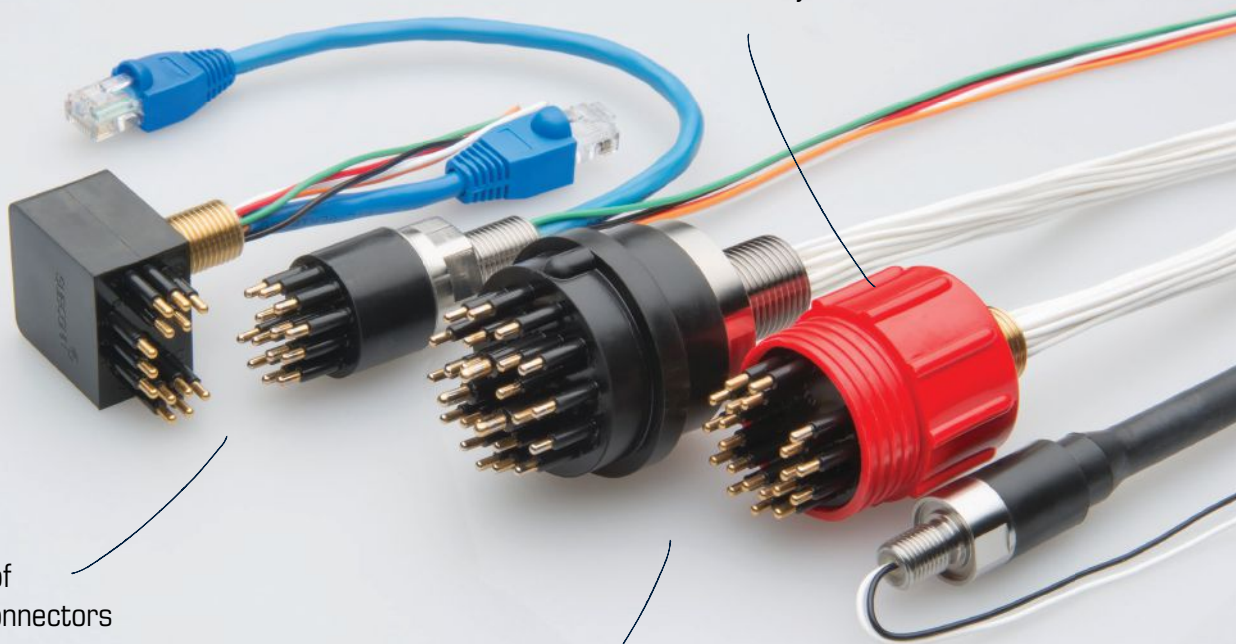


Wet-mate connectors

Recognised throughout
the industry

Full range of
Ethernet connectors

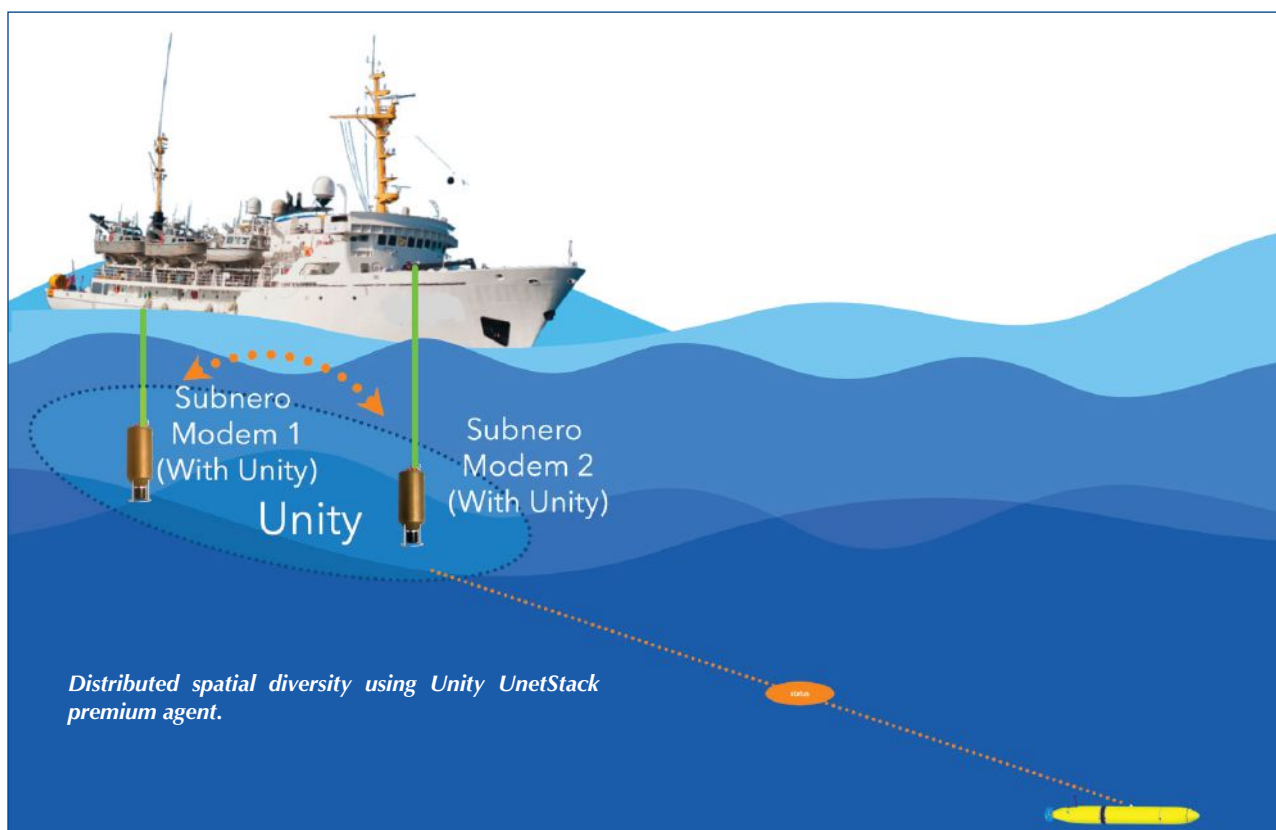
More than 40 years
proven track record



Available worldwide

Denmark | Norway | Sweden | Finland | United Kingdom
Netherlands | Germany | Poland | France | Spain | Portugal
Italy | UAE | Israel | Turkey | South Africa | USA | Canada | Mexico
Colombia | Chile | Brazil | Singapore | China | India | Pakistan
Russia | Belarus | South Korea | Japan | Taiwan | Australia





the addition of one more receiving channel (total of two receiving channels), the packet delivery rate became 98 percent. In the case of the data channel, the packet delivery rate was 56 percent with a single receiving channel, which improved to no packet loss (100 percent packet delivery rate) with the addition of one more receiving channel. The addition of more channels resulted in further improving the results in the case of the control channel (100 percent packet delivery rate).

Exploiting Spatial Diversity Without Multichannel Modems

What if you have multiple single-channel Subnero acoustic modems and still want to exploit spatial diversity to improve communication performance? Consider a case where you are on a ship with a modem deployed and you've been receiving status updates from a deployed AUV every few minutes. The AUV moves into an area where the connectivity is poor, and you can no longer successfully receive the status reports.

If you have a second modem available on the ship, you can deploy it from another part of the ship. Multiple communication nodes deployed at spatially distinct locations can receive independent copies of the same information. The two modems can act as a combined spatial diversity receiver and cooperate by sharing copies of information to provide you with similar performance improvements we have seen from the multichannel modems. Such spatial diversity combining with distributed modems is termed "Unity" (patent pending) and is available as a UnetStack premium agent for software upgrades.

Localization Using Multichannel Modem

Exploiting diversity to improve communication performance is not the only advantage that one can get by using a multichannel modem. Localization is a key application that is enabled by the presence of multiple receiving channels. Using the same hardware platform for multiple use cases helps to avoid redundancy and saves valuable real estate for any underwater platform. Having multiple synchronous channels makes the multichannel modem an ideal candidate to be used for localization applications.

We tested our localization solution using the Subnero multichannel modems and standard acoustic modems in different scenarios. These scenarios are distinguished based on the ratio of the distance between the multichannel modem and the mobile node (D) to the distance between the hydrophones mounted on an equilateral triangle (L).

In scenario one, the distance between the multichannel modem and the mobile node (D) is large in comparison to the distance between hydrophones on the multichannel modem (L), i.e., the ratio D/L is large, typically in the order of hundreds or more.

In scenario two, the distance between the multichannel modem and the mobile node (D) is still large in comparison to the distance between hydrophones (L) on the multichannel modem; however, the ratio D/L is typically in the order of tens but less than 100.

In scenario three, the distance between the multichannel modem and the mobile node (D) is in the same order as the distance between hydrophones (L) on the multichannel modem, i.e., the ratio D/L is approximately

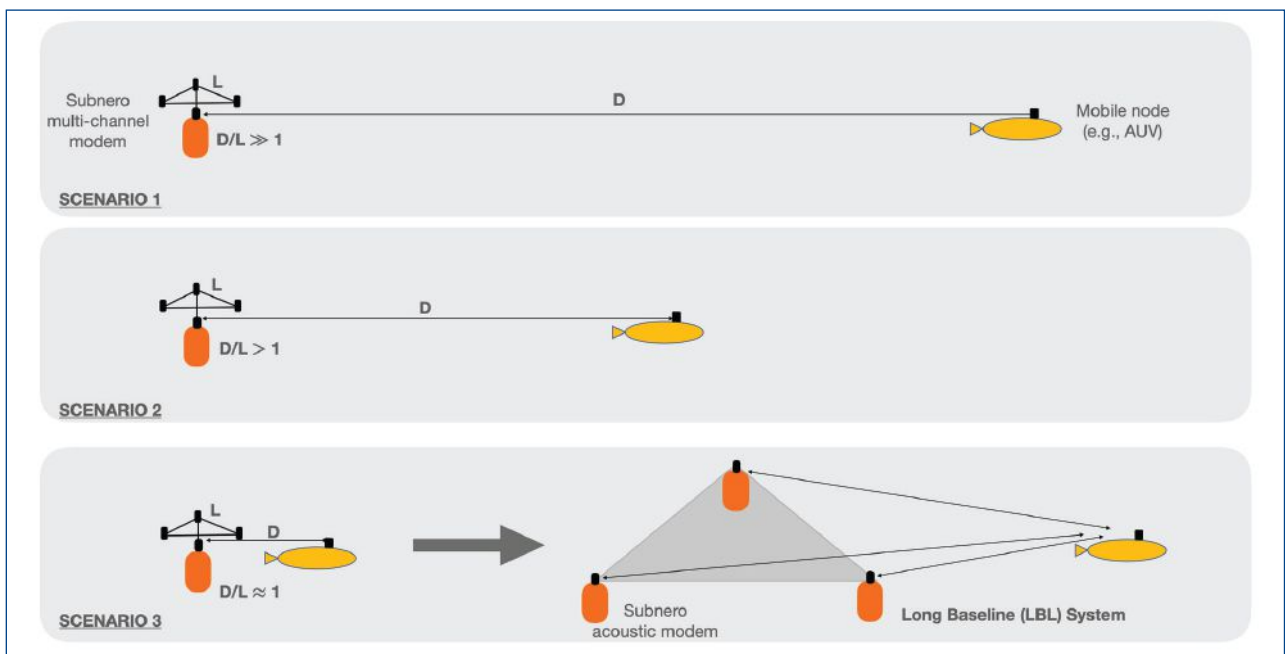


Illustration of different scenarios in which the localization solution using multichannel modems is tested.

equal to 1. Note that such a scenario might not be useful in practice with multichannel modems. However, it is conceptually similar to a long baseline (LBL) system where the distance between the beacon nodes are at almost the same distance to the mobile node.

The multichannel modems allow us the flexibility to position the hydrophones at desired positions, and, therefore, different geometries can be explored when deploying a multichannel modem. We deployed a multichannel modem with one configuration in which the distance between hydrophones was approximately 0.1 m, resulting in scenario one, with D/L approximating to over 400. In a second configuration, the distance between hydrophones was much larger, about 0.9 m, resulting in scenario two, with D/L approximating to about 50. In both cases, testing demonstrated an estimated bearing accuracy of about 0.3° to 1.7° . Using the same software framework, we were also able to test the LBL configuration (scenario three) with our standard acoustic modems when divers were in the water and the localization solution provided real-time updates on the diver location and vital parameters.

Conclusion

From the experimental outcome, it is clear that there is a substantial performance improvement when using more than one channel for an underwater communication system. A single device can also be used for multiple applications, such as acoustic recording, communication and localization. The smaller aperture of the compact array provided by the multichannel modem makes it ideal for applications that involve AUVs.

Since users can get direct access to raw data from all the channels in real time, power users can extend the built-in capabilities of the multichannel modem through the customizability of UnetStack. With native support for scientific computing languages such as Julia, or Unet-Stack gateway support with Python, these devices dramatically reduce the time to deployment of your algorithms.

For more on the Subnero multichannel modems, visit our website at: www.subnero.com.

References

For a list of references, contact Florie Mancel at: florie@subnero.com. **ST**

Manu Ignatius is the CEO of Subnero, a Singapore-based start-up that develops underwater communication, navigation, monitoring, and sensing technology, products and solutions. He is an active member of the IEEE Oceanic Engineering Society and supports various events such as OCEANS conferences and the Singapore AUV Challenge (SAUVC). Before joining Subnero, he worked at several multinational companies on embedded systems and computer networks. He received a bachelor's degree in electronics and communication engineering from Mahatma Gandhi University College of Engineering, Kerala, India, and an M.S. in electrical and computer engineering from the National University of Singapore in 2004 and 2010, respectively. You can learn more about Ignatius at: thedragonflypage.com.

Dr. Prasad Anjani is a research scientist at Subnero Pte. Ltd. He worked in the semiconductor industry with Atmel and STMicroelectronics as firmware and senior design engineer, respectively, from 2009 to 2012. His current research interests include underwater acoustic communications, signal processing, networking protocol design and AUVs. Anjani has served on the technical program committee of WUWNet (Association for Computing Machinery) and is a reviewer for the IEEE Journal of Oceanic Engineering and IEEE Transactions on Communications. He received his Ph.D. in electrical and computer engineering from National University of Singapore in 2016. He received a bachelor's degree in electronics and instrumentation engineering from Andhra University, Andhra Pradesh, India, in 2007 and a master's degree in biomedical engineering from the Indian Institute of Technology, Bombay, India, in 2009. You can learn more about him at: prasadtiru.github.io.

Modern Naval Radar

Software-Defined Radio Supports Maritime Security

By Victor Wollesen

Radar (radio detection and ranging) is a technology that involves transmission, reception and processing of radio signals with the aim of estimating the characteristics of the target object. Although the technology was initially developed for military applications, it has a broad array of commercial applications.

A typical radar system consists of a transmitter that generates and propagates an electromagnetic signal toward an object of interest and a receiver that receives the portion of the signal that is reflected back when the signal hits the object. The reflected signal is then processed to reconstruct an estimate of the speed, range and size of the target object. Marine radars operate in C-band, S-band or X-band and are used in ships for detecting vessels, buoys, landmasses and other obstacles. These radars are a key component of collision avoidance systems that are used for sea navigation.

In naval defense, marine radars are at the core of many sophisticated systems used for early detection and identification of vessels. Some of these advanced systems include active electronically scanned array (AESA) systems, anti-tactical ballistic missiles (ATBM) systems and air breathing threat (ABT) defense systems. An AESA system is a sophisticated array of antennas in which the transmitted signal is electronically steered toward a target without moving the antenna.

Features of Marine Radar Systems

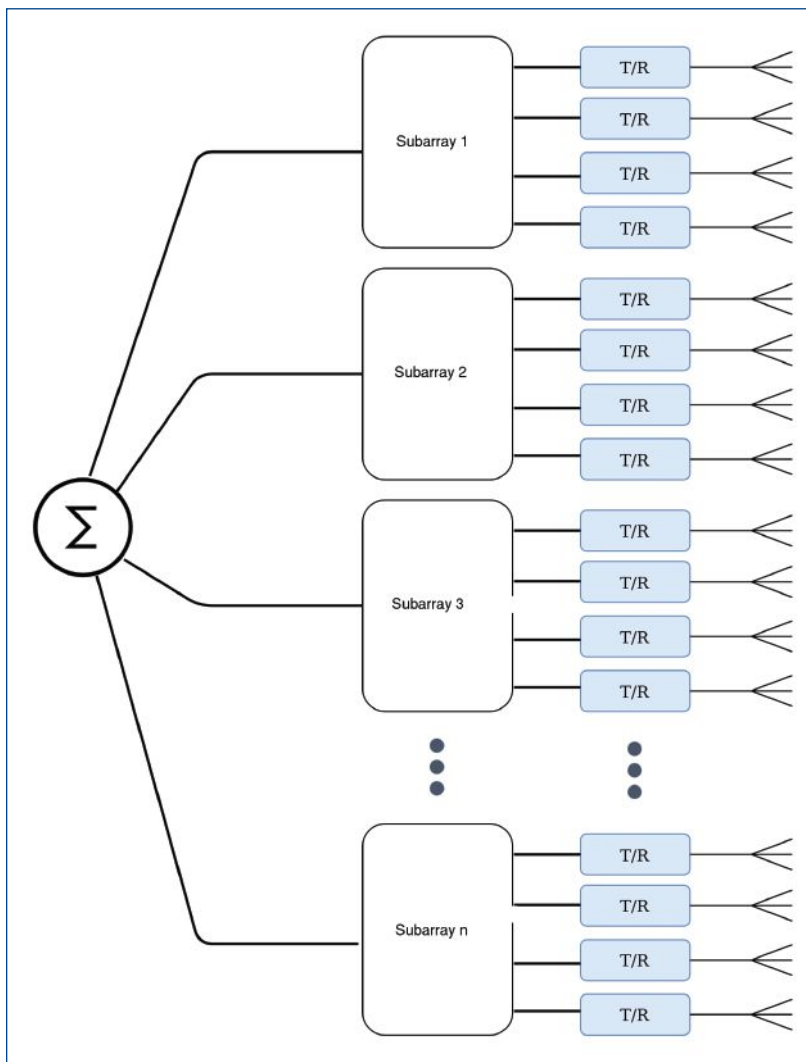
An most important feature of a marine radar system is the guard zone alarm, which enables a vessel to set a safe distance, below which an alarm is triggered. The alarm is triggered when the separation between the vessel and the obstacle (landmass, buoy or any other barrier) is less than the vessel's safety distance. The echo trails system is another important feature of modern marine radars, allowing a vessel to track movements of other vessels. With this feature, you can see a faint trail of another vessel on your ship's radar display for a set period of time.

Ocean conditions are unpredictable and can change within a very short period of time. Bad weather conditions such as dense fog, massive waves and strong winds can limit visibility, thereby increasing chances of catastrophic collisions. With marine radar, you can navigate a vessel in bad weather with a minimum risk of colliding with another vessel or a barrier. The International Regulations for Preventing Collisions at Sea 1972 (COLREGs) stipulates requirements that are aimed at preventing collisions between vessels and enhancing the overall safety of vessels at sea. Among other things, these rules, published by the International Maritime Organization (IMO), specify the requirements for using marine radar for sea navigation. Rules Six, Seven and 19 provide guidelines on the use of marine radar technology for collision avoidance between vessels.

Marine Radar for Naval Defense: Unique Threats and Requirements

Unlike conventional marine radar systems, marine radar for defense systems has stricter performance and reliability requirements. To begin with, these systems are required to have the capability to simultaneously search and track targets. They achieve this by performing three-dimensional beam scanning. This includes the ability to scan and detect enemy surface vessels at a long range. Apart from surface targets, marine radars for defense systems are also required to perform anti-aircraft searching and tracking. This capability allows naval radar systems to detect and counter airborne threats such as high-diving missiles. Modern naval radar systems are also required to have the capability to evaluate threats depending on their priority classifications. With these systems, high-priority threats are assigned a dedicated tracking system with short update periods to allow extremely fast reaction.

Some naval defense operations require dedicated tracking to ensure high tracking accuracy. In active mis-



Active electronically scanned array (AESA) radar systems, like the one in this simplified schematic, are often used on naval vessels.

sile guidance systems, dedicated tracking helps to improve the precision with which an enemy vessel is targeted.

Jamming is commonly used in naval operations to prevent detection and tracking by enemy radar systems. Without identifying the presence and position of jamming strobes, some high-priority threats can go undetected. With jam strobe detection and tracking capability, these threats can be identified and tracked as early as possible.

One way of ensuring early detection of threats is increasing the surveillance range of your radar system. Naval radar systems are required to have long surveillance ranges to ensure that enemy vessels are identified as early as possible. Some of today's naval radar systems have surveillance ranges of over 250 km.

Failure to correctly identify an approaching vessel can be costly since it can result in attacking a friendly vessel or ignoring a potential threat. Today's naval radar systems

are required to be capable of identifying vessels with high accuracy and identifying other ships as friend or foe (IFF), or using IFF transponders/interrogators. In addition, naval ships are required to have the capability to detect submarines. This is achieved by using advanced systems such as periscope detection systems and pop-up missile detection systems.

Unlike conventional marine radars, naval radar systems are required to meet additional internationally accepted safety standards. These standards, commonly referred to as the Naval Ship Code, are published by the North Atlantic Treaty Organization (NATO) and are aimed at ensuring that safety is a top priority.

Physical and Computation Requirements For Naval Radar and Control

When designing marine radars for use in naval defense, it is critical to consider a broad array of factors. In nearly all cases, the goal is to design a product that is smaller, lighter and more powerful. The acronym SWaP is used by research and development teams to denote the three key design considerations: size, weight and power. In some cases, the cost of the new design is included as one of the key considerations, yielding what is commonly known in R&D circles as size, weight, power and cost criteria (SwaP-C).

The importance of SwaP can be seen when considering naval radar designs.

Compared to ordinary ships, the decks of destroyers, frigates and other naval ships have space constraints, making it critical to optimize the size of naval radar systems. A lean design creates more space for other technologies that are needed in modern naval vessels. Moreover, naval vessels have limited power since they rely on gas turbines. In an AESA naval radar system, a significant amount of power is required for generating beams, running the mechanical systems and powering the computational devices. These constraints make it critical to minimize the power requirements of naval radar systems. To ensure that naval radar systems are as light as possible, precision machining technology is used to produce rotating and other mechanical parts.

Compared to their predecessors, modern naval radar systems utilize advanced digital signal processing techniques and deliver superior capabilities. Digital beamforming and space-time adaptive processing are some of the digital signal processing techniques that are revolutionizing naval radar. These advanced techniques are core elements in radar clutter mitigation, electronic protection and passive radar technology. With these advanced digital processing techniques, it is possible for naval radar systems to perform threat tracking with impressive update rates of 1 sec.

$$f_d = \frac{2vf}{c}$$

Noise and interference can greatly affect the performance and reliability of marine radar systems. The latest advancements in digital signal processing deliver impressive noise and interference rejection capabilities, thereby enhancing the overall performance of naval radar systems. In addition, the automatic environmental adaptation capability of modern naval radar systems allows automatic suppression of sea clutter.

Both continuous and pulsed wave modes are commonly used in today's naval radar systems. The pulsed mode is an integral element of today's surface naval radar systems, while continuous wave mode provides critical target Doppler information for missile engagement. Integrating both waveform technologies enhances the overall capability of a naval radar system.

Software-Defined Radio for Naval Radar Systems

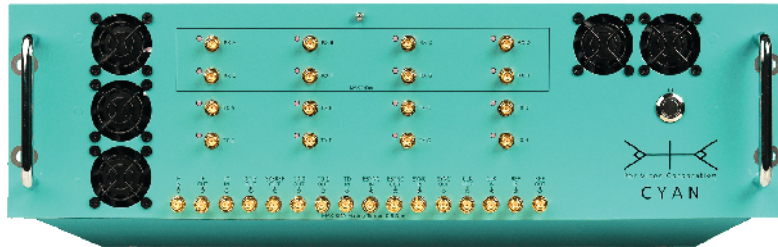
An SDR (software-defined radio) is a flexible radio communication system that utilizes reprogrammable software-based modules instead of traditional hardware-only circuits. A typical SDR consists of an analog front-end and a digital back-end. The radio front-end utilizes analog components and processes signals in the analog domain. This section features a frequency-tuning device that converts the frequency of signals.

The digital back-end contains a field programmable gate array (FPGA) with embedded digital signal processors (DSPs) and handles the computational tasks of an SDR. This section utilizes reprogrammable components and processes signals in the digital domain.

Numerous challenges exist when implementing modern naval radar systems. A modern naval radar system is required to support multiple functions on different bands simultaneously. For instance, a typical naval radar transceiver operates in S-band for navigation functionality and C-band for threat detection and tracking functionalities. Apart from increasing design complexity, this need to support multiple functionalities in different frequency bands strains conventional radio technologies. In order to support advanced digital processing technologies, such as digital beamforming technologies like AESA, multiple-input multiple-output (MIMO) channels

are required. With most conventional radio communication systems, only a limited number of channels are available. MIMO SDR provides multiple channels, thus allowing easy implementation of new and emerging digital processing techniques.

A broad array of technologies is used in today's naval vessels. With traditional radio communication systems, it is difficult to accommodate multiple legacy systems. SDR platforms are highly flexible, making them a suitable choice for applications where it is necessary to integrate multiple legacy systems.



(Top left) The ability to take account of Doppler shift provides a radar system with more information on the target. In addition, this capability enables radar systems to isolate background clutter more efficiently. For example, consider a static ship with a radar system that is transmitting a signal toward an approaching vessel at a frequency of f Hz. If the moving vessel is traveling at a speed of v m/s and the speed of sound in vacuum is c m/s, the Doppler frequency can be calculated using this equation. (Above) Software-defined radio must be high-performing, like this wide-band SDR from Per Vices called Cyan, to meet the performance and reliability levels needed to carry out military functions.

Equipment for use in military applications is exposed to extreme weather

conditions and is required to meet stringent performance and reliability requirements. These requirements are stipulated in military standards such as MIL-STD-167-1A and MIL-STD-810F. Per Vices offers SDR platforms, such as Cyan, that are engineered to meet the most stringent performance and reliability requirements.

There are various trade-offs in terms of benefits and drawbacks when considering SDR for radar integration. Regarding benefits, to begin with, SDR platforms offer

the multiple channels required for beamforming and other advanced digital processing technologies. Highest channel count SDR platforms offer up to 16 RF channels. Moreover, unlike conventional solutions, SDR platforms are designed to operate over a wide range of frequencies, usually from DC to 18 GHz. This makes them compatible with a broad array of radio communication technologies.

SDRs use reconfigurable FPGAs for computational tasks, making them flexible and interoperable with different radar systems. In addition, these platforms are designed to offer high throughput. Highest throughput SDR platforms are designed to stream to host machines at ultrafast speeds of up to Quad 40 Gbps. Apart from their flexibility, SDR platforms offer excellent sensitivity, impressive dynamic range and IIP3. In addition, these platforms offer high tolerance to vibrations and variations in temperature and other weather conditions.

Drawbacks to using the technology also exist. For one, although SDRs are highly flexible and suitable for a broad array of applications, some sophisticated processes require dedicated RF equipment. In cases where the performance matters more than flexibility, radar systems based on dedicated RF devices can outperform SDR-based solutions. In cases where this is of great concern, application-specific integrated circuits (ASICs) are com-

THE FUTURE OF FIBER OPTIC GYROSCOPES

BOREAS - GNSS / INS

-  0.005 ° Roll & Pitch
-  0.006 ° GNSS Heading
-  0.01 ° Gyrocompass Heading
-  0.001 ° /hr Gyroscope



BOREAS

THE WORLD'S 1st FULLY DIGITAL FOG

Boreas takes FOG technology to the next level with new patent pending digital FOG (DFOG) technology. The revolutionary DFOG technology combines a specially designed closed-loop optical coil with advanced digital signal techniques that have been developed over the last 25 years. This ground-breaking gyroscope combined with our AI-based algorithm provides unparalleled performance and reliability, with the lowest SWaP-C (Size, Weight, Power and Cost) on the market.



**ADVANCED
NAVIGATION**

“SDRs use reconfigurable FPGAs for computational tasks, making them flexible and interoperable with different radar systems. In addition, these platforms are designed to offer high throughput.”

monly used in today’s radar systems. Although these devices are usually more expensive compared to FPGAs, they are faster and consume less power.

The flexibility of an SDR platform is greatly dependent on the specifications of a device, including type of FPGA, number of channels and bandwidth. For SDR platforms with limited resources, it can be challenging to add more functionalities. When planning to extend the functionality of your SDR-based radar system, it is important to consider the license from the manufacturer. Some licenses do not allow users access to the FPGA/DSP resources, and this can greatly limit the flexibility of your radar system.

Conclusion

Modern naval radar systems are highly advanced and utilize sophisticated digital processing techniques. SDR

platforms use reconfigurable software-based components and can be upgraded without the need to modify the available hardware. Apart from flexibility, SDR platforms offer multiple channels, high throughput and wide bandwidth, and can operate over a wide range of frequencies. The performance characteristics of software-defined radios make them a suitable choice for radar in naval defense. **ST**

Victor Wollesen is the CEO and co-founder of Toronto-based software-defined radio company Per Vices Corp. He has an honor’s degree in physics with a specialization in astrophysics from the University of Waterloo in Ontario, Canada. He has co-authored several peer-reviewed papers on SDR technology, one of which was presented at IEEE’s Radar Conference in 2020. Wollesen is a member of the Canadian Armed Forces, and in his free time he enjoys putting his recreational pilot’s license to use.



**Custom Sonar Solutions
for Challenging Defense
Applications**

MSITRANSDUCERS.COM

MSI[®]
TRANSDUCERS

Flying Ships

Autonomous Wing-in-Ground-Effect Vessels Coming to Market

By Bill Peterson • Gus Bateas • Capt. Steve Bomgardner

Imagine shipping fresh caught lobsters and cod overnight from Maine to Georgia at a fraction of the cost of airfreight. What if you could save thousands of dollars and several days of freshness when you ship ripe fruit and flowers from Brazil to New Orleans? How many lives could be saved if we were able to deliver vital relief supplies, food, equipment and medical instruments more rapidly in response to natural disasters?

The U.S. military and civilian logistics markets have seen a surge in demand for time-critical, price-sensitive deliveries to coastal regions around the world. This is part of a larger dynamic of growth in the logistics and transportation sector, which is projected to grow from \$7 billion to \$15 billion by 2026.

However, current modes of transportation to serve this explosive growth are either inexpensive but slow—such as boats, trucks and trains—or fast but expensive—such as airplanes. Autonomous Flying Ships will fill this gap by providing access to countless delivery points at an order of magnitude faster than boats and at a fraction of the cost of aircraft, radically lowering shipping costs for time-sensitive goods.

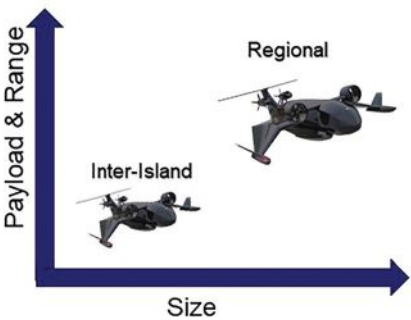
The Flying Ship Co. has taken proven technology that harnesses the aerodynamic principle of ground effect to create advanced unmanned maritime shipping vessels that fly just over the water. These green energy Flying Ships will disrupt the global logistics in-

dustry with the combination of electric propulsion and 21st century aerodynamics. Integrating these concepts dramatically decreases vessel cost, improves energy efficiency and eliminates greenhouse emissions. It also permits delivery to thousands of additional access points because Flying Ships can land on water and unload on beaches or boating docks, taking full advantage of existing infrastructure.

The Flying Ship Team

The Flying Ship Co. consists of a well-rounded team

Flying Ship Evolution

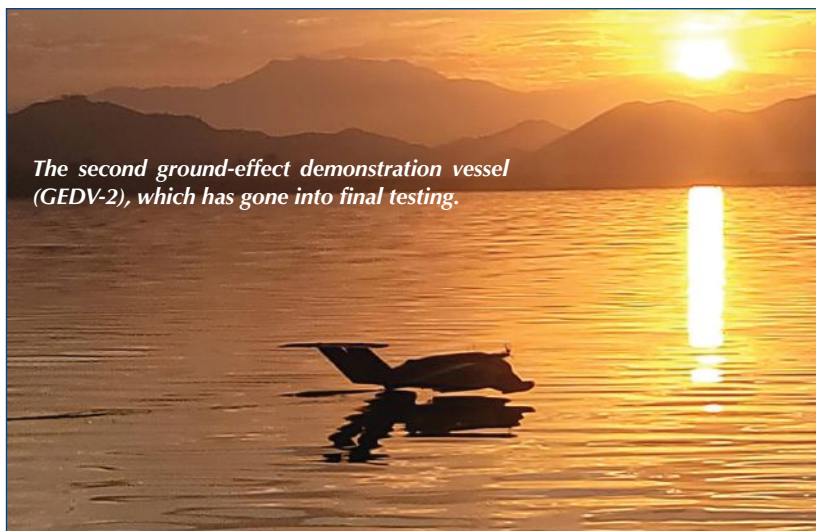
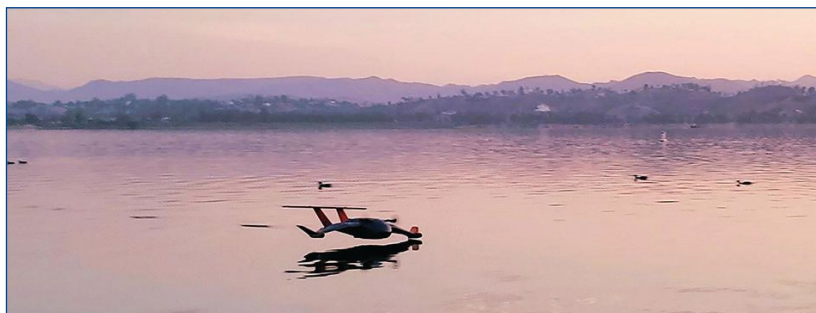


Type	Inter-Island	Regional
Range	500 nm	1,000 nm
Payload	1200 kg	2,700 kg
Length	10 m	16 m
Propulsion	Electric	Hybrid Electric & H ₂

The graphic outlines plans for the two initial Flying Ship variants.



21st Ground Effect Technology LLC ©



The company first operated and tested a prototype uncrewed ground-effect vessel in 2018. The second vessel was completed in August 2021 and features improved aerodynamics, propulsion, batteries and autonomy. The new vessel has a 6-ft., 5-in. wingspan and will be used to validate multiple systems and, later, used in multiple demonstration programs through spring 2022. Plans for construction of a full-size, all-electric version for field testing on select trade routes are being finalized. Full commercialization of the smaller initial variant will run concurrently with final development of the larger regional model.

Technical Overview

Wing-in-ground vessels have existed since World War II. Recently, there have been several new entrants in the market providing personal recreational and commercial passenger solutions. The Flying Ship is the only one focusing on autonomous cargo and a logistics solution.

Two initial Flying Ship versions are in development. A 12-m (approximately 40 ft.) vessel having 1,200-kg (2,500-lb.) cargo-carrying capacity with a range of up to 500 nautical mi. (nm) will serve offshore locations such as ships and islands. A larger, 15-m (approximately 50-ft.) vessel with a 2,700-kg (6,000-lb.) cargo capacity and a 1,000-nm range will serve regional routes. These vessels will have a cruise speed of 100 kt. and are planned for initial commercial operation in 2024.

There are no humans on board Flying Ship vessels, which eliminates potential risk for crew injury or death as compared to today's sea planes, ships and trucks. Moreover, the Flying Ship Co. is partnering with artificial intelligence (AI) companies to jointly develop and test autonomous ground-effect systems that will eliminate pilot-induced error and avoid

collisions.

Flying Ship Co.'s first prototype ground-effect vessel was remotely operated, and the current ground-effect demonstration Flying Ship has been outfitted with semiautonomous systems. Flying Ships will gradually incorporate higher levels of semiautonomous systems and then fully autonomous systems. Flying Ships' autonomous navigation, sense and avoidance, and communication systems are being developed with a hybrid of those used in the aviation and maritime industries. While the systems must adhere to all International Maritime Organization (IMO) regulations, they will also use a flight control and stabilization system like those used by commercial aircraft to stabilize the main parameters

of engineers, pilots, captains and executives. The team members have expertise in multiple disciplines, including engineering, international business development, maritime, aviation and contract law, supply chain management, operations, communications, government relations, human resources, and corporate strategy in the aerospace, maritime and defense sectors.

The team is assessing test locations and manufacturing partners to field test and refine the design, then commercialize the vessels. We are accepting additional investment and aim for full commercialization of the initial variant in three years, followed by larger versions with enhanced range and payload capabilities in 10 years.

of the craft's altitude (flight, trim and pitch) and control the craft's motions (roll, pitch/sway and yaw/heave). Additionally, Flying Ships' navigation and communication systems are coupled with maritime systems and ground-based systems for loading, unloading and refueling. The technology is proven and commercially available today.

Flying Ships must also avoid ship traffic, rogue waves, marine life, floating debris and any other obstructions that they may encounter. The highest volume of boat traffic is around ports, taxiing to load and unload cargo.

Initial stages of semiautonomy use remote human operators when navigating in heavy-traffic areas, such as ports, and will have greater autonomy when in areas with little traffic, such as the open ocean. The flight-proven AI systems incorporate inputs from video, radar, LiDAR, ground-based avoidance information and several other sensors to determine the safest and most efficient routes during all modes of operation. The AI systems provide the remote operator with the latest and safest operating information.

The Flying Ship vessels incorporate the latest operationally proven technology at a commercially acceptable cost. For instance, power-augmented ram thrust is deployed during the marine-to-flight transition, as well as maneuvering. These lower cost, electrically powered fans are suitable for the seawater environment. In addition to the power-augmented ram, the Flying Ship has been designed with a variety of all-electric and hybrid-electric main propulsion. The vessels will be configured based on customer delivery route and operational requirements.

Unlike traditional vessels, Flying Ships have no draft depth limitations while in cruise, so they will not run aground. This has benefits when traversing frozen bodies of water or shallow areas, like shorelines, low-tide zones, river rapids and coral reefs, or even floating debris, icebergs, underwater mines, and potentially bridges, locks and dams. Additionally, cruising flying ships will not damage or kill protected marine life and can operate in the vicinity of these animals with no impact on their populations. This also means that underwater cur-

rents will not impact cruise speed and performance. And, since Flying Ships fly over rough seas, they will avoid the slowdown and damage to cargo that boats experience from waves.

Furthermore, the IMO, under the Maritime Safety Committee's 76th session in 2002, approved interim guidelines for low-altitude maritime wing-in-ground (WIG) vessels. This means they are not subject to expensive aviation commercial operation restrictions under the International Civil Aviation Organization.

Maritime Regulations

WIG craft are supported in their main operational mode solely by aerodynamic forces that enable them to operate at low altitude above the sea surface but out of direct contact with that surface. The arrangement, engineering characteristics, design, construction and operation of WIG craft have much in common with those characteristics for aircraft. WIG craft must operate with other waterborne craft and use the same collision-avoidance rules as conventional shipping.

The IMO Maritime Safety Committee has approved the annexed Interim Guidelines for WIG craft, which were developed in view of the configuration of WIG craft, falling between the maritime and aviation regulatory regimes. The basis for the Interim Guidelines is flexible risk management. Although this is a fundamental change from the prescriptive standards forming the basis of the 2000 International Code of Safety for High Speed Craft (HSC Code), the intention is to achieve safety standards comparable to those of the 1974 SOLAS (Safety of Life at Sea) Convention. However, relevant provisions of the 2000 HSC Code have been included in the Interim Guidelines.

The Maritime Safety Committee approved Interim Guidelines for Maritime Autonomous Surface Ships Trials in June 2019. Four degrees of autonomy have been identified for the purpose of the scoping. Degree One refers to a ship with automated processes and decision support. Seafarers are on board to operate and control shipboard



SENSOR
TECHNOLOGY

Global Leaders in Piezoelectric Based Acoustic Tools and Systems

705-444-1440 • www.sensortechcanada.com

The advertisement features a dark blue background with a stylized illustration of various acoustic sensors in use. At the top, a green helicopter is shown with a sensor beam directed at a large ship on the horizon. Below the ship, a yellow autonomous underwater vehicle (AUV) is depicted with a sensor beam directed at a smaller submarine. In the foreground, two divers are shown with sensor beams directed at the seabed. The text 'SENSOR TECHNOLOGY' is prominently displayed in the upper center, with 'SENSOR' in large white letters and 'TECHNOLOGY' in smaller white letters below it. At the bottom, the text 'Global Leaders in Piezoelectric Based Acoustic Tools and Systems' is written in white, followed by the phone number '705-444-1440' and the website 'www.sensortechcanada.com'.

“We are accepting additional investment and aim for full commercialization of the initial variant in three years, followed by larger versions with enhanced range and payload capabilities in 10 years.”

systems and functions. Some operations may be automated, and at times unsupervised, but with seafarers on board ready to take control. Degree Two refers to a remotely controlled ship with seafarers on board. The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions. Degree Three refers to a remotely controlled ship without seafarers on board. The ship is controlled and operated from another location. There are no seafarers on board. Degree Four refers to a fully autonomous ship: The operating system of the ship is able to make decisions and determine actions by itself.

The Flying Ship will follow Degree Three, with testing in the future to achieve Degree Four.

US Military Applications

Flying Ship Co.'s unmanned, autonomous vessels could serve military requirements exceptionally well. From prepositioning and sustainment in a contested environment to distributed logistics, operational support and manned-unmanned teaming, our vessels match the Tri-Service (U.S. Navy, U.S. Marine Corps, U.S. Coast Guard) need for a versatile, highly advanced platform that is significantly less expensive to acquire, operate and maintain than existing alternatives.

The most direct application is for unmanned, autonomous logistics vessels. Think about UPS trucks at sea: Our vessels not only can serve points on land but also can serve ships at sea—allowing for quick resupply of forward-deployed assets.

Another potential application is combat search and rescue for downed pilots. Several Flying Ships could work in concert to help conduct a search more quickly, without further risk to critical personnel.

Flying Ships also could be equipped with a suite of sensors and communications equipment to conduct command, control, communications, computers, intelligence, surveillance and reconnaissance missions in advanced, contested positions. The natural stealth capabilities of this platform make it an ideal choice for these kinds of missions.

Flying Ships could also fulfill mission requirements for low-payload, long-duration Arctic patrol flights at zero risk to U.S. military personnel.

These potential defense applications are just a few possibilities.

Current and emerging technologies offer sustainable and cost-effective solutions to traditional cargo operations and a variety of military missions. The Flying Ship Co. has seized on operationally proven science to present safe, unique, efficient and cost-effective alternatives. These concepts—and dreams—are now becoming reality. **ST**

Bill Peterson is CEO of Flying Ship Technologies Corp. He holds an aerospace engineering degree from Embry-Riddle Aeronautical University and an M.B.A. from George Mason University. He is accomplished in developing and executing corporate strategy, design and business capture activities for a multitude of aerospace suppliers.

Gus Bateas is executive vice president and chief operating officer for Ground Effect Technologies Corp. An aerospace, defense and maritime executive with proven leadership and technical accomplishments at Boeing, Northrop Grumman, Raytheon and Triumph, Bateas earned engineering and business degrees from SUNY Maritime College and the University of Southern California.

Capt. Steve Bomgardner is regional managing director for the Americas and global commercial director at the Bahamas Maritime Authority. A global leader in the oil and gas and maritime industries, Bomgardner earned his M.B.A. from Georgetown University's McDonough School of Business and a B.S. in marine transportation from Texas A&M University at Galveston.



SAAB SEAEYE



SAAB

international

New Member of IWSA

Vesconite Bearings is the newest member of the 130-organization-strong International Windship Association (IWSA). IWSA facilitates and promotes wind propulsion for commercial shipping worldwide and brings together all parties in the development of a wind ship sector to shape industry and government attitudes and policies. Vesconite Bearings can contribute its experience in renewable energy, marine and shipping to IWSA.

New Company to Minimize Vessel Emissions

Volvo Penta and Qamcom Group have formed a start-up under the company name Cetasol. The new company is based on a spin-off from Volvo Penta and will be targeted to help commercial marine vessels minimize emissions and maximize efficiency.

The partnership was formed with the support and guidance of CampX, the Volvo Group's global innovation arena for technology and business transformation.

DNV Maritime Forecast to 2050

DNV has launched "Maritime Forecast to 2050," part of the Energy Transition Outlook suite of reports. Conceived to help shipowners navigate the technologies and fuels needed to meet global greenhouse gas (GHG) targets, the report features an updated carbon risk management framework, including a new "decarbonization stairway" model to help owners map a path to sustainability. The 80-page report aims to assist an industry facing the dual challenge of increasingly stringent climate change targets and regulations coupled with uncertainty over future fuel choices, technology and supply. You can download it at: www.dnv.com/maritime/publications/maritime-forecast-to-2050-download.html.

Eksfin Helps Finance Maritime 'Green Shift'

Norwegian export credit agency Eksfin is playing a major role in accelerating the "green shift" at sea, providing loan guarantees approaching €1 billion for the construction of 35 eco-friendly vessels over the last four years, including *Le Commandant Charcot*, a polar exploration cruise ship recently delivered to French cruise line Ponant by Norwegian shipbuilder Vard.

Eksfin is a governmental financial enterprise under the wing of Norway's Ministry of Trade, Industry and Fisheries. Eksfin promotes Norwegian exports by supporting Norwegian companies, foreign buyers and their banks with a broad range of state-backed loans, guarantees and expert advisory services.

NAVTOR Joins Cyber-Physical Consortium

NAVTOR, a specialist in maritime e-navigation and performance optimization, has been selected to join a European-funded, Philips-led consortium focused on exploiting the potential, and ensuring the integrity, of cyber-physical systems. The Norwegian-headquartered firm has joined 30 other European partners in launching the

ECSEL Joint Undertaking TRANSACT-project, funded by the European Union's H2020 Framework Programme. NAVTOR will team up to develop new applications and AI-enhanced maritime services for improved performance and safety.

Wärtsilä Joins CCS Consortium

Wärtsilä will take a central role in developing maritime carbon capture and storage (CCS) technologies as part of the LINCCS (linking carbon capture and storage) consortium. LINCCS is focused on reducing costs for new carbon storage facilities by 70 percent and advancing the development of carbon capture technologies in a range of sectors. The LINCCS consortium will receive support from the Norwegian government's Green Platform Initiative. Carbon capture technology can be a significant enabler for decarbonization of the maritime industry.

Call to Action for Shipping Decarbonization

More than 150 industry leaders and organizations representing the entire maritime value chain, including shipping, cargo, energy, finance, ports and infrastructure, have signed onto the Call to Action for Shipping Decarbonization, which calls on governments to work together with industry to deliver the policies and investments needed to reach critical tipping points in decarbonizing global supply chains and the global economy.

The signatories for the Call to Action urge governments to: commit to decarbonizing international shipping by 2050; support industrial-scale zero-emission shipping projects through national action; and deliver policy measures that will make zero-emission shipping the default choice by 2030.

LR Acquires GreenSteam

Lloyd's Register (LR) has acquired GreenSteam, a marine data intelligence company specializing in improving vessel efficiency through machine learning. The acquisition will be integrated and managed by i4 Insight, a subsidiary of Lloyd's Register.

i4 Insight, part of LR's Maritime Performance Services business, is a digital platform that allows shipowners, operators and charterers to easily access insights on vessel performance and fuel consumption across their fleets. The acquisition will see GreenSteam's vast array of machine learning services, from fouling analysis and trim planning to dynamic trim and speed optimizers, fully integrated with the i4 Insight platform.

Unique Group Buys Gaps M7

Unique Group has added an iXblue Gaps M7 USBL acoustic and positioning system to its rental pool of equipment. It will be available to clients in the Americas.

Gaps M7 has horizontal tracking capabilities and very high-precision georeferenced positioning performance, from extremely shallow water depths to 4,000 m. It can be used for applications such as ROVs, AUVs, gliders, tow-fish tracking and dynamic positioning, to name a few. Gaps M7 can be deployed from small vessels of opportunity.

SUBSALVE USA

UNDERWATER LIFT BAGS
ENGINEERED FROM THE BOTTOM UP!

The World's Best
Underwater Lift Bags
from 25 lbs. to 50 tons.
Water Load Test Bags to 50 tons.
IMCA Compliant.
ABS Approved.

INNOVATORS IN BUOYANCY AND ENGINEERED INFLATABLES.

MARK VORCA • RAPID RECOVERY SYSTEMS • AIRCRAFT LIFTING BAGS
WATER LOAD TEST BAGS • VEHICLE RECOVERY SYSTEMS • CABLE & PIPELINE FLOATS
LIFEBOAT DAVIT TEST KITS • FEND-AIR • INFLAT-A-TANK • PIPE PLUGGERS

P.O. Box 2030, North Kingstown, RI 02852, USA
Tel: +1 401 884 8801 Fax: +1 401 884 8868
www.subsalve.com richard@subsalve.com

Order for AquaPix MINSAS

Kraken Robotics Inc. has received an order for an AquaPix MINSAS 120 sonar system from a Fortune 500 company with activities in the defense sector. This is a new Kraken customer, and the company expects to fulfill the order in the first quarter of 2022.

AquaPix MINSAS is an off-the-shelf configurable synthetic aperture sonar (SAS) that replaces high-end side scan systems at an affordable price, while delivering significantly higher resolution, range and area coverage rates. MINSAS is capable of 2-cm-by-2-cm ultra-high-definition seabed imaging.

Woolpert Acquisitions

Woolpert has acquired Optimal GEO, an Alabama-based company that specializes in providing photogrammetric mapping, orthoimagery, LiDAR and GIS data to defense and federal intelligence communities. Optimal GEO and Woolpert have worked together on projects to support federal clients, including the U.S. Geological Survey, the Naval Facilities Engineering Systems Command and the U.S. Army Corps of Engineers.

Woolpert has also acquired AAM, a global geospatial services company that specializes in aerial mapping, surveying, GIS, and the development of innovative geospatial processes and technologies. AAM is headquartered in Australia and has offices in New Zealand, Asia, Africa and the Middle East.

Chevron to Invest in New Energy Businesses

Chevron Corp. will invest more capital to grow lower-carbon-energy businesses. It has set 2030 growth targets for new energy businesses, including: to increase renewable fuels production capacity to 100,000 barrels per day; grow hydrogen production to 150,000 tonnes per year; and increase carbon capture and offsets to 25 million tonnes per year by developing regional hubs in partnership with others. Chevron will invest more than \$10 billion between now and 2028, including \$2 billion to lower the carbon intensity of operations.

Large-Scale CCS Tech in Houston

Eleven companies have expressed interest in supporting the large-scale deployment of carbon capture and storage (CCS) technology in Houston. Calpine, Chevron, Dow, ExxonMobil, INEOS, Linde, LyondellBasell, Marathon Petroleum, NRG Energy, Phillips 66 and Valero will begin discussing plans that could lead to capturing and safely storing up to 50 million metric tons of CO₂ per year by 2030 and about 100 million metric tons by 2040. Houston aims to be carbon neutral by 2050.

Teledyne Launches Geospatial Group

Teledyne Geospatial has launched with the unification of Teledyne's Optech and CARIS businesses. Its offerings will seamlessly map land and sea through the integration of LiDAR sensors and software workflows.

The CZMIL SuperNova, the first product from Teledyne Geospatial, integrates Optech's bathymetric LiDAR with CARIS's comprehensive processing software. **ST**

Ocean Monitoring

OceanPack™ Underway
RACE
pCO₂ / GHG optical Analyzer
Sampler for Microplastic & Plankton
Components

Monitoring for GHG, pCO₂, Analyzer & Sampler

Modular, easy to use and reliable monitoring systems.
Water quality monitoring for: profiling, underway and mooring **Learn more**

SubCtech GmbH
www.subctech.com
info@subctech.com

ISO 9001

subCtech

DHS AI/ML Strategic Plan

The U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T) has released its Artificial Intelligence & Machine Learning (AI/ML) Strategic Plan: www.dhs.gov/publication/st-artificial-in-telligence-and-machine-learning-strategic-plan.

S&T will incorporate the technological advancements in AI/ML to enhance the efficiency and effectiveness of the DHS operational components and the broader Homeland Security enterprise. The Strategic Plan identifies research S&T will conduct to understand the opportunities, as well as the risks, that accompany the rapidly changing AI/ML technology landscape and its impacts to DHS missions.

S&T's three strategic goals are to: drive next-generation AI/ML technologies for cross-cutting homeland security capabilities; facilitate the use of proven AI/ML capabilities in homeland security missions; and build an interdisciplinary AI/ML-trained workforce. The Strategic Plan aligns with the DHS Artificial Intelligence Strategy (December 2020).

FAU Harbor Branch Gets NASA Grant To Study Marine Sediments as Carbon Source

Coastal ecosystems sequester large quantities of carbon through processes at risk of disturbance from changing climate, land use change and rising sea levels. How carbon moves from land to ocean is one of the critical knowledge gaps needed to constrain the structure and functioning of the Earth system. In coastal regions, the origin of various carbon sources is very difficult to identify, and the generalization of these sources and the processes involved in transport to the ocean is even more difficult, thus limiting the ability to make future projections based on a changing climate and associated events.

One potentially underappreciated carbon source, the underlying marine sediments, may be particularly impacted under these conditions and may play an outsized role in the overall carbon budget. Satellite remote sensing is often used as a tool to characterize and quantify the various sources of carbon in coastal regions by measuring colored dissolved organic matter (CDOM), or the "brown stuff" in rivers in Florida and beyond. However, it is not currently possible to discriminate between sediment-derived carbon versus other sources.

Using satellite images, hydrodynamic modeling and field work, scientists from Florida Atlantic University's (FAU) Harbor Branch Oceanographic Institute are setting out to quantify this sediment carbon contribution, make historical reconstructions and contribute to future projections of the coastal budget. They have received a three-year, \$736,000 grant from NASA's Minority University Research and Education Project Ocean Biology and Biogeochemistry (OCEAN). FAU is one of 10 universities in the U.S. to receive this grant in support of NASA's Science Mission Directorate in seeking a better understanding of the ocean's role in the Earth system.

If successful, this research in the Gulf of Mexico's hypoxia region off the coasts of Texas and Louisiana may demonstrate not just the ability but also the utility of remote sensing as an observational technique for characterizing potentially critical but often neglected carbon cycle processes related to marine sediments. Marine sediments are essentially a permanent means for carbon removal from the surface of the Earth over geological time scales. Yet, a changing climate, coastal eutrophication (i.e., excess nutrient inputs), and processes such as trawling are reducing their carbon storage capacity, resulting in the "browning" of coastal waters.

NOAA Shuts Down RNC Tile Service, Viewer

NOAA shut down its Raster Navigational Chart (RNC) Tile Service and the online RNC Viewer in October. The NOAA Seamless Raster Navigational Chart Services will be shut down on January 1, 2022. This is part of a larger NOAA program to end production and maintenance of all NOAA traditional paper and raster nautical charts.

The RNC tile and seamless services provide repackaged chart images that are based on the traditional nautical chart products that are being canceled. As these charts are canceled, a patchwork of holes will grow within the coverage of the raster services, which will eventually render them unusable. Therefore, the RNC Tile Service and the Seamless RNC Services will be turned off early in the raster sunset program. The online RNC Viewer displays data from the RNC Tile service, so it will be shut down at the same time.

Project 11 Greenlight

The Port of Houston and U.S. Army Corps of Engineers (USACE) have committed to a channel infrastructure widening project of the Houston Ship Channel, *DredgeWire* reported. Once widened and deepened, the Houston Ship Channel will benefit over 22,000 vessel trips a year and support more than 200 private and public facilities.

USACE ranked the Port of Houston as the largest port for total and foreign waterborne tonnage. A wider and safer channel that maintains two-way vessel traffic is critical. The Houston channel handles more vessel traffic than the three largest U.S. ports combined: Los Angeles, Long Beach and New York/New Jersey.

This deepening and widening of the channel will be the 11th major improvement project to the federal waterway over its history that dates back more than a century, which is why it is called Project 11.

Fugro to Support National Geospatial Program

The U.S. Geological Survey (USGS) has awarded Fugro a new Geospatial Products and Services Contract to support the National Geospatial Program (NGP), which provides a digital foundation for geospatial infrastructure in the U.S. Work will be done on an as-needed basis for up to 5 years. USGS will have access to multiple innovative LiDAR mapping solutions, crewed and autonomous systems, and cloud-processing technology. The resulting geodata are critical to effectively manage infrastructure, natural resources and inland water channels. **ST**

productdevelopment

For more information on any of these products, visit our website at www.sea-technology.com/products

Subsea Robotic Tools



OM-1 is a compact and cost-effective single-function manipulator for use on smaller ROVs. The grabber suits a range of applications, such as recovering ordnance from the seafloor or stabilizing an ROV by holding onto an object. The jaw head is detachable, allowing for other attachments to be fitted by the operator, including rope cutters, sampling bottles and a magnetic clamp. OceanTools Ltd.

Uncrewed Coastal Security

The Maritime Autonomy Surface Testbed (MAST) vessel is similar to a waterborne drone that can be partly or fully autonomously controlled to identify threats such as enemy ships or collect intelligence on targets while moving at high speeds. Users can deploy uncrewed missions to minimize the risk to service personnel by taking them out of harm's way. Ploughshare/U.K., Defence Science and Technology Laboratory (Dstl) and L3Harris Technologies.

Acoustic Wind Profiler

PA-5 is a long-range sodar with an average altitude range of 3,000 m AGL. Data include measurements of turbulence. The device does not require authorization with respect to radio regulations. Remtech.

Military Life Preservers

This new range of defense-grade life preservers is designed specifically to improve the safety of military aircrews. The three new lifejackets form part of the AirPEX (Aircrew Protection Extreme) product portfolio. Survitec Group Ltd.

Cloud Simulation



The Cloud Simulation Solution is now available on the Ocean Learning Platform. This includes instructor-led interactive simulation training, automated assessment solutions, and a growing library of self-directed simulation exercises suitable for a wide range of deck and engineering learning pathways. Wärtsilä Corp. and Ocean Technologies Group.

Fast Crew Boat

Gen 4 FCB is an aluminum 42-m vessel featuring a highly efficient new hull form and Z-bow that improves sea-keeping and requires less power for the same speed and deadweight, reducing fuel consumption and lowering emissions. The new hull form was developed in collaboration with Southerly Designs, with CFD analysis and optimization by Seaspeed Marine Consulting. Strategic Marine (S) Pte Ltd.

Carbon Emissions Monitoring

The Carbon Intensity Monitoring (CIM) service that monitors and visualizes CO₂ emissions from ships is now fully operational. Third-party endorsement by ClassNK validates the authenticity of CIM operational data and the sophisticated calculation method. Shipping companies can use the service with full confidence both for internal data management and public announcements/reporting. Weathernews Inc.

**FOLLOW
SEA TECHNOLOGY
ON...**

twitter

twitter.com/SeaTechnology

Data Sharing

An application programming interface (API) enables Sea/ to surface RightShip data for the benefit of shared customers. The integration will give Sea/trade customers access to RightShip's Safety Score, GHG Rating and RightShip Dry Bulk Inspections outcomes without leaving the Sea/trade platform, providing increased digital agility. Users can make informed chartering decisions sooner. RightShip and Sea/.

Gauge for Sensors

VL Flex 52 J1939 is an all-in-one 1.44-in. round gauge that can display two sets of diesel engine data simultaneously and is easily configured using a mobile device and the companion Veratron app. It supports input from analog sensors, as well as J1939, LIN 2.0 and other digital networks. Veratron US Inc.

Solar Marine Lantern



SL-75 is now available with the addition of an internal satellite communications module as an option. Other enhanced features include Bluetooth as standard, and GSM connectivity and GPS synchronization as options. SL-75 connected to the Star2M portal provides advanced monitoring and control from your phone, tablet or desktop. Sealite Pty Ltd.

Electric Ferry for Public Transport

Fassmer CIT-E is powered by a Torqeedo integrated drive system, and it can be operated through inner-city waterways in a cost-effective way. Commuter vessels typically operate at efficient speeds and are in use for 8 to 14 hr., leaving plenty of time for overnight charging. Fassmer GmbH & Co. KG and Torqeedo GmbH.

Digital Twin Tech

SWIM (Subsea Wellhead Integrity Monitoring) is a system that employs retrofittable subsea sensors to monitor and measure stability, load, fatigue and structural integrity of the wellhead system during drilling operations. It has a battery life of up to five years and can operate in water depths to 3,000 m. Digital twin technology provides early warning and improved accuracy in structural health monitoring compared to traditional analyses. 4subsea AS.

Network, Device Management

SmartBoat is a vessel management solution for all marine-sensor protocols and network types. The NMEA 2000-certified SmartBoat offers a highly configurable sensor interface; supports a wide range of sensors and protocols; and provides remote discovery, management, programming and wireless features. AIRMAR Technology Corp.

Onboard Isolation Transformers

Six models separate the dock power from the boat's for clean, safe and consistent onboard 120/240-V electricity. Isolation Transformers are available in combinations of 15 and 25 kVA, and 60 or 50/60 Hz, for 50- and 100-amp systems. Hubbell Marine Electrical Products.

Nadir Gap-Fill Sonar

The 2205 system with gap-fill technology is complemented by SonarWiz software to support processing and mosaicking. It was designed specifically for hosted platforms operating in shallow water or within close proximity to the bottom. The sonar is ideal for USVs, UUVs and AUVs. EdgeTech and Chesapeake Technology Inc.

Multiplexer

NEXUS 8 is an HD video and multi-beam sonar multiplexer, with ultrahigh bandwidth and three full HD video interfaces for up to three HD cameras. It provides real-time monitoring without any latency and enables running of instruments and sensors for measurement, surveys, sonar, manipulation and control. MacArtney A/S. **ST**



enquiries@blueprintsubsea.com
sound by design

oculus

Multibeam Imaging Sonars
Single and Dual Frequency Operation
500m and 4000m Depth Rated



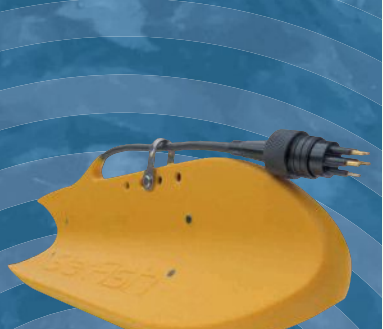
seatrac

Micro-USBL Tracking Beacons
Bidirectional Acoustic Data Modems



starfish

Portable Sidescan Sonars
Towed, OEM, Hull and Pole Mounted



find out more
www.blueprintsubsea.com



Data Quality Guidelines

ClassNK has released its "Data Quality Guidelines" to facilitate the processes of collecting and utilizing shipboard data among various stakeholders. The guidelines outline points to note for ensuring high data quality in accordance with related international standards.

As digitalization in the maritime industry is advancing, achieving data quality is a key element. The guidelines explain characteristics of shipboard data, management procedures for ensuring high quality of shipboard data, and relations for data quality with ISO19847 specifying requirements for shipboard data servers and ISO19848 specifying data formats. They also include an overview of major international standards such as ISO8000, DAMA DMBok to help understand data quality management.

The guidelines are available to

download free of charge at www.classnk.com for those who have registered for the ClassNK "My Page" service (also free of charge).

RINA Acquires Logimatic

RINA has acquired the entire share capital of Logimatic Solutions, a software company headquartered in Denmark. The company will be fully integrated into the RINA Group, and its nearly 50 employees will continue in the current structure from its offices in Denmark, Singapore and Chile.

This acquisition will boost RINA's first-class knowledge of digital solutions, providing support to customers for efficient and sustainable business operations.

The move will add SERTICA to the RINA portfolio of maritime offerings. SERTICA is a powerful fleet management solution for all areas of maritime business. INEXTIA,

FOTODOK and RENOMATIC will complement RINA's businesses in the energy and industry sectors.

Mobile Battery Container

Wärtsilä has developed and delivered a mobile battery container solution that will enable inland waterway vessels to operate with zero emissions. The first order, comprising three units, was placed by ZES (Zero Emission Services) BV, a Netherlands-based company founded in 2020 by ING Bank, energy and technical service provider Engie, the Port of Rotterdam, and Wärtsilä. The order was placed and two containers delivered in June 2021.

The battery containers are installed on a 104-TEU inland waterway container vessel. The system enables the vessel to operate on full electric power alone, with no carbon emissions being generated. The energy capacity is equivalent to that of approximately 36 electric passenger cars. When discharged, the containers can be exchanged and charged onshore using energy

NEW class of ROV Propulsion



Powerful and silent subsea thrusters from Copenhagen Subsea A/S have been developed with reliability as the highest design priority.

The ROV thrusters are responsive, powerful and easy to integrate – and will provide vehicles with a unique combination of silent power and high maneuverability.

COPENHAGEN SUBSEA A/S

sales@copenhagensubsea.com • www.copenhagensubsea.com

from renewable sources. This replaceability is unique because battery containers have thus far been stationary installations.

Atomic Clocks for Galileo Second Generation System

Orolia, specializing in resilient positioning, navigation and timing solutions, has been awarded two contracts to provide atomic clocks for the first 12 satellites of the Galileo Second Generation System (G2S). The first is from the European Space Agency (ESA), and the second is from Leonardo.

Each of the new G2S satellites, designed to provide unprecedented accuracy worldwide, will contain three Orolia Rubidium Atomic Frequency Standards (RAFS) and two Orolia atomic clock physics packages integrated with Leonardo's Passive Hydrogen Masers (PHM).

According to ESA, the G2S satellites will revolutionize the Galileo constellation, joining the 26 first-generation satellites currently in orbit. They will be much larger than the existing Galileo satellites, use electric propulsion for the first time and feature a more powerful navigation antenna. The G2S constellation should achieve decimeter-scale positioning precision.

Flat-Panel Antenna Operates With OneWeb Sat

Low Earth orbit (LEO) satellite communications company OneWeb and global mobile communications company Kymeta have successfully tested the Kymeta u8-based LEO terminal with OneWeb's LEO satellite constellation. Kymeta and OneWeb performed a series of LEO satellite acquisition, tracking and throughput measurements in Toulouse, France. Kymeta plans to leverage these results in the definition of future-proof solutions that are fully integrated and compatible with the rapidly expanding OneWeb system. The u8 is the first commercially available flat panel antenna to interoperate with the OneWeb satellite constellation.

OneWeb is working with several new user terminal integrators like Kymeta to explore solutions that

meet the needs of government, military, enterprise, maritime and first responder customers.

Funding to Install Hydrogen Fuel Cell on USV

SEA-KIT International, a designer and builder of USVs, has won funding to install an innovative PCB-based hydrogen fuel cell, engineered by project partner Bramble Energy, on its 12-m USV Maxlimer

and to demonstrate zero-emission maritime operations. SEA-KIT secured the grant from the Department for Transport, working with InnovateUK, to showcase a successful diesel-to-hydrogen conversion of SEA-KIT's USV design and demonstrate a route to fulfilling the U.K.'s Clean Maritime Plan Strategy commitment of reducing greenhouse gas emissions from shipping by at least 50 percent by 2050. **ST**



WHY MESS AROUND?

Professionals stick with In-Situ water quality monitoring equipment because they trust it to work every time.

Redundant, on-board data storage, fully potted sensors, and integrated optical compensation on our fluorometers ensure reliable performance. So, you can focus on the data.

Learn more at in-situ.com/seatech



environmental monitoring

Robots Collect Glacier Data

Marine scientists have deployed robotic vehicles on the face of a glacier in Svalbard to study the hidden link in how rapidly melting Arctic ice is changing the ocean.

The mission to Ny Ålesund, the world's most northerly settlement, was a collaboration between the Scottish Association for Marine Science (SAMS), UiT The Arctic University of Norway, the Norwegian Polar Institute and University Centre on Svalbard. The team examined the Kronebreen glacier in Kongsfjorden, measuring the freshwater runoff as it melts and assessing how it interacts with the saltier sea water coming into the fjord from the North Atlantic.

Humans are unable to sample at the glacier face because of the risk of glacier calving. Instead, the team used an ASV built by Norwegian company Maritime Robotics

to record various oceanographic measurements at the face of the glacier, while an ecoSUB AUV took temperature, salinity and oxygen readings below the surface. Aerial drones surveyed the freshwater plumes that run off from the glacier.

While rising global temperatures increase glacial melt, glaciers are also breaking up below the surface of the water. In a process known as subglacial discharge, meltwater flows down through the glacier and out into the ocean. This water is fresher than the surrounding seawater, so it starts to rise in the water column, creating a plume that pulls in warmer Atlantic water, which increases the melt rate at the face of the glacier, causing glacial calving.

Turbidity Loggers off France

Offshore of Brittany, in the western-most part of contiguous France, seven autonomous seabed platforms

have been deployed to monitor turbidity. The measurements are being collected as part of France's Réseau d'Observation Haute-Fréquence pour l'Environnement Côtier (ROEC), a network for high-frequency coastal ocean observing, of which ROEC-Benth is the branch responsible for observing turbidity at the seabed. Bottom-mounted tripod cages are deployed, carrying several monitoring instruments, including RBRvirtuoso³ | Turbidity Loggers in areas of interest relating to human activities such as offshore construction, as well as fluvial outputs, which increase particulate matter in the water column. The data collected by ROEC-Benth will address the causes and attributes of benthic turbidity.

Subsea Fiber to Support Earthquake Monitoring

Alaska Communications is collaborating with the University of Michigan's Department of Earth and Environmental Sciences to allow earthquake monitoring data to be

em euromaritime

FEBRUARY 1-2-3

2022

MARSEILLE - FRANCE

THE EUROMEDITERRANEAN
BLUE GROWTH EXHIBITON

organised by

le marin

**ouest
france**

GICAN

SOGENA

with the support of

**Cluster
Maritime Français**

EDITION
2022

PHOTO: GILLES MARTIN-ROGER

collected from the ocean floor via the company's subsea fiber-optic cable. The University of Michigan attached a DAS (distributed acoustic sensing) interrogator to Alaska Communications' landing station in Florence, Oregon. The instrument uses a beam of light inside the fiber to analyze seismic activity and report data back to the research team. With the Cascadia subduction zone stretching along the Pacific Northwest coastline, this is in an ideal location to gather seismic data.

This research project will support continued learning about utilizing fiber for earthquake research and to provide early warning for tsunamis.

Combo of Gliders and ADCPs For Global Ocean Observing

Alseamar, a producer of glider UUVs, has been able to create highly accurate data plots of current profiles from large swaths of the water column. A combination of tailor-made algorithms, underwater gliders and a high-performing ADCP from Nortek has helped break new ground for the oceanographic community, making high-quality data more accessible for a multitude of stakeholders.

Glider missions contribute to the international efforts of the Global Ocean Observing System (GOOS). The UNESCO-led GOOS program coordinates observations, focusing on three critical themes: climate, operational services and marine ecosystem health.

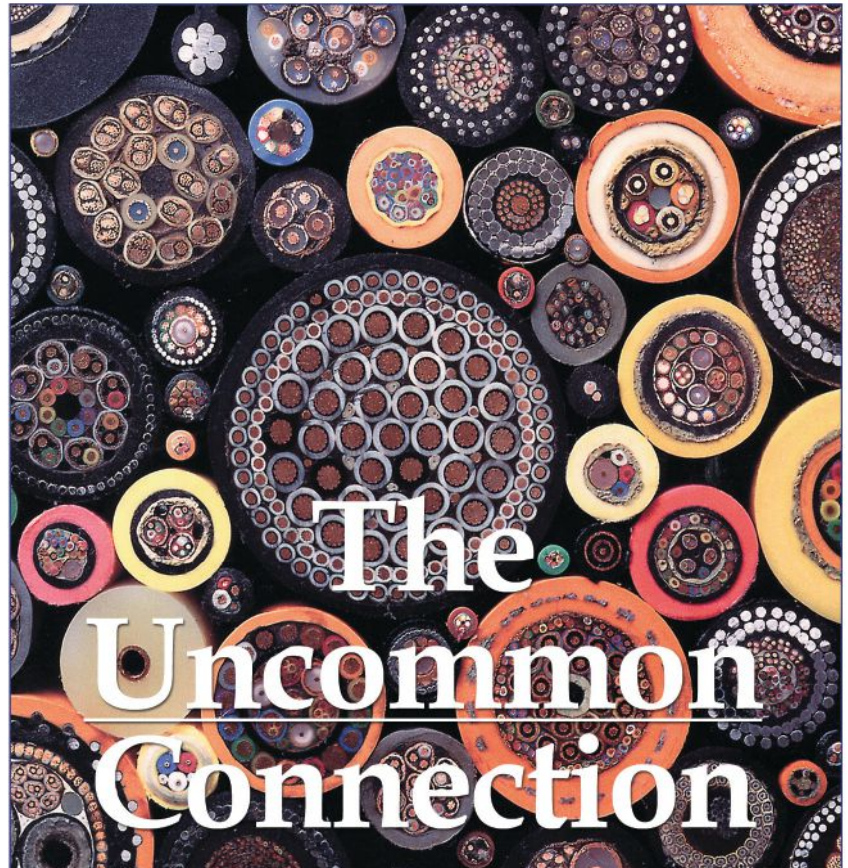
Dune Monitoring, Modeling For Offshore Wind Farms

Underwater dunes are common in France off Dunkirk and Le Tréport. Formed by marine currents and swell, they are highly variable in morphology and can shift. In parallel with the development of the future offshore wind farm off Dunkirk and its electrical connection, a collaborative R&D project, called DUNES, was initiated in 2019 to study sedimentary and biological dynamics in the area. In order to determine the evolution of the underwater dunes with a high spatial and temporal resolution, eight bathymetric surveys were carried

out between November 2019 and July 2021, at three study sites, each covering an area of 1 km². A current measurement campaign lasting more than a month was also done in spring 2021, enabling the hydrodynamic processes at work in the area to be monitored.

Initial data analysis suggests that the underwater dunes in the Dunkirk area have moved continuously eastward over the period

studied at variable speeds. Extreme events such as storms seem to influence this migration. Movements will be anticipated to optimize installation and manage maintenance of offshore wind farms and their electrical connections. The collaborative R&D project MODULLES will start at the end of 2021 to model long-term interactions between underwater dunes and components of future offshore wind farms. **ST**



SOUTH BAY CABLES are the uncommon connection for tough jobs around the world. Established in 1957, we design, test, and produce Electro Optical Mechanical Cables withstanding the harshest of environments. With over 60,000 different cables produced, our cables support a wide range of ocean applications: from Towed Arrays to Side Scan Sonars, ROV Tethers and Umbilicals to Seismic Lead-ins and MUX BOP Control Cables. Contact the uncommon leader.



SOUTH BAY CABLE

Idyllwild, CA 92549 USA • Phone: (951) 659-2183 • Fax: (951) 659-3958
sales@southbaycable.com • <http://www.southbaycable.com>

offshore oil & ocean engineering

Xodus Supports Electrification Study in Central North Sea

Xodus is assessing the infrastructure and modifications required to enable electrification of Harbour Energy's Central North Sea assets following the successful delivery of a power optimization study examining the opportunities available to rationalize the generation systems on the Everest and Lomond assets.

Implementing electrification on offshore assets can reduce operational expenditure, increase uptime across all assets and minimize carbon emissions to atmosphere.

The Oil & Gas Authority's UKCS Energy Integration Report last year calculated that electrification could abate U.K. Continental Shelf (UKCS) oil and gas operational emissions by 2 to 3 Mt CO₂ p.a. by 2030, which is the equivalent of reducing 20 percent of today's production emissions, rising to 40 percent by 2030.

It also noted that platform electrification could extend the operating life of existing assets and achieve cost efficiencies in the development of new oil and gas fields.

Xodus performed an in-depth, integrated subsea and topsides study to assess the scope and scale of the project required to electrify the assets. The company also analyzed the operational savings that could be realized in terms of fuel usage and maintenance burden across all assets from now until cessation of production.

Marine Partnership Renewal

The Institute of Marine Engineering, Science and Technology (IMarEST) has renewed its Marine Partnership with Malaysia-based international offshore energy facilities and services business, Bumi Armada Berhad (BAB).

Marine Partner status is awarded

by the IMarEST to organizations that demonstrate a continued commitment to professional development in the marine sector. The IMarEST works with BAB to promote professionalism and technical leadership through continuing professional development, knowledge sharing and learning opportunities within BAB.

With headquarters in Kuala Lumpur and a presence in over 29 countries, BAB is one of the largest floating production storage offloading (FPSO) players in the world.

Revolutionary Subsea Install

Fugro has revolutionized a subsea installation program for Gulf of Suez Petroleum Co. (GUPCO) with its innovative QuickVision technology. Used for the first time in Egypt, the contactless positioning solution replaced the conventional survey sensors typically attached to subsea structures during installation.

Under a contract with Dragon Oil (GUPCO), Fugro delivered subsea positioning support for the installation of multiple subsea structures off

HERE FOR YOU



**DEC. 1 - 3, 2021
NEW ORLEANS**

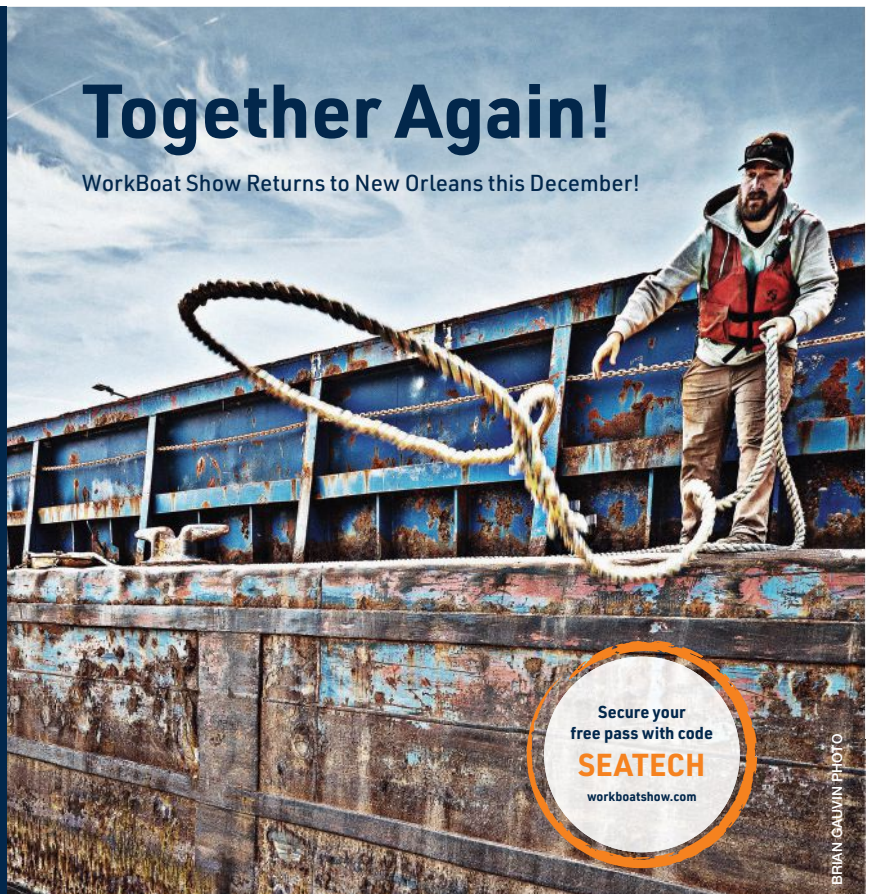
Morial Convention Center, Halls B, C, D, E & F

Produced by **diversified**

Presented by **WORKBOAT**

Together Again!

WorkBoat Show Returns to New Orleans this December!



Secure your
free pass with code

SEATECH

workboatshow.com

BRIAN CALVIN PHOTO

the coast of Egypt. To meet the requirements for improved safety and lower project costs, Fugro deployed its QuickVision solution. This state-of-the-art vision technology uses a smart camera attached to an ROV that can determine the heading and attitude of a subsea structure as it is landed. This eliminates the requirement to pre-install a sensor package on the structure, and retrieve it once installation is complete, which reduces the time and costs associated with a dive support vessel.

Online Certificate Verification

The International Marine Contractors Association (IMCA) has launched a new online facility as part of the association's digital transformation program to enable members to access verification services 24 hr. a day. It will cover all five certificate types currently issued: Air Diving Supervisor, Bell Diving Supervisor, Life Support Technician, DP Company Authority and DP Trials & Assurance Practitioner. New initiatives such as Accredited Diving System Inspectors will also benefit from the service.

A search form is now available at imca-int.com/verify for registered website users to check the status of any certificate provided to them by its holder. The existing option of contacting the IMCA certification team will remain available during London office hours.

The online verification facility also confirms the in-date status for continuing professional development (CPD), which became mandatory for Diving Supervisors at the beginning of 2021. Users of the IMCA Diving CPD App will continue to be able to share detailed CPD progress, with the existing app function redirected to the new facility automatically.

Shell Commits to Solar/Wind-Powered Platform in Malaysia

Sarawak Shell Berhad (SSB), a subsidiary of Royal Dutch Shell plc, has taken a final investment decision on the Timi gas development project and, together with its partners PETRONAS Carigali Sdn Bhd and Brunei Energy Exploration, will

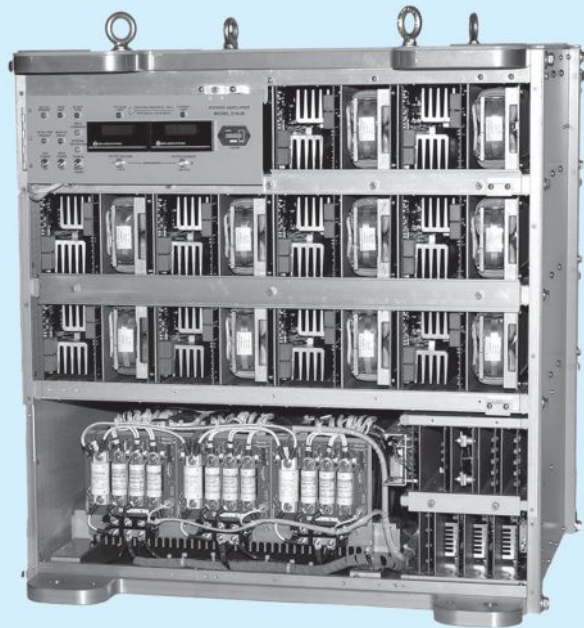
deliver this for Malaysia. The Timi field is situated approximately 200 km off the coast of Sarawak. The Timi development features SSB's first wellhead platform in Malaysia powered by a solar and wind hybrid renewable power system. This unmanned platform is approximately 60 percent lighter than a conventional tender-assisted drilling wellhead platform. This project also includes the drilling of two wells.

Exceed Moves into Australia

Exceed, the Aberdeen-headquartered well management and performance improvement specialist, has launched Exceed Australia as it eyes the country's burgeoning decommissioning sector and a revitalized offshore market. Exceed's entry into Australia is bolstered by a collaborative relationship with Perth-based oil and gas services provider ICON Engineering. **ST**

POWER AMPLIFIERS SWITCHING & LINEAR

**For more than 30 years we have been
building amplifiers to drive reactive loads.**



Model S16-20
20kVA continuous; 50kVA 20% duty
35 x 31.5 x 35.5 inches; 985 lbs.

Visit our Web site www.instrumentsinc.com



Instruments, Inc.

7263 Engineer Rd., San Diego, CA 92111-1493
(858) 571-1111 FAX (858) 571-0188 info@instrumentsinc.com
Copyright 2021

contracts

GMS, Abu Dhabi, United Arab Emirates, has signed a contract for the installation of the Hanseaticsoft Cloud Fleet Manager (CFM) software solution that will provide a central, cloud-based single source of truth and applications to increase collaboration and streamline processes between departments. Lloyd's Register.

OceanWise, Alton, U.K., was awarded the multi-year U.K. National Tide Gauge Network contract for 42 Class A tide gauges on behalf of U.K. Coastal Flood Forecasting, alongside RS Divers. U.K. Environment Agency.

Vard Electro, Alesund, Norway, has signed two new contracts for the SeaQ Energy Storage System for the vessels *Stril Orion* and *Stril Polar* that are scheduled to be hybrid ready by the end of 2021 and the beginning of 2022, qualifying them for DNV's Battery Power notation. Simon Møkster Shipping.

Kongsberg Maritime, Kongsberg, Norway, has signed a contract to supply a large package of permanent magnet (PM) thrusters for installation on two new offshore wind farm maintenance vessels. The scope of delivery includes PM azimuth thrusters, PM tunnel thrusters and a retractable azimuth thruster. VARD shipyard.

Woolpert, Dayton, Ohio, will provide mapping and survey services throughout the U.S. and its territories under its shared capacity Geospatial Products and Services Contract 4. These services include imagery and LiDAR data acquisition, photogrammetric mapping, GIS development, ground control survey, and data processing and analysis. U.S. Geological Survey.

Wärtsilä, Helsinki, Finland, has signed a joint development program agreement aimed at developing ammonia-fueled vessels with four-stroke auxiliary engines available

for future newbuild projects. Samsung Heavy Industries.

Seatronics, Singapore, is the first customer for the new SPRINT-Nav Mini Navigator. Seatronics has purchased the small hybrid acoustic-inertial navigation instrument for its VALOR ROV. Sonardyne.

Rolls-Royce, Friedrichshafen, Germany, will collaborate on smart ship and autonomous ship control solutions, including comprehensive remote command and intelligent crew support systems. This will complement Rolls-Royce's mtu NautiQ marine automation portfolio. Sea Machines.

PortXchange Products B.V., Rotterdam, Netherlands, has made an agreement for a five-year partnership for the adoption and further development of the PortXchange system, a collaborative vessel and terminal planning platform. Greater Houston Port Bureau. **ST**

meetings

Note: The coronavirus (COVID-19) pandemic could affect event dates. Check event websites for the latest updates.

DECEMBER

December 1-3—International Work-Boat Show, New Orleans, Louisiana. www.workboatshow.com.

December 6-10—World Ocean Summit Asia-Pacific, Virtual. ocean.summit@economist.com or <https://events.economist.com/world-ocean-summit-asia-pacific>.

December 15-17—UDT, Rostock, Germany. www.udt-global.com.

2022

JANUARY

January 10-13—Nor-Shipping, Oslo, Norway. www.nor-shipping.com.

January 26-27—ACIs Ship Recycling Congress, Rotterdam, Neth-

erlands. +91 9921 81 9902 or skanwar@acieu.net.

FEBRUARY

February 1-3—Euromaritime, Marseilles, France. www.euromaritime.fr.

February 17-18—Indian River Lagoon Symposium, Fort Pierce, Florida. www.fau.edu/hboi/50/events.

February 21-24—OCEANS 2022 Chennai, India and Virtual. <https://chennai22.oceansconference.org>.

February 22-24—Blue Innovation Symposium, Newport, Rhode Island. info@blueinnovationsymposium.com or <https://blueinnovationsymposium.com>.

February 22-24—Subsea Expo, Aberdeen, Scotland. www.subseauk.com.

MARCH

March 1-3—Floating Wind Solutions, Houston, Texas. <https://floatwindingsolutions.com/fws-22>.

March 27-29—Canadian Underwater Conference and Exhibition, Halifax, Canada. www.cuce.ca.

APRIL

April 25-28—AUVSI XPONENTIAL, Orlando, Florida. www.xponential.org/xponential2022.

JUNE

June 1-2—Navigate, Turku, Finland. info@navigate.fi or www.navigate.fi.

June 19-24—Frontiers in Hydrology Meeting, San Juan, Puerto Rico, and Virtual. www.agu.org/FIHM.

June 21-23—Interspill, Amsterdam, Netherlands. +0333 444 1890, info@interspill.org or www.interspill.org.

OCTOBER

October 9-12—Maritime Cyprus, Limassol, Cyprus. <https://maritimecyprus.dms.gov.cy>.

For more industry meetings, visit sea-technology.com/meetings. **ST**

HII to Maintain US Navy Carrier, Surface Ships

Huntington Ingalls Industries' (HII) Technical Solutions division has been awarded a five-year contract with a total value of \$273 million to support the U.S. Navy's carrier engineering maintenance assist team, surface engineering maintenance assist team for West Coast surface ships, and other maintenance and material readiness programs.

Work performed on the contract will support maintenance and planning for the overhaul and repair of equipment and systems, including: hull, mechanical and electrical; aviation equipment and systems; command, control, communications, computer and intelligence; and combat support systems.

The programs follow a "find, fix and train" philosophy with assessments, maintenance, and training to enhance sailor self-sufficiency and maintenance capabilities while ensuring platforms remain mission capable.

Clean Electricity for Israeli Navy Bases

Eco Wave Power Global AB has entered into a collaboration agreement with the Procurement Administration in the Israeli Ministry of Defense for the Israeli Navy to examine the feasibility of installing Eco Wave Power technology in the Navy's bases. Eco Wave Power will immediately begin the procurement and deployment of wave-measuring systems to collect extended wave data in one to three potential locations in the Navy's bases, while the Navy will secure all permits for the deployment of the wave-measuring equipment.

The Navy's specialized diving team will install the measurement equipment in the territorial waters of the Navy's bases. At the end of the measurement period, Eco Wave Power will share the information collected with the Navy, and the Navy will test the applicability of the technology in line with the prevailing waves in the selected sites. Then, Eco Wave Power and the Navy will jointly analyze the results and create energy production forecasts based on the analysis.

Upon identifying the most suitable locations for the installation, and provided that the technology is found to be feasible for the proposed locations, the Navy and Eco Wave Power will collaborate on potential deployment of the Eco Wave Power technology for production of clean electricity for the Navy's bases.

Power, Propulsion Chosen for LDUUV

General Atomics Electromagnetic Systems (GA-EMS) has been awarded a design contract from the U.S. Office of Naval Research (ONR) to develop a concept for integrating a unique GA-EMS motor and next-generation power system into a Large Displacement Unmanned Underwater Vehicle (LDUUV). The planned systems will provide the LDUUV with power for propulsion and an energy storage system to support improved system performance necessary for future LDUUV operations. At-sea testing will occur during a later phase of the program.

Svitzer Australia to Provide Naval Towing

Svitzer Australia has won a long-term contract to provide towing services for the Australian Department of Defence, servicing the Royal Australian Navy. Svitzer will provide towing services for Australia's naval fleet, the management of Navy towing assets, and the development of naval personnel training in major ports around Australia.

Svitzer Australia has a network of over 20 ports nationally and is the largest employer of Australian seafarers.

Sonardyne Threat Detection in Middle East

Underwater intruder detection technology from Sonardyne has been chosen to protect a string of naval facilities and critical national infrastructure in the Middle East. Sonardyne's Sentinel Intruder Detection Sonar (IDS) will be deployed on fixed and floating assets to provide perimeter and mobile protection from threats, including unauthorized divers and UUVs. More than 10 Sentinel sonar systems will be part of a 360° NiDAR surface and subsurface waterline surveillance system, an artificial intelligence-powered Internet of Things platform developed and supplied by Sonardyne's long-term maritime security partner, MARSS Group. In addition to this order, an order for multiple Sentinel sonar systems will also be supplied via MARSS Group in the third quarter of 2021 to protect coastal infrastructure. Another order, with a separate client, will see another Sentinel system used on a vessel for the protection of offshore infrastructure. **ST**

NEW

Improved Electronics

Low Power Consumption

**Mini Rosette®/CTD Water Sampler
1018 M**

with Model 316 or 320 Idronaut CTD

- Lightweight, small, compact
- Allows operation from a small boat
- Conducting cable or battery-powered
- Programmable timed operations
- Pressure-activated bottle closing (optional)
- Deep & shallow water models available
- Optional Teflon®-coated Water Sampler
- CTD compatible
- Flag Pulse to CTD A/D input



General Oceanics Inc.

1295 N.W. 163 St., Miami, FL 33169
Tel: (305) 621-2882, Fax: (305) 621-1710
E-mail: Sales@GeneralOceanics.com
<http://www.GeneralOceanics.com>

professional services directory

An effective medium reserved for listing professional and consulting services. Size: 3-3/16" wide x 1" deep, to a maximum depth of 3". Rates: \$95 per one-inch insertion for 1-6 times; \$90 each for 7-12 consecutive times. Payment terms: net 30 days. Discounts: 10% for advance payment for 6 or more insertions without copy change; no agency commissions. No charge for typesetting. Send your electronic file or text and images (300 dpi) to seatechads@sea-technology.com by the 10th of the month preceding insertion month.

Relax.
We can take the pressure.



Subsea Instrumentation Housings and Junction Boxes
Contact us for a FREE Brochure

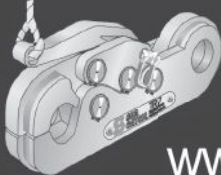
10,000 N. Technology Drive, Fountain Hills, AZ 85268
877-3PREVCO [Toll-Free] 480-837-0100 480-718-7723 [Fax]
noleaks@prevco.com www.prevco.com

SONOTRONICS
MARK YOUR EQUIPMENT



Mark your underwater equipment for later recovery in case of loss. With *close to 50 years* of experience in the manufacture of sonic pingers, hydrophones, and receivers, SONOTRONICS can provide equipment for your underwater tracking needs.

www.sonotronics.com
(520)746-3322



SEACATCH
TOGGLE RELEASE

Tel: 253-858-1985 Fax: 253-858-1986
Email: jmcmillan@seacatch.com
WWW.SEACATCH.COM

McMillan DESIGN, INC.
9816 Jacobsen Lane
Gig Harbor, WA 98112
USA

GALVANIC TIMED RELEASES

Cost-effective electrochemically degraded links available in durations ranging from one minute to 100 days. Trigger closure mechanisms, open escape panels, release cable support buoys or subsurface instrument locator floats. Stock and custom-designed releases available from:

International Fishing Devices, Inc. 18246 134th Way N., Jupiter, FL 33478 Ph: (954) 574-9517	André LaBonté P.O. Box 60, Waipou, New Zealand 0545 Ph.Fax: 011-64-9-432-0645
---	--

underseareleases.com

HYDROSPACE Group
PVHO Windows and Acrylic Pressure Vessels



**Fabrication – Certification – Engineering – Repair
Replacement – Hydrostatic Testing – Custom Design**

Contact: Michael Azer Tel + (909) 989-7773 - pvho@HydrospaceGroup.com
www.HydrospaceGroup.com

Sea Technology magazine

Since 1963, *Sea Technology* has been the industry's recognized authority in providing information in design, engineering and application of equipment and services in the global ocean community.

Let *Sea Technology* work for you by providing published editorial content to validate your marketing initiatives.

Electronic Reprints

Digital versions of *ST* articles in high-resolution PDF format can be posted directly on your company's website.

For additional information, please contact:
Compass Publications, Inc.
T 703.524.3136 • F 703.841.0852
seatechads@sea-technology.com • sea-technology.com

Transitioning from Defense to Conservation: A Career Journey—Melanie Olsen

Melanie Olsen is project director of ReefWorks, the tropical marine technology test range at the Australian Institute of Marine Science.



An electronic warfare engineer, she fosters technological innovation and sustainable integration of new tech and autonomous solutions into Australia's tropical marine observation network. Olsen is the IEEE Northern Australia Section Chair and a member of the Australian Army Reserves.

I worked for 10 years on missile defense and electronic warfare systems, with the goal of driving rapid technological innovation in Australia's marine research and monitoring. Now, I'm the director of the world's first tropical marine technology test range, ReefWorks, at the Australian Institute of Marine Science (AIMS).

My journey has been interesting and unusual.

Growing up in a third-generation farming family about 200 km northwest of AIMS's headquarters near Townsville, on the doorstep of the Great Barrier Reef, I originally thought engineers were train drivers. That changed when a university engineering lecturer visited my small rural high school with a quad helicopter. That was the moment I knew I had found my career path.

I studied computer systems engineering at James Cook University and was accepted into the Defence Material Organisation (now Capability Acquisition and Sustainment Group) graduate program, which gave me the opportunity to conduct three six-month rotations across Defence, helping to build and sustain Defence capabilities. When I rotated into maritime electronic warfare systems and missiles, I knew I had found my niche.

For 10 years, I worked closely with project teams in Canberra, Adelaide and the U.S. in the design,

acquisition, and sustainment of future maritime electronic warfare technology, such as the Nulka hovering rocket active missile decoy system.

After hours, I studied part time to obtain a master's in electronic warfare systems engineering from the University of New South Wales.

I discovered I have a talent for translating science-speak to engineers and stakeholders, and engineering-speak to scientists and project managers.

Throughout my career in a male-dominated industry, I pushed through awkward moments of being singled out, focusing on delivering solutions to the challenges at hand. I hardly ever noticed I was the only female in the room until people pointed it out. Once, when meeting my U.S. collaborators face to face for the first time, they were surprised to discover I wasn't a bloke called Mel (short for Melvin, they had thought).

While I loved that job, the long hours, overnight international teleconferences and short-notice travel was difficult to manage as a single mother of two young children, with no family support nearby. So, I applied for a job closer to home as AIMS engineering team lead for technology development.

I was accepted and started working at AIMS in 2016. I discovered there are many similarities to my role at Defence; but, instead of helping to defend national sovereignty, I now lead a team helping to defend coral reefs from the existential dangers they face, such as mass coral bleaching triggered by warming ocean temperatures.

Our team is driving rapid innovation and designing technological solutions to create capabilities that allow AIMS to deliver twice the information in half the time and at half the unit cost. This includes introducing autonomous vehicles and artificial intelligence (AI) solutions

to make data collection and analysis more robust, efficient and safe.

A key project is the development of the ReefScan suite of smart, efficient marine monitoring systems that can be configured for a wide range of needs and environments. ReefScan products seamlessly integrate machine learning, advanced imaging sensors and robotics, offering an end-to-end approach to coral reef monitoring, from design to data collection, analysis and reporting. The aim is to significantly scale up the areas that can be monitored and provide new insights, while freeing human effort from routine and sometimes dangerous tasks.

I am also the project director of ReefWorks, AIMS's newly established tropical marine technology test range, the first such facility in Australia and the first in the world to be located in tropical waters. ReefWorks was established to propel the nation's burgeoning marine technology industry into a sustainable market sector. ReefWorks enables a streamlined pathway for transitioning marine technology innovation from development through to operation. ReefWorks also provides an excellent opportunity for our scientists and engineers to learn from colleagues in related industries, such as defense.

ReefWorks' facilities include three marine test ranges that offer different environments, land-based test tanks within the National Sea Simulator, and a test-range digital twin. It aims to drive value and innovation in a range of sectors, including marine monitoring, reef restoration, defense, education, agriculture, film-making, search and rescue, transportation, storm tracking, forecasting, and mapping.

My journey began in a small rural town near the Great Barrier Reef, and I've returned nearby. I've come full circle and am now able to help attract the innovative marine technology industry to our region. **ST**

november advertiser index

Advanced Navigation..... 25 www.advancednavigation.com	MSI Transducers 26 www.msitransducers.com
BIRNS, Inc. 15 www.birns.com	Massa Products Corporation..... 3 www.massa.com
Blueprint Subsea 35 www.blueprintsubsea.com	RBR Ltd..... 49 www.rbr-global.com
Copenhagen Subsea A/S..... 16, 36 www.copenhagensubsea.com	Saab Seaeye Limited 30 www.seaeye.com
EUROMARITIME 2022..... 38 www.euromaritime.fr	Sea & Sun Technology 5 www.sea-sun-tech.com
EvoLogics GmbH 47 www.evologics.de	Sensor Technology Ltd..... 29 www.sensortechcanada.com
General Oceanics, Inc. 43 www.generaloceanics.com	*South Bay Wire and Cable LLC..... 39 www.southbaycable.com
In-Situ 37 www.in-situ.com/seatech	SubConn 19 www.macartney.com
*Instruments, Inc. 41 www.instrumentsinc.com	SubCtech GmbH..... 32 www.subCtech.com
International WorkBoat Show..... 40 www.workboatshow.com	*Subsalve USA Division 32 www.subsalve.com
Knudsen Engineering Ltd..... 10 www.knudseneng.com	UDT 2021..... 48 www.udt-global.com

*For more information, consult the digital 2021 *Sea Technology Buyers Guide/Directory*:
<https://lsc-pagepro.mydigitalpublication.com/publication/?i=649355>

SEA TECHNOLOGY

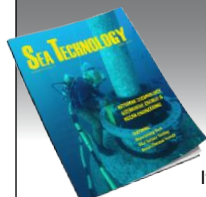
Available free of charge to qualified individuals (those involved in the marine industry) – in digital format.

www.sea-technology.com/subscribe-free

Also available, at no charge: our bi-weekly e-newsletter, *Sea Tech e-News*. Sign up here:

<https://sea-technology.com/enews>

If you prefer a more personal touch, please contact us at +703 524 3136 or seatechads@sea-technology.com.



MISSION STATEMENT

Sea Technology is the worldwide information leader for marine business, science & engineering. Our goal is to provide our global audience with current information on the various segments of the worldwide marine/ocean industry through state-of-the-art and application articles, news columns, and staff reports; and to provide our advertisers with a cost-effective, valuable, and useful vehicle by which to promote their products and services.

For permission to photocopy portions of *Sea Technology*, please contact the Copyright Clearance Center • 222 Rosewood Dr. • Danvers, MA 01923 • Phone (978) 750-8400 • FAX (978) 750-4470

Sea Technology news magazine, including Underwater Engineering, UnderSea Technology, Oceanology International Offshore Technology, and its website, is edited for executives, scientists, engineering and technical personnel in industry, government, and education engaged in the field of undersea defense, oceanography, anti-submarine warfare, marine sciences, underwater exploration, diving and construction, drilling, and mining. While effort is made to verify material published, opinions of authors are not necessarily those of the publisher, and the publication accepts no responsibility in connection with any liability that might occur as a result of published material.



EvoLogics®

SMART SUBSEA SOLUTIONS

Delivering data in most adverse conditions: underwater acoustic modems with advanced communication technology and networking

Accurate USBL and LBL positioning of underwater assets

Modem emulator and other cost-saving developer tools

Autonomous surface vehicle for bathymetry, monitoring and AUV support

**NEW
USBL BUOY**

**AVAILABLE
NOW**

The easiest way to deploy a USBL transceiver:

the USBL buoy is a fully integrated solution based on EvoLogics S2C USBL devices



REGISTER TO JOIN US

UDT 
2021
Undersea Defence Technology

15-17 December
Rostock, Germany

REUNITE IN ROSTOCK

You're invited to attend the world's largest Undersea Defence Technology conference and exhibition, UDT 2021, in Rostock, Germany.

As the first opportunity to reunite in person since the outbreak of COVID-19, UDT 2021 will provide an invaluable platform for all stakeholders in the undersea defence community to come together, learn, expand networks and explore business opportunities. The event will be hosted in Rostock, the location of the German Navy HQ. The city is also the future home of the Baltic Sea Maritime Component Command, which will oversee naval operations in the region. To join us, register on our website.

Current Exhibitors Include:



BAE SYSTEMS

babcock[™]



Gold Sponsor:

Bronze Sponsor:

Organised by:



GET IN TOUCH:

 team@udt-global.com

 +44 (0)20 7384 7788

 www.udt-global.com

You could catch a *wave*...



Or catch *every wave*.

Equipped with the proven Paroscientific Digiquartz® pressure sensor, the **RBRquartz³ Q|plus** tide and wave logger is intended for long-term autonomous or realtime observations of water level, tides, and waves. With flexible measurement schedules, continuous and burst sampling up to 16Hz, large battery and memory capacity, and a novel no-tools-required housing, the **RBRquartz³ Q|plus** is the pressure logger of choice for coastal dynamics.

RBR

SENSORS | **LOGGERS** | SYSTEMS | OEM

rbr-global.com