DEFENSIVE *Drivers*

It is no secret that the defense industry is a driver for innovation in the subsea sector, with the deep pockets and the interest in driving tech to the next level. MTR checks in with four leaders in the sector of their insights on the pace and direction of development.

By Greg Trauthwein

The Participants

- **Ben Kinnaman,** CEO, Greensea Systems, Inc.
- **Mark Kenney,** General Manager, Unmanned Maritime Systems, L3Harris
- **Jesse Rodocker,** President, Strategic Robotic Systems
- **Chris Gibson,** VP of Sales, Marketing & Business Development, VideoRay

Tell us a bit about your company, its technology, with specific insight on your offering for the defense sector.

Kinnaman, Greensea

Greensea Systems, Inc. (Greensea), founded in 2006, develops advanced technologies to improve the relationship operators have with robotics and machines in the maritime domain. Our mission is to make operators and technicians working with robotics more productive. We do this through three primary technology areas: Navigation and Localization, Control and Autonomy, and Human Machine Interfaces. All of our solutions are built on an open architecture software framework for marine robotics called OPENSEA that Greensea owns, develops, and maintains. Greensea directly supports three key application areas in the defense sector: Maritime Explosive Ordnance Disposal (EOD), Special Operations Forces (SOF), and Ship Hull Robotics. In each of these areas, we provide operators with holistic, real-world solutions by partnering with them during product development, training, support, and research and development. Our work in these areas is actively supported by multiple US government programs including R&D programs, CRADAs with NUWC and NIWC, and SBIR/STTR programs.

Gibson, VideoRay

Founded in 1999, VideoRay underwater robots help prevent terrorism, find and retrieve objects, inspect infrastructure both inland and offshore, and keep divers safe from hazardous conditions. Hallmarks of VideoRay systems are ruggedness, reliability, portability, ease of use, and integration with a wide range

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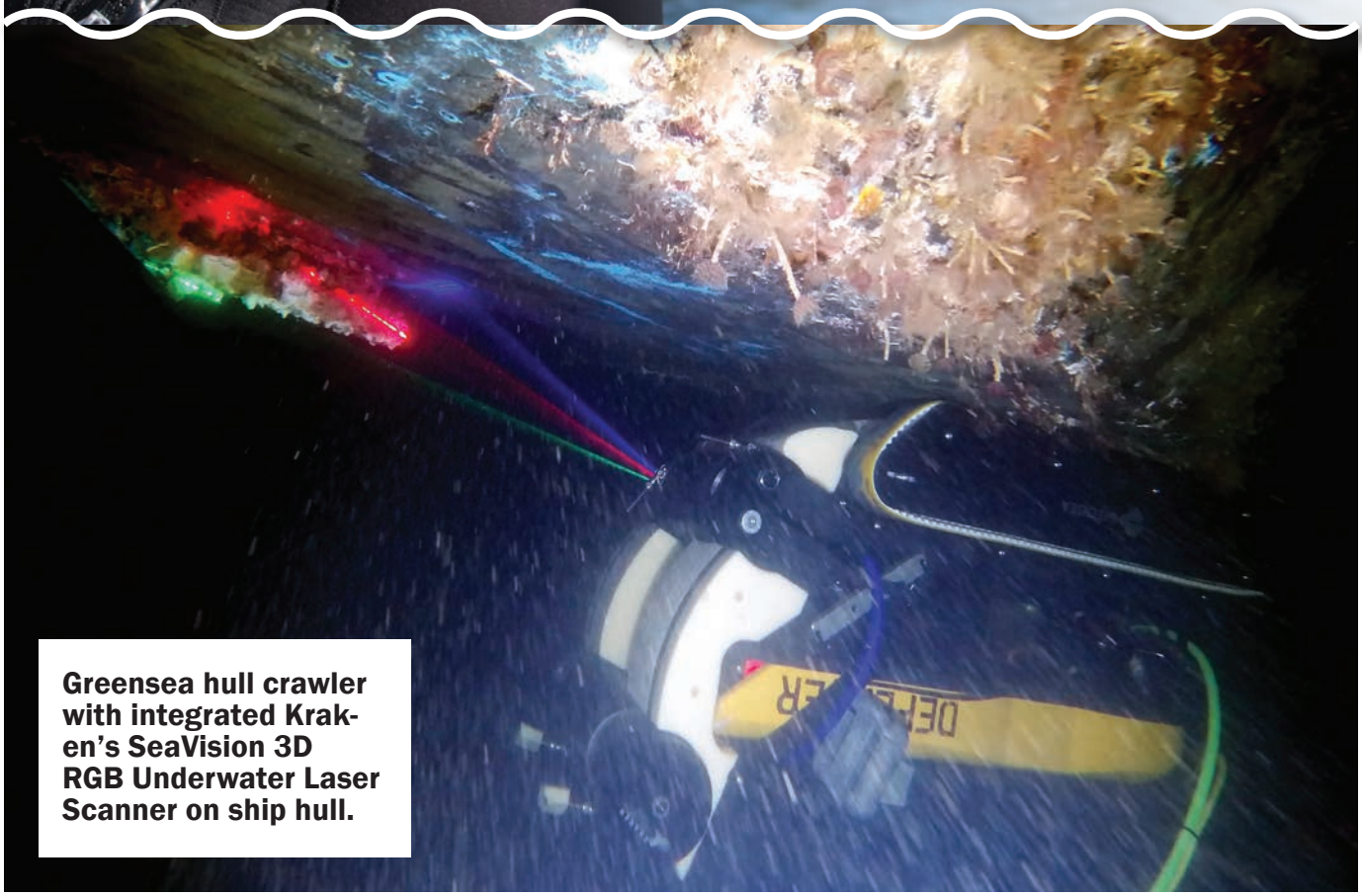
CEO, Greensea



Greensea hull crawler with integrated Kraken's SeaVision 3D RGB Underwater Laser Scanner on ship hull.

Photos: Greensea Systems

of sensors and tools available for inspection-class vehicles. VideoRay specializes in one-man portable underwater systems.

Since launching Mission Specialist technology in 2017, the VideoRay Defender and Pro 5 models have become increasingly dominant for one-man-portable systems for the world's Navies and Coast Guards. The largest and most powerful Mission Specialist configuration, the Defender, is optimized for precise control, heavier payloads, lifting, and specialized operations. The most portable, the Pro 5, has similar advantages but is smaller. Mission Specialist technology is unique in the ability to add new sensors and accessories from a broad range of manufacturers, as it supports a wide range of power and communications options.

Standard VideoRay Mission Specialist ROV modules include cameras with a wide range of resolutions, bright and efficient LED lighting, and powerful thrusters capable of up to one horsepower. There is a broad assortment of accessories and instruments, including manipulators, positioning and navigation systems, radiation sensors, water quality, metal thickness, imaging and multibeam sonars. Options include purpose-built frames customized around the payload requirements of the operator's chosen sensor and tooling package.

Rodocker, Stratgic Robotics

Strategic Robotics Systems manufactures the FUSION hybrid ROV/AUV system, which was specifically designed for defense operators. The goal of the design was to create an effective acquire and reacquire tool for EOD/MCM operators by bring next generation designs and features. FUSION is designed to operate from a rubber boat by a couple operators without the need for a generator or large footprint. The system is tightly integrated around key sensors for most missions with the ability to accept unique options. Specifically the FUSION has a payload bay that features modules such as a release mechanism for payload delivery. With FUSION operators can take already captured target databases and using automation go to each target for ID and interrogation.

Kenney, L3Harris

L3Harris has approximately $18 billion in annual revenue and 50,000 employees, with customers in 130 countries. As part of our unmanned maritime system offerings to the subsea defense community, we offer the Iver family of UUVs. The Iver4 is a next-generation small diameter UUV featuring ultra-low logistics, extended mission duration, highest quality sensor data, and swappable payload and battery sections.

What percentage of your business in 2019 was in the defense sector?

Kinnaman, Greensea

A little more than 60% of Greensea's business in 2019 either sold directly to defense customers or to OEMs who sold into the defense sector.

Gibson, VideoRay

About 30% of VideoRay's business in 2019 came from the Defense sector.

Rodocker, Stratgic Robotics

SRS business is approximately 90% or more defense.

Kenney, L3Harris

Unmanned Maritime Systems does about 66% of our business in the defense sector. Much of this work is US and International defense contractors and agencies who procure our goods and services via commercial contracts.

In general, discuss the importance of the defense sector to your company and the trends regarding the size and pace of the market in recent years.

Kinnaman, Greensea

The defense sector is a strategic priority for Greensea. Not only is the military a primary consumer of marine robotics technology, the warfighter faces more challenges than other operators. Greensea have successfully provided the military with cutting-edge technologies to solve their most demanding operations.

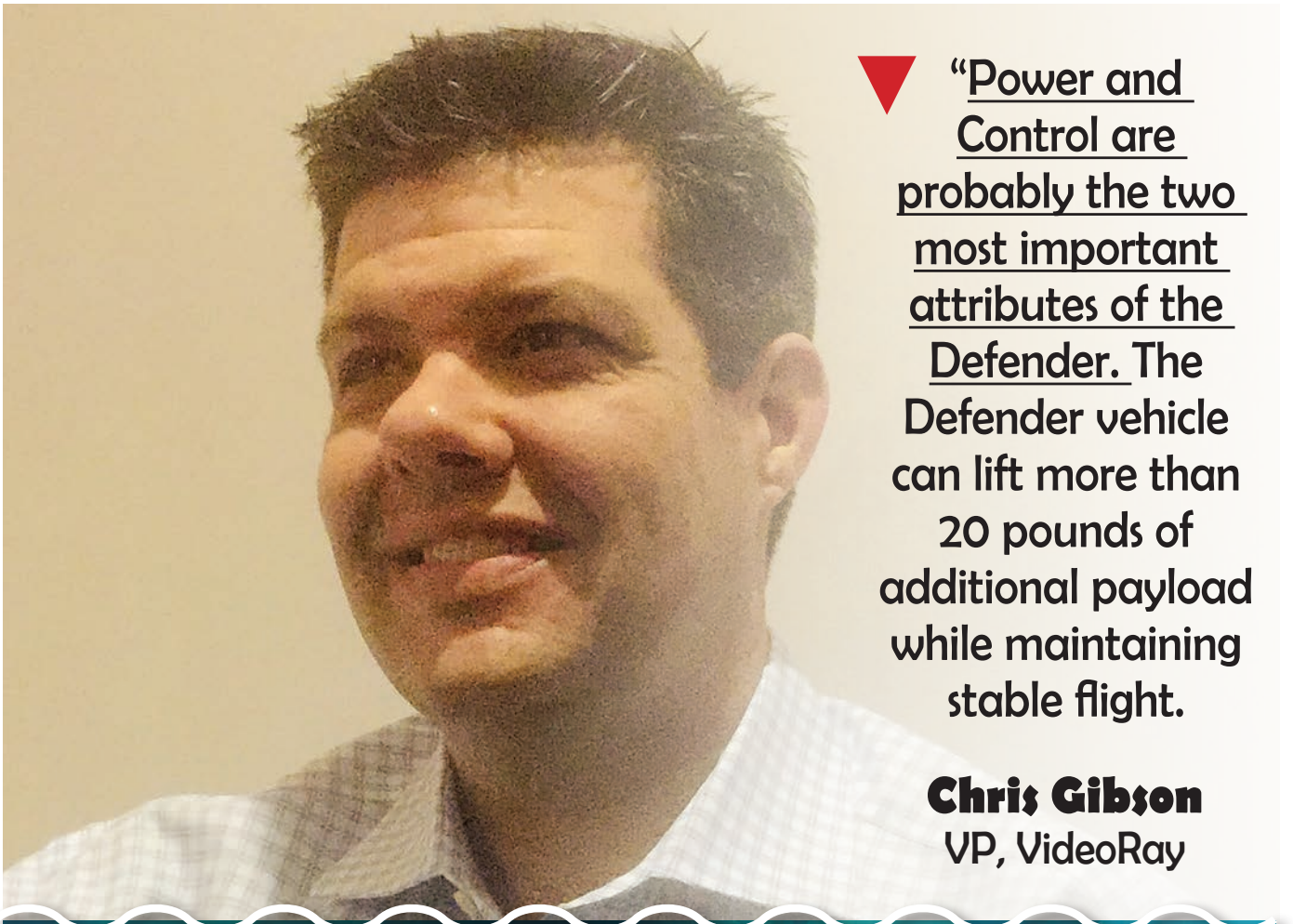
Greensea engages in the defense sector in three ways:

- Technology and product development. Direct-funded government programs to develop solutions required by the warfighter and to evolve existing products.
- Manufacturers and Defense Prime contractors. Prime contractors utilizing Greensea's OPENSEA open architecture software platform to develop emerging technologies and solutions for defense. Manufacturers providing Greensea's defense technologies in their robots, vessels, and products offered to the military.
- Direct support for the warfighter. Training, service, and support directly to technicians and operators using Greensea's defense products. This also provides invaluable feedback to Greensea's product development.

In the past two years, we believe the US military has made significant progress implementing processes to deliver needed technologies and capabilities more rapidly to operators and technicians. Greensea's software platform, OPENSEA, is an important component for supporting those initiatives because it is robust and flexible enough to support emerging requirements. It's not enough to be fast, the technology needs to be reliable and operationally ready. OPENSEA is the framework that can deliver both.

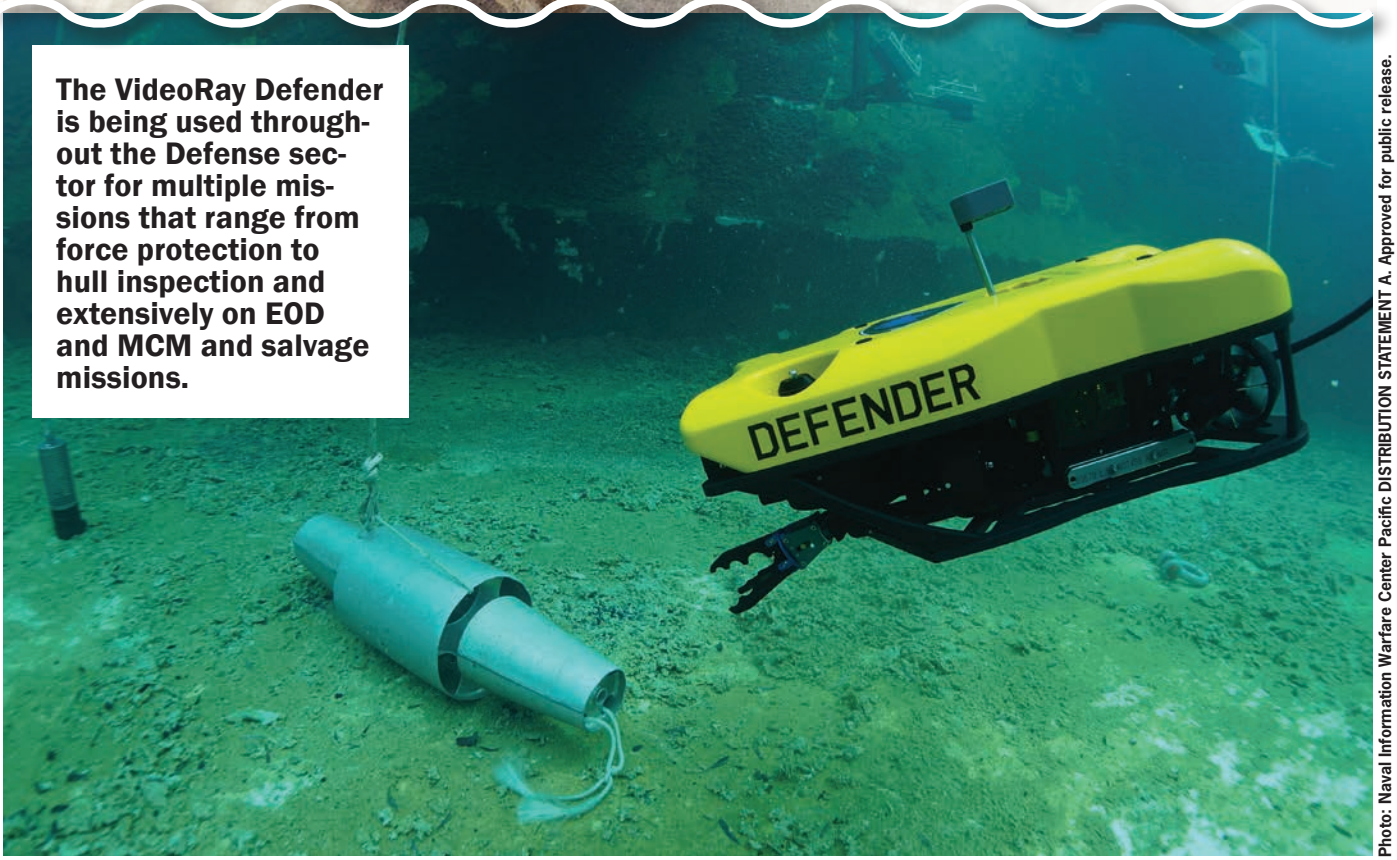
Gibson, VideoRay

We see technology initially developed for the Defense sector provides capability needed by commercial customers as well. We have also seen technology developed specifically for the oil & gas challenges demanded by our Navy users. VideoRay is positioned to share and commercialize technology across our more than 15 market segments.



"Power and Control are probably the two most important attributes of the Defender. The Defender vehicle can lift more than 20 pounds of additional payload while maintaining stable flight.

Chris Gibson
VP, VideoRay



The VideoRay Defender is being used throughout the Defense sector for multiple missions that range from force protection to hull inspection and extensively on EOD and MCM and salvage missions.

Photo: Naval Information Warfare Center Pacific DISTRIBUTION STATEMENT A. Approved for public release.

Rodocker, Stratgic Robotics

SRS was founded specifically to be a defense company and provide a solution to EOD/MCM operators globally. Beyond defense SRS only really works with public safety/law enforcement. Virtually all our R&D goes into improving the capability of FUSION for defense, albeit the system is a commercial product that could benefit many clients outside defense. More often we are seeing defense clients globally increase their use of UUVs as they try to remove the man from the minefield. There is only going to be more use by robots in the future.

Kenney, L3Harris

Growth of unmanned in the defense sector, whether it be international or domestic, is of critical importance to the growth of our business. There are five business units in the Unmanned Maritime Systems division and each were acquired to bring a unique and differentiating capability to compete in this space. It is the growing demand for unmanned systems to meet mission requirements for the U.S. Navy, whether under the surface or above, that is fuel for our business.

Discuss how defense sector requirements have helped to drive your company's R&D/ Product development over the past few years.

Kinnaman, Greensea

In addition to providing OPENSEA as a development platform to numerous defense contractors throughout the industry, Greensea directly supports three primary defense applications: maritime EOD, SOF combat diver mobility, and ship hull robotics. The solutions we provide in these three segments are based on years of direct feedback from technicians and operators throughout the defense industry, both domestic and international. We have carefully designed our business strategy within these segments to not only provide products, but to also provide training, service, and support directly to trainers, operators, and technicians. It is through this outreach that we receive the most valuable feedback that informs our product development.

Our company's R&D/Product Development for OPENSEA as well as for the products within our programs is guided by direct input from Program Offices as well as the Fleet. Greensea invests substantially to provide solutions to the military that address immediate requirements and that can evolve as those requirements evolve. Greensea also engages in funding opportunities that advance our products within our core program support focus.

Gibson, VideoRay

The Defense sector has driven several aspects of VideoRay's new Mission Specialist technology. Our engineering team maintains a close relationship with our military customers, through programs like our Cooperative Research and Development Agreement. This ensures rapid progression of projects through R&D, field trials, revisions, then production. Portability requirements have been designed into the Defender product. It is critical that the Defender be able to be transported anywhere in the world for rapid deployment while being operated and deployed by one man. Operational availability requirements are critical for the Defense sector. Modular Mission Specialist technology allows operators to quickly swap modules in the field minimizing downtime, while maximizing operational availability. Ease of use is another requirement that is important in the Defense sector. Auto flight controls delivered in Greensea's OPENSEA platform have engineered the talent out of piloting, making it much easier to perform operations. This also reduces training burden and skill fade.

Kenney, L3Harris

L3Harris had fielded more than 300 Unmanned Undersea Vehicles (UUV) before the Iver4 product was introduced. Through many years of successful operations and engagement with the warfighter, L3Harris saw a gap in capability between small and medium UUVs. Small diameter UUVs did not have the endurance, modularity, safe battery chemistry, and mission performance the operators needed, but medium class UUVs were difficult to handle with a large logistics footprint. After years of prototyping, L3Harris released the Iver4 900 to meet the requirements of the operators. It delivered a small diameter UUV (<10inches) that matched the capability of the medium vehicles (10-21 inches) without the logistics and battery safety challenges that kept these vehicles from being used for critical EOD, Submarine, and Naval Special Warfare missions.

What are the specific tech attributes of your system(s) that you have found to be particularly attractive to the defense sector (please be specific)?

Kinnaman, Greensea

Both our platform and the technology we build on that platform have significant benefit to the defense sector.

We build all of our products and solutions on an open architecture software platform called OPENSEA. This is a commercially controlled open architecture software platform that enables the development of specialized capabilities leveraging existing robust solutions. OPENSEA provides the defense sector with a scalable, flexible, and severable platform that can respond rapidly to evolving requirements while maintaining the maturity of proven systems. We are using OPENSEA in several continuous integration and development programs where we are fielding new capabilities very rapidly, almost every two weeks, in mature software products to meet fleet requirements. This is a paradigm shift in defense technology development but essential for the modern fleet to respond to changing threats. An open architecture platform such as OPENSEA also allows the use of existing technology investments and provides a path for

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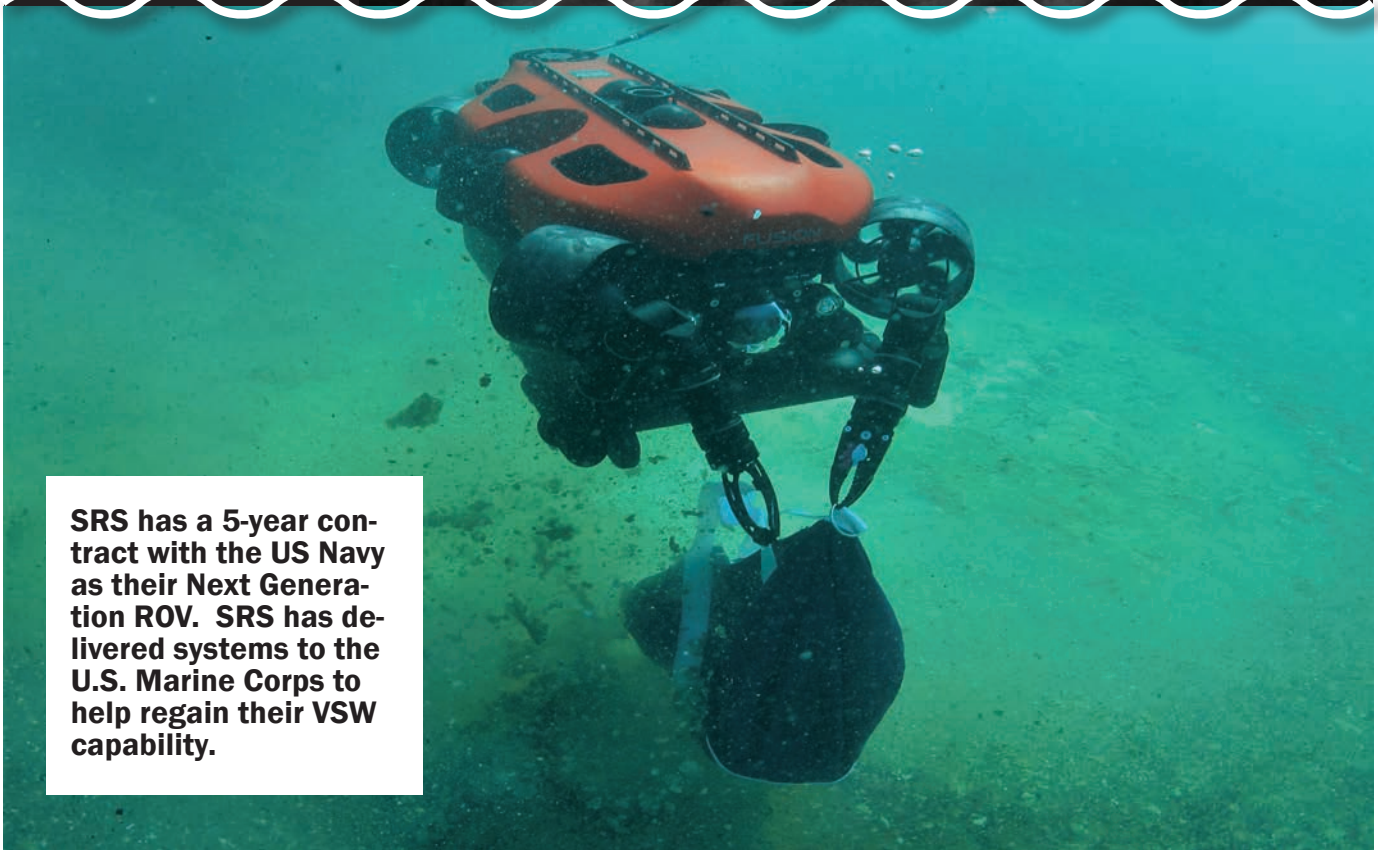
Jesse Rodocker,
President, Strategic Robotic Systems



SRS has a 5-year contract with the US Navy as their Next Generation ROV. SRS has delivered systems to the U.S. Marine Corps to help regain their VSW capability.

Photo: Strategic Robotic Systems

emerging technologies, regardless of the developer. This a powerful concept for the defense industry. Greensea specializes in technology that improves the way operators work with robotics. There are many application areas where robotics could solve tremendous problems, allowing our soldiers to be more effective and stay safe. Some of these most critical application areas cannot realize the full potential of robotics until specific technical problems are solved. These are typically navigation and localization challenges or control and autonomy problems. Often, the challenges could simply be the communication interface the operator is using to work with the robot. Greensea's technical products for the military provide novel solutions to these challenges. Our navigation technology optimizes the Size, Weight, Power, and Cost (SWaP-C) equation to provide exceptionally accurate navigation and localization solutions for constrained systems and CONOPS. A good example of this is our hull relative navigation solution we are developing with support from the US Navy Office of Naval Research. This is an open architecture navigation solution to provide 15cm positional accuracy for a miniature autonomous robot crawling on a ship hull.

Our control and autonomy technology specifically addressed the work-relationship of operators and robots. This technology provides robots with a high-level of control so that operators can have a smarter machine coworker. Moving more self-reliance, autonomy, and tasking capability to the robot frees the operator to be a Subject Matter Expert and conduct his job safely and effectively without having to be a robot operations specialist. This technology helps teams stay agile and helps minimize the specialized training for operators that has traditionally been required to field robotics for military applications.

Lastly, we focus heavily on the interface the operator has to communicate with the robot. Like our own relationships, the relationship an operator has with a robot comes down to communication. If he cannot communicate effectively the relationship is doomed. An operator needs to pass high-level instructions, receive concise and meaningful status, and execute quick accurate decision making. This comes down to the interface we provide for him to use.

To provide effective technology solutions to the warfighter, we have to listen carefully and then respond. OPENSEA provides us the ability to iterate on user interfaces quickly to find the best solution for our operators. We listen closely to what operators are telling us, and iterate until we get it right. This is the secret sauce and it is catching on the defense sector.

Gibson, VideoRay

Power and Control are probably the two most important attributes of the Defender. The Defender vehicle can lift more than 20 pounds of additional payload while maintaining stable flight. This power expands operational windows in high current or tidal areas where traditional ROVs struggle. The Defender can fly in pitch, which, for many defense customers, is a huge advantage. When you combine superior power with Greensea's OPENSEA control system, the operator can add unique payloads without needing to ballast or configure the vehicle for operation. The result is a powerful, flexible solution that a Navy can deploy as the operational environment dictates. When fitted with the Navigation package, the vehicle can mark and navigate very accurately to known points repeatedly.

Rodocker, Stratgic Robotics

FUSION is a completely different approach to UUVs and there are so many attributes that make a difference. Whats sets FUSION apart starts with the incredible attention to detail and thought that has gone into every aspect of the system. FUSION is built around specific sensors that are more tightly integrated through strategic industry partnerships. The user interface is recognized as the best in the industry. Completely battery powered system that doesn't require a generator and has a very minimal footprint requirement. The automation system is more stable, more precise and more intuitive. FUSION is both a ROV and an AUV. And to top it off the complete package is lower cost than our competitors.

Kenney, L3Harris

The Iver4 carries the highest performing navigation and imaging sensors available, while using swappable battery chemistries that meet flexible mission needs. The clean power architecture and signature mapping of the UUV ensure that the highest quality data is produced from the onboard imaging sensors. The unique, wet-mateable sections allow payload changes in the field that also ease commercial and military transport. The Iver4 provides an open interface and optional payload section for third party sensor providers to integrate their own hardware and software. Titanium and carbon fiber construction maximizes the useable volume in the pressure hull and decreases maintenance requirements when operating in harsh, open ocean environments.

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This virtual round-table was conducted with individual interviews with the four subsea industry leaders profiled here. The full text of each individual interview can be found on *www.marinetechnology.com.*