Sea Technology, December 2020
https://sea-technology.com/

The Law of More

How to Advance Industry and State of the Art for Undersea Vehicles

By Robert Wernli, Sr.

I've had the pleasure of writing several articles on underwater vehicles and technology for this magazine in the past. In a June 2006 Soapbox article, I compared the upcoming development of AUVs to Moore's Law, i.e., the number of transistors on a microchip doubles about every two years, while the cost of computers lowers by half, essentially forecasting an exciting time of advancement of AUVs worldwide.

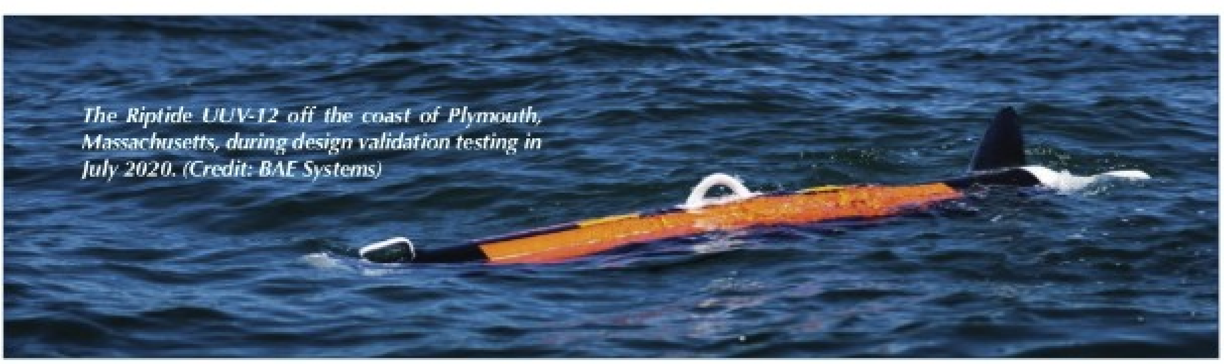
In the decade prior to my 2006 Soapbox, the use of AUVs was beginning to advance, but that was slowed by the financial crisis of 2007 to 2008. The academic community of researchers, however, continued developing smaller vehicles on tight budgets. Such successful developments led to spinoffs such as Hydroid (from the Woods Hole Oceanographic Institution's Oceanographic Systems Lab) and Bluefin (from the Massachusetts Institute of Technology's AUV Lab), two of today's most successful AUV companies, which will be addressed later in this article.

The larger-diameter AUVs, such as Kongsberg's HUGIN, were projected to possibly have only 28 or so operating by 2008. This slower growth was affected by the fact that they were very efficient in their planned surveys, especially when compared to towed systems. Because of such efficiency, companies like C&C Technologies were completing surveys so fast that the vehicles, at that time, were often sitting at the docks waiting for additional work.

On the military side, the focus was more on large vehicles, such as 21-in.-diameter systems that could be launched from a submarine's torpedo tubes. None of these were inexpensive endeavors—and they still aren't. The government and military are the users of about 75 percent of today's AUVs. Mine countermeasures (MCM) and intelligence, surveillance and reconnaissance (ISR) are leading missions in today's battlespace.

The U.S. Navy is still investing heavily in very large, mission-specific systems. One example is Boeing's Echo Voyager vehicle, the third in a line of large UUVs (the military's term for AUVs). It is a fully autonomous, extra large unmanned undersea vehicle (XLUUV). Because of its size (8.5 by 8.5 by 51 ft. without a payload) and energy capacity, it can be used for a variety of missions for months at a time. These aren't cheap vehicles; Boeing received a $274 million contract in 2019 to build, and deliver by 2022, five of these Echo Voyager-based whale-sized vehicles, which are appropriately named Orcas.

Another example of expensive programs is the Navy's desire to launch and recover AUVs from a submarine's torpedo tube. One such program was Boeing's AN/BLQ-


The Riptide UUV-12 off the coast of Plymouth, Massachusetts, during design validation testing in July 2020. (Credit: BAE Systems)

Iver3 AUV being launched from a RHIB. (Credit: L3Harris OceanServer)

11, which was a 21-in. heavyweight system capable of being launched and recovered from a submarine or a surface ship. This five-year $100 million program ended in December due to technical and engineering limitations, which has been the case in most sub-launched AUVs.

Miniaturization

The problem with so many government programs is that they are expensive, take a long time, and often end up depending on technology that has become obsolete. So, how do you solve such a problem?

One company that took these issues to heart was Riptide Autonomous Solutions, which launched in 2015 and was acquired by BAE Systems last year. They took a page from the decades-earlier playbook where the goal was to spin off the vehicles and technology from academic institutions and a few companies and develop a line of successful small AUVs. The problem was that the technology at that time had not advanced to a level of miniaturization to allow such cost-effective solutions, especially when taking into account the miniaturization of the payload and sensors required to complete the missions.

Enter Riptide with a goal of producing a micro-UUV for $10,000 initially. Optimistic, yes. Successful, also yes.

Sabertooth with underwater docking station. (Credit: Saab Seaeye)

By adapting the latest in low-power microelectronics technology and production methods such as 3D-printed titanium hull components Riptide developed an array of scalable vehicles, which have a nominal depth rating of 300 m. To prove that micro-UUVs can be used for full-ocean-depth missions, they delivered a 6,000-m-rated vehicle, without payload, to the U.S. Navy for $100,000.

Riptide's vehicles range from diameters of 4.9 to 12.8 in., with associated price ranges that are well below the norm, thus supporting the young company's sale of over 150 vehicles.

As previously mentioned, the government uses the majority of the smaller AUVs that have been developed, in addition to a few of the multimillion-dollar behemoths. But will the high level of government funding for the development of AUVs aid the commercial industry? The capability is there, so successful mission completion comes down to the payload, where industry plays a part. Endurance of vehicles, especially at deep depths, depends on enough onboard energy to complete the missions. Such advanced energy systems are being developed commercially. Electronics, software, camera systems, sonars and other instruments are shrinking dramatically, and these advancements are allowing payloads to match the physical capabilities of AUVs. Government/military/commercial/academic partnerships will support future success, and this will increase the use of AUVs for commercial and academic applications.

L3Harris OceanServer produces its line of small Iver AUVs that has an extensive array of sensors for various missions, are man portable, and range from 5.8 to 9 in. in diameter, with depth ratings from 200 to 300 m. Over 300 of the vehicles have been sold to date.

Bluefin Robotics, now a General Dynamics Mission Systems company, has produced a line of three vehicles that range from approximately 9-, 12- and 21-in. diameters up to 16 ft. long and with depth ratings from 200 to 4,500 m. They have sold more than 100 UUVs that can carry a wide array of sensors for defense, commercial and scientific missions. In addition, Bluefin is continuing the development of the Knifefish, a 21-in.-diameter, 19-ft.-long UUV for the U.S. Navy. The Knifefish will be a key MCM component of the littoral combat ships, which will each carry two of the AUVs.

Hydroid and its line of REMUS vehicles is now a part of Huntington Ingalls Industries. It has fielded over 500 AUV systems, from small to extra large, for a variety of domestic and international customers.

There are many other companies, labs and academic institutions that are also developing advanced AUVs, but listing all of them is not the intent of this article.

'Inter-Sea-Net'

So, where is this all going? Because of the COVID-19 virus worldwide, the employees of many companies are now working remotely at home, and this may continue for a long time. No one envisioned such a dramatic change. The technology was there, but the mindset wasn't. Things change quickly—it wasn't that long ago that a phone was a phone; now, what we carry with us can do everything except cook our meals.

Can such a change happen offshore? In my co-authored book "The ROV Manual, Second Edition," I project that an "Inter-Sea-Net" type of infrastructure is on its way. Why? Because the technology is there, and we just need to be pushed a little into using it. Not only do we have the technology, but, because of the hazardous offshore environment, there is a strong case to apply it so that things can be done remotely, especially during challenging times such as the coronavirus pandemic.

The elements of this infrastructure for remote operations already exist. There are hybrid AUV/ROV systems that can remain below the surface to conduct maintenance under control of a land-based operator. Underwater charging stations have been developed that can keep an AUV operating for months or years at a time. Resident vehicles, such as Saab Seaeye's Sabertooth AUV, can stay on site for more than six months. The hybrid AUV/

Naviator AUV. (Credit: Javier Diez, Rutgers University) (Below) Ocean Infinity's ships are each outfitted with five HUGIN AUVs. (Credit: Ocean Infinity)

ROV can be operated directly via a tether or pre-programmed to perform inspection, maintenance and repair (IMR), offshore surveys, and other tasks. The vehicle can use the docking station to recharge batteries and transfer data via satellite or cable to shore. Autonomous vehicle technology exists for underwater, surface and air vehicles that can allow them to communicate and operate as a team. Swarms of such systems, which could be remotely delivered, are on the horizon. The Aquanaut AUV, being developed by Houston Mechatronics Inc., can reach a remote site and change into a "humanoid" type of system. AUVs are also being developed to surface and become an unmanned aerial vehicle (UAV), such as the Naviator being developed by Rutgers University.

The requirement for mandatory use of surface ships to deploy vehicles is going the way of the rotary phone. The ability (and requirement) to control vehicles and systems from a remote land-based station will extend the Internet into the "Inter-Sea-Net."

Use It Heavily, Then Lose It

A battle cry I ended many of my past AUV presentations with was: "Now is the time to lose some AUVs." Why? Once something is used enough that it provides an excellent return on investment (ROI), you will usually replace it.

Therefore, the more you use your vehicles, the better the ROI, and, thus, the more vehicles that will be built, in turn, likely improving performance and driving down cost of ownership.

The first major AUV lost was Southampton Oceanography Centre's Autosub 2 that disappeared under the Arctic ice in 2005 after 382 successful missions. Now named the National Oceanography Centre, it figured the ROI was acceptable and has since built Autosub 3 (now retired), Autosub6000 and three Autosub Long Range vehicles, all with 6,000-m depth capability.

More recently, Ocean Infinity took on the job of trying to locate the lost Argentinian Navy submarine San Juan. The unique aspect of Ocean Infinity's operations is that its ship carries five HUGIN AUVs with a depth capability of 6,000 m that can operate as a team to reduce the search time. The submarine was located in November 2018. Ocean Infinity has lost two HUGIN vehicles, one last year in the Weddell Sea ice pack, and the other on the MH170 search. Two lost vehicles, and they're not cheap. Such losses are not all negative, though. According to RAdm. (retired) Nick Lambert (see his article on creating a national maritime security infrastructure in *Sea Technology*'s November 2020 issue), who was the project manager on the San Juan search and is co-founder and director of NLA International, which champions the implementation of blue economy solutions: "These are the technologies and systems necessary to understand our planet. If you don't use and operate them, then you don't stress test the technology and you don't push the boundaries."

Ocean Infinity has taken that to heart. It now has three multipurpose support vessels, all with five HUGINs, three USVs and two ROVs. They're also adding a fleet of 15 large Armada robotic ships.

According to Kongsberg, two other HUGINs were lost by other users, but that hasn't slowed Kongsberg, or the users, down any. They have fielded over 85 HUGIN and HUGIN Superior AUVs over the past 20 years. And considering that about two-thirds of Kongsberg's work today is with the defense industry and government, the probability of losing some more vehicles is certainly on the horizon.

Others have indicated a possible 2 to 3 percent loss rate, which seems acceptable because more and more AUVs are being developed.

ROI rules. It's time to lose some more AUVs.

The Law of More: Beyond Theory

According to Douglas Westwood's World AUV Market Forecast 2012 to 2016, the number of active AUVs in 2009 was 390, which increased to 560 active vehicles in 2012 and was projected to reach 930 by 2016. Other projections have the number around 1,000 vehicles operating by 2020, with about 75 percent on government and defense industry jobs. And this has become fact—just the number of vehicles sold by the companies listed in this article is well over 1,000. The majority of these vehicles are not necessarily small, but the technology is there, their numbers are increasing, and their size is shrinking. Most of the major AUV companies now have 6,000-m versions of their vehicles.

On the academic side, the advancement of technology to develop cost-effective systems continues to support the AUV market. There is no shortage of applications for future AUVs, and the number of vehicles, especially smaller ones, will increase, continue to support the various missions…and occasionally get lost. For proof, see my 2030 *Sea Technology* article, "2020 Hindsight and The Law of More." **ST**

Robert Wernli, Sr., a mechanical engineer, engineering consultant and writer, spent his career developing undersea vehicles and work systems at a U.S. Navy lab in San Diego. His most recent technical book is "The ROV Manual, Second Edition," and he has also published a series of techno-thriller novels (www.wernlibooks.com).