Norwegian company Eelume, partnering with Kongsberg Maritime and Statoil, has developed a novel AUV resembling a sea snake. (Photo: Kongsberg)

DEEP THINKING

Removing personnel from dangerous environments and taking over the work on 'dull and dirty' tasks, AUVs are seeing continuing advances and applications, both civil and military. **By Heidi Vella**

Planning and conducting safe and successful subsea operations requires great ingenuity due to the hostile nature of the environment, which is often torrid and has poor visibility, with many known and unknown dangers present.

This is why operations managers in a number of offshore industries now try to avoid using divers for subsea tasks. They are even eschewing ROVs, when possible, in favour of AUVs. The oil and gas industry, navies and other offshore operators have become progressively open to using the latter to conduct what are often referred to as the 'dull, dirty and dangerous jobs'. These include pipeline maintenance and inspection, underwater mine reconnaissance and hydrography. AUVs are proving safer, cheaper and more efficient in these areas.

Great leaps

The technology has also become increasingly sophisticated. Great leaps in computing, communications and energy solutions in the past decade or so mean that AUVs can now complete more intricate tasks independently, remain below the water's surface for longer and even stay subsea permanently, operating as and when needed.

OEMs consider this realisation of the 'digital ocean' concept – where a variety of independent technologies can be networked and function together in the water – to be the next step in offshore autonomy evolution.

However, technological improvements to power systems, subsea communications and operational capabilities are still required.

Increased safety and cost savings are the main reasons operators invest in AUVs. When conducting routine inspection or maintenance tasks of subsea infrastructure with ROVs or divers, contractors typically use a large support ship with full crew and equipment on board, costing thousands of dollars per hour. However, an AUV requires only a simple surface vessel to remain continuously in the ocean.

'That is why operators see a lot of cost savings and process effectiveness using autonomous technologies – they don't need a big ship to baby-sit operations,' said Carl-Marcus Remén, underwater systems sales director at Saab Dynamics. 'We see more AUVs being used in different operations that were not used before.'

One of Saab's most advanced AUVs is the Seaeye Sabertooth, which is a combination of Double Eagle Saab Autonomous Remotely Operated Vehicle (SAROV) and Seaeye technologies. Available in both single- and double-hull versions, it is designed for inspection and light maintenance and repair tasks.

Sensor tools

The company markets the Seaeye Sabertooth as a hovering hybrid AUV/ROV that can be used for subsea installations, tunnels and offshore survey work. 'The main purpose of the Seaeye Sabertooth vehicle is to carry different tools for sensors,' said Remén. 'We do a lot of collaboration with different vendors of sensors, so we can tailor and adapt our vehicles for different tasks.'

Its small size, tether-free operation and manoeuvrability permit easy and safe access inside and around complex structures. The system can remain at a subsea docking station for more than six months at a time without maintenance, so it is not necessary for a support ship to be on station, reducing operational costs. Powered by long-life batteries, the vehicle can swim autonomously to the docking unit, dock and, if required, connect to a tether for manual operation.

The docking node, according to the company, allows for data exchange, with sensor data and video uploaded to the surface and new instructions downloaded.

The Seaeye Sabertooth has a six-degree-of-freedom control system, which allows it to work closely around underwater installations. It also provides orientation capability to maintain stability, including in completely vertical positions. The vehicle can move through shafts or over gradients while attending to its light intervention work, survey or inspection task, according to Remén.

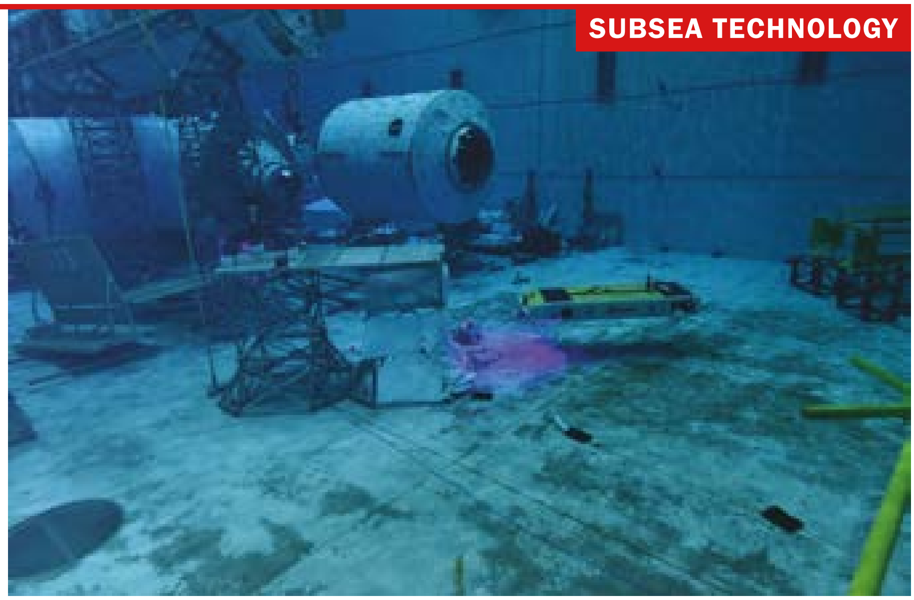
'As soon as you get into complex inspection work underwater, you need to have a good control system,' he added. 'The control system of the Seaeye Sabertooth is something we are very proud of at Saab and have implemented on many of our vehicles.'

The technology helped Hibberd Inshore, its first commercial user, set a record for the longest flooded tunnel inspection against flow at Rio Tinto's aluminium smelting plant in British Columbia.

Going longer

In terms of power technologies, advances have meant that operational times for an AUV are considerably longer compared to ten years ago, when OEMs were reliant on acid batteries to power their vehicles. Nevertheless, there are still challenges.

The automotive industry has greatly improved batteries for electric cars, with the development of lithium-ion cells. According to Remén, Saab has implemented advances from the motor industry within its own technologies and tailored them to the underwater environment.



Saab's Seaeye Sabertooth has a six-degree-of-freedom control system, allowing it to work losely around underwater installations. (Photo: Saab)

Enabling AUVs to remain subsea for long periods of time to avoid the cost of launch and recovery is an important, but relatively new, capability.

A collaboration between Eelume, a spin-off company of the Norwegian University of Science and Technology, Kongsberg Maritime and Statoil, has developed a novel new inspection and maintenance AUV system called the Eelume, which will live below the water's surface.

The concept is a set of self-propelled robotic arms resembling sea snakes, which can transit over long distances and conduct inspection and maintenance in confined spaces inaccessible to conventional underwater vehicles.

The technology, which is still in the test phase, is currently powered via a small tether, but the plan for 2018 onwards is to have batteries installed inside the vehicle to remove the tether. The batteries will be charged in a subsea dock to which the Eelume will return between missions, residing there for months at a time.

Richard Mills, director of sales for marine robotics at Kongsberg, said: 'It will be instantly available for routine and unplanned tasks, including inspection and light intervention.

'This means obvious cost savings for operators and reduces any health and safety risks associated with operating heavy equipment on board ships in potentially bad weather,' he added.

There will be system redundancy and the potential to operate multiple Eelume vehicles from a single dock.

One of a kind?

Furthermore, Mills said there are tasks that Eelume can do that no other vehicle can. For example, the small size and flexible shape enables it to access confined areas that have traditionally been difficult or impossible for other systems to inspect.

'As standard, it is equipped with two cameras, one in the front looking forwards, and a rotating camera in the aft section which enables the vehicle to inspect where it is going and look all around it.'

He explained further: 'Eelume 2 will be equipped with a grabber manipulator and a lightweight torque tool for valve operation. It will be capable of cleaning, picking up objects and more intervention tasks.'

For close inspection work and all intervention tasks, Eelume will be directly controlled by an operator. The system will require no maintenance and networks will be monitored continuously and notifications sent to operators should anything require attention.

The next demonstration of the Eelume concept will be in Trondheim in late 2017, with the first deliverable vehicle scheduled for 2018.

Mills said Kongsberg envisions that communication between Eelume and the surface vessel or offshore installation will ▶

happen via a high-bandwidth bidirectional system, comprising a mix of Wi-Fi, RF or optical techniques.

Communication is still one of the biggest barriers for AUVs. Acoustics are used to communicate in the ocean, but the constantly changing environment – temperatures, salinity layers, topography – dampens signal strength so it is hard to broadcast large chunks of data over a long distance.

'There is a lot of development going on around the world in regards to subsea communication – this is a boundary that every OEM would like to break,' said Remén.

Subsea communication is possible, but only at a low data rate. In the future, it needs to have a higher bandwidth because AUV sensors are becoming more advanced and the data needs to be transmitted, preferably in real time, while the vehicle is still in the water.

Presently, it is customary for data to be recovered from an AUV by bringing it to the surface and downloading it by radio or satellite. Alternatively, an AUV will send data to the operator on board a ship via underwater receivers using COTS technologies.


OEMs are slowly overcoming challenges in the AUV sphere, including power for long-range missions, and real-time communications. (Image: Saab)

Surfing the wave

Liquid Robotics, a Hawaii-based start-up that was purchased by Boeing a few years ago, believes its Wave Glider technology is the only proven USV for real-time ocean data collection and communications over long durations and in varying sea states.

Resting on the top of the water, the Wave Glider links the sea floor to the surface, creating a network to help solve some of the challenges of subsea communication.

'To communicate with, and to, underwater systems you need to have a platform at the surface of the ocean to bridge the air and sea gap,' said Graham Hine, senior VP for global partner development at Liquid Robotics.

'The Wave Glider, configured with acoustic modems or towing hydrophones, can act as a gateway or communications hub, if you like, by communicating acoustically with manned and unmanned systems, sensors and/or devices.'

Wave Gliders also come configured with redundant receivers that enable GPS capabilities via SATCOM. This enables the platform to provide navigation assistance for underwater systems, as well as overall navigation capabilities for the Wave Glider.

'If your AUV is inspecting a pipeline and needs to know its position precisely, or if it finds something that needs action, you don't want to have to bring it back to the surface to communicate,' explained Hine. 'With the Wave Glider at the surface, you can continue to have the AUV do its job and communicate without bringing the information back manually.'

When the Wave Gliders are far from the coast, the communications capability narrows to SATCOM. Near the shore, the Wave Glider can connect to a cellular network and get a high data rate and stream video and audio back to shore, however this cannot be done in mid-ocean yet.

'Getting real-time information from the deep ocean is a game changer,' continued Hine. 'This has been cost- and risk-prohibitive to do – until Wave Gliders you had to send expensive, large ships.'

Furthermore, the platform can transit itself across the ocean to a chosen location and then back. Many operators have yet to utilise this autonomous capability, however, because 'people are just used to doing it the old way'. It is something the company continues to demonstrate.

To launch from a large ship can cost around $50,000, whereas to allow the system to do it autonomously costs around $5,000, then the only other cost is that of communications, according to Hine.

Currently, Liquid Robotics works with many oil and gas majors, including BP and Shell, as well as the US Navy, for which Wave Gliders are being used to hunt submarines.

Better option?

Hine said Wave Gliders are cost-effective for the navy because they are cheaper than deploying boats, underwater systems or aeroplanes that drop drifting sonar buoys.

'When detecting a ship or a submarine, there is often an acoustic problem,' he said. 'The Wave Glider is a very quiet platform, it doesn't make much noise of its own, it does not pollute the environment and it can stay at sea for a very long time.

'Combine these and you have a platform that can stay in the ocean for long periods of time, listening for submarines, and ▶

upon detection can communicate in real time to alert authorities.'

Liquid Robotics has built around 400 Wave Gliders to date. They have a three- to five-year lifespan and cost from $100,000 – the price rising depending on the sensors configured on the platform.

Most OEMs agree that the future of AUV technology is many different autonomous vehicles communicating and working with each other, further reducing the need for manned assistance, enabling workers to be out of harm's way and concentrating on other more important tasks.

To demonstrate this concept, Lockheed Martin conducted a cross-domain C2 demonstration last year with its Marlin AUV, along with the Vector Hawk UAV and the Submaran USV developed by Ocean Aero.

The Submaran sent instructions to Marlin from a GCS via underwater acoustic communications and the Marlin then launched the Vector Hawk from a canister.

During the trial, the company demonstrated the capability to execute the navy's Rapid Prototyping, Experimentation and Demonstration (RPED) concept, by integrating the service's Topsides C2 system software with the Marlin AUV and Ocean Aero's Submaran USV.

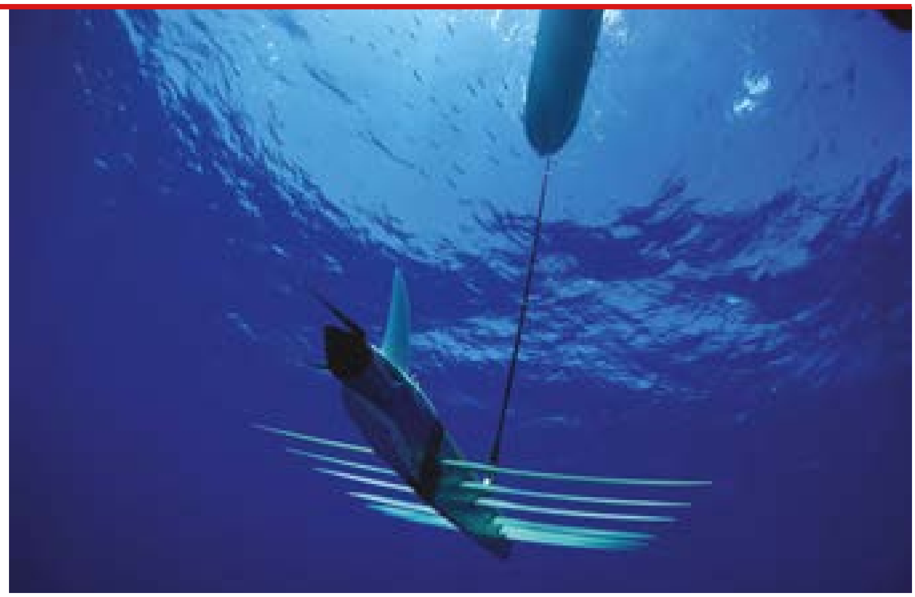
The company provided an awareness display for the Vector Hawk UAS culminating in a live multi-domain communication demonstration using existing COTS technology.

Coming together

'This cross-domain command and control demonstration marks a milestone in showing that an unmanned aircraft, surface vessel and undersea vehicle can communicate and complete a mission cooperatively and completely autonomously,' said Doug Prince, UUV business development at Lockheed Martin.

'The collaboration between remote operators and the autonomous unmanned assets allows for the successful completion of complex tasks, while the remote operators focus on other key aspects of a mission,' he added.

The Marlin system is designed for civil and military users to conduct subsea surveys and inspections using 3D sonar technology coupled with autonomous logic to build real-time 3D geo-registered models of the subsea infrastructure. These models can then be used by operators to make precise measurements and determine the absence or presence of damage.



Liquid Robotics' Wave Glider can be configured with acoustic modems or towed hydrophones, meaning it can act as a gateway or communications hub for UUVs. (Photo: Liquid Robotics)

Lockheed's demonstration is an example of the 'digital ocean' concept in action. In Liquid Robotics' vision for the concept, Wave Gliders will work with other manned and unmanned systems to form a system of systems.

'We are going to have unmanned satellite systems, unmanned aerial systems, unmanned underwater systems and unmanned sea floor sensors, all forming systems at sea that can do useful things like monitor offshore infrastructure, measure the environment and much more,' said Hine.

'There are some jobs that humans need to do at sea and it will remain that way for a long time – that is good,' he added. 'However, there are some jobs that are tedious and dangerous and are well suited to roboticisation. These are the kind of jobs unmanned systems can do, and if they can do it relatively cheaply and at scale it will open up the ocean to better economic and environmental management.'

He added that Boeing's Autonomous Systems group is now working to ensure interoperability between all its systems, and the Wave Glider will be a part of the technology offering.

According to Remén, the digital ocean concept will require increased monitoring and legislation if it is to be used safely and securely.

'As soon as you talk about unmanned technology, it is important to remember they must be safe,' he added. 'To develop technology takes a couple of years, but to get the legislation and rules and practice in place to use the systems safely is something that needs to be invested in. There is work ongoing now in different domains – both civil and defence.'

No one size fits all

It is also important to remember that there is not a one-size-fits-all approach.

'I think it is necessary to emphasise that there is no silver bullet – you need to have a little bit of a toolbox approach for the operators, both in military and civil operations, and implementing autonomous technologies is one kind of tool,' said Remén. 'I think there is always going to be a mix, because you never know what you are facing when it comes to operations in this harsh remote environment.'

For this, OEMs will need to take a modular approach so that different systems can communicate and operate alongside each other easily. Furthermore, to fully realise the digital ocean concept, increased collaboration between OEMs to integrate systems and break some of the technological barriers is going to be necessary.

'I think we all realise that what we have here is a market that is growing and all our energies are best spent growing and improving the overall market,' explained Hine. 'There are areas where you could use one of theirs or one of ours, but the largest effort should be in working together.' ■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