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Maritime exploration has long depended on vessels of impeccable structure and material selection to keep sailors alive. While some onboard personnel have become redundant with the advent of remotely operated and autonomous systems, UMs are still constrained by the properties of the substances used in their construction.

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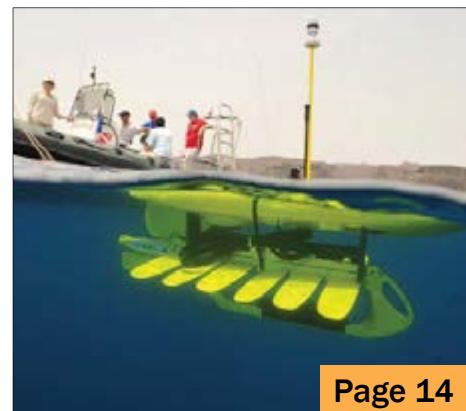
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Fresh from attendance at defence shows in India, Malaysia and Singapore, UV examines some new regional designs.

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UAVs have become a major media focus over the last decade, whether through their military use in Afghanistan or the work being carried out by Silicon Valley giants. Now, the sector is increasingly attracting the attention of investors. Gerrard Cowan talks to Andrew Chanin, CEO of industry specialist PureFunds.



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Front cover: A UAV's-eye view of the streets of San Francisco. (Photo: UV picture library)

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Richard Thomas, Editor

Risk assessment

You know an industry has hit the big time and is being taken seriously when the insurers move in and start competing to quote a price to cover your little commercial UAS business.

It marks the transition from prospective opportunity to an established market place and the point at which operators have to start taking into account the (perceived) more mundane administrative tasks that come with the job.

It is perhaps a journalistically less explored aspect of the immense boom in commercial operations, but the need for the lawyers and insurers to properly cover aerial platforms and their operators in the event of a mishap is clear and present.

Speaking to one vendor at AUVSI's Xponential in New Orleans, I learned how the UAS law firms found themselves both in great demand from the myriad of start-ups, but also slightly perplexed as to why the interest in obtaining a little bit of insurance wasn't totally universal. There are apparently operators out there that just don't think they need it, or else just looking to wing it.

Winging it?

Put it this way, if you're flying a nice \$5,000 UAS over an event (one that you have been paid to cover, I might add, none of this rogue operator stuff) it might pay to provide some sort of insurable and legal coverage in the event of a gimbal dropping off onto a parked Bentley or some other suitably precious target.

All joking aside, operating a UAS in an area where an accident could result in

If you're flying a nice \$5,000 UAS over an event (one that you have been paid to cover, I might add) it might pay to provide some sort of insurable and legal coverage.

physical damage to persons or property, only the foolhardy would ignore the risks. If you're looking to take your nice new work van out on its first job, or indeed, a new biplane out to dust some crops, it is part and parcel of the game in making sure that the paperwork is all in order.

And as with many other forms of insurance for manned transport (commercial or otherwise) a quote isn't simply a number pulled out of fresh air, but the result of determining risk based on background information on the operator, company or typical uses, to name but a few.

Fortunately, UV has written about this very topic just a few pages from here so, given that this is the beginning, middle and end when it comes to publications for the unmanned world, claiming ignorance of the fact is longer an option.

And while we are talking about Xponential, it might be an opportune time to talk about where this most

expansive of unmanned shows is headed. If anyone managed to catch the intro and outro videos on our show news site at www.shephardmedia.com, or indeed the general theme of the content, one could not help but notice the emphasis being placed on commercial operations and businesses.

Commercial opportunity

Whether in the guise of manufacturers, operators, maintenance, training, testing, the vast majority of discussion for better and worse was civil (in both senses of the word). What is interesting to note is how some normally defence-focused OEMs are creating commercial business units, solely focused on non-military functions and applications.

It might also be worth a mention of just how many of these commercial operators will be back for the show, and others like it, in 2017. Although the potential size of the market has been measured in the billions of dollars, likely future costs (either of a financial or administrative nature), and the sheer number of NewCos could well push some to the wall. ■

In the next issue

- Maritime UAS
- Navigation systems
- Tactical UAS
- Payloads

Legacy Black Hawks go unmanned



Sikorsky is pushing optionally manned capabilities.
(Photo: Sikorsky)

Sikorsky is on track to roll out the first UH-60A Black Hawk prototype fitted with optionally piloted capabilities later this year, company officials have confirmed. It marks the first time that a legacy aircraft, with no fly-by-wire capability, has been modified with a conversion 'kit' that enables the helicopter to fly with just one pilot, or even without any pilots in an unmanned role.

Unlike previous unmanned Black Hawk trials, the prototype will demonstrate that optionally piloted capabilities can be

integrated onto 'Alpha' variants or the current UH-60M.

Roll-out of the first optionally piloted UH-60A prototype – which Sikorsky bought from the US Army as an excess defence article – will be followed by first flight and a test programme starting next year, said Chris Van Buiten, VP of technology and innovation at the company.

'We have shifted our focus to making a prototype of the real product,' he continued. 'If you can show that you can convert [a UH-60A], you can convert any Black Hawk to an optionally piloted aircraft.'

The Alpha variant has what is known as a mixing unit, which takes the input from the pilot's flight controls and provides output, through mechanical linkages, to the main and tail rotors. Sikorsky will replace this with a computer-controlled set of electro-mechanical actuators that will enable autonomous flight.

This could pave the way for the technology to be inserted into the current UH-60M variant being built for the US Army and other nations, as well as updating older models. 'It's an exciting study that we are doing, and we're

sharing with different Black Hawk customers what is possible and how this technology can, pretty easily, be inserted into the aircraft,' he explained to *UV*.

'The army is interested in improving the safety of the platform, addressing obsolescence issues that keep the platform relevant in the future fight all the way to 2070,' said Van Buiten. 'They want to do more with less, and this falls in line with that.'

Supporting the technology development, Sikorsky continues to fly a modified S-76 it calls the Sikorsky Autonomy Research Aircraft, or SARA. That platform has now accumulated over 100 flight hours and Sikorsky pilots have gained a significant amount of optionally piloted experience on the programme. Two systems integration labs are also in operation in Stratford, Connecticut, where pilots can evaluate the optionally piloted technology and understand the safety improvements it enables.

'The idea in wartime operations of doing troop assaults using the flight crew hours and then transitioning to doing autonomous logistics and flying even more hours – it's a way of doing more with less,' Van Buiten concluded.

By Grant Turnbull, New Orleans

Robotic option for future US Army kit

Future procurements of vehicles or aircraft by the US Army will likely include the requirement that they have optionally manned or robotic capabilities, the general responsible for defining the future direction of the army has said.

Speaking to *UV* at the AUVSI Xponential event, Gen David Perkins, Commanding General of US Army Training and Doctrine Command (TRADOC), said the army would, in the future, require a platform that could be manned or unmanned 'depending on the situation'.

'If you have a situation where you need that cognitive ability, you could man it. If

not, it's unmanned,' he explained. 'We are not looking specifically for a separate capability like a robot to do this, we are looking at when you procure systems in general that everything has the ability to be part of manned-unmanned teaming or autonomous system swarms.'

Part of TRADOC's role is responsibility for the US Army's long-term vision, trying to describe what future the service faces and coming up with 'first order capabilities'. It released the army operating concept in 2014 titled 'Win in a Complex World', a strategic framework for the rest of the service to work towards.

Asked how unmanned systems fit into this concept, Perkins said that everything being done in the army related back to the army operating concept. Even though a fully autonomous system, such as a vehicle, is still several years away from being operational, there are already efforts under way to turn this into reality.

'You're seeing increments in the systems we currently have. We are looking at taking platforms that we have now and asking: "Can you robotise them?" We are confirming or denying concepts,' he said.

By Grant Turnbull, New Orleans



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More laser designators for Shadow

The US Army wants its unmanned aircraft fleet to have a greater role on the battlefield, including the vital job of laser-designating targets so that manned platforms – such as the AH-64 Apache – can unleash their guided munitions from safer distances but with the same effect.

The service is expected to award a contract this fiscal year for additional laser designators (LDs) for the RQ-7B Shadow, offering up the contract on a competitive basis to two sources annually until FY2018, when all funded units should have been procured.

There is a chance, however, that this procurement could run into a delay due to 'language in the appropriations bill', stating that the Secretary of the Army had to validate the LD strategy before awarding the contract.

'Which is fine, because we have a competition strategy and we are going to give that to the army, and let them validate it before we award the contract,' said Lt Col Tory Burgess, Shadow UAS product manager at Program Executive Office Aviation.

The strategy will see two companies compete against each other every year, for three years, to provide LD units to the army. These are Stark Aerospace, which supplies the POP300D that is already fitted to half the army's Shadow fleet, and



The RQ-7B has seen extensive operational use.
(Photo: US Army)

L-3 Wescam, which could provide its MX-10 EO/IR sensor.

The latter company won the competition in 2012 to be the second source of LD payloads, and its MX-10 was integrated and qualified on the Shadow. This year, several government-owned, contractor-operated Shadows will deploy to theatre with the sensor, said Burgess.

Currently, two out of four RQ-7B Shadow aircraft in a 'system' have a laser designator incorporated into their EO/IR sensor. Influencing that decision has been the army's Aviation Restructure Initiative, which divested the OH-58D Kiowa Warrior armed scout helicopter, and calls instead for the RQ-7B to be forward-deployed and

linked with the AH-64 Apache, in what is known as manned-unmanned teaming.

As well as adding new payloads, the US Army is also upgrading or adding new technologies as part of Shadow v2, including Type 1 encryption protection on video and control data links, STANAG 4586-compliant software and an endurance increase from six to nine hours.

Despite this, the army still has a requirement for more LD units. 'We've made an unfunded requirement request to the army, as we do every year, saying that if you would like to finish off having every Shadow with a laser designator, we are short 66 payloads,' Burgess said.

By Grant Turnbull, New Orleans

India needs more MALEs

India's MoD will issue an RfI within a month to solve a pressing requirement for MALE UAVs, as revealed by AVM Sandeep Singh, the Indian Air Force's (IAF) Assistant Chief of Air Staff (Plans), at a Delhi seminar on 19 April.

The RfI is likely to go to Indian companies including Alpha Design, Larsen & Toubro, Mahindra Defence Systems and Tata, who could collaborate with OEMs such as BAE Systems, Elbit Systems, IAI or General Atomics, for unarmed MALEs. An RfP is expected in six months.

Approximately 100 MALEs are needed for the IAF and Indian Army. Singh told UV the 'urgent requirement' for MALEs are those 'in the non-weaponised class'.

The reason why India is issuing this tender is because of a more than two-year delay in the indigenous Rustom II MALE. Singh said: 'Our requirements are large... When the indigenous design comes up, we will have adequate numbers for it.'

By Neelam Mathews, Delhi

UMS Skeldar gets flight approval across Norway

Norway has granted UMS Skeldar the right to conduct commercial operations countrywide, excluding certain restricted zones such as airports and urban areas. This approval extends to beyond visual line of sight operations.

Following a series of demonstration flights in collaboration with Nordic Unmanned, UMS Skeldar and its in-country partner will be able to perform missions such as infrastructure monitoring and survey, and officials also say there could be potential for similar agreements in other European territories in future.

Speaking to UV, Carl Foucard, deputy head of business development and sales

at UMS Skeldar, said that the trials demonstrated handling, avoidance and flight capabilities working around complex environments, such as utilities.

Meanwhile, prospects in North America will likely have to wait until next year at the earliest for UMS Skeldar, as it focuses on a near-term, sales-driven programme. Foucard said that although there were potential programmes of interest for the company, these were not the focus for this year. 'Our products would fit, but it takes investment. It is very competitive and we think we can get sales [instead] in Asia-Pacific, Latin America and the Middle East,' he said.

By Richard Thomas, New Orleans



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ASSET PROTECTION

Insuring a UAS can be very similar to getting cover for any other aviation platform, depending on what the operator intends to do and the type of policy they require. However, there are some key areas of difference, not least regarding the perceived growth potential of this burgeoning sector.

By Gerrard Cowan

The commercial UAS sector has rapidly expanded over the past few years. Plans announced by Amazon and other large companies to deploy unmanned systems for deliveries and other activities are just the tip of the iceberg. Globally, UAS are being used for everything from wedding photography to construction work. Not only are companies springing up that specialise in operating the systems, but firms in other sectors are acquiring UAS to operate by themselves.

Growth sector

This has led to growth in the industry that insures these systems. US-based Transport Risk Management is a major player in the aviation insurance market. The company's founder and president, Terry Miller, told *UV* that his firm is also a large insurer of aerial film production, which naturally led the company into the unmanned market about five years ago, with film work representing one of the major areas of work for UAS. Since that time, the firm has insured

Commercial operators have to consider insurance issues when carrying out flights. (All photos: UV picture library)

around 5,000 UAS made by 25 manufacturers worldwide. UAS now represents about one-fifth of the company's gross revenue.

Miller compared the growth of the sector to the rise of the personal computer, in terms of the speed of its development. Indeed, many of the people who were involved in the PC business are now heavily involved in the UAS industry, he said.

'They have told me – they're partners and clients of mine – that they see this as parallel to that type of technology,' he said. 'And I would agree with that.'

Other companies in the insurance sector have noted the growth potential. 'In many ways, the sector is similar to smartphone technology, in that it undergoes significant change every six months to a year,' said Grant Goldsmith, president of Overwatch, a US broker that is part of Avalon Risk Management.

'Something today that you wouldn't even consider using a drone for becomes ubiquitous a year from now,' he said. 'I think there's many people that are using a drone in their business or that want to use a drone in their business.'

Overwatch focuses on emerging risk markets. It does a lot of war zone-related work, as well as insuring other types of emerging technologies, and it is mainly focused on the US market. It had been doing UAS work on a case-by-case basis up until 2010, when it decided to make a concerted effort in the market. Like the industry itself, the insurance side was quite small at that stage.

'When we started looking at it in 2010, it was very underserved,' he told UV. 'In 2010, you could buy some drone insurance from London markets, but at that time the minimum premium was \$10,000, sort of in that range... a smaller buyer in the US would really need the pricing at around \$1,000 for using a small drone in conjunction with their business. So that's why we knew that we would have to help the markets develop some products stateside to fit that pricing point.'

The company was working with UAS users from a wide range of sectors, Goldsmith said. 'We see a lot of aerial mapping, GIS [geographic information system], we see commercial roofing companies that want to survey the roof of your house rather than

putting someone on a tall ladder. We see of course aerial photography companies. Hollywood is using a lot of drones. But we also have farmers using drones to check the irrigation of their fields... there's just so many people that want to have access to some kind of an aviation asset to use within their business.'

The insurance policies required for operating UAS are very similar to the types of policies needed if you were to operate a fixed-wing aircraft commercially, experts say. An operator would generally take out third-party liability coverage and sometimes would take out hull cover to protect their own UAV, particularly if they are operating expensive equipment.

Standard assessment

Miller said there were three basic criteria that the company applied when assessing risk. 'Does the aircraft operator or pilot, the aircraft type and the aircraft use all make sense? If those three components fit, then it's probably something that we would insure... if any of those three pieces do not fit, we would decline.'

Goldsmith said that underwriters will determine in their questions what the exposure might be to having a collision with people, particularly where operators are describing their work as aerial or wedding

photography, or anything involving events with large numbers of bystanders.

'They're going to ask specific questions with respect to how you're doing that and they will often put an endorsement on the policy that prohibits coverage or overflight of large public gatherings, just to let you know "we don't want to cover that risk".'

Chris Arnold, a broker at aviation insurance broker Sutton James, echoed this point. Underwriters were concerned about UAS being used around large groups of people, he explained, where third-party exposure was heightened.

'The thing that worries them the most is people operating at events around large crowds,' he said. 'That's the big thing that scares the insurance companies, that a lot of the smaller operators never even think about. They just think that they have a UAV so they're going to go out and film music festivals and film weddings, and those are the things that really do scare the insurance companies.'

Arnold said that a lot of insurance companies will try to find out the nature of the work when they carry out their initial underwriting, 'and if that's a big part of your plan and if you plan to do a lot of events and things of that nature, then that will affect how they underwrite the risk'. In fact, some may not offer insurance at all. ▶

Sizeable platforms used for commercial operations, such as monitoring or event photography, can weigh several kilograms and cost thousands of dollars.



'They might say: "This is a risk, we don't want to be involved in something like this, so we're just not going to offer a quote".'

Mark Dombroff is a partner at US law firm Dentons, which has a large aviation practice and identified UAS as an area of potential growth about three years ago. Dentons is counsel to the UAS Insurance Association.

'The mission of the UAS Insurance Association is to inform, to educate and to give a voice to the... UAS insurance industry and where appropriate advocate on their behalf,' he said.

Risky business

There are a number of key differences between UAS and other forms of aviation that insurers need to get grips with, Dombroff said. For a start, the general aviation insurance market has been around for a long time, meaning insurers have a very large statistical database by which they can assess the risk – they know what the risks are and they know how to set the premiums. This is not the case with UAS, which is a new market that lacks the same statistical database.

'You've got a lot of first-time operators, first-time users and first-time manufacturers, so really it's an issue of assessing who is the manufacturer, who is the operator and making some

Insurers have to weigh up each request on individual merit and calculate the risks involved. Sometimes, this means insurance is not offered.

judgements regarding how they set the premiums, until they build up this database,' he said. 'But you can't rush experience – it just takes time.'

Another key difference with insuring UAS surrounds the nature of the operators themselves. Unlike in other types of aviation, an operator is not necessarily an experienced aviator – he or she could just as easily be an entrepreneur looking to break into a new market.

'[They are] entrepreneurs, they're start-ups, they're people who are entering the regulated world of aviation in all of its risks for the first time,' Dombroff said. 'As a result, they need to be informed and educated as to not only the nature of the risks, but the nature of the way that they can mitigate those risks, both through contracts and through insurance.'

There were different levels to this challenge, he said, with giant corporations at one end of the spectrum and wedding photographers or property companies at the other. 'And then you've got a lot of people who just see a business opportunity... the start-up costs are not very high.'

Goldsmith agreed: 'The most unique factor to flying a UAS is that the pilot in most cases is not going to be a qualified commercial pilot in the traditional sense of having gone to flight school.'

He also identified another major difference, related to the fact that the unmanned nature of the systems could lead to riskier behaviour. 'These systems are more or less disposable aviation and as such, pilots and operators may take greater risk with them than they would if their actual life was on the line, if they were flying themselves.'

Privacy protection

An area that is largely unique to UAS is the concerns surrounding privacy, said James Gadbury, COO of UK-based UAV-Protect. His firm offers a privacy product, designed to cover a company in the event that it was pulled into a lawsuit because someone deemed it to be trespassing or infringing their privacy. This was the type of thing that no one really thinks about in the manned aviation sector, he said.

'I think the difference is that drones at the moment typically fly at between 0-500ft, so it's the kind of proximity of them, it's the fact that people can see them... a manned aircraft is going to be sufficiently high enough in the sky to not have anyone worrying too much about it.'

UAV-Protect is part of Prospect Insurance Brokers. Prospect has been involved with UAS for a couple of years now, Gadbury said, but set up UAV-Protect at the beginning of 2015 as its vehicle for targeting the sector. Since then the business has grown quite rapidly.

Insurance is very international in outlook and the UAS part of it is no exception. For example, UAV-Protect has seen its business grow in a number of countries outside the UK, including Canada, Ireland and Italy, Gadbury said. UAV-Protect will work with a broker in each of these countries who sends submissions for the company to quote. It is also growing its interests in the US, where it is partnered with All Risks.

'We're looking to form relationships with other brokers and start to build up a kind of web of different brokers who are providing it locally,' Gadbury explained.

Likewise, the UAS Insurance Association has an international feel to its membership, Dombroff said. The association's founding board includes Germany-based Allianz, for example, along with a number of other major names in the insurance sector, including ►





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AIG and Transport Risk Management. This has also moved in the other direction, with a number of board members based in the US but overseeing significant operations in other countries.

'In some instances, probably in all instances, they have US operations, but their corporate headquarters may not be in the US. Allianz Aviation is based in Germany, but they have a very large US aviation operation. AIG Aviation is based in the US but they have a very large European, London-based operation,' he added.

Not every operator at this stage believes it is necessary to get insurance. Sutton James has seen a lot of interest in people who are looking for quotes, but 'not necessarily a whole lot of people that are really buying insurance as of yet', said Arnold.

'We see a lot of people that aren't so sure if they need it or not. Their thought process is that these drones are so small that they're not going to do that much damage. I've heard that from numerous people.' Part of the reason for this may be that 'people are just in the planning stages at this point trying to figure out if this is a viable business'.

However, he said that the volume of interest was picking up and that people are at least starting to question it and look and see what's available. Arnold expects to see the insurance side growing in the coming years and that while many people did not currently think they needed it, this would change as claims were made. 'People are really going to realise that these [UAS] can do a lot more damage than they think,' he said.

Goldsmith agreed that the insurance business still had to catch up with the size of the market as a whole. 'I would say we're still a little bit on the cusp. I still go to a lot of trade shows where people are surprised that they can buy insurance at all. They're still operating under the notion that the risk is uninsurable. So we're trying to get the message out.'

Still, he was confident the market would grow. He envisions a future in which companies can buy UAS insurance as an add-on to a general business commercial insurance product, without having to go to a specialist aviation market.

'That's going to do two things. It's going to pull that risk really from the special



Many operators are not sure whether they need to obtain the necessary coverage, say insurers.

aviation market and they're going to ultimately write less of it,' he argued. 'And it's going to put that risk back on the desk of insurance generalists... those generalists without specific aviation experience are going to have to struggle to decide how to write and price this product.'

Affordable costs

The cost of an insurance policy clearly depends on a number of different factors. Still, Dombroff insisted that UAS policies were affordable. 'Insurance is not going to – and should not – represent a barrier to entry into the commercial use of UAS. I think it's a necessity if you want to be a responsible operator, but economically I don't believe that the cost of insurance should represent a barrier to entering the market.'

He said that people who hired a UAS company would expect it to have appropriate insurance cover. 'It's no different to the homeowner who has their roof redone – they have a house built, they have contractors on their property, or the chemical company that has somebody come in to do repairs,' he said. 'You want people on your property who are not only good at what they do but financially responsible, so if something

goes wrong they've got insurance and you're protected.'

The insurance industry is keenly aware of the potential for growth of the commercial UAS business. Dombroff compared it to the fixed-wing sector, which has developed over the course of more than a century, since the Wright brothers flew their aircraft in 1903. He said that on a scale of one to a hundred, in terms of maturity, the general aviation industry was probably close to or at 100.

'There's always advances being made, but it's a very mature industry. If you look at UAS, however, the drone industry, certainly the commercial drone industry, it's probably at the 15 or 20 level. So it's really in its infancy. It's sort of in kindergarten or first grade, as compared to being in graduate school.'

Dombroff pointed out that while the technology has been around for a long time, with militaries of many nations flying UAS for years in the defence context, the technology has only been commercialised relatively recently.

'It's on that commercial side that we're still in elementary school,' he said. 'But it's growing very quickly because it's not going to take 113 years to get to higher levels of maturity and growth.' ■



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Watchers in the water



Searching for the Holy Grail of complete security for port operations, authorities are turning their gaze to what the unmanned industry can contribute in a layered, system-of-systems approach that complements existing capabilities. **By Richard Thomas**

The improving technology of USVs, UUVs and AUVs in terms of endurance, payloads and data dissemination has pushed such platforms into new markets and opportunities, assisted by a growing understanding among port authorities in what they bring to the party.

Whether it is a USV tacking back and forth along a pre-planned perimeter route keeping a watch out for the small signatures that betray the presence of something or someone lurking beneath

the waves, or an AUV or UUV operating around the breakwaters monitoring the harbour bottom, these systems have a role to play.

Companies such as Bluefin Robotics (and its parent General Dynamics), Liquid Robotics, Saab and VideoRay, to name but a few, are all investing time and resources in exploring what commercial potential maritime unmanned vessels have to offer.

Speaking to *UV* at AUVSI's Xponential exhibition in New Orleans, Dan Middleton, EVP of global sales and business

development at Liquid Robotics, described the role that they could play in the overall strategic security plan as being the 'outer layer'. The company is working with an unnamed port authority to explore how its platforms, such as the SV3 Wave Glider, could operate and thinks that the sector in general holds a promising future.

It is a theme that has been oft repeated by those working in the unmanned industry, which in terms of maturity is still in its relative technological adolescence, particularly with land and marine-based

The Wave Glider could operate as the first line of detection in a combined approach to port and harbour security. (Photo: Liquid Robotics)



systems, when compared to the maturity of manned alternatives.

Nevertheless, as Middleton said, larger USVs and AUVs can suit the role of first line of defence or inshore watchman capably, and civil maritime authorities are at the very least keeping a close eye on industrial developments.

Leveraging experience

Bluefin Robotics is leveraging years of experience operating its family of AUVs such as the Bluefin-21, Bluefin-12D,

Bluefin-12S, Bluefin-9M, Bluefin-9, HAU and SandShark. While all systems listed could perform a role in ensuring port security, the 9M, 9 and HAU would find themselves operating closest to shore.

At the top end of Bluefin's products in terms of endurance are the 12D and 12S, which are able to maintain themselves on station for up to 30 hours (for the D model) at a time. Mobility for the family is most often provided by ducted thrusters.

According to company information, the 9 and 9M variants typically perform a variety of roles including: inshore survey; environmental protection and monitoring; mine countermeasures; port and harbour security; unexploded ordnance disposal; rapid environmental assessment and ISR.

The 9M has a length of 2.5m (compared to 4.93m for the larger Bluefin-21) and is sized to operate in the tight confines of commercial or military ports and harbours. A ten-hour endurance is achievable when manoeuvring at 3kt, although this reduces when the platform reaches its top speed of around 5kt. Multiple payload functions are possible, including a side-scan sonar (Edge 2205), multi-beam echo sounder, sub-bottom profiler and EO camera, covering roles ranging from MCM to hydrographic survey.

The HAU, the smallest vehicle in the portfolio, covers roles such as ship hull inspection. Equipped with a high-resolution imaging sonar, it can search out imperfections or faults on a vessel in a fraction of the time it would take a diver to complete the same task. Using this sonar, it can survey with minimal prior knowledge, and although capable of conducting autonomous tasks, it can be switched to manual control for closer inspections by the operator should something of interest come to light.

Functional family

Kongsberg Maritime, through its subsidiary Hydroid, has a family of AUVs capable of functioning in port and near-port environments, mapping and monitoring designated areas. The REMUS 100, 600 and 6000 models offer differing levels of capability and over 250 of them have been delivered to civil and military customers around the world. Functions include aiding maritime security, hydrography and marine research.

The HUGIN and MUNIN AUVs specialise in monitoring and hydrography and are also capable of search and recovery, particularly the former platform. Defence applications for the HUGIN include MCM, environmental assessment and ISR. The MUNIN, with its more compact design, allows for operations from smaller launch vessels, although in not as capable a platform for defence and security purposes as its larger cousin.

According to information from Kongsberg, HUGIN payloads can include: a high-resolution interferometric synthetic aperture sonar; an EM 2040 multi-beam echo sounder; a side-scan sonar; a sub-bottom profiler; a still image camera; and turbidity and methane sensors. Kongsberg states that one of the key characteristics of the HUGIN payload system is that all sensors can operate together and the time-stamped data makes accurate geo-referencing easier.

ROVs can also be fitted with sensor capabilities, such as Kongsberg's EM 3002 multi-beam echo sounder, which when installed surface-facing can scan for threats attached to ship hulls and conversely assess potential risks and boost port security by mapping harbour and port beds.

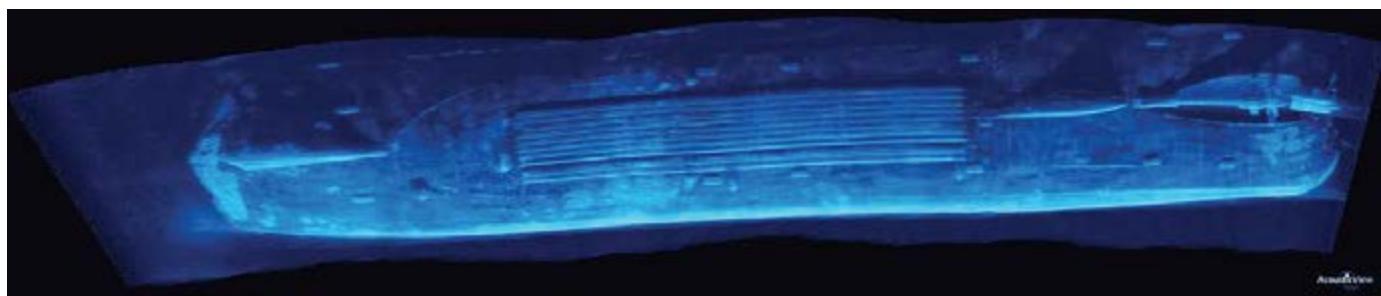
There is also a perception in the marine industry that unmanned solutions will remove the person from the equation, and in the most basic sense, cost him or her their job. This need not be the case, according to Rand LeBouvier, strategic communications director at Bluefin Robotics, speaking to UV at Xponential 2016.

'A seaport due to accept a cruise ship will send divers along the pier before it arrives and this is not always 100% reliable and it is dangerous. Our Mk 19 [HAUV] system can inspect those pier pilings very quickly and efficiently and provide real-time data and make changes if something has been placed.'

'We are not replacing the divers – we are keeping them out of harm's way. That's the key, you don't want to put those guys out of business. We need to convey the message to them that they can do ten jobs instead of one job [using unmanned systems] with those divers and make more money.'

Commercial approach

Speaking to UV earlier, officials from Liquid Robotics said that for port security, whether it was underwater or on the surface, it ►



ROVs are commonly used to inspect ship hulls, a process that some think could be expanded to reduce dry-dock periods. (Image: Bluefin Robotics)

was important to provide 'layers of detection' for site defence. To that end, a fleet of Wave Glider USVs could be configured 'in a picket fence formation', holding station and silently listening outside the port and away from the background noise created by merchant shipping traffic.

In this way, real-time early warning of suspicious vessels and communication to the authorities for interdiction could be enabled. Platforms such as the Wave Glider can operate for months at a time monitoring the seas.

The company was also 'actively engaged' with the US and other navies and coast guards in providing new submarine detection capabilities.

A spokesperson told UV: 'In the past, this level of persistent, long-duration coverage was not cost-effective or feasible using manned assets such as ships, planes or subs. The majority of applications we see at this time for underwater detection are offshore military missions for ASW surveillance. We are seeing a new trend emerge, however, where

there is global interest in deploying USVs to monitor coastal areas and maritime borders for illegal drug or human trafficking. Targets of interest here include high-speed surface vessels such as "Panga" boats and semi-submersibles.'

Discussing the system-of-systems approach with UV, officials at Liquid Robotics said that offshore USV surveillance can be combined with satellite data to identify threats or suspicious activity at the outer edge of a perimeter. The platform can collect traffic data over



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time (thanks to the enduring advantage unmanned systems have over manned capabilities) for analysis, which is then integrated with radar, communications and other inputs to optimise the deployment or response of inshore assets such as boats, aircraft or onshore personnel.

'Through this approach, one can offload the dull and dangerous tasks of offshore surveillance to unmanned systems. This reduces the risks to personnel, reduces operational costs and increases the efficiencies of the overall mission.

Missions can now deploy robots to patrol day or night, through all [types of] weather to listen, see and alert coast guards, navies and homeland defence to send high-value manned assets for interdiction,' said the spokesperson.

The use of unmanned assets was therefore changing the manner in which the world addresses maritime surveillance, monitoring and observation, the official added.

'Wave Gliders can stay at sea for months or up to a year, collecting and communicating data in greater densities and resolutions over vast coverage areas and over seasons... This level of long-duration persistence is not economically practical or safe with manned systems. A new frontier is emerging for ocean robotics that will positively change maritime surveillance.

'Today the Wave Glider carries sensor payloads including towed acoustic sensors for surface and subsurface vessel detection, and deck-mounted payloads, including an AIS receiver to help identify legitimate vessel activity and an HD camera for close-range visual identification.'

Business models

Bluefin Robotics is meanwhile pushing ahead in securing customers in the commercial market, using a combination of models such as fee-for-service, franchising and direct sale to companies currently performing harbour inspection work. This is primarily focused on the HAUVE, although officials did say that all its systems could be of use in securing a port, such as the SandShark AUV surveying the littorals.

The representatives told UV that although it was not an industry it had to date penetrated, it had technology

that was 'immediately applicable' and that it was now a matter 'of talking to the right people'.

An advantage for the civilian market is that militaries have already tested many of the same platforms in port security and harbour survey roles. It is just a case of shifting the approach from a defence perspective into a commercial one.

There are also unexplored cost savings coming to light, according to Bluefin, in other uses such as vessel hull inspection, a

time-consuming and expensive process for merchant shipping companies. By using an AUV or ROV to perform the inspection while the ship is in the water, even unloading containers in port, would be of significant value to the ship owners.

The benefit is more than just a map of the ship hull – that certainly has value – but there are also requirements for ships to periodically undergo thorough inspection, and this usually means dry docking. This is an expensive process not only in and of

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In US trials, the VideoRay Pro 4 would attach floatation markers to a suspicious object, enabling it to be dealt with later by dive teams. (Photo: VideoRay)

itself but also in terms of the lost time that the ship is out of commission.

'So the model, the fee for that type of business, may actually end up being smaller than they would end up paying if you look holistically, and not just at threats like limpet mines attached to the hull but also ship husbandry.'

Military sense

Unmanned systems are also being used by militaries, eager to protect their sleek grey-hulled assets from unwanted attention, for harbour security.

In May, personnel from the Royal New Zealand Navy (RNZN) conducted further training exercises with a Saab Seaeye Falcon, regularly used by the service for

reconnaissance and security duties. In a release issued at the time, a senior naval officer was quoted as saying that this type of ROV had been used for 'security reconnaissance for harbour inspections, hull inspections, mine location and disposal', in addition to operations further out to sea and in inland lakes and other water bodies.

Another officer was quoted in the same release stating that 'remote technologies are highly valued for the range of options they provide', and that since its entry into service the RNZN has utilised 'an observation-class' ROV to conduct a variety of operations, including hull inspections. The Falcon has a 300m depth rating, obviously far in

excess of what is needed for port operations, and a 450m umbilical cord which can be extended to 1,100m when using a fibre-optic pack.

Vectored thrust, high optical sensor fidelity and a 14kg payload capacity make this platform well suited to a range of operations, as the RNZN can testify.

Other naval operators of ROVs and AUVs for port security include the US Coast Guard (USCG) and the Department of Homeland Security, tasked with port protection. Operating VideoRay's ROVs and unmanned systems at a number of ports since 2003, the USCG has used the platforms for ship and harbour inspections, according to the US-based manufacturer.

VideoRay is among the most active distributors of ROVs around the world, with more than 3,500 delivered to customers.

Additionally, and contrary to much of the suspicion laid at the ROV's anthropomorphic feet, they have been used to complement, rather than replace, manned dive teams in providing information ahead of a deployment.

Navy trials

The US Navy also trialled the VideoRay Pro 4 ROV last year to counter the risks posed by waterborne improvised explosive devices (WBIEDs). According to the company, a US Central Command UOR saw two initiatives sponsored to this end. VideoRay was chosen for the Joint Improvised Device Defeat Organization (JIEDDO) initiatives

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The programmes' assessment phase 'aims to identify mid-water and swimmer threats attempting to enter a security perimeter through a USV/ROV combination', states the company. The next stage of the project is to develop a mine neutralisation capability, also known as Submerged Threat Identification – Neutralization (STID-N).

When equipped for this role, VideoRay says that in addition to the original configuration of the Pro 4, a manipulator arm is fitted to the ROV's skid, allowing the platform to carry both payload and floatation package to the target location.

In 2015, Bluefin Robotics announced that it had delivered the fourth and fifth 'ship hull inspection systems' to the USN, which comprises two HAUVE vehicles and support equipment, to develop search capabilities for harbour sea floors and other underwater infrastructure.

LeBouvier said that the system, known as the above-mentioned Mk19, can inspect

piers quickly and efficiently while providing real-time data to operators.

'[General Dynamics] has a very good idea for how they would approach port protection in a holistic way that incorporates not just unmanned systems but above- and below-water sensors as well, to provide a very, very robust package. It is ready to go; it's just a matter of finding the right person to acquire it.'

'There is a market for it and it doesn't have to be expensive. It could be a regional capability rather than one installed from port to port. So, for example, a US Coast Guard area commander could have them and then deploy quickly. It's sort of inimical to making money but it is the right stewardship way to do it.'

Crystal ball challenges

That's not to say there are not details that still need to be ironed out. Officials at Liquid Robotics say that despite the capabilities USV and UUV platforms have in adding to a layered approach to port

and coastal site security, 'near-shore detection of quiet electric submersible vehicles remains extremely difficult', especially in high-traffic areas.

While widespread use of USVs, AUVs and ROVs providing or adding to port security, certainly in the commercial and civil sector, has not been witnessed to date, there are nevertheless signs that both suppliers and customers are beginning to see the possibilities in having assets patrolling, just a few cool feet beneath the waves.

Both sides of the industry are learning how they can apply unmanned thinking and capabilities to domains that previously were generally confined to static sensors and manned (sea and land) patrols.

'There is a market and interest in particular from some of the oil-producing countries and countries that depend entirely on commerce via the sea. The challenge now is not developing the technology, it is putting it in place and developing the CONOPS to make it work,' concluded LeBouvier. ■

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Use of IEDs in recent terrorist attacks in Europe illustrates the importance of teams and technology deployed to neutralise this threat. Top of the list of critical equipment for such missions is the UGV, which can be deployed to find, fix and neutralise suspect devices while operators remain at a safe tactical distance.

By Andrew White

Troop drawdowns from lengthy campaigns in Iraq and Afghanistan have done little to reduce the threat of the IED, which remains one of the primary weapons of choice of insurgent combatants and terrorists worldwide.

Recent terror attacks in Paris and Brussels mimicked tactics, techniques and



A Canadian Armed Forces EOD operator in a bomb suit approaches the site of a simulated IED during an exercise.
(Photo: Canadian Armed Forces)

SAFER STREETS

procedures adopted by insurgent cells operating in the Middle East and Southwest Asia over the past decade or so, which saw vehicle-borne IEDs (VBIEDs) and/or suicide vest IEDs (SVIEDs) used to gain entry to a building or compound, followed by multiple shooters, also equipped with SVIEDs and assault rifles.

Report rules

According to the EOD equipment market report published by Transparency Market Research in February, the sector is expected to be worth approximately \$8.56 billion by 2023, up from \$5.74 billion in 2014. This report describes a system-of-systems approach currently being undertaken by specialist EOD units, with UGVs providing a critical element alongside portable x-ray systems, projected water

disruptors, bomb containment chambers, EOD suits and blankets, explosive detectors and search mirrors.

'Defence forces' modernisation programmes are one of the major factors responsible for the growth of the EOD equipment market. Governments from various countries are opting for EOD equipment as a result of the increasing bomb attacks. Moreover, defence organisations across the globe are focusing on providing defence forces with modern equipment so as to counter any form of intrusion,' the report reads.

'In addition, modernisation of police forces is also expected to have a positive impact on the demand for EOD equipment during the forecast period. [An] increasing number of instances of terrorist attacks is also expected to boost the demand for [EOD] equipment globally.'

'Africa and the Middle East have experienced a number of terrorist attacks recently, especially from outfits such as Boko Haram and Daesh. These factors in combination are expected to impact the growth of the EOD equipment market positively during the forecast

period from 2015 to 2023,' the report concludes.

According to Harris, which has been manufacturing UGVs for EOD for the past two decades, the market continues to witness some exciting developments. Speaking to UV, a company spokesperson explained: 'Our customers have developed a keen sense of what is needed to successfully fulfil their missions based on long deployments and thousands of hours in active operations. Sending men and women into harm's way is not ideal if avoidable, which is why robotic technology is increasingly deployed on high-risk missions to protect lives.'

The spokesperson went on to say that the company had developed technologies that 'extend the reach of the warfighter', giving robots human-like capabilities and maximising operator safety with reliable, large-platform EOD UGVs that can serve multiple roles.

'Much like other areas, robotic programmes recognise that it is not feasible to field single-use products. Harris robotic

solutions execute a wide range of missions including IED defeat, EOD, chemical, biological, radiological, nuclear and explosives (CBRNE) detection, ISR and hazardous materials (HAZMAT) clearance,' the spokesperson said, highlighting future plans to develop robotics platforms with sensing that protect warfighters while offering improved situation awareness. 'This is imperative to ensure that warfighters and decision-makers have the crucial functionality and information they need.'

UK operations

One of the most important programmes currently under way is the UK MoD's Project Starter which will replace the Wheelbarrow family of systems which have been in operational use since the 1970s for homeland security operations in Northern Ireland.

First unveiled in March 2014, Project Starter represents a category C programme to procure a new EOD remote-controlled vehicle (RCV) for use on contingent operations. An assessment

phase was initiated towards the end of 2015.

The effort, under the control of the MoD's Special Projects Search and Countermeasures team, has already completed its concept phase and reached an initial gate decision with a procurement budget which could reach as high as £80 million (\$115 million).

A total of 56 UGVs are expected to be procured with options for an additional 30, should the operational tempo demand it. Specifications, announced in the publication of the MoD's system requirement document in August, include a 70kg platform measuring 40cm in width.

Industry sources told UV that an evaluation process will be initiated by the end of Q2 2016 with a contract award confirmed by Q3 2017. Elements from across the UK armed forces are expecting to receive the technology in 2018 and beyond. Participating companies are understood to include Cobham, ECA Robotics, Endeavor Robotics (formerly iRobot), Harris, Qinetiq, Reamda and Remotec.

A remote-controlled PackBot operated by personnel from the Virginia Army National Guard's 753rd EOD Company investigates a suspicious vehicle during training. (Photo: WVNG)



Cobham's Telemax UGV is capable of reaching targets 2.4m in height and has been designed with EOD and HAZMAT missions in mind, according to company officials. The vehicle relies upon a four-track running gear, allowing it to handle gradients as steep as 45° in elevation as well as surmount of obstacles up to 500cm high and trenches of 60cm in width.

Describing a basic CONOPS for the Telemax, which could see it deployed in cooperation with a larger mothership-style EOD platform, a spokesperson for Cobham explained: 'The basic principle of "less is more" applies with special forces, if the situation involves working in confined spaces. In all cases where the big EOD robot cannot be used, its little brother provides that vital distance between the bomb disposal engineer and the explosive device (IED, EOD or bomb). It can mean the difference between life and death, in aircraft, subways, buses or other public transport.'

Telemax's four individually articulating tracks have been designed to optimise mobility in confined spaces, with a

The Telemax has been designed to work in confined spaces and negotiate difficult terrain.
(Image: Cobham)

capability to be operated independently, in pairs or as a whole, depending on the ground being covered and operational parameters. An intelligent control system, integrated into the platform and GCS, also configures the UGV's tracks to cope with particular situations. The UGV, which has a top speed between 4km/h and 10km/h dependent upon configuration, also includes a balance indication sensor to prevent it from toppling.

'These features make it easier for the operator to control the vehicle, especially in tricky situations such as narrow stairways and high steps,' it was explained. The UGV can be integrated with a Tool Centre Point controller with either a gripper or disruptor for handling and neutralisation of IEDs, mines and bombs.

Robot reptile

ECA Robotics' Iguana family of UGVs made its international debut at the DSEI exhibition in London in September 2015. Designed for internal security operations, the UGVs can be used for mission sets including EOD, IED and CBRN tasks.

Officials from the company explained to UV how the UGVs had been optimised for 'interventions in complex and narrow areas', making them suitable for rapid-reaction duties in wider internal security and counter-terror operations on board platforms including aircraft, trains, buses and coaches.

Available in 'E' (EOD and CIED) and 'C' (CBRN) configurations, the Iguana can be fitted with manipulator arms and payloads for battle damage/risk assessment scenarios.

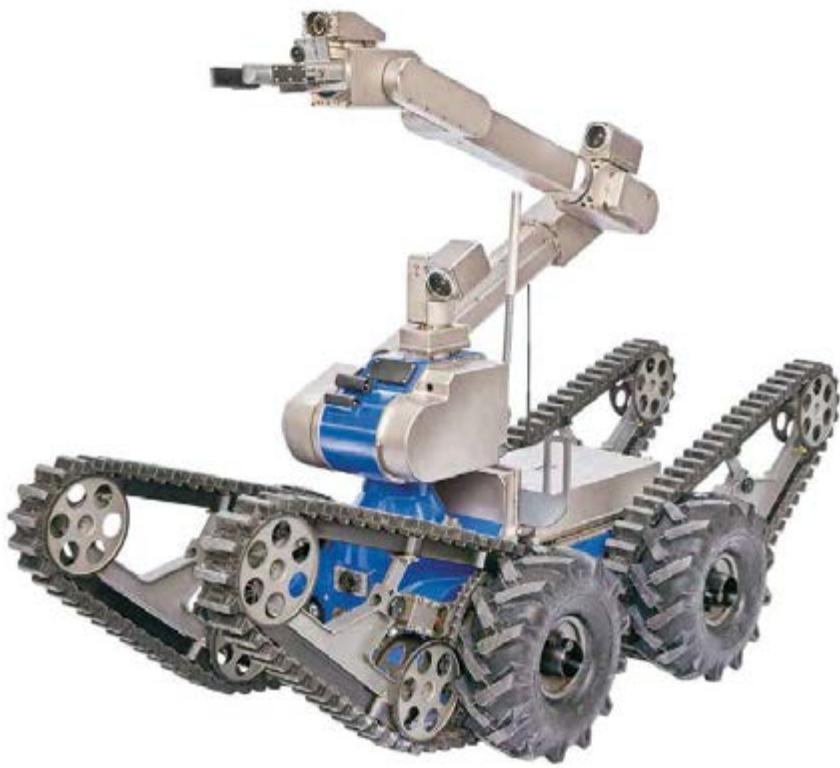
Meanwhile, industry sources suggested Qinetiq's Talon UGV is also likely to participate in Project Starter, with the platform's modularity allowing it to conduct a range of operations ranging from standard military missions through to HAZMAT, first response and counter-terror. The Talon can be reconfigured to a 'V' standard for C4ISR missions, including the integration of a high-definition video camera and communications rebroadcasting capability.

'In military, law enforcement and first responder applications, these lightweight, tracked vehicles are widely deployed for IED and EOD, reconnaissance, communications, CBRN, HAZMAT, security, heavy lift (up to 70kg), defence and rescue missions,' a company spokesperson explained, describing how the UGV has the capability to climb up and down stairs, and overcome difficult terrain including rock piles and barbed wire, as well as manoeuvre through snow.

Endeavor Robotics' Warrior 710 platform has also been designed with modularity in mind, with a capability to conduct EOD and ISR missions for the provision of real-time intelligence and situation awareness to dismounted and specialist users. The UGV can travel at speeds of nearly 20km/h with capacity to carry up to 70kg in payload over staircases and rough terrain.

Roles include EOD detection, route clearance, counter-terror, reconnaissance, building clearance, breaching missions and heavy lifting. The UGV measures 105cm in length and weighs 165kg when fitted with a two-link manipulator arm.

The Warrior 710 can also self-recover following a roll, and has proven the ability to overcome 47cm-high vertical obstacles and 45° gradients. It can also conquer 45cm



water fords. Running on 12 BB-2590/U batteries, the Warrior 710 has a maximum endurance of ten hours, dependent upon usage, although battery packs can be removed and replaced within a minute, officials from Endeavor explained.

On 3 August 2015, the USMC awarded the company a \$9.8 million contract to supply 75 Small UGVs (310 SUGVs) with deliveries due to be fulfilled by the end of Q2 2016.

Defence sources told *UV* that the SUGV will be used for a variety of EOD mission sets including vehicle checkpoints, confined space searches, persistent observation operations and route clearance, all of which can be conducted in visually obscured areas with low or no light, smoke, dust and airborne debris from explosions and fires.

The 310 SUGV is man-portable and weighs 14kg. It can be equipped with wide-angle colour and IR cameras, as well as manipulator arms capable of lifting up to 7kg and multiple disruptor options. The vehicle is controlled by an Android-based

end-user device, capable of commanding multiple systems.

Battery power

The Harris RedHawk T7 IED defeat system was originally developed for specialist EOD missions, following the US DoD's Advanced EOD Robotic System interoperability standards allowing for the integration of most accessories including manipulator arms, disruptors and ISR payloads.

The UGV, which has an all-up weight of 23kg, includes a four-channel remote initiation system, front and rear cameras and four fender-mounted corner cameras for navigation and a pan/tilt/zoom camera mast with 120x zoom capability for ISR, high-power multiple-input and multiple-output (MIMO) communications capability and an operator control unit using haptic technology, designed to provide 'precision control and human-like dexterity' across multiple mission sets.

Measuring 47x27x45cm, the UGV also runs on 12 BB-2590 batteries, providing an

endurance of greater than four hours, Harris explained to *UV*. The platform has a top speed of 6km/h and has proven a capability to climb stairs and slopes greater than 40° as well as traversing lateral slopes of more than 30° with a turning circle of 139cm. The UGV, which also features a self-righting capability, has a horizontal reach of 220cm and vertical reach of 122cm. Lift capacity is 113kg in regular configuration and 27kg when fully extended.

Connectivity to networked systems is via four Ethernet and 24V DC connectors. It also has Picatinny rails for the integration of accessories including VBIED defeat equipment, a remote initiation system, single/dual band MIMO radios, a manipulator-mounted disruptor payload, non-conductive, wire-cutting gripper and forklift attachment (with 30kg maximum capacity). Gripper payloads also feature visible or IR lights for overt, discreet and covert operations.

Company officials explained to *UV*: 'We are developing modular, expandable ►

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systems composed of wireless haptic controllers, precision manipulators, advanced ground platforms and accessories that can be adapted for specific mission profiles.

'The T7 was purposefully designed from the ground up to support the demanding requirements of EOD missions. Its highly intuitive interface makes it very easy to use and includes dynamic force feedback. That is, our controls allow for an operator to get pressure feedback, almost like an extension of your own hand, from the robotic arm that provides unmatched command and control for sensitive missions.'

'Our systems are developed with a multi-functional and open-architecture mindset. They are capable of incorporating a variety of attachments that allow our platform to support a wide range of missions without expensive hardware investments,' the spokesperson concluded.

Vehicle-borne threats

Remotec would not confirm to UV whether it was participating in the UK tender, although it is likely the company will put forward one or both of its Andros FX and Cutlass UGV platforms for the MoD's programme. On 4 August, it unveiled its latest system in the F6 family of vehicles. The Andros FX has been designed to handle specialist VBIED



The Iguana UGV is another platform built for operating in tight spaces, and is available in two variants, the EOD 'E' model and a 'C' version for CBRN work. (Photo: ECA Group)

threats in line with demands from the contemporary operating environment.

The platform has four track 'pods' which replace legacy articulators, while the chassis has been upgraded with a greater lift capacity. Other upgrades include improvements to system electronics, speed and manoeuvrability enhancements and the introduction of a new operator control unit with 3D graphics display and user interface.

Addressing the media at the launch, Walt Werner, director of Northrop Grumman Remotec explained: 'Bomb squads have told us what they need most are more capabilities to counter VBIEDs. Andros FX

was designed from the ground up, based on that feedback to give the bomb tech community the most advanced technology, while at the same time making the system easier to use and maintain to keep danger at a distance.' The company was ready to begin manufacturing vehicles from April.

Additionally, Remotec's Cutlass platform could be offered up for Project Starter. The UGV was specifically designed to reduce the chances of EOD personnel conducting the 'long walk' out to neutralise an IED by hand, with further preservation of forensic evidence through minimised damage to surroundings.

The vehicle, which measures 130x70x121cm and has an all-up weight of 420kg, can be remotely controlled at ranges out to 1km LoS. The UGV can also be operated in tethered mode out to 500m. Payloads include a rear drive, manipulator-mounted and gripper cameras as well as a 1.8m camera mast. Additionally, the vehicle includes an onboard microphone suite for monitoring of atmospherics and general situation awareness.

Running on a 42V lithium-ion battery, Cutlass can operate in a 'creep' mode of 0.01m/s or up to 11km/h and can mount kerbs of 300cm and cross gaps of 500cm in width. The platform has a lift capacity of 100kg and has proven its ability to operate across multiple environments, ranging from -20 to 60°C in dust and rain conditions.

Next-generation options

However, market trends also suggest a move towards modular systems capable of conducting multiple tasks, with quick

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interchange of mission payloads to reduce overall and through-life costs.

On 18 February, the US DoD released a pre-solicitation request for its Common Robotic System (CRS) following an initial market survey conducted in August 2014. According to a system description summary, CRS Increment 1 is being considered to 'enhance manoeuvre and force protection for dismounted warfighters', with the deployment of a UGV weighing less than 11kg (not including payload) in all-up weight and commanded by an operator control unit.

According to the DoD, the CRS will comprise a 'highly mobile and modular system capable of being reconfigured for multiple mission roles by adding or removing sensors, modules, mission payloads and/or subsystems'.

Payloads include engineer, infantry, CBRN and EOD configurations, dependent upon mission profiles, with manipulator arms, sensors and mission-specific cameras. Additionally, the UGV platform should be future-proof and capable of integrating next-generation payloads, as yet unidentified in this particular solicitation, as and when they become available. The UGV itself, described as the 'mobility base unit', will also have a mobility platform radio subsystem, controls, cameras and manipulator arm. According to DoD sources, an RfP will be issued in Q1 of 2017.

'The CRS Increment 1 system will operate in all types of operations and provide protective manoeuvre for soldiers and marines for dismounted assault, and will be employed in all environments to include asymmetrical and military operations in support of conventional war, explosive hazard detection, combating terrorism, peace enforcement and peacekeeping operations,' the DoD explained.

'The warfighter must possess a superior capability to detect and confirm the presence of threats when the tactical unit commander suspects the presence or a high possibility of a threat. In addition, CRS Increment 1 must be able to locate and identify IEDs and booby traps such as side-charge and remotely detonated mines. Furthermore, dismounted warfighters must be capable of operating and quickly transitioning without pause across the full range of military operations,' it was detailed.

The CRS Increment 1 will be required to conduct a number of mission sets, ranging from surveillance and reconnaissance missions in urban and subterranean environments to remote detection and recognition (via a man in the loop) of explosive and non-explosive obstacles and subsequent neutralisation or bypass by force elements.

Additional mission requirements call for remote detection of subterranean avenues of approach to prepare obstacle plans, remote assessment of battle damage and subterranean structural integrity and the need to remotely place unattended ground sensors in an area of interest.

Baltic system

Further afield, Estonian company Milrem has also responded to multi-mission requirements from the user community with the introduction of its Tracked Hybrid Modular Infantry System (THEMIS) at the Singapore Air Show in February. The double-tracked vehicle is propelled by a hybrid electric/diesel engine, with the ability to operate in remote-controlled and semi-autonomous modes, and the option of using pre-set navigational waypoints or a 'follow-on' capability.

The platform has already conducted cold-weather trials in Estonia, with further

exercises in collaboration with the country's armed forces expected later this year. The UGV has been designed for multiple missions which include demining and CBRN detection, but can also be fitted out for communications relay, medevac, cargo resupply, offensive action, heavy lifting, UAV hosting, anti-tank and fire-fighting operations.

However, Milrem is also in the process of developing an EOD capability for THEMIS with the integration of a manipulator arm and supporting sensors for CIED missions. Additional consideration is being given to cooperation between the UGV and UAVs for the identification of IED threats further afield. Options could see the THEMIS hosting, launching and recovering UAVs such as rotary-wing platforms.

The threat of IEDs, mines and roadside bombs does not appear to be reducing in the contemporary operating environment, with the tactical, operational and strategic importance of EOD teams expected to continue into the near-, medium- and long-term future.

Therefore, supporting EOD UGVs (with modular capabilities to conduct multiple mission sets) look set to prove a popular, cost-effective and efficient solution for armed forces seeking a next-generation robotic capability. ■

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Maritime exploration has long depended on vessels of impeccable structure and material selection to keep sailors alive. While some onboard personnel have become redundant with the advent of remotely operated and autonomous systems, UUVs are still constrained by the properties of the substances used in their construction.

By **Rory Jackson**

The importance of materials science and engineering to UAS is well known – aircraft must be developed in accordance with optimising SWaP constraints, maximising speed and endurance while minimising weight. Many new materials present advantages and opportunities in this regard, such as thermoplastics or advanced alloys.

Nautical systems, however, carry additional burdens. The hull of a USV or UUV must be strong enough to withstand ocean effects such as repeated breaking waves or underwater pressure, as well as accidental collisions with piers and rocks or in busy shipping lanes, but without adversely affecting weight or buoyancy requirements.

Materials must also resist corrosion and biofouling from micro-organisms such as algae or barnacles, without making the hull too heavy or impacting marine ecology. All this must be achievable with a material that can be shaped and bonded hydrodynamically and smoothed out to minimise drag. For reasons such as these, new UUVs almost always feature a chassis built using composite materials.

A combination of two or more materials, typically a flexible matrix and a strong reinforcer, achieves qualities greater than its constituents. Strength and stiffness by weight can exceed that of most metals, while still being long-lasting and corrosion-resistant. This improves a craft's speed and manoeuvrability without driving up costs of development, production and maintenance or fuel consumption.

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ECA Group's Inspector Mk2 uses aluminium rather than fibreglass-reinforced plastic, unlike most craft of its class and size.
(Photo: ECA Group)

Ocean Aero's Submaran S10 uses composite materials for its unique sail.
(Photo: Ocean Aero)



Proven effective

Given these advantages and its decades of use in boat hulls, it should come as no surprise that fibreglass composite is widely adopted in modern USVs. UAE-based Al Marakeb Boat Manufacturing is helping to lead this trend.

The Beagle-7 (B7) debuted at IDEX in March 2015, with the larger B10 showcased at UMEX a year later. The woven mat fibreglass in both takes on different forms, either 300, 600 or 800gsm. The 800gsm type uses 'roving', in which the fibreglass is woven into a lattice, as opposed to the scattered composition in the 300gsm and 600gsm varieties. Each offers different structural strengths, with the 800gsm roving being strongest.

The hulls, decks and fuel tanks are made in moulds, where the fibreglass mats are laid out, layered and laminated using polymer resins and hardeners that enable a solid outcome once cured. 'Fibreglass is an excellent material to use – it is strong, easily repairable and modifiable, easy to cast in any form. [It is easy] to obtain a good aesthetic finish and to join and seal different GFRP [glass fibre reinforced plastic] components together,' said Nour Al Sayed, director at Al Marakeb. 'We use it for individual, recreational, commercial and unmanned boats.'

The B7 can achieve 45kt and has an endurance of 1,000km per equipped fuel tank, due in no small part to its strength, hydrodynamics and low weight. 'We are a GFRP manufacturing facility so are equipped to work with those materials. It is readily

available and perfect for this application,' Al Sayed added. 'Metals and carbon fibre glass may be used, depending on the application and the end user.'

A joint venture was announced at UMEX 2016 between Raytheon and Al Marakeb to manufacture USVs for security, surveillance, commercial and target purposes. Subsequent comments from the former company confirmed that the 'H-series' of Raytheon USVs would be based directly on Al Marakeb's Beagle – accelerating the spread of fibreglass-built boats.

Wave motion

Glass-fibre composites are also being adopted in more unconventional systems. The Liquid Robotics Wave Glider SV3 is the first USV to complete missions from the Arctic to the Southern Ocean and achieved the 2013 Guinness world record for the 'longest journey by an autonomous unmanned surface vehicle on the planet'.

Although the craft's solar panels, energy storage technology and wave motion propulsion are crucial to its range and endurance, the use and configuration of composite materials also merit recognition, not least in terms of the vessel traversing seventeen hurricanes and typhoons.

The 'float' and 'sub' are linked by an Elgiloy alloy-polyurethane composite cable. Though towing cables – often reinforced with Kevlar or other aramids – are easily purchased, Graham Hine, senior VP at Liquid Robotics, explained: 'Round cables in the water will strum, causing extra frontal area and extra drag, so we realised we had

to fair the cables. We tried clamp-on fairings, clip-on fairings, glue-on fairings -- we finally started casting them over mould and that was when the system started becoming reliable.

'The right alloys, end terminators and moulding material were critical to making that component survivable, because that's where the force is being transmitted for the system. Through every up-and-down stroke of the wave, you're sending that force down the cable to lift the glider back up so it can drop back down again for its next cycle. That's our piston rod.'

The float's deck is laminate fibreglass, thick and heavy to provide a secure lid over the payloads. The frame is GFRP with two to three layers of bi-directional cloth (BID), with ten-layer BID underneath the screwheads for additional mounting strength for threaded inserts.

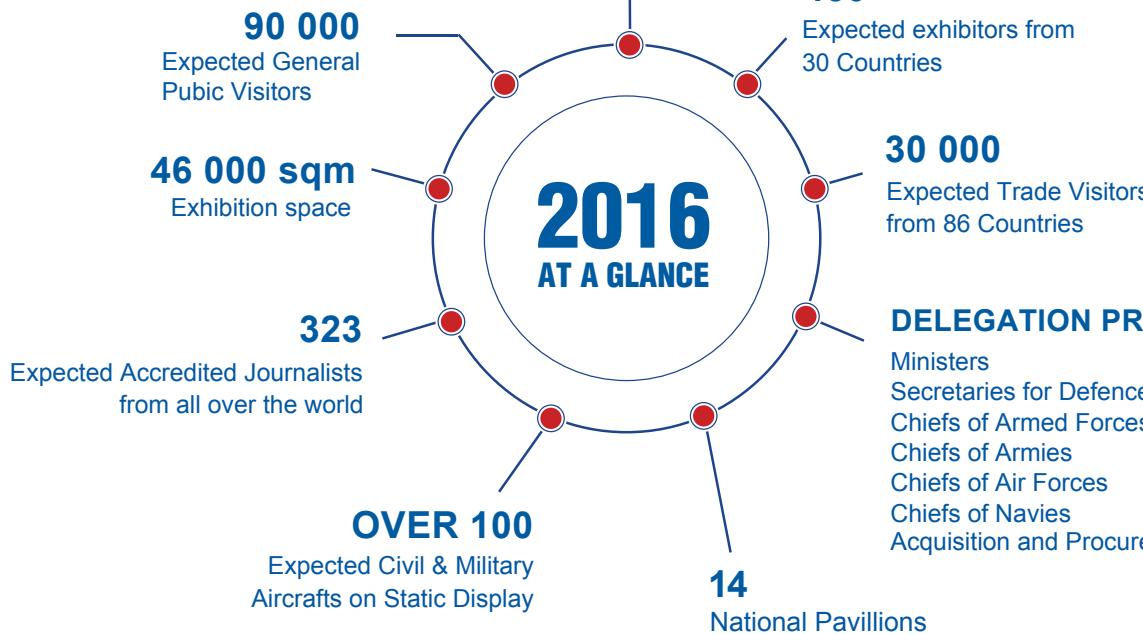
The sub's main bar is stainless steel, with the wings milled from plates of G10 (a pre-made laminate fibreglass-reinforced epoxy). As with the cable, the composite wings are critical to the USV's functioning. Hine noted: 'It's very strong, resistant and about neutrally buoyant in the water, so when we want the rest of the sub to sink when it hits the downstroke of a wave for propulsive reasons, the wings will tilt from that up-to-down stroke easily. We've had shark teeth bite-marks on the wings, but never through them.'

The propellers are carbon fibre and the pole holding the Air-Mar weather station is round, tapered fibreglass – a carbon-fibre pole was tested, but eventually

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The strength and weight of fibreglass makes it attractive for boat builders, including those working with USVs. (Photo: Al Marakeb)

discarded due to being galvanically active. Inevitable contact with certain metals would induce corrosion, which is problematic for a system operating at sea for a year at a time.

In addition to these various composites, a copper-epoxy 'paint' is being tested for future anti-fouling in the Wave Glider. As Hine explained: 'Most of the material in the matrix is copper. You can paint it on, give it a bit of a sand to clear the resin off the copper particles, and it exposes the copper layer on which biological creatures won't form. We've just started using it and it's quite promising.'

Deep sailing

Ocean Aero's Submaran S10, a submersible 'UUSV', also uses a combination of clean energy systems (solar panels and wind propulsion) and a structure combining composite and non-composite materials.

The wingsail consists of a wing and flap of equal chord. The wing is Tedlar (polyvinyl fluoride film)-covered Kevlar reinforced with carbon, with a stub carbon box spar and core transitioning to C-Spar (carbon composite tubing used in masts). The wing is stiffened with Kevlar-cored ribs and the flap contains carbon C-Spar with similar construction to the wing. The load transition from wingsail to hull is conducted through an aluminium trunnion captured into a composite bearing can.

The outer hull and core are built from 0.17kg and 1.70g plates of E-glass laminate and H80 foam. Ocean Aero CEO Eric Patten explained further: 'The hull is

constructed on a female mould using a vacuum bag infusion process. The structural backbone is assembled into the hull and the skin and frames are removed as one piece.'

The payload area interior is made from waterjet-cut E-glass and G10 sheets.

A number of metals are also used. The keel is milled 6063-T6 aluminium alloy with rifling. The steering rudders are Type 316 stainless steel, constructed as 14mm shafts within the balanced planform of plastic machined sections. Patten attributed the selection of composites and avoidance of carbon steel as crucial for minimising corrosion damage during the UUSV's long ocean missions.

Littoral choice

It should not be assumed however that composites are, or will be, universally adopted in USVs/UUVs. Modern USVs developed for the littoral or fresh water rely notably less on composites than oceanic systems.

For example, ECA Group's Inspector Mk2 uses aluminium rather than GFRP, unlike most craft of its class and size. Marketed as a riverine boat, greater resistance to impacts, fatigue and delamination were called for. Advances in fabrication techniques and alloys have also lowered the cost of working aluminium into hydrodynamic forms.

Teledyne Oceanscience's Z-Boat family uses acrylonitrile butadiene styrene (ABS), with an acrylic layer for improved ultraviolet resistance. Engineering director Ashley Cantieny explained: 'We did start out building fibreglass boats and tend to prototype and do short runs in fibreglass, but thermoforming our boats in ABS is a good alternative for us that produces strong and lightweight parts, with a nice finish without the need for a gel coat or hand work. The material is easier for our technicians to work with than fibreglass and allows for quick customisation of the platforms.'

ABS also experiences reduced wear and tear compared with gel-coated fibreglass 'because the colour is integral to the

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Teledyne Oceanscience's Z-Boat family uses acrylonitrile butadiene styrene, with an acrylic layer for improved resistance.
(Photo: Teledyne Oceanscience)

material'. A little nick or scratch is hardly visible, according to Cantieny, who added: 'We also find that ABS is very easy to adhere to and a very strong bond can be achieved. This helps with manufacturability and customisation.'

Sales and marketing may also influence the evolution of AUV material standards. Kongsberg Maritime's newest system, the MUNIN AUV, utilises an aluminium shell and plastic in the propellers and rudders.

Richard Mills, sales director for marine robotics at the company, explained further during MUNIN's unveiling at Oceanology International 2016 in London: 'What we did was take the REMUS 600 body, but take out all of the electronics, the navigation, the payload and put the HUGIN AUV's systems onboard instead. It's a quick way of getting the product to market using the commercial success of the HUGIN and the military success of the REMUS 600.'

Carbon basis

This was a departure from the HUGIN model, which relied on composites. Syntactic foam, a key composite for buoyancy, was wrapped around the metal body, which was in turn wrapped

in carbon fibre for its strength-to-weight ratio.

'That [carbon fibre] gives it rigidity as well. It means the vehicle is very robust, it doesn't twist, it doesn't flex at all. You can actually lift the HUGIN by the nose, even the two-ton vehicles, because of the strength,' Mills added.

However, Duane Fotheringham, president of Kongsberg's subsidiary Hydroid, reaffirmed that composites will play a role in the future of Kongsberg AUVs. 'We have a prototype vehicle that we're running right now and we're looking at places that we can incorporate composite materials, either into the hull or the internal structures, to further bring down the weight. We haven't completed that work and we don't know where exactly it'll end.'

'The heavier it is, the bigger it has to be to displace that weight and stay neutrally buoyant. Anything we can do to reduce the weight and make the vehicle smaller means less drag, makes it able to stay in the water, or go faster. It's even more important for the two-man-portable vehicle. One of our goals is to keep it under the most stringent two-man-portable standards of 30kg. It gets difficult to get of all that into the vehicle and stay under that weight.'

Fotheringham additionally disclosed: 'We do have one other vehicle we're working on – I can't talk a lot about that right now – other than that we are using a carbon-fibre hull in that vehicle.'

Carbon-fibre AUVs are being more firmly established as a standard by Switzerland-based company iRobotica, whose wide range of AUVs have utilised pressure-resistant cylindrical and spherical carbon fibre hulls since the 1980s. These platforms are designed for missions such as mine countermeasures, scientific research and object recovery. Corrosion is avoided by almost exclusively employing stainless steel where metal is required.

Floating bonds

To operate in a wide range of aquatic environments and depths, UUVs are often, as previously indicated, reliant on syntactic foams, a composite material consisting of macrospheres or – increasingly – microspheres, held by a workable solid matrix. A foam is cast via mould tooling for consistent, repeated production, which is useful for work-class ROVs, especially where contracts are signed for multiple units.

Microspheres are normally 10 to 300 micrometres in diameter and made of glass, although they can also be formed from carbon or polymer. Matrix materials include metals, ceramics and plastics, with customisability being a key draw. However, most companies pitch their own proprietary foams to UUV companies and carefully guard their material choices.

One such company, Balmoral Offshore Engineering, has undertaken long-term R&D to develop unique low-density foam (LDF) systems. Steve Gibb, PR manager at Balmoral, stated: 'The use of LDF means the size of the buoyancy modules is minimised, thereby reducing the weight and dimensions of the vehicle.'

Such reductions enable increased payload capacities for ROVs so far as the buoyancy operates – Balmoral's LDF, for example, allows operations at 7,000 metres of sea water (MSW), almost double the average depth of the ocean (estimated at around 3,680m). The company has also tested a 10,000MSW foam, on offer to customers requiring extreme depth capability.

Future matter

Though well-known composites continue to be tested and improved, a number of advanced materials merit further investigation and trials for seafaring applications.

Adopting bio-composites – natural fibre-reinforced materials – sounds ideal for sustainable operations in marine biospheres, but potentially dubious for something in that is continuous contact with water. A UK-based bio-composites firm, Composites Evolution, has identified the replacement of fibreglass with its natural fibre reinforcers and resins as a key target market.

Technical director Dr Brendon Weager also commented that 'Biotex works well in a hybrid lay-up with carbon fibre – a carbon-flax-carbon sandwich – to reduce cost, improve vibration damping and reduce environmental impact compared to all-carbon laminates.' He added, however, that the company had not yet begun work on applications for USVs or UUVs and that Biotex ought not to be continuously exposed to water.

Additive layer manufacturing represents another crucial area for advancing UMV

composites. General advantages of the technology include reductions in material wastage and labour intensity, as well as the elimination of production flaws due to precision software and hardware.

3D-printed braids of fibre may potentially retain higher tensile and compression strength after impacts, reducing vehicle damage. The interlocking 3D-woven reinforcement protects against delamination and fatigue.

Current limitations of the technology include difficulties producing epoxy matrices due to the need for rapid cooling and the relative weakness of composites manufactured by laser sintering. Glass and carbon fibres printed this way must be chopped and the short, non-continuous fibres produce weaker parts compared to traditional methods.

Few companies offer 3D printing of composite materials. Thus far, no one seems to have considered applying the technology to the marine environment, with most applications focusing on UAVs.

US-based Markforged prints nylon components reinforced with glass, carbon and Kevlar. By extruding continuous fibres instead of laser sintering, the company claims stronger parts. Although these have not yet been tested in UMVs, spokesperson Rebecca Dilthey said: 'We have marine

customers that use our printer to create parts for their boats, in marine biology research. All the surface areas on our parts are nylon, with continuous fibres inside the part. While all nylon does absorb some water, the parts can definitely be used in underwater environments.'

For now, most work still continues to focus on UAVs. In November, Stratasys showcased a UAV made from 3D-printed alloys and thermoplastics – but could not disclose any work in this arena related to UUV/USV parts.

Even farther beyond the horizon are 'robotic materials' – composite materials integrated with sensing, computing and communication capabilities. The technology gained attention in 2015, following a paper by Nikolaus Correll and Andy McEvoy of the University of Colorado Boulder. Unmanned aquatic systems utilising blends of robotics and materials science may one day change colour and shape for camouflage or hydrodynamism, or enhance the realism of biomimetic UUVs such as the GhostSwimmer or BIOSwimmer. They might also localise sounds, sense toxicity or radiation levels in the water, or even be used to form an intelligent swarm of identical UUVs to overwhelm anti-submarine defensive countermeasures. ■





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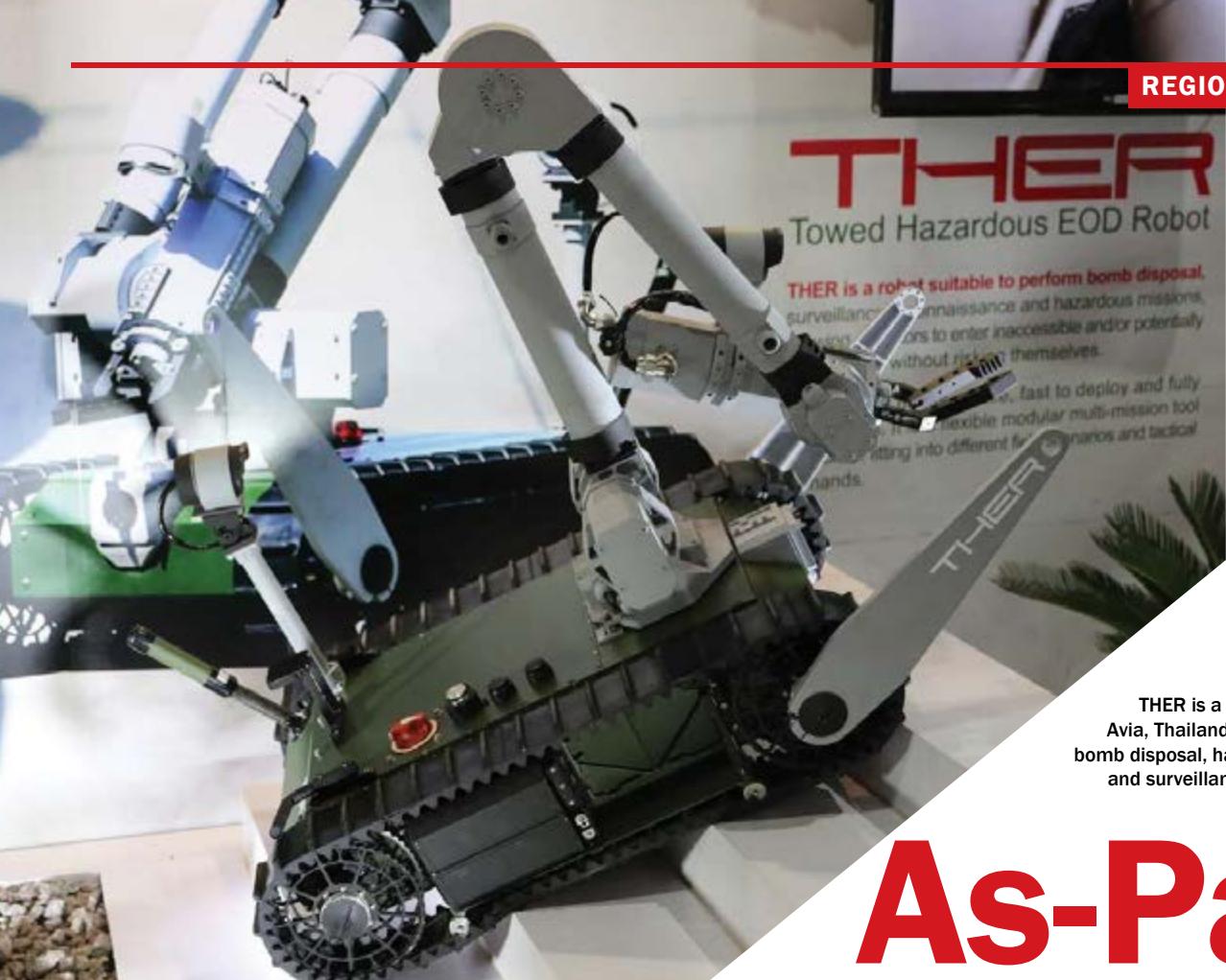
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THER is a tracked robot from Avia, Thailand. It can be used for bomb disposal, hazardous materials and surveillance. (Photo: author)

As-Pac playback

Fresh from attendance at defence shows in India, Malaysia and Singapore, UV examines some new regional designs. **By Gordon Arthur**

Unmanned systems are on the rise in the Asia Pacific region. Indigenous design and production are well established in China, Singapore and South Korea and some companies are competing on the export market too. For those wanting a more systematic account of the region, readers may refer to the article 'Rising in the East' in the April/May 2015 issue. Here we instead take a sweeping view of selected regional unmanned revelations in the air, water and on land.

Indigenous increase

We begin in India, where the biennial DefExpo show was held March. India was the world's largest importer of military UAVs from 1985 to 2014, but it is seriously attempting indigenous development. The

Aeronautical Development Establishment (ADE) of the state-owned Defence Research and Development Organisation (DRDO) exhibited a family of UAVs, the smallest being the 550g Golden Hawk, offering a 2km range and 30-minute endurance. The hand-launched micro-UAV is currently undergoing Indian Army and paramilitary trials. Next in size is the 2.9kg Indian Eagle mini-UAV with 10km range. The design was completed in 2012 and has been undergoing trials by the army and security forces.

The updated Netra v2 micro-UAV, with 40-minute endurance and 4km range, was completed last year. About 25 are being supplied to paramilitary units for jungle operations.

Also at the show, the ADE displayed two scale models of larger UAVs, the Rustom I and II. The former is a testbed while the Rustom II is a HALE design, offering

24-hour endurance. Still on the drawing board, a spokesperson predicted it should fly before year's end.

All three branches of the Indian military intend to adopt the Rustom II and a consortium comprising Hindustan Aeronautics, the DRDO and Bharat Electronics is expected to build 76 examples. The platform can accommodate a 350kg payload, but its overweight airframe forced fitment of a larger 170hp Austro Engine AE300 unit. The ADE is attempting to bring the weight down from 2,400kg to 1,700kg after delivery of the first 24 aircraft. Operational LoS range for the Rustom II is listed as 250km while flying at a 95kt cruising speed.

Because of the Rustom II's two-year delay, the MoD announced on 19 April that within a month it would issue an RfI to local companies, who could collaborate with foreign OEMs to supply unarmed MALE

UAVs. An RfP is expected within six months for approximately 100 examples for the Indian Air Force and Indian Army.

Larsen & Toubro (L&T) unveiled its Adamya AUV, which was to head off for sea trials soon after the exhibition. The 1,000kg Adamya is launched from a submarine torpedo tube or from a surface vessel. The heavyweight prototype of 5.8m length and 533mm diameter will be scaled down to medium-weight and lightweight types in the future. The Indian Navy has already issued RfPs for all three AUV types. L&T lists potential applications as: hydrography; mine countermeasures (MCM); ISR; clandestine monitoring; environmental monitoring; and ASW. Development is expected to conclude mid-year.

Primal urge

The Daksh UGV family from the DRDO includes the Primal six-wheeled robot for bomb disposal and IED handling. Alok Mukherjee, head of robotics, said that the military has been using 20 Primals for the past two years and that a larger Daksh order is expected in 2016. The DRDO's development and manufacturing partner is Hi-Tech Robotic Systemz. The Daksh Spotter has a manipulator arm and

chemical, biological, radiological, nuclear and explosive (CBRNe) sensors.

The Daksh Warrior is an armed version, boasting a 7.62mm machine gun and 30mm automatic grenade launcher. Live firings have already been conducted. Next in the series is the tracked Daksh Mini designed to operate in train and aircraft aisles. Its manipulator arm reaches 2.5m high to search overhead baggage compartments. The DRDO said it is in service with Indian military, paramilitary, police and rail and airport authorities. Finally, the tracked Daksh Scout is used for silent surveillance or counter-terrorism missions.

Private firm OIS Advanced Technology (OIS-AT) has invested heavily in UAVs over the past four years. Indeed, Sanjay Bhandari, founder chairman and managing director, said OIS-AT may have the largest range of UAVs in India. The oldest designs in the line-up are the Octane quadrotor and WaveSight fixed-wing type, sold through Avaana. The 800mm-long Octane, with a 25-minute endurance and 4km range, is in service with Indian paramilitary forces. The SQ-5, a quadrotor designed for Indian paramilitary forces, has the ability to fly inside buildings and, after landing, act as a

surveillance source with a live camera feed for six hours.

In terms of OIS-AT UAV evolution, next came the hand-launched fixed-wing UAV with three-hour endurance. The newest design is the 25kg Multi-Mission Hybrid UAV, a fixed-wing design possessing four wing-mounted propellers to give a VTOL capability. Its maiden flight occurred on 28 January. It is powered by a petrol engine to a range of 150km for up to six hours and can carry 10kg of explosives for a strike capability.

Singapore sub-aqua

At the Singapore Airshow in February, ST Aerospace demonstrated the novel Unmanned Hybrid Vehicle (UHV), offering through-air and underwater travel modes. This proof-of-concept vehicle is designed to fly to an area of interest and dive into the sea to perform underwater SAR or mine detection missions. Its chief advantage is its ability to move rapidly to an area of interest to conduct underwater tasks.

ST Aerospace has already tested the 25kg UHV underwater, where it achieved 3kt speeds and a three-hour endurance. It should fly later this year once the developer gains civil aviation approvals. The UHV has



The 13m-long High-Speed Intercept Boat, able to perform both manned and unmanned missions, will be ready next year. Poly Technologies marketed it at DSA 2016. (Photo: author)



Saab Australia continues developing Bonefish for military and commercial customers and it is moving closer to Royal Australian Navy demonstrations. (Photo: Saab)

differential propellers, with one set propelling it through the air and another set in the water.

An unmanned MCM combo was showcased by ST Electronics. Two scale models illustrated the teaming arrangement that would see a Venus USV with a Thales towed-array sonar to detect and classify mines. Once spotted, another USV with an ECA expendable mine disposal system would be launched to neutralise it. ST Electronics is now utilising two 9m hulls and one 16m hull as prototypes, although the Venus is available with 9.5m, 11.5m or 16.5m hull sizes. A spokesperson indicated development could be completed by 2017.

The Singaporean company has tested both propellers and waterjets on its USVs. Other mission platforms being developed are an ASW type with dipping sonar and a force protection USV, fitted with a 12.7mm machine gun in a remote weapon station (RWS).

Turning to land, the Kinetics Advanced Robotics division of ST Kinetics has been developing the Jaeger UGV since late 2015. The company displayed a 2.9m-long 8x8 Jaeger with 680kg payload capacity at the Singapore Airshow, although a 2.4m-long 6x6 configuration with 250kg payload limit is also available. The Jaeger's COTS chassis was converted to operate on lithium-ion batteries (four-hour endurance) and an onboard electrical generator (24 hours). The Jaeger can operate in two distinct modes: tele-operation and semi-autonomous navigation. A future application may be a follow-me mode.

Tan Kat Chui, principal engineer, told *UV* that his team is now integrating an RWS

with 7.62mm machine gun, with live-firing scheduled later this year. Various types such as missile system, logistics carrier, communications relay, ambulance and security patrol are planned.

Peninsula progress

UV met with Composites Technology Research Malaysia (CTRM), a subsidiary of Deftech, at the DSA 2016 exhibition in April. CTRM is seeking to extend the endurance of its Aludra Mk5 UAV from six hours to ten. The Malaysia Remote Sensing Agency is currently using two Aludra Mk5s, which have a 6.1m wingspan, for sensitive security-related missions.

CTRM's other UAV platform is the Aludra SR-10. G Jeyaganesh, Deftech's head of business development, said development had 'just finished'. Last year, it completed an aerial and seashore mapping project for the Ministry of Environment. Nine SR-10s have been built to date and Jeyaganesh said the company is proposing it to the Malaysian Army. The hand-launched, 4.5kg SR-10 flies for one hour and has a 10km range. CTRM is talking to foreign partners about the possibility of developing different operational and strategic types of UAVs, too. Jeyaganesh noted the civilian market is a priority for CTRM because there are fewer export restrictions.

Avia, a Thai company in which Saab holds a 37% stake, exhibited unmanned technologies at the Defence & Security exhibition in Bangkok, last November. The Black Kite II tactical UAV has evolved with a new engine and airframe. An Avia spokesperson confirmed an entity in Thailand was already a Black Kite client

and that it had more than one military export customer too. The Black Kite II with 4.3m wingspan has a range of 180km and speed of 70kt.

Avia revealed it is also working on a larger next-generation platform called the Shikra, which will have a 250kg maximum take-off weight. With Avia heavily involved in Saab's network-centric programme for the Thai military, UAVs may be integrated in the future.

Avia also has a tracked UGV, the Towed Hazardous EOD Robot (THER). A spokesperson said it was designed for bomb disposal, hazardous materials and surveillance. Work on THER commenced in 2013 and while development continues, it has already found acceptance with a Thai industrial customer.

At the same exhibition, Thailand's state-owned Defence Technology Institute (DTI) updated *UV* on its range of five UAVs. After continual modification, the current medium-range tactical Tiger Shark II with 6m wingspan is ready for series production to commence in 2016. Two systems are already in Royal Thai Air Force service. The twin-boom pusher design has a 100km range and a flight endurance of more than ten hours.

Two DTI designs for the army are the 2.5kg Eagle Eye III and the Siam. Three systems of the former were operationally tested in insurgent-plagued southern Thailand in April-May 2015, as well as one in eastern Thailand. A parachute recovery system has been installed, making it suitable for urban areas. Its range is listed as 15km, but DTI is attempting to extend this.

The Siam, a quadrotor design, has a 2km range and 60-minute endurance. It is being tested by the Royal Thai Army this year. Next in DTI's line-up are fixed-wing UAS and VTOL UAV. The latter, somewhat resembling a motorbike due to two in-line shrouded rotors, is operated by the Royal Thai Navy. The fixed-wing UAS, also called the RD02, has an operational radius of 150km and 55kt cruising speed.

HALE and MALE

Local media revealed in December that Vietnam was developing its largest UAV yet, the HS-6L HALE platform. With 22m wingspan, it will have a purported range of 4,000km and 35-hour endurance via a



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Rotax 914 engine. The twin-boom design is being developed by Vietnam's Academy of Science and Technology. Local reports indicate the first prototype was completed on 1 November 2015, with flight tests over the South China Sea scheduled for Q2 of 2016.

In developing this type, there is speculation Vietnam benefitted from technical assistance from Belarus (UV believes the country acquired the Grif-K in 2013). If Vietnam successfully fields the HS-6L, further development could see munitions added or even sensor payloads to guide Klub-S missiles fired by the navy's six Kilo-class submarines.

The Chengdu Aircraft Industry Group (CAIG) took the wraps off its Wing Loong 2 MALE UCAV at the Beijing Air Show, last September. The turboprop-powered aircraft has a 30,000ft ceiling and 200kt top speed. With 11m length and 20.5m wingspan, it is 2m longer and 6.5m wider than its predecessor. The aircraft's endurance is listed as 20 hours, while a CAIG brochure depicted it as having six hardpoints carrying 12 air-to-surface missiles. Possible sensor payloads include an EO/targeting system, synthetic aperture radar, electronic countermeasures, radar warning receiver and communications relay. The Wing Loong 2 will doubtlessly enter People's Liberation Army Air Force (PLAAF) service, just as the original Wing Loong 1 has done.

Interestingly, the existence of the rival CH-5 UCAV from the China Aerospace Science and Technology Corporation (CASC) with 30-hour endurance was revealed a month earlier. The PLAAF flies the predecessor CH-4. CASC revealed recently that its CH-series UAVs have been sold to 20 military users in more than ten countries outside China to date.

An intriguing USV was shown by Poly Technologies at DSA 2016. Called the High-Speed Intercept Boat, it is still in development, although a company representative said the 13m-long craft will be ready for sale next year. It is being created in conjunction with Harbin Engineering University and it is understood that the PLA Navy has been trialling it to secure a naval base.

In tests, the trimaran-hulled vessel has achieved a top speed of 75kt, although the target is 80kt. The High-Speed Intercept



Korean Air was awarded a \$333.5 million contract in January to begin manufacturing its KUS-FT tactical UAV system for the Republic of Korea Army. (Photo: author)

Boat can accommodate six crewmen, meaning it can perform either manned or unmanned 'patrolling, intercepting and military missions'.

Mountainous exploration

South Korea is delving deeply into UAVs. Foraying into the sector for the first time, Hankuk Carbon has been cooperating with Israel Aerospace Industries (IAI) since 2014 to produce the FE-Panther VTOL UAV with 8m wingspan that features a petrol-powered front-mounted propeller and two electrically powered tiltrotors. In a mountainous country like South Korea, a VTOL capability is useful. IAI and Hankuk Carbon signed a memorandum of agreement earlier this year and they hope to sell the FE-Panther to the Korea Forest Service, the navy and the Korea Coast Guard.

At last October's Seoul ADEX show, Hanwha Techwin displayed two UGVs suitable for monitoring the Demilitarised Zone (DMZ). The smaller 4x4 vehicle is the Star-M3 Multi-purpose Mobile Robot Platform (250kg weight and 1.96m long), while the Star-M4 Unmanned System for Surveillance and Reconnaissance (USSR) is larger (350kg and 2.3m long). The Republic of Korea Army (ROKA) has already tested them in the field, where soldiers used their autonomous function to patrol the fortified border. The USSR has a five-hour mobile endurance, plus it can conduct stationary

surveillance for ten hours. Apparently the ROK Air Force (ROKAF) is also interested in these UGVs to patrol air bases. Testing is expected to conclude in 2017.

Hanwha Techwin's smallest UAV is the Cube with 20-minute endurance. Moving up in size is the Star-AM1 quadrotor, weighing 1.1kg, that first flew in 2014 and which has a 30-minute endurance. Larger is the Star-AM2, which can fly for 40 minutes carrying a 5kg payload. Its maiden flight was in 2015. UAVs can help fill surveillance gaps along the DMZ, via what Hanwha Techwin calls a Drone-CCTV Cooperative Surveillance System, whereby sensors and cameras alert operators to a potential intrusion, at which point a UAV can be sent aloft.

Korean Air's Aerospace Division (KAL-ASD) showed a complete KUS-FT tactical UAV system at Seoul ADEX 2015, comprising four UAVs, a ground control system, ground support system and catapult launch/recovery set. Development successfully concluded in November 2014 and Choi Young Jun of Korean Air said it completed 200 sorties in conjunction with ROKA tests. A \$333.5 million contract was announced in January covering KUS-FT production from 2016-20. Under the first phase, KAL-ASD will manufacture 16 shipsets. The KUS-FT is 3.4m long, has a wingspan of 4.2m and it uses a deep-diving landing technique requiring just 150m of runway, thanks to an arresting cable. ►

The other four UAVs in KAL-ASD's range are the stealthy KUS-FC UCAV, KUS-FS strategic MALE platform, KUS-VT tiltrotor and KUS-VH unmanned rotorcraft. The KUS-FS, destined for the ROKAF, first flew in 2012 and UV understands an armed version is likely to follow the initial ISR variant.

The KUS-VH, meanwhile, is an unmanned MD 500 helicopter, with Boeing supporting this effort as part of offset obligations until late 2015. Korean Air will continue pursuing the KUS-VH as a solo effort, with the intended customer being the ROKA, which will retire up to 175 MD 500 airframes in coming years. The unmanned rotorcraft could operate in teams with manned attack helicopters, as well as perform amphibious operation support. The maiden flight could occur in late 2016/early 2017.

Crash discoveries

In 2014, South Korea discovered four crashed North Korean UAVs on its territory and Uconsystem is proposing a novel approach to tackling such incursions. The Dronekiller is a 'kamikaze' UAV that brings down hostile UAVs after locking on and auto-tracking them during the terminal attack phase. The catapult-launched Dronekiller has hooks above the nose, on the wingtips and tail to entangle the target. Park Ui Chung, Uconsystem's international marketing manager, said the

South Korean military urgently needed this kind of UAV. The Dronekiller has a 100kt top speed, which is ample to chase down hostile UAVs.

Uconsystem currently produces the 3.4kg RemoEye-002B for ROKA battalions and will supply 500 systems by 2017. Additionally, manufacture of six RemoCopter-004X UAVs for ROKA artillery units commenced in July 2015. The ROKA and ROKAF have each ordered one tethered TRotor UAV, with these aircraft able to fly for up to 24 hours. A nuclear power plant also acquired one for facility surveillance. Completed just two weeks prior to the Seoul ADEX show, the RemoCopter-001 platform weighs 1kg and has a 5km range. Uconsystem is aiming it at a ROKA special forces requirement. Furthermore, the stealthy 700g RemoEye-X7 concept design is also aimed at South Korean special forces. A tiltrotor VTOL design with a 80kt top speed is under development with the Korea Aerospace Research Institute.

Eco-friendly

The Royal Australian Navy is pondering a USV for future ASW duties. At the Pacific 2015 exposition in Sydney, last October, Ocius Technology exhibited a capability and technology demonstrator (CTD) for which the DoD awarded a \$2.1 million contract. The company signed up Thales to help develop a thin-line towed sonar array

A scale model of the Rustom II HALE platform from the Defence Research and Development Organisation was shown at DefExpo 2016. (Photo: author)



for the Bluebottle craft. Powered by solar, wind and wave energy, harnessed by hull solar panels, a solar sail and wave oscillators, the next-generation CTD will double the 2.8m length of the original Bluebottle USV.

The low-cost Bluebottle is designed to operate autonomously for six months or more on end. Robert Dane, CEO of Ocius, envisioned a single operator controlling 200 such low-cost and persistent vessels. The project aims to have a CTD completed by October 2017, ready for approval by Australia's Capability, Acquisition and Sustainment Group.

After relinquishing cooperation with Indonesian firm PT Lundin, Saab Australia is developing Bonefish for defence and commercial customers. At Pacific 2015, Saab exhibited a modular Bonefish mission control system, able to fit a rigid-hulled inflatable boat to give it an unmanned capability. Derek Rogers, head of Saab's Centre of Excellence in Autonomous Vessels, said: 'USVs are an excellent complement to manned systems, allowing their operators to do dull, dirty and dangerous jobs from a place of safety.'

Bonefish now has waypoint autonomy, with collision avoidance, autonomous navigation and an ability to respond to dynamic conditions being added in the coming year. The engineering team has already successfully integrated it with Saab's 9LV combat management system, which reduces the footprint on a mother vessel. Other capabilities to be incorporated are swarm technologies that allow multiple USVs to be controlled by one operator.

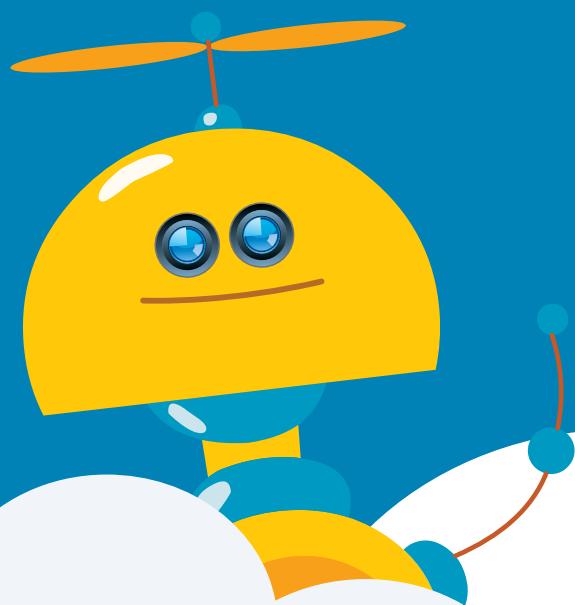
Saab has been discussing with the navy and Defence Science and Technology Group the potential for installing its system on two different vessels, working towards a major demonstration of capability. Rogers said: 'The opportunity to trial our system on two different vessels will also demonstrate the scalability of the Bonefish system across multiple hulls and a variety of different operational scenarios, including working towards combined USV-UUV and over-the-horizon mine countermeasures as applicable for Sea 1778 [Task Group MCM] and Sea 1180 Phase 2 [offshore patrol vessels].' He earlier predicted that fisheries could be the first Bonefish user. ■

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UAVs have become a major media focus over the last decade, whether through their military use in Afghanistan or the work being carried out by Silicon Valley giants. Now, the sector is increasingly attracting the attention of investors. **Gerrard Cowan** talks to Andrew Chanin, CEO of industry specialist PureFunds.

High-flying funds

It has been clear for some time that there is money to be made in UAVs – this stands to reason in a growing industry with a global reach. However, new ways are developing to put your money into the business. This was highlighted in early March, when US exchange-traded fund (ETF) specialist PureFunds launched a product focusing specifically on the UAV industry.

An ETF is a fund that trades on stock exchanges, like an ordinary stock. They tend to track a certain benchmark, allowing investors to achieve returns that reflect the general performance of the sector they are interested in.

Thematic funds

The PureFunds Drone Economy Strategy ETF – which has the ticker symbol IFLY – is designed to provide investment results that correspond to the Reality Shares Drone Index. PureFunds specialises in ‘thematic’ ETFs that focus on niche sectors. It also has ETFs in cyber-security and video games, for example.

Reality Shares, which approached PureFunds to work with it on the project, developed the index, which comprises a range of companies that have major interests in the UAV sphere, either military, civil or hobbyist.

‘They built their own proprietary index that rates... what they call a “drones score”,’ said Chanin. ‘It’s a metric that’s determined by the size of [a company’s] role in the drone industry.’

The ETF has holdings in companies right across the business, with some focused on manufacturing UAS and others for whom this is only a small part of their business. These companies are involved in both the military and the civilian side. For example,

the single largest holding is AeroVironment, followed by Parrot, though the ETF is also invested in BAE Systems, Dassault, GoPro and Thales.

‘I think you’ll notice that there’s a mix of both right now, and it’s because that’s where a lot of the early drone demand and technology was coming from – a lot of the aerospace [and] defence companies,’ Chanin said. ‘So you’ll see right now that there are many companies in the fund that are in the aerospace/defence space but not necessarily a pure-play drone company. [However], they are deriving some revenues from their drone businesses.’

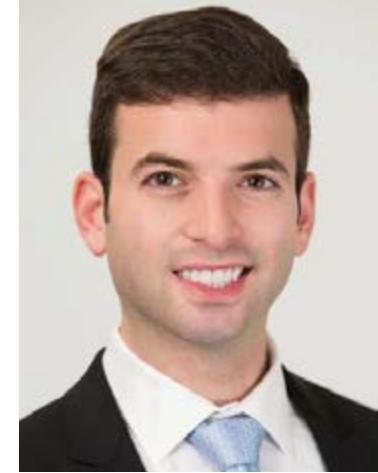
The index holds companies of varying sizes, although there are limits at the lower end, he explained. ‘You don’t want to create an ETF that focuses on a lot of very, very small companies... there are various liquidity parameters that are put into the screening process.’

Wider view

IFLY is also attempting to look across the broader industry, Chanin said, and not just to UAV manufacturers. ‘So it’s software for drones and input pieces used in the production of drones. It doesn’t need to be that your final product is a fully functioning drone,’ he explained.

The ETF includes companies based in a range of countries, as ‘this is definitely a very global industry. It made a lot of sense to see it as a global basket of companies as well.’

The UAV sector is relatively young and developing quickly. This means that it can be difficult to predict which companies will be the giants of the sector in the long or even the medium term. This provides advantages to a fund that



“So you’ll see right now there are many companies in the fund that are in the aerospace/defence space but are not necessarily a pure-play drone company.”

tracks the industry as a whole, Chanin argued.

‘Part of the thing that we like about developing funds in some of these industries is that they could be volatile because they’re in the very early stages. So you don’t necessarily know who the leader’s going to be one year, five or ten years from now,’ he said. ‘Being able to invest in a basket of companies that are doing different things within the drone industry, with different takes on it and approaches, is a way to diversify your exposure to the industry.’

The ETF has only recently been launched, so it is too early to gauge levels interest. However, Chanin said that he believed there is demand from individual investors and professional money managers, given the range of areas for growth in the UAV sector.

‘This is an industry that we realise has many incredible benefits... there’s so many different ways that companies have the ability to incorporate drones into their business model, and to us it’s really interesting to see this industry that’s still fairly nascent, yet it has the ability to impact so many different industries around the world.’ ■



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