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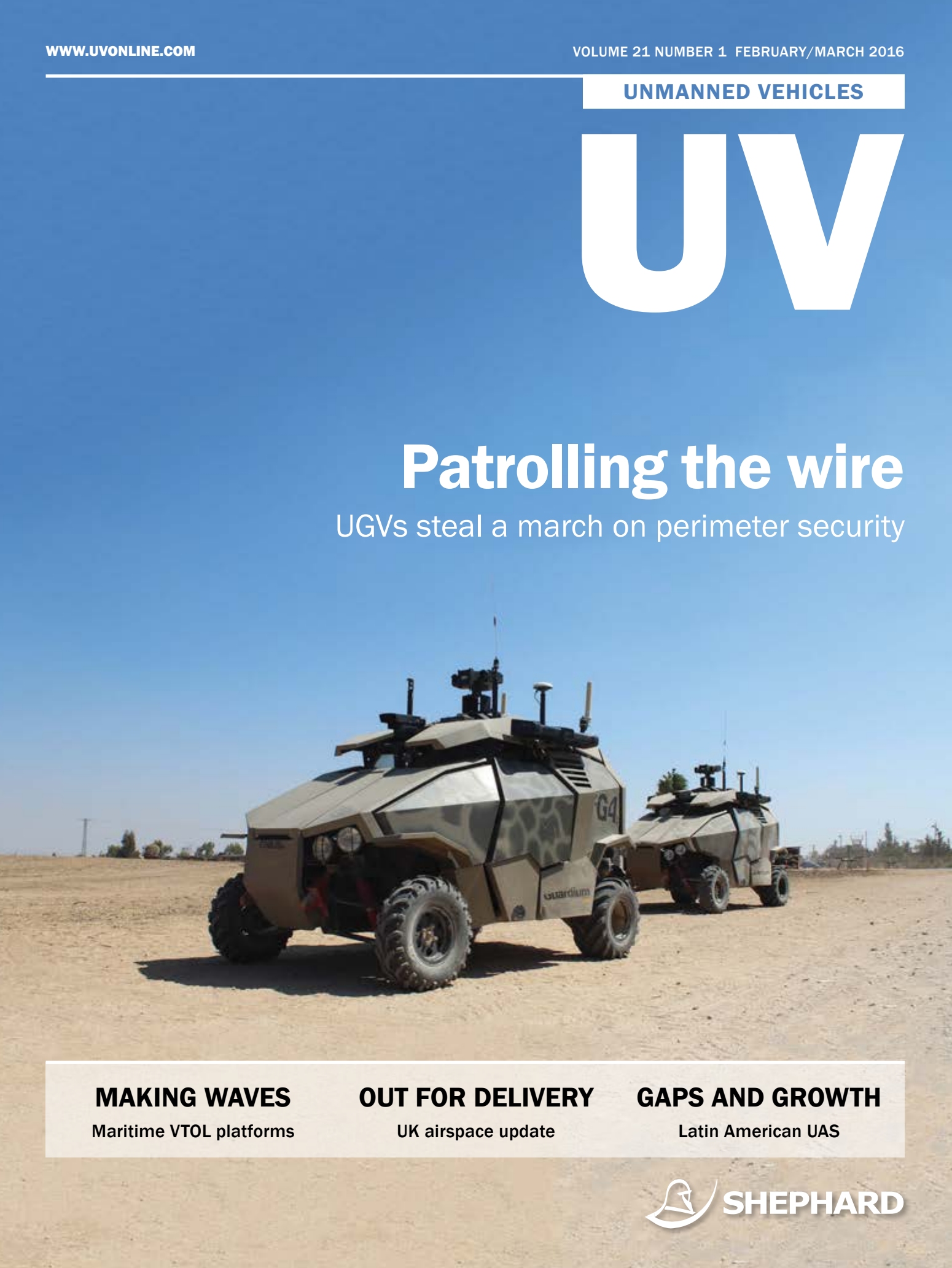

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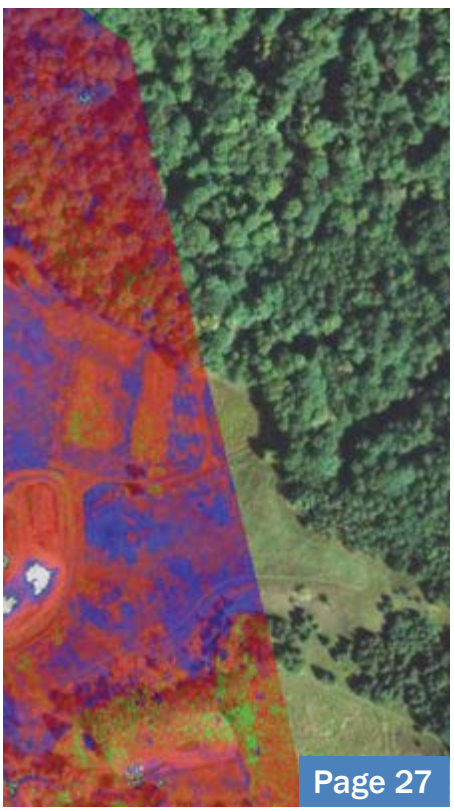
CONTENTS



Front cover: The Guardium is one of a number of UGVs that could bring force protection and base security into the unmanned mainstream. (Photo: IDF).

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Richard Thomas, Editor

Playing by the rules

The honeymoon for the UAS enthusiast appears over, as the powers that be in the US, named the FAA, opt for a comprehensive registry of operators. This process covers a broad spectrum of platforms weighing from 250g to 25kg.

As far as the rules go, any owner of a small UAS (SUAS) who has previously operated an unmanned aircraft exclusively as a model aircraft prior to 21 December 2015, must register by no later than 19 February this year. Owners of any other UAS purchased for use as a model aircraft after 21 December 2015 must register before the first flight outdoors.

Think of all those newly ordained UAS operators who splashed a bit of cash as a treat during the holiday period, wanting nothing more than to fly outside for a little while. Estimates in the US had up to 400,000 new UAS being purchased during Christmas and New Year – sorry, register first please.

Registrants will need to provide their name, home address and email address. Upon completion of the registration process, the web application will generate a certificate of aircraft registration/proof of ownership that will include a unique identification number for the UAS owner, which must be marked on the aircraft.

The $5 cost won't break most banks and the registry is valid for three years.

Failure can result in civil and criminal penalties, says the FAA. Financial penalties can reach $250,000, while a three-year vacation from normal life can also be handed out to the most culpable of culprits.

US Transportation Secretary Anthony Foxx said: 'Make no mistake: unmanned aircraft enthusiasts are aviators and with that title comes a great deal of responsibility.'

One wonders if enthusiasts of hobby-grade RC cars are considered drivers, or captains and commanders are being made from those looking to try out their little RC yacht on the local pond. The argument is of course not as simplistic as that.

The FAA is dealing with a 3D technology that can pass unhindered over boundaries that otherwise worked in a 2D environment. Hobbyist UAS are not bound by the same rules as their UGV counterparts, having to park their mini-Nascar on the side of the street while the SUV passes. This, combined with advanced camera payloads, has meant that new rules have had to be thought up.

Risk assessment

Those UAS whizzing about at low levels, ten metres say, are an obvious risk to the public, while the more advanced hobbyist platforms can get to heights that begin to interfere with manned aviation on final approaches or take-offs.

It's more a case of taking the first tentative steps in making people accountable for how they choose to follow their hobby.

However, this will only catch out people who have registered and subsequently misused their UAS. Presumably this will most likely have been accidental, or minor in nature, but perpetrators could face civil or criminal action as a result.

UAS operators who choose not to register can therefore stay clear of this accountability process, leaving authorities back to square one when it comes to determining proof of misuse or trespass into restricted areas.

This, of course, is where technology will have a part to play in creating invisible barriers to prevent SUAS access to areas of import. Such 'drone-free' zones have been in operation for some years, but widespread proliferation of such technology is yet to be reached and properly applied.

Some manufacturers have also been proactive in the prevention of misuse of their products, actively stopping flight into restricted areas, although this capability is by no means universal across the industry.

The FAA is also developing a process for the online registration of SUAS being operated for commercial and business means, which some news on is expected in early 2016. At present, commercial operators have to apply for a Section 333 exemption to fly in certain areas and this at-times lengthy process has resulted in significant backlogs.

So, the US and FAA have played their hand. The question now is how the rest of the world will also adapt to SUAS and the army of enthusiast aviators looking to take to the skies. ■

In the next issue

- UAV training
- Launch and recovery
- Commercial SUAS
- UUV/USV hydrography

Zephyr in mind for Roke data link integration

The Airbus Defence and Space Zephyr high-altitude pseudo satellite (HAPS) has been deemed 'an obvious candidate' by Roke Manor Research for platform integration of its new high-altitude cellular communications technology currently in development.

Roke was awarded a contract on 9 December by the UK MoD to design an advanced data link, although the platform it will be installed on has not been determined.

The company was selected through the Defence Growth Partnership (DGP) Innovation Challenge to design a high-altitude data link to communicate directly with ground-based cellular infrastructure at a distance of more than 50km.

'The Zephyr platform is a logical vehicle for this technology given its ability to provide persistent surveillance from above 60,000ft. In proposing our solution therefore, we have specifically borne in mind the Zephyr SWaP constraints and are keen to see the adoption of our technology on this platform,' said Bob Dalgleish, business development manager at Roke.

'The DGP is all about export growth, so although Airbus's Zephyr UAV is an obvious candidate, we anticipate other countries will at some stage in the near future be creating similar offerings.'

The contract is said to be worth around £1.25 million ($1.77 million). 'We identified this particular communications payload technology as being a potentially valuable payload addition to UAVs which are increasingly being used for persistent battlefield surveillance,' Dalgleish told *UV*.

The system will use COTS 3G hardware, which alone cannot successfully transmit from high altitude to a base station on the ground. To achieve this, Roke will develop adaptive beam-forming technology to direct the signal to ground-based commercial cellular infrastructure or a dedicated military base station.

During the recent UK Strategic Defence and Security Review (SDSR), the Zephyr HAPS was alluded to as Prime Minister David Cameron talked of a surveillance UAV that could fly to the edge of the atmosphere. The SDSR document itself speaks of providing special forces with 'the information they need, including through our investment in advanced high-altitude surveillance aircraft'.

Roke was planning to have a proof of concept demonstration as *UV* closed for press and will compete for Phase 2 of the project in mid-2016. The company is expecting to deliver an airworthy demonstration system within 12 to 18 months.

By Beth Maundrill, London

Northrop confirmed for DARPA UAV project

Image: DARPA

Northrop Grumman has been selected to develop a working demonstrator for DARPA's Tactically Exploited Reconnaissance Node (TERN) programme, it was revealed in a statement issued by the US DoD on 24 December.

According to the statement, the TERN programme will 'design, develop and demonstrate' enabling technologies for a MALE UAV, together with a shipboard-capable launch and recovery system for use on smaller vessels.

The $93 million contract will focus on the design, construction and testing of a prototype TERN system. An announcement in September by AeroVironment, the only other competitor for the TERN programme, revealed that the company had not been selected for the Phase 3 contract. The firm had competed with Northrop Grumman in Phase 1 and Phase 2.

At the time, Kirk Flittie, VP of AeroVironment, said that the OEM had developed 'a truly innovative approach to addressing DARPA's requirements', but that the customer had 'elected not to pursue our proposed solution'.

The TERN programme is a joint undertaking by DARPA and the Office for Naval Research to provide fleet escorts with the capability to operate long-endurance UAVs from their smaller flight decks.

By Richard Thomas, London

Vietnam unveils new indigenous HALE platform

Despite outsiders knowing little about Vietnam's UAV developments, local media revealed in December that the country was designing its largest vehicle yet, a HALE platform.

Known as the HS-6L, the aircraft's wingspan measures 22m and it will purportedly have a range of 4,000km and endurance of 35 hours. A Rotax 914 engine provides its propulsion.

The twin-boom design is in development by Vietnam's Academy of Science and Technology in conjunction with the Ministry of Public Security.

Vietnamese reports indicate the first prototype was completed on 1 November, with flight tests over the South China Sea scheduled for Q2 of 2016. Dr Pham Ngoc Lang, chairman of the research project, commented that Vietnam has sufficient ability to manufacture a range of UAVs to serve the nation's economic development.

In the future, such a HALE platform carrying an optical and radar payload could prove extremely useful in monitoring the actions of the Chinese and others in the South China Sea.

The maritime area has seen rising tensions as China reclaims a number of reefs for strategic and military purposes. Indeed, Vietnam's desire for such a platform might be directly attributed to Beijing's actions.

In developing this HALE type, there is speculation that Vietnam benefitted from technical assistance from Belarus. *UV* believes the country acquired the Grif-K UAV manufactured by the Belarus 558 Aircraft Repair Plant in around 2013, although a spokesperson refused to confirm this when asked in 2015.

With a 5.7m wingspan, the improved Grif-K is much smaller than the HS-6L, but it has a similar twin-boom design. The former, which has a 100km range, 65kt cruising speed and a ceiling of 11,500ft, performed its maiden flight on 26 February 2012.

This speculation was strengthened by the fact that the UAV's debut coincided with a visit to its developer's institution by Professor Vladimir Gusakov, chairman of the Presidium of the National Academy of Sciences of Belarus. In 2013, the Academy of Science and Technology announced successful testing of five short- and medium-range UAVs it had been developing.

If Vietnam successfully fields the HS-6L, further development could see munitions added to the UAV to produce a UCAS. Additionally, appropriate sensor payloads could help guide Novator 3M-54 Klub-S missiles fired by the navy's six *Kilo*-class submarines that are currently in production.

Important Chinese military facilities on Hainan Island, including a naval base for strategic nuclear submarines, would be a prime target for Vietnam in any conflict.

By Gordon Arthur, Hong Kong

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Germany confirmed to lease IAI Heron TPs

Germany will lease up to five IAI Heron TP UAVs ahead of the eventual development of a European MALE UAS in the mid-2020s. Germany's Defence Minister, Ursula von der Leyen, announced on 12 January that Chief of Staff Insp Gen Volker Wieker had informed parliament about his decision to lease the Heron TP as the Bundeswehr's new MALE UAS.

The Heron 1 is currently in use as an interim solution for Germany's System for Image Generation in Theatre Depth programme, which is being provided by Airbus Defence and Space together with IAI. The decision to opt for another IAI solution is likely to be motivated by the German military's desire to build on experience gained with Heron 1 and ease the transition to a new system.

Although negotiations are ongoing, the MoD appears to want to lease up to five MALE UAS as a bridging solution, which are to be stationed in Israel and enter service in 2018.

The new systems will be equipped with EO/IR and SAR/GMTI sensors and be capable of being armed, von der Leyen indicated. From 2025 onwards, a final European MALE UAS solution is expected to enter service, tentatively called the Eurodrone, and is being developed by Germany together with France, Italy and Spain. Another contender for the follow-on MALE UAS requirement was General Atomics' MQ-9 Reaper, which, pending the outcome of the negotiations, is likely to remain Germany's preferred backup solution.

By Pieter Bastiaans, Breda

Colombia's IRIS UAV eyes operational focus

Colombia's indigenous tactical UAV, IRIS, developed by the government-owned Corporación de la Industria Aeronáutica Colombiana (CIAC), is set to be delivered to the Colombian Air Force next year. A pair of proof-of-concept air vehicles was flown in 2007, and with $1 million in funding from state-run defence policy and manufacturing firm Indumil, the first prototype IRIS was flown in 2010.

CIAC was due to produce six units by 2014, but the project ran into delays. A second IRIS was scheduled to have completed a four-flight trial programme by the end of 2015. According to CIAC, the test flights addressed design flaws including a problem with the landing gear when operating from rough airstrips. Further flight trials are being carried out in January at Marandúa Air Base in eastern Colombia.

Following this, series production will begin at CIAC's facility at Madrid Air Base, north-west of Bogota, prior to its projected entry into service with the Colombian Air Force in late 2016.

IRIS will be capable of a range of military and civil applications once operational. According to air force engineer Alejandro Vargas, who was involved in the aircraft's development, even if the Colombian government signs a peace deal with Marxist rebel groups, the IRIS UAV will be needed. 'Initially it will carry out IRS operations,' he said. 'However, it can also be used to monitor meteorological and volcanic activity, as well as oil pipelines and the drug trade.'

Resembling a scaled-down IAI Heron 1, the twin boom IRIS has a wingspan of 10m, length of 7m and is powered by a single 80hp Rotax 912 UL four-cylinder, four-stroke engine. It is designed to have a maximum ceiling of 17,000ft carrying a 100kg payload, including a Star Safire II FLIR, for up to ten hours of autonomous flight with an operational radius of 150km at a speed of 90kt. A version that allows the carriage of weapons is also planned and CIAC is looking at Latin American markets for future export sales.

By David Oliver, Bogota

Royal Navy's lean RIBs could run unmanned

Photo: BAE Systems

The Royal Navy's (RN's) new Pacific 24 rigid inflatable boats (RIBs) could include an unmanned capability in future by retrofitting technology demonstrated earlier this year.

In October, BAE Systems and ASV trialled aspects of the fledgling USV programme in UK waters and although the technology was fitted onto a different platform, it is compatible with future Pacific 24 RIBs.

As revealed in mid-December, BAE Systems announced that the UK MoD awarded a £13.5 million ($19.1 million) contract for 60 new Pacific 24 RIBs, which will be deployed on a range of vessels such as *River*-class OPVs and *Queen Elizabeth*-class carriers.

The first next-generation Pacific 24 RIB destined for the RN will come off the BAE Systems specialist small boat production line in Portsmouth, UK, in April this year.

Weight savings were found in order to fit new equipment onto future RN Pacific 24s, which are able to run at the same speed as achieved by the unmanned technology demonstrator vessel in October.

'The technology is designed to be fitted to the RIBs like those already used extensively by the RN and the new order for 60 Pacific 24s,' confirmed a spokesperson.

An earlier release stated that ASV developed the platform and software algorithms that controlled the trial boat in cooperation with BAE Systems to prove the technology. Legacy Pacific 24s in service with the RN were also able to retrofit an unmanned capability. The next stage will be to integrate the sensor suite with the combat management system on the parent ship.

By Richard Thomas, London

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More vital functions set for DOK-ING MVF-5


Photo: DOK-ING

Unmanned fire-fighting and mine clearance platform manufacturer DOK-ING plans to add CBRN and HAZMAT detectors to its MVF-5 system. The company aims to do this in 2016 and is eyeing further expansion into the global market beyond 2017.

The MVF-5 UGV is designed specifically for fire-fighting in industrial areas, such as oil refineries and terminals, military depots, chemical storage and nuclear power plants. The design has been developed from earlier DOK-ING platforms used for mine clearance tasks and is generally fitted with fire-fighting capabilities to allow the operator to use water, foam or a combination thereof from its two storage containers.

'Some of the changes that we are planning in 2016 are multi-functional blade and gripper tool which incorporates a cutting mechanism, then integration of CBRN and HAZMAT detectors in order to cover some of the essential recce and survey tasks and missions,' said Mislav Manda, key account manager at DOK-ING.

'The biggest upgrade for 2016 is development of a complementary solution – a tactical command and control centre. Command and control... gives end users the possibility of rapid deployment and situation awareness in demanding environments, through data and video link readouts from a safe distance.'

Manda said that there were orders for around 80 systems to a number of customers due for delivery by 2018, with target markets in Europe, the Middle East, Asia-Pacific and the US lined up for 2017 and beyond.

In 2012, the company's production facilities were expanded by 200% in order to meet any potential future commercial expansion. Meanwhile, development of the MV-4 mine clearance UGV is expected to continue, with Manda adding that the aim was to increase sales in military, government, humanitarian and commercial markets. He added that exact sales figures and customer details were classified.

The MV-4 is explosion-proof against all anti-personnel mines and unexploded ordinance with similar blast characteristics and, to a certain extent, anti-tank mine detonations, according to Manda.

'We have sold the MV-4 in 30 countries worldwide in numbers exceeding 250 pieces. This year we only sold 13 pieces in four different countries and we plan for 2016 [sales] to exceed numbers from 2015.'

The platform has undergone development into a multi-purpose combat engineering system, with possible modular additions including a dozer blade for route clearance, rear forklift and a 5m manipulator arm capable of lifting 400kg at maximum reach. When configured for mine clearance, the MV-4 will have a standard fit of a tiller tool and flail.

By Richard Thomas, London

France orders additional Reaper UAVs

General Atomics Aeronautical Systems (GA-ASI) has been awarded a $43.7 million contract for the production of an MQ-9 Reaper for the French Air Force (FAF) as part of the second batch currently on order.

The contract, which was part of a sole-source acquisition, follows an order for a third batch placed by the French defence procurement agency in December 2015. The contract was awarded as part of an FMS by the US DoD and manufacturing will be carried out in Poway, California.

GA-ASI has delivered three Predator B/MQ-9 Reapers to the FAF to date. This contract is for the first aircraft from the next three systems and includes associated GCS, sensors, ground support and spares for the first and second systems in this order.

While the purchase of the UAVs is ongoing, it is expected that the MQ-9s will eventually be replaced by a European programme in the mid-2020s. The first Reaper for the FAF was delivered to the Sahel region in Africa to support operations there in January 2015.

In 2013, France put in a request for the purchase of 16 Reaper UAS at a total cost of $1.5 billion. However, it is now expected that 12 aircraft will be acquired.

By Beth Maundrill, London

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Rotary revolution?

Unmanned helicopters will transform the way naval operations are conducted, allowing warships to project over-the-horizon ISR and strike into areas considered too dangerous for manned aircraft, with much greater endurance. However, doubts persist over whether the rotary-wing UAV offers a more affordable route towards an embarked aviation capability.

By Jon Rosamond

To the casual observer, particularly those inclined to believe all but the tallest of UFO tales, the sight of Canadair's CL-227 Sentinel hovering over a warship 25 years ago must have conjured up images of imminent invasion by extra-terrestrials. Nicknamed the Flying Peanut, the Sentinel rotary-wing UAV (RWUAV) had an other-worldly appearance thanks to its upright hourglass profile and two sets of waist-mounted contra-rotating coaxial blades.

Although the British and American navies evaluated the remotely piloted Sentinel system in the early 1990s on board the frigates USS *Doyle* and HMS *Cleopatra*, neither was persuaded to procure the aircraft and it never saw operational service.

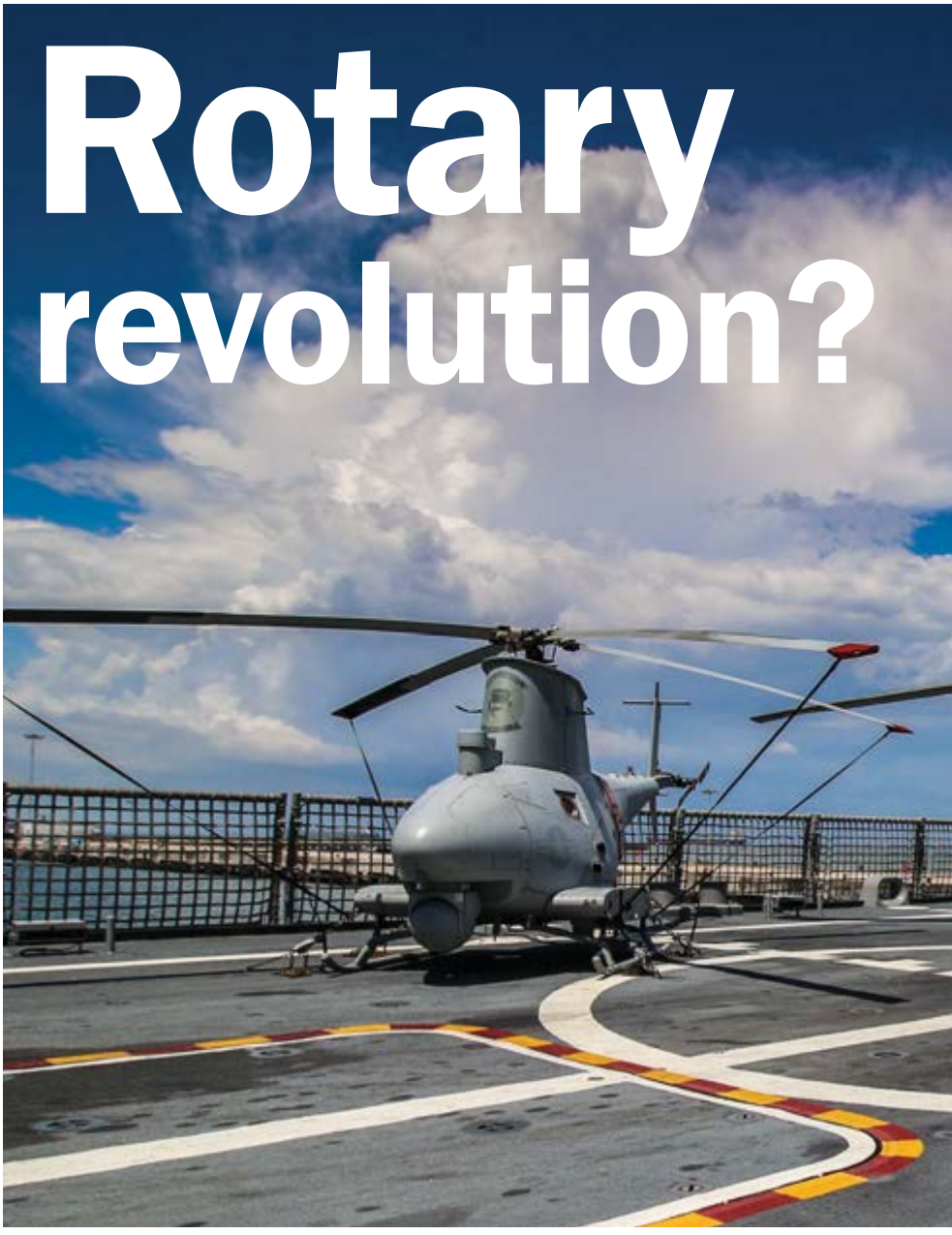
As memories of the Cold War receded into history, proponents of the maritime RWUAV had to wait many years for signs that the concept was anything more than a plaything for industry boffins, but rapid progress was made once Northrop Grumman's MQ-8B Fire Scout commenced flight trials from the frigate USS *McInerney* in late 2009.

It could be argued that the shipborne unmanned helicopter finally came of age in April 2010, when the radar carried by one of *McInerney*'s two embarked MQ-8Bs – still on test – detected a speedboat and support vessel engaged in drug smuggling activities in the eastern Pacific. 'With its extremely small profile, Fire Scout was able to maintain an unprecedented covert posture while feeding real-time video back to *McInerney*,' stated a USN release at the time. The warship and its security detachment intercepted the suspect vessels soon afterwards, seizing 60kg of cocaine and detaining several suspects.

By 2011, the MQ-8B was proving its worth as an ISR platform over Libya. In June of that year, another (altogether less welcome) milestone was reached when a Fire Scout deployed from the frigate USS *Halyburton* was shot down by pro-Gaddafi forces near Zliten.

Meanwhile, Northrop Grumman was developing the larger and significantly more capable MQ-8C, which has now completed initial flight tests from a USN destroyer as well as a land-based operational assessment. A contract for full production is expected in 2016. Austria-based manufacturer Schiebel has also been in the vanguard of the maritime RWUAV revolution, selling its lightweight Camcopter S-100 UAS to the French, Italian and South Korean navies among others, and demonstrating its utility to maritime agencies worldwide.

Chinese naval forces have also deployed unmanned helicopters, with ships of the People's Liberation Army Navy flying what



appears to be a Camcopter derivative over the disputed waters of the South China Sea and the country's customs agency acquiring the Apid 60 system from CybAero of Sweden.

Revived importance

So what is driving this renewed – some might say belated – interest in RWUAVs among senior naval officers and defence procurement chiefs?

In general, there seems to be greater reluctance nowadays to risk human casualties in high-threat environments, while at the same time, years of fiscal austerity have forced navies to investigate cheaper ways of achieving the operational effects provided by manned helicopters. The absence of aircrew and associated safety systems means that remotely piloted or autonomous rotorcraft are invariably smaller and less costly to buy than their manned counterparts.

Unmanned air platforms also score highly for persistence – their ability to loiter on station for half a day or more makes them particularly useful for ISR missions, mine-hunting operations in shallow waters, or as communications relays.

RWUAVs have important advantages over fixed-wing types when it comes to providing an organic air capability for frigates and destroyers, according to Cdr Bow Wheaton, the RN's Commander Maritime Capability (Aviation). Speaking at the UAS 2015 conference in London in December, he said that rotorcraft require less launch and recovery equipment on board ships and have SWaP in reserve to accommodate future payloads such as collision-avoidance sensors.

Chris Day, Schiebel's head of capability engineering, cites the proliferation of small offshore patrol vessels (OPVs) without a helicopter deck. 'You've got OPVs with a reach of 3,000 nautical miles but no airborne asset,' he told *UV*. 'All of a sudden the S-100 comes along. It's got a small footprint and you only need a couple of guys on the ship to operate it, who can be skilled in other tasks, too.'

Day said that there were clear cost savings to be had in addition to providing a capability for smaller ships that they would otherwise not have. Such unmanned systems are able to give almost the same surveillance capability as manned alternatives but with fewer people, saving on manpower. 'In the last five or six years, navies have done lots of testing and evaluation and they're starting to realise that [RWUAVs] are complementary to manned platforms. We're not interested in pushing manned platforms out of business, as they do things that we can't,' he said.

This point is demonstrated by the MQ-8B Fire Scout's current deployment to the South China Sea on board the *Freedom*-class Littoral Combat Ship USS *Fort Worth*, where it shares hangar space with a manned Sikorsky/Lockheed Martin MH-60R Seahawk from Helicopter Maritime Strike Squadron 35, the USN's first composite expeditionary helicopter squadron.

According to Northrop Grumman, Fire Scout 'complements the MH-60R by extending the squadron's range and endurance, thereby enhancing maritime domain awareness' while also providing 'unique situation awareness and precision target support' for the USN.

Measuring 7.3m in length and with an MTOW of 1,430kg, the MQ-8B is designed to provide real-time ISR, target acquisition, laser designation and battle management functions. Maximum speed is 86kt, range 1,100km and endurance 7.75 hours with the baseline FLIR Systems Brite Star II ▶

The MQ-8B shares the USS *Fort Worth*'s flight deck with an MH-60R Seahawk naval helicopter. Both aircraft belong to Helicopter Maritime Strike Squadron 35, the USN's first composite expeditionary helicopter squadron. (Photo: USN)

EO/IR sensor payload, the company states. Maximum payload is 136kg.

Telephonics' AN/ZPY-4(V)1 maritime surveillance radar was integrated into the MQ-8B in 2013-14 'to provide the USN with increased visibility far beyond the horizon', according to a Northrop Grumman spokesman. Modes include synthetic aperture radar (SAR), inverse SAR, weather detection and avoidance and search-and-rescue transponder beacon detection.

Other likely payloads include the Coastal Battlefield Reconnaissance and Analysis (COBRA) sensor suite, which is designed to detect minefields and other obstacles guarding a beach prior to an amphibious assault, and the Advanced Precision Kill Weapon System (APKWS), which converts unguided 70mm Hydra rockets into laser-guided munitions, providing a low-cost surgical strike capability.

Bespoke platforms

The next-generation MQ-8C Fire Scout weds the avionics and autonomous control systems from its older, smaller sibling with the proven airframe of the Bell 407 commercial helicopter, in a 12.6m-long package weighing up to 2.7t. Designed as a bespoke maritime RWUAV, the MQ-8C is considerably faster (135kt top speed) and promises much greater endurance (up to 12 hours), range (2,270km) and payload (227kg internal, 1.2t underslung) than the in-service model.

The MQ-8C flew for the first time in October 2013, at Naval Base Ventura County, California, and after a year of land-based testing began embarked trials in December 2014, conducting over 50 precision take-offs and landings aboard the destroyer USS *Jason Dunham*. The rotorcraft was fitted with Northrop Grumman's own AN/ZPY-1 Small Tactical Radar – Lightweight (STARLight) system. Larger and more powerful than the MQ-8B's ZPY-4 sensor, STARLight combines SAR with three moving target indicator (MTI) modes: ground, maritime and dismounted personnel.

In November 2015, the MQ-8C completed a three-week land-based operational assessment period at Ventura County, demonstrating sensor integration, endurance and reliability during 11 flights totalling 83.4 hours.

The aircraft's multiple intelligence capability – which fuses different types of data to provide a more complete picture of the area of interest – and its 'outstanding' reliability are 'changing the way ISR systems are measured' Northrop Grumman said in a press release.

Officials at Naval Air Systems Command seem to agree, with programme manager Capt Jeff Dodge quoted as saying that the MQ-8C 'represents a significant capability improvement to the fleet' and will 'greatly impact how we monitor, understand and control the sea and air space' around the smaller warships from which it will operate.

With the USN planning to buy 40 MQ-8Cs, decisions on full-rate production and the sensors to be integrated in operational aircraft are anticipated in 2016. 'As the MQ-8Bs attrite or end their service life, the MQ-8C will be the version going forward,' the manufacturer told *UV*.

The MQ-8C Fire Scout completes a test flight at the USN's Point Mugu sea range in California in November 2015. This was one of 11 operational assessment events to validate the RWUAV's performance, endurance and reliability. (Photo: Northrop Grumman)

Ahead of the pack?

Leading the RWUAV pack in Europe is Schiebel, which has sold a single Camcopter S-100 to the French Navy, two aircraft to the Italian Navy and multiple units to the Republic of Korea Navy, as well as to a number of unidentified naval and coast guard customers. With a fuselage constructed from carbon fibre and titanium, the 3.1m-long Camcopter has an MTOW of 200kg, maximum speed of 120kt, typical payload of 50kg and endurance in excess of six hours at 55kt with a 34kg load, rising to ten hours with an optional auxiliary fuel tank.

In June 2015, Camcopter was demonstrated to the Royal Australian Navy with a standard three-sensor payload consisting of a PicoSAR active electronically scanned array radar (offering all-weather SAR and GMTI modes) and a Sage electronic support measures (ESM) sensor, both supplied by Selex ES, and an MX-10 lightweight EO/IR sensor from L-3 Wescam.

Trials a year earlier with an *Amazonas*-class OPV of the Brazilian Navy included the same sensor package with an Automatic Identification System for identifying and tracking ships of 300 gross tonnes or more. Targets were detected at ranges of almost 170km. Schiebel claims that Camcopter is the only RWUAV in the 200kg class able to carry a 50kg payload – including SAR, ESM and EO/IR sensors – without having to dump fuel in order to maintain endurance. Thales' I-Master radar is available as an alternative to the PicoSAR.

The Italian Navy confirmed in January 2014 that it was leasing an S-100 UAS (two vehicles and a control station), and conducting technical and tactical evaluations from the amphibious transport ship ITS *San Giusto*. The procurement, which followed a trial two years previously on board a *Lupo*-class frigate, has impacted positively on migrant rescue operations in the Mediterranean.

In December 2013, France's defence procurement agency, the DGA, and naval shipbuilder DCNS completed sea trials validating the functional integration of ▶

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Camcopter's control systems with the Polaris combat management system, on board the *Gowind*-class OPV *L'Adroit*. The aircraft had already been flying from the ship since 2011. However, while the French Navy is looking to acquire an organic shipborne UAV capability from 2020, the approved programme will almost certainly involve an airframe larger than Camcopter and with a more powerful radar.

Airbus's DeckFinder pseudo-satellite local positioning system (which provides precision near-field navigation, enabling automated take-off and landing on a ship when GPS access is denied) and Riegl Laser Measurement Systems' VQ-820-GU airborne bathymetric laser scanner (for hydrographic surveying) have also been successfully integrated into Camcopter, along with LIDAR, loudspeaker and leaflet-dropping systems. For customers who require a submarine-hunting capability, the company plans to install a magnetic anomaly detector for evaluation in Q2 of 2016, Day told *UV*. A mine countermeasures capability is also being investigated.

Little birds

Other lightweight maritime RWUAVs on the market include CybAero's Apid One, the related Pelicano from Spanish company Indra, Saab's Skeldar and the Tanan from Airbus. CybAero signed one of the biggest deals in UAV history in July 2014 – an eight-year framework agreement with Aviation Industry Corporation of China (AVIC) to deliver at least 70 unmanned helicopter systems worth between SKR700 million ($82 million) and SKR800 million. AVIC will supply the systems to clients in the maritime and energy sectors, including the China Maritime Police and the China Maritime Safety Administration.

Apid One Defence is a 3.2m-long RWUAV with an MTOW of 220kg, maximum speed of 81kt, an endurance of up to six hours (depending on mission) and range of 50-200km at a cruising speed of 48kt.

Larger platforms derived from manned helicopters include the Naval Rotary Unmanned Air Vehicle (NRUAV) advertised by IAI and Boeing's H-6U Unmanned Little Bird (ULB) demonstrator. According to company literature, IAI's Malat division is offering a helicopter modification suite intended to transform Hindustan Aeronautics' Chetak manned rotorcraft into a 2.2t, 12.8m-long NRUAV with a maximum speed of 100kt, range of 150km and endurance of six hours.

The SW-4 Solo completed 28 take-offs and 22 landings on a surrogate flight deck with millimetric accuracy, according to Finmeccanica, despite relative wind speeds of up to 27kt. (Photo: Finmeccanica)

However, the development programme – which was intended to provide the Indian Navy with an unmanned airborne ISR capability – has slowed almost to a standstill in recent years, with local reports pointing to technology issues surrounding shipboard automatic take-off and landing functionality. NRUAV's advertised payload consists of EO/IR, multi-mode radar and ESM sensors and a communications intelligence/direction-finding system; maximum payload weight is 220kg.

At a rather more advanced state of maturity is the ULB H-6U, which flew for the first time in 2004. Based on the civilian MD 530F helicopter and closely related to Boeing's AH-6 manned light attack and armed reconnaissance helicopter, the ULB flew for the first time in land-based unmanned mode in 2006.

In 2011, DCNS and systems specialist Thales teamed up to investigate an autonomous deck landing capability for the ULB to meet a French Navy requirement, and developed an RF-based navigation system (designed to minimise ship emissions and avoid reliance on satellite-based navigation solutions such as GPS or GLONASS) and a ship 'green deck window' safe landing period predictor.

A truck-trailer was fitted with a 4.9x4.9m helipad and a NATO standard harpoon grid to emulate the flight deck of a frigate for runway trials at Spaceport America in New Mexico. The front portion of the trailer was equipped with the RF navigation system, a tactical common data link, a differential GPS/inertial measurement unit and video cameras.

The following year, ULB performed numerous autonomous take-offs and landings during sea trials in the Gulf of Mexico and a few weeks later completed deck landing qualifications on board a French frigate in the Mediterranean. ULB is 9.9m in length with a MTOW of 1,610kg, maximum speed of 145kt, range of 430km and six hours' endurance. Boeing says the aircraft can carry useful payloads of 544kg with a crew or 635kg unmanned.

Concept demonstration

Meanwhile in the UK, the RN and its industry partners have been poring over the wealth of data that has emerged from a study commissioned by the MoD into the utility, or otherwise, of operating a future multi-role RWUAV from frigates and destroyers.

The Rotary Wing Unmanned Aerial System (RWUAS) capability concept demonstration (CCD) was initiated in 2010 to examine whether such a system could provide surface combatants with an immediate, intimate and assured ability to deliver three key functions: persistent shallow-water mine-hunting; littoral hydrographic survey; and situation awareness.

The study ended in May 2015, when an optionally manned AgustaWestland SW-4 Solo RWUAS technology demonstrator, based on a single-engine helicopter design from Polish subsidiary PZL Świdnik, completed a series of autonomous landings and ▶

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take-offs using a surrogate ship's flight deck at Llanbedr airfield in Wales.

Soon after, the idea of the RWUAS CCD was mooted five years ago, a scoping exercise was conducted by Navy Command, the Maritime Warfare Centre, the MoD's Defence Equipment and Support (DE&S) agency and the Defence Science and Technology Laboratory. 'We concluded that a small-to-medium size RWUAV was most likely to deliver what became known as the Tactical Maritime Unmanned Air System [TMUAS] concept, ie a single system that could deliver all three capabilities from a small-deck ship, complementary to the manned helicopter that might also be on board,' said Philip Betson, RWUAS CCD project manager at DE&S.

Addressing December's UAS 2015 conference, he said that the new system would require greater endurance (six hours plus) than the manned helicopter, a maximum payload of at least 50kg (to accommodate several sensors) and be small enough to share a frigate hangar with the existing aircraft. Officials agreed to focus on rotorcraft because the RN was already acquiring operational experience of small fixed-wing UAVs, courtesy of its contractor-operated ScanEagle programme.

Sweet spot

AgustaWestland was selected as RWUAS CCD prime contractor and brought together an industry team comprising fellow Finmeccanica subsidiary Selex ES for surveillance sensors, Atlas Elektronik for mine countermeasures, BAE Systems for the surface ship combat management system and Pelydryn for airborne hydrographic surveying.

A number of RWUAV size categories were considered, including: 'intermediate' (five-tonne) aircraft with twin engines; 'light intermediate' (three-tonne) twin and single-engine platforms; 'light' (1.8-tonne) single-engine types; 'small' (650kg); and 'very small' (180kg) craft.

The team identified a 'sweet spot' of about three tonnes 'which allows a very useful load and a very useful endurance', Rick Wellesley, AgustaWestland's UK head of defence strategy, told the conference. However, the company opted instead for a 1.8-tonne civil certified airframe as a cost-effective means of developing a RWUAS demonstrator.

While the SW-4 was flown remotely from a GCS, a safety pilot was always in the cockpit and could have assumed control at any time. 'What that allowed us to do', said Betson, 'was fly this aircraft, operating as a UAV, in unsegregated airspace, under civil regulations, and effectively it was treated as if we had a really, really clever autopilot in this helicopter.' AgustaWestland fitted a trailer with a surrogate flight deck and automatic landing system and used a motion table to mimic the pitch and roll of the 'frigate' as it was towed by a truck along Llanbedr's runway.

An initial phase at Llanbedr included launch and recovery, mission management, integration with the Outfit DNA(2) combat management system

(which equips the RN's Type 23 frigates) and degraded operations; Phase 2 saw the SW-4 make a number of automated take-offs from, and landings onto, the pseudo-deck; and Phase 3 involved demonstrations of the RWUAS's littoral reconnaissance, counter-piracy, counter-smuggling and counter-fast inshore attack craft capabilities.

The SW-4 Solo completed 26 flights totalling 27 hours over 12 days. Some 16 of the flights involved pseudo-deck take-offs and landings, all with 'millimetric accuracy' despite relative wind speeds of up to 27kt, Wellesley noted.

He outlined a number of potential roles for a TMAUS: wide-area surveillance (while loitering); identification and monitoring of small watercraft; third-party targeting using radar, ESM and EO/IR; or 'blind spot' coverage during vessel boarding operations.

Mine warfare tasks might include: conducting shallow-water mine detection using LIDAR, hyperspectral processing or LWIR; relaying instructions to a mine-sweeping USV operating beyond line of sight of its mother ship; relaying burst transmissions from a UUV to a surface ship; or using an airborne mine neutralisation system to clear a safe passage through a minefield.

Operations over longer distances will be facilitated by 'manned/unmanned teaming', with multiple TMAUS assets transferring surveillance data to a manned helicopter for onward relay to the command team in a ship. This tactic 'delivers much more effect, much more bang for the buck, much more capability' from a single warship, Wellesley said.

But there will be occasions when the RWUAV will have to operate alone. In rough seas, for instance, a ship will normally be prohibited from launching a manned helicopter if its safety boat – which must be on standby to rescue aircrew in the event of ditching – cannot be put into the water. Removing the crew from the aircraft will make the safety boat redundant, allowing rotary-wing flying to continue in higher sea states.

Although the concept demonstration achieved its objectives, the MoD has no plans to procure a maritime RWUAV system. Wheaton said that unmanned rotorcraft have a number of weaknesses when compared to their fixed-wing cousins, including cost, complexity, vulnerability (due to Doppler, noise and visual signatures), and launch and recovery limits. However, 'the principal reason that the RN only has a limited organic UAS capability to date is that unmanned air systems cannot deliver like-for-like against their manned rotary-wing counterparts,' he told *UV*.

For example, the Wildcat and Merlin manned maritime helicopters 'provide effects that, in the UAS world, are technologically too immature or too costly to implement on a UAV at this time. It will be a transitional process as UAS-delivered capabilities are able to compete effectively and affordably with legacy manned systems.' ■

OUT AND ABOUT

Outside the EOD role, the development of UGVs continues to progress slowly by comparison with rapidly evolving UAVs, but there are clear signs of progress towards deploying the technology for perimeter and border security duties. **By Andrew White**

The contemporary operating environment is now seeing an emphasis on the security of porous borders in order to find and fix terrorist groups seeking to infiltrate nations. According to a report on the global military UGV market, published by Visiongain on 10 December, this particular sector generated more than $412 million alone in 2015, with hot-spots including Brazil, Canada, France, India, Israel, Poland, the UK and the US.

Growth areas include not only EOD but also ISR, logistics and supply and border patrol. However, development progress and operational utility remain slow in the latter area, although options continue to be considered for operation in collaboration with wide-area surveillance UAVs for more networked security solutions.

A spokesperson from Visiongain explained: 'As recent [terrorist] attacks demonstrate, weak border security provisions can directly expose citizens to these external threats, causing significant instability for internal, regional and international peace and security. As such, investment will continue in such areas as unmanned technology and advanced IT systems, including biometrics and networked border surveillance protection, despite budgetary constraints and the sharing of resources from growth in multi-government border projects.'

Modular solutions

The latest trends in the market certainly point to requirements for modular UGV systems, capable of fulfilling a multitude of uses, ranging from EOD, counter-IED (CIED), force protection and border security to cargo resupply, as well as the contentious issue of armed UGVs. Such modularity requires interchangeable payloads designed for these specific mission types, all of which can be carried on board a standard unmanned chassis.

In line with this trend, several manufacturers have recently unveiled modular UGV products, including HDT,

The Guardium UGV was designed to perform missions such as programmed patrols along a perimeter, but also to react to unscheduled events (Photo: IDF)

which highlighted its Micro-Utility Vehicle (MUV) at the AUSA exhibition in Washington, DC in October.

According to HDT officials, the MUV has a maximum payload of 570kg, allowing it to carry modular payloads for mine and IED clearance missions and perform casualty evacuation, as well as tote remote weapon stations (RWS) and sensor payloads for force protection and border security applications. Speaking to *UV*, a company spokesperson explained: 'The versatility of the HDT MUV, along with its modularity, mobility, remote-control operation and host of attachments, make the unit a reliable workhorse to ease the burden on field-deployed warfighters.'

Originally designed for the support of dismounted infantry units on the battlefield, the MUV is powered by a 32hp turbodiesel engine which is capable of propelling the UGV up 45° slopes. Measuring 91cm in width, the UGV has a 57l fuel tank providing it with a maximum operating range of more than 96km, HDT claims, making it a solid candidate for endurance border protection missions.

HDT's solution includes a modular accessory pack for force protection and border security comprising: a semi-autonomous navigation kit; SATCOM capability; a tethered rotary-wing UAV for persistent and networked surveillance of subjects of interest; and Kongsberg's M153 Protector RWS, which permits the integration of either a 5.56x45mm, 7.62x51mm or .50cal machine gun, or alternatively, a 40x46mm automatic grenade launcher.

Control options include a hand controller with 1km-range line of sight (LoS) communication to the MUV or a cruise control mode in which the UGV selects its own speed and direction, dependent upon mission parameters and terrain encountered. In line with growing requirements for littoral force protection, the MUV also has an amphibious capability, using inflated tubes on each side of the chassis to carry it over water. The amphibious kit, which remains in development, includes a pod-mounted propeller for steering and propulsion with a 360° yaw axis.

Referring to this littoral role, HDT explained: 'Using our optional satellite communications kit, the robot is capable of being launched from over the horizon and swimming to shore. Until the amphibious kit is built and tested, it is not possible to know its actual performance in terms of speed and sea state.'

The AvantGuard Mk I is controlled by mobile or portable operational control unit. It can also operate in follow-me mode, where it autonomously trails a dismounted guiding soldier or vehicle. (Photo: G-NIUS)

The company is planning a series of amphibious evaluation tests in May, under the control of US Pacific Command. Scenarios are expected to include tests in Hawaii's jungle environment, with the UGV attempting to conduct a series of river crossings.

Previously, the MUV took part in the US Army's Network Integration Evaluation exercise at Fort Bliss, Texas, in August, specifically working in collaboration with Stryker infantry fighting vehicles operated by the army's infantry brigade combat teams. A total of eight MUVs has been procured by the US Army for evaluation.

'Electrical power is simply not practical. In addition, the robot must be tracked, in order to match as closely as possible the rough-terrain capability of legged infantry. Finally, the robot has to be narrow and small, so it can fit on goat paths and jungle trails, as well as get through narrow openings in walled compounds,' HDT officials described.

The company has also designed a 'heavyweight' MUV variant, capable of carrying a 900kg payload at speeds up to 50km/h. Measuring 1.35m in width, this particular vehicle could be used for force protection missions, with sufficient power available to operate hammer flail or roller/rake systems to clear suspect devices such as roadside bombs and IEDs in a designated area of interest. HDT explained how a test programme, conducted in collaboration with the US DoD at Yuma Proving Grounds, Arizona, earlier in the year, had demonstrated 90% effectiveness against IEDs and mines.

Extra duties

Referring to additional force protection duties for UGVs, other than long-range patrol, one HDT spokesperson explained to *UV*: 'Constructing a combat outpost currently takes the efforts of over half of the unit's manpower for three months. By the time the unit can begin actively patrolling, the local opposing forces have already fully adjusted to new situation. These outposts are too small and remote for heavy equipment, but filling Hesco barriers with entrenching tools is very time-consuming.

'The [US] Army Corps of Engineers funded our development of a backhoe loader kit for the MUV. With this kit, a small unit can build an outpost in less than two weeks, while almost all of the personnel can begin their primary mission right away,' it was explained. In this respect, the MUV can be fitted with a backhoe loader capable of digging 1.5m trenches and lifting 100kg of soil or sand into Hesco-type barriers for protection against small arms, rocket-propelled grenades, mortar rounds and IEDs.

Any force protection or border security operation requires mature ISR solutions and communications capabilities. The ►

MUV's ability to operate a tethered UAV at an altitude up to 1,000ft above ground level allows for the availability of a solution for over-the-hill reconnaissance requirements. This enables EO/IR sensors to be deployed quickly from the host UGV for wider area coverage.

Finally, border protection requirements call for a rapid-reaction capability to forward-mount UGVs to an area of operation. HDT has proven that a CH-47 Chinook has the capacity to carry up to eight MUVs for exactly this purpose, while the V-22 Osprey tiltrotor has the capacity to carry three vehicles. Such a concept of operations is appealing to armed forces seeking to protect long perimeters of main operating bases, such as those witnessed in Afghanistan over the past decade.

Milrem's tracked UGV platform, pictured above during recent cold-weather trials, is designed to accommodate a range of different payloads, which could include remote weapon systems. (Photo: Milrem)

Israel options

Israel remains at the front end of UGV deployment and over the past five years has used such systems to patrol the 96km perimeter of the Gaza Strip with a remote-controlled weapon capability and sensor payloads for surveillance tasks, aimed to find and fix smuggling of materiel and personnel through underground tunnels.

A long-term advocate of UGVs for border and force protection duties, the IDF continues to take huge interest in this area, with ongoing trials of systems including G-NIUS's Guardium family. At the AUSA exhibition in October, the company unveiled the 4x4 Guardium Hybrid Multipurpose Vehicle with integrated loitering munition (UVision's Hero) for precisely this type of mission set.

Speaking to *UV* at the DSEI event last year, industry sources explained how the platform could also be capable of carrying various other anti-tank guided munitions (ATGMs), such as Rafael's Spike family, as well as additional small and micro-UAVs for over-the-hill reconnaissance.

The company's AUSA exhibit comprised Guardium Mk I variants, one of which was fitted with an RWS. This particular platform was designed in collaboration with Israeli Army operational laboratories for perimeter security and force protection at strategic locations including airports and energy plants.

To date, undisclosed variants of the Guardium Mk I have been used operationally, although the IDF is understood to be gearing up options to deploy its latest variant, based on the chassis of a Ford F-350 Super Duty truck. This model has been called the Border Patroller.

Defence sources in Israel suggested to *UV* the new platform would be capable of conducting intelligence-gathering missions for ground force elements as well as monitoring networks of tunnels used by insurgent fighters to smuggle personnel, weapons and supplies in and out of Gaza. The sources explained how the IDF's concepts of operation will see vehicles deployed at battalion level along the Gaza Strip perimeter, controlled from a single tactical operations centre nearby.

'The Guardium UGV was designed to perform routine missions, such as pre-programmed patrols along a perimeter, but also to react to unscheduled events in line with a set of guidelines specifically programmed for the site characteristics and security routines,' a G-NIUS spokesperson explained.

However, the company's latest variant – the Guardium Mk III – has been dubbed an unmanned ground combat vehicle (UGCV) with company officials explaining: 'The Guardium Mk III creates deterrence by rapid closure of the sensor-to-shooter

loop, identifies and classifies hostile activity, gives advance warning to military forces and provides a threat response, all without endangering personnel.' According to company officials, the system could be used for identification and interception of IEDs and mines as well as 'around-the-clock defence for border and strategic installations'.

Additional UGV capabilities from G-NIUS comprise the AvantGuard series of vehicles, including the Mk II, another UGCV designed for ground manoeuvre combat missions, based on the Dumurs Tactical Amphibious Ground Support platform, a tracked vehicle optimised for operations across difficult terrain. The AvantGuard Mk II has been designed in multiple variants with force protection and border security operations in mind, including 'advance guard and armed sentry' platforms.

ISTAR solutions

Without mature ISTAR payloads, UGV effectiveness as a force protection and border security platform quickly evaporates. To this end, G-NIUS has integrated technology from fellow Israeli company Controp's family of scanning and observation surveillance camera systems, on board its fleet of UGVs.

Options include short-, medium- and long-range solutions providing situation awareness at ranges up to 20km, using high-resolution IR and image-intensification cameras, automatic moving target indicators and panoramic scanning cameras. Variants are usually mast-mounted on board low-profile UGVs for increased range.

Multi-role platform

Elsewhere, Taiwan's Ministry of National Defense has unveiled a modular UGV which is capable of force protection duties. Exhibited for the first time at the Taipei Aerospace and Defense Technology Exhibition earlier in 2015, the Remote-Controlled Light Combat Vehicle (RCLCV) can be equipped with kinetic weapon systems including ATGMs and coaxial machine guns.

Weighing 200kg, the RCLCV can be fitted with 5.56x45mm, 7.62x51mm or .50-cal light, medium and heavy machine gun variants for force protection duties plus an EO/IR sensor suite with integrated laser rangefinder, providing full-motion video capability to find and positively identify subjects of interest.

According to industry sources, the RCLCV features ballistic protection against small-calibre weapon systems, with the addition of minimised heat and noise signature for more discreet operations. Designed as a multi-role platform, the RCLCV can also feature an integrated ground-penetrating radar for CIED and mine-clearance as well as CBRN detection systems, particularly suited to protection of critical national infrastructure.

Additional UGV models for force protection and border security have been developed, with examples including ST Kinetics' collaboration with Estonia's ▶

Taiwan is looking to develop the RCLCV as a multi-role UGV, able to be configured for operations such as EOD, mine clearance, CBRN detection and perimeter security. (Photo: Gordon Arthur)

Milrem for the manufacture of a weaponised variant. On show at DSEI in September last year, the tracked UGV featured STK's Adder RWS, a day/night solution equipped with 7.62x51mm or .50cal machine guns or a 40x46mm automatic grenade launcher, available in single or dual mountings.

The RWS includes a sighting and video tracking system for target identification and engagement, whether on the move or stationary. STK's Compact Sensor Unit can also be fitted to provide a CCD day camera and cooled thermal imager.

Speaking to *UV*, a spokesperson for Milrem explained how the electric/diesel hybrid UGV could be used in areas where it is not safe or reasonable for military personnel to be, including on long-range perimeter patrol tasks required to protect borders and critical infrastructure. 'The UGV can be driven from a distance and also a predetermined path can be entered. This project has been funded by the Estonian Ministry of Defence,' the spokesperson added.

With a top speed of 50km/h, the as-yet unnamed UGV has a base kerb weight of 700kg and capability to carry an additional 700kg in sensor payloads, weapon systems and ammunition. The UGV has a maximum endurance of eight hours and measures 2.5m in length, 2m wide and 0.6m high. In addition, equipment fits could include a communications relay payload for platforms used for ISR tasks, including CBRN detection missions.

Milrem is working on a number of options suitable for force protection and border security operations including communications relay, ISR, RWS, UAV carrier and anti-tank variants. Initial technology demonstrators were expected to be ready for a trial programme in January.

Eastern interests

Moving further east, Russia continues to invest heavily in robotics with the country's MoD signing a cooperation agreement in November with the South Western State University in Kursk, designed to further explore AI for tracked UGVs.

The university's Research and Production Centre is studying AI control systems for multiple tracked platforms, allowing UGVs to autonomously operate around critical infrastructure and border areas, relying upon obstacle-avoidance technology to map a route around difficult terrain. The Russian MoD claims the technology will be capable of identifying and avoiding obstacles at speeds up to 30km/h.

In line with the MoD's robotics drive, local company Avrora Robotics unveiled the Mars A-800 UGV at the Russia Arms Expo on 10 September. The platform is a tracked UGV, similar in size to Lockheed Martin's Squad Mission Support System and is capable of carrying up to six soldiers with combat loads at ranges out to 200km. The UGV has a payload of 500kg and range can be extended to nearly 500km with the integration of an additional external fuel tank.

In development for several years now, the Mars A-800 is based on a COTS chassis. In a force protection and border security role, the UGV can be fitted with C4ISTAR technology including full-motion video cameras, EO/IR cameras, radar and LIDAR payloads, according to Avrora. In a troop carrying role, the Russian MoD has earmarked the vehicle for rapid reaction duties, capable of delivering a quick-reaction force to a situation should suspicions be raised.

The UGV can operate autonomously via the Russian MoD's GLONASS satellite constellation as well as an inertial ▶

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AR4 EVOLUTION

Speed:	80 km/h
Range:	20 km
Flight Time:	2 h

Missions:

- ISTAR Missions
- Environmental Surveillance
- Anti-terrorist Surveillance
- Infrastructure monitoring

AR5 EVOLUTION

Speed:	140 km/h
Range:	Sat comm
Flight Time:	8 - 12 h

Missions:

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navigation unit, navigation waypoints or under the control of a driver if operated in manned configuration. The vehicle also has a follow-on mode allowing it to patrol behind a troop formation, allowing a squad to carry additional ammunition and supplies as well as providing immediate access to C4ISTAR and networking capabilities.

Avrora Robotics described to *UV* how the UGV was capable of executing tasks during the day or at night, as well as in adverse weather conditions. An evaluation programme is in the process of being organised with the Russian armed forces for 2016.

Russian responder

Meanwhile, at the same exposition, the All-Russia Research Institute of Automatics unveiled a 6x6 wheeled multi-purpose UGV for operation across harsh terrain. The Institute's Center of Robotics and Accident Response has a remit focused on the creation of 'robotics complexes, remotely controlled systems, and development of basic technologies for execution of remote activities, aimed at elimination of radiation accident consequences', a spokesperson said.

The Institute's RTK-AM UGV also represents a multi-purpose capability which can be re-roled for force protection and border security operations, including in winter conditions on Russia's northern borders with Norway and elsewhere, for example. The UGV has already demonstrated a capability to transit through 10cm of powder snow as well as an ability to cross 0.5m trenches and depths of 0.25m in water.

The electric 6x6 wheeled UGV, which weighs approximately 130kg, measures 1.5m in length but is capable of shortening itself via a hydraulic system to just 0.8m in order to move through, over or across difficult terrain in a fashion similar to the compression and decompression of a caterpillar's body. However, such an ability to cross harsh terrain has impacted the UGV's top speed, which institute officials revealed is just 3km/h.

The RTK-AM can be remotely controlled via RF signals or a tethered cable requiring an operator to remain within 100m of the vehicle. It is understood that 2016 will see an evaluation programme for the UGV with the integration of a series of modular payloads comprising surveillance and reconnaissance systems and CBRN detectors as well as EOD and CIED technology.

The UGV sector has some way to go before it reaches the levels of maturity currently witnessed in its aerial counterparts. However, it appears further development is required regarding the ability to cross harsh terrain, and to provide fully autonomous capabilities to armed forces seeking to operate UGVs for force protection and border security operations, not to mention more complex ISR-generating missions which also require stealth. ■

Perimeter security for military bases looks like one application well suited to armed UGVs. (Photo: US DoD)

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The Watchkeeper UAV could well be fitted with a variant of ViaSat's ES-1200. (Photo: UK MoD)

Memories *are made of this*

Intelligence gathered by UAS is only useful if it can be disseminated and analysed. Increasing levels of sensor sophistication and fidelity are placing an ever-greater burden on onboard data storage and transmission capabilities, creating challenges for developers. **By Jonathan Tringham**

UAVs have proven indispensable to the military across a wide range of mission-critical tasks including ISR, EW, battlefield management, search and rescue and attack missions.

New advanced sensor capabilities can include HD full-motion video cameras, EO/IR imagers, multispectral sensors, synthetic aperture and ground/digital moving target indicator (SAR/DMTI/GMTI) radars, SIGINT collection systems and communications relay/networking equipment.

However, uprated sensors have created a commensurate requirement for enhanced data processing and storage capabilities – for example, the ability to efficiently store the data acquired by a UAV deployed on ISR operations is key to the success of the mission.

Ruggedised and ready

Data storage components deployed on board military UAVs must be able to cope with harsh operating environments, necessitating a high degree of ruggedisation to enable the system to endure conditions ranging from desert heat to the sub-zero temperatures encountered during high-altitude flight.

The overall design of UAV information processing and storage systems is largely determined by the strict SWaP parameters that military hardware must conform to, meaning that the lighter the system and the smaller its footprint and power consumption, the better. The data storage systems deployed with military UAVs are typically comprised of a data storage chassis, removable data storage units, input/output (I/O) modules and additional encryption modules to secure classified data, if required.

Modularity is also a desirable attribute in storage systems to facilitate the transportation of captured data between locations following the conclusion of a mission, such as from a landing zone to a ground station.

Data captured during a mission will usually need to be removed from the UAV and taken somewhere to be processed and analysed, typically referred to as an ▶

"Data captured by sensors or subsystems installed on board a military UAV is frequently sensitive in nature, and therefore must be protected from unauthorised access."

after-action review. As such, the drives need to be easily removable from the platform and simple to use in a ground-based system.

Defence contractor Curtiss-Wright manufactures COTS modules and system-level products for defence and aerospace applications, including ruggedised data storage units designed to perform optimally in airborne applications constrained by SWaP considerations.

For unmanned applications, the company has developed the Compact Network Storage 4-slot (CNS4) rugged network file server and data recorder, designed for use in high-speed ISR and EW applications, where sensor data needs to be captured for later analysis. The Federal Information Processing Standards (FIPS) 140-2 compliant CNS4 is a convection-cooled modular unit comprised of a 1/2 ATR CNS chassis and one or two flash storage modules (FSMs), which can be easily removed, and supports industry-standard network storage protocols (NFS, CIFS, HTTP and FTP) through four 1GbE ports.

The ruggedised network attached storage system can support up to four 2TB FSMs, giving it a total current capacity of 8TB. The company states that the memory modules are based on industry standard 2.5in solid-state drives (SSDs).

The reason for this was to offer flexibility, low obsolescence risk and increasing capacities in the coming years, given that SSD memory is doubling every 24 months. The whole unit weighs in at just over 6.8kg, and has a footprint of 123x124x321mm, with the single-FSM version using 62W and the double model 69W.

One major challenge for onboard data storage solutions for UAVs is coping with the vast array of I/O options that exist in modern avionics setups. To combat this, the CNS4 is installed with four 1GbE or two 10GbE ports and a 3U VPX slot. The company says installing a VPX carrier card expands the system functionality and I/O capability without requiring additional single-board computers.

The CNS4 can record multiple channels of time-stamped SFPDP, GbE and 10GbE data using the Universal Capture Card XMC module, and in combination with a VPX carrier card it can host a wide range of I/O XMC cards such as 1553 and ARINC 429 for capturing legacy protocols.

Data encryption

The data captured by sensors or subsystems installed on board a military UAV deployed during missions and operational exercises is frequently sensitive in nature, and therefore must be protected from unauthorised access in the event of a downed aircraft.

There are several levels of encryption, ranging from basic unclassified data, Sensitive but Unclassified (SBU) up to higher classification types including NSA Type 1 Secret and Top Secret. The lower levels like SBU can be adequately addressed with commercial encryption solutions validated by FIPS 140-2, or the CESG standards in the UK.

For unmanned mission sets where the UAV is at risk of enemy capture, the CNS4 is designed to integrate various levels of encryption to secure the stored critical data, and supports AES256, FIPS 140-2 and NSA Type 1 encryptors, in addition to providing advanced key management.

In some instances, a single platform may be required to store multiple data sets with different levels of security classification. The CNS4 module accomplishes this by assigning an individual chassis to each classification level, which houses its own storage media and encryption. Encryption modules operate independently of the storage drive installed in the UAV, and work by passing incoming and outgoing data through an inline media encryptor (IME) before the data is stored or after it is retrieved from the storage media.

One company looking to meet the encryption requirement for stored data classified Secret and below is US defence giant General Dynamics, which has developed the ProtecD@R Embedded Data-at-Rest (DaR-400E) encryptor.

According to the company, the DaR-400E is optimised for use with ruggedised VITA applications, unattended platforms such as tactical vehicles and UAVs where there is a potential threat of the platform being compromised or overrun. It is incorporated into the Curtiss-Wright CNS Type 1 file server, where it encrypts incoming data and stores it on a removable 1TB FSM in the second slot of the unit's chassis.

Data recorder

Not all IMEs are certified for unmanned use, as regulatory authorities impose a stricter criterion for securing data stored on UAVs, UGVs and USVs. Currently the DaR-400E is certified by the NSA to secure information classified Secret and below in attended environments, with requests for use on UAVs referred to an internal review by Curtiss-Wright.

C4ISR specialist L-3 Communications has developed the RM-3000 solid-state recorder specifically designed for UAV payload, telemetry, surface, subsurface and military vehicle applications. The RM-3000 is part of the company's Strategic/Tactical Airborne Recorder (S/TAR) family of equipment and is an established option for UAV sensor collection, flight test/system evaluation data storage and telemetry applications.

The solid-state recorder has an open-architecture design with industry-standard data and control interfaces, fast random access to mission-critical data, high data rates, playback to display or data link capability, removable memory and a total package weight of 9.9kg, depending on its specific configuration.

Rockwell Collins has also developed a small, ruggedised onboard mission computer for UAS that offers wide mission capabilities, data storage and built-in security features, dubbed the GPC-3000.

The general-purpose GPC-3000 module was launched on the Textron Shadow tactical UAS, and can host a variety of mission and payload applications, including data storage, digital video recording and playback, multi-payload sensor fusion and other applications for ISR operations.

Ruggedised data storage units and embedded data-at-rest encryptors are being optimised for UAV platforms. (Photo: General Dynamics)

Embedded security

Global broadband service and technology company ViaSat has developed the Embeddable Security System 1200 (ES-1200) to secure C2 links for UAVs and a variety of other wired and wireless applications.

The ES-1200 is optimised for embedment in host systems that have low SWaP requirements, and was awarded secured standard FIPS 140-2 Level 2 certification from the National Institute of Standards and Technology in 2014. In addition to its function as a crypto engine, the ES-1200 provides a comprehensive cryptographic system that includes key management, data storage, power conditioning, IP optimisation, zeroisation, trusted bypass and control.

ViaSat supplies the cryptographic storage systems for the British Army's Watchkeeper WK450 UAS, manufactured by Thales and Elbit Systems. Although the exact technology used on the platform is classified, it is likely based on a version of the ES-1200.

In July 2015, ViaSat announced a £3.8 million ($5.4 million) contract from General Dynamics to provide encrypted data storage for the British Army's Scout SV armoured vehicles, which will be modelled on the systems utilised on unmanned platforms. The system is based on CAPS-accredited data encryption, which is one of the only hardware-based encryption technologies certified to protect Top Secret data at rest by the CESG.

In a statement following the announcement, Chris McIntosh, CEO of ViaSat UK, said: 'Our experience providing secure systems to programmes including the Lynx Wildcat helicopter and Watchkeeper [UAS] has stood us in good stead for ensuring that sensitive information remains safe.'

In June, ViaSat also announced a strategic alliance with UAS manufacturer Tekever to expand the civilian and commercial use of drones with advanced SATCOM. The joint collaboration will introduce ViaSat's communication technologies to Tekever's range of unmanned platforms in order to increase the range of the company's UAS in beyond-line-of-sight commercial and hobbyist applications.

Advanced imaging

In addition to onboard data storage, unmanned military aircraft with greater data processing demands, such as those involved with HD video imaging, are paired to a GCS with sophisticated C2 and data storage and exploitation capabilities. Perhaps the most advanced imaging system being deployed on an unmanned system to date is the Autonomous Real-Time Ground Ubiquitous Surveillance Imaging System (ARGUS-IS), developed by BAE Systems and funded by DARPA.

ARGUS-IS is designed for use on large unmanned platforms such as the Northrop Grumman RQ-4 Global Hawk or General Atomics MQ-1 Predator, from an altitude of 20,000ft. With 1.8 billion pixels, the ARGUS-IS is claimed to be the world's highest resolution camera and offers a persistent surveillance capability equivalent to 100 Predator UAVs simultaneously focused on an area the size of a medium-sized city.

According to BAE Systems, it can record real-time video of an area comprising 24km^2, at a resolution high enough to pick out objects no larger than 15cm in size on the ground, with everything that moves within the image automatically tracked, generating an 'unprecedented' amount of surveillance data from an unmanned platform.

The system creates a mosaic image using 368 image processing chips – similar to those found in mobile phones – to create a 1.8 billion pixel live video stream. As the sensor data generated by the cameras outputs at an enormous 32.4GB/s, and the Common Data Link used by the system has a capacity of 34.25MB/s, a 32-processor unit carries out the data compression and object tracking function.

Uncompressed, the data storage requirements would exceed ten petabytes or 10,000TB per day of raw video. However, only the compressed stream from the ARGUS-IS is stored, needing only 6TB. This allows up to 36 hours of reviewable footage, with DARPA ultimately aiming for 70 hours.

The stored data passes to a ground exploitation system, which provides a visual interface that enables analysts to control more than 100 windows. These are used to view MTIs that follow tens of thousands of ground targets while maintaining background imagery and context with the ability to create 3D terrain models.

Elsewhere, Lockheed Martin's range of large and small unmanned aircraft have operated tens of thousands of hours ▶

over combat theatres across the globe. For its UAS, the company has developed the Expeditionary Ground Control System (EGCS), designed to be a complete, transportable UAS data computing and storage platform. According to the manufacturer, the EGCS has the computing power, system resources, data storage and interface capability to monitor and control multiple airframes and their associated ISR payloads.

The system comprises dual processing compute nodes that can run multiple instances of mission management and image exploitation software, commercial RAID network storage for scaling and data redundancy, an embedded redundancy feature to prevent data loss due to hardware failure and ensure continuous usage, and external drives for data storage and transfer to DVD.

Commercial considerations

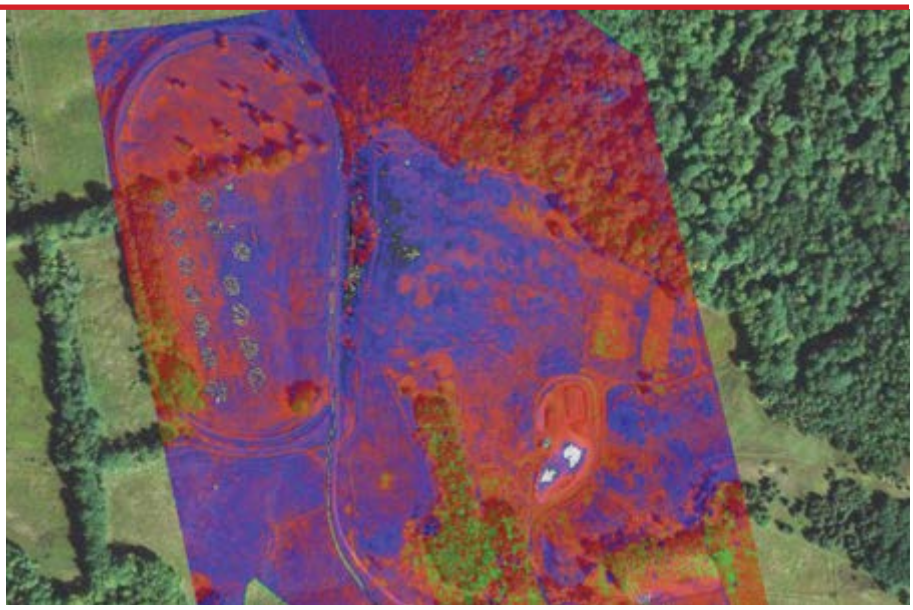
The fact that the military remains the predominant user of UAVs today is largely due to the lack of flight restrictions when operating in airspace over conflict zones. According to technology market intelligence company ABI Research, the commercial market for small UAVs will surpass $5.1 billion by 2019, a growth of 51% from 2014 levels.

In a 2015 report entitled 'Small Unmanned Aerial Systems (SUAS) Solutions Ecosystem', Dan Kara, practice director of robotics at the company, said the key drivers for growth in the commercial UAS sector were application services – industry-specific applications, as well as data, operator and modelling services – and not platforms and other hardware technologies.

'The commercial sector is the sweet spot for the SUAS market, a fact recognised by both traditional defence industry suppliers such as Elbit, AeroVironment and Aeryon Labs, as well as providers to the prosumer/hobbyist marketplace including DJI, Parrot, senseFly, 3D Robotics and others,' he said.

'As a result, both groups of SUAS makers, along with other classes of solution providers, are aggressively targeting the commercial sector through acquisitions, internal development, partnerships and investment.'

Commercial operators are now poised to use UAVs across a wide range of industries, from aerial surveillance of crops to SAR operations and delivery of medical supplies to remote or otherwise inaccessible regions. All of this is generating a huge requirement for UAS data storage capabilities.



Agriculture is one industry less restricted by legislation, where farmers make use of collected data to improve their businesses. (Photo: PrecisionHawk)

The widespread commercial use of such technology is only being held up by the pace of legislative initiative by the FAA in the US, the UK CAA and the EASA, in finding a way to ratify a comprehensive set of regulations to govern UAV use. Commercial unmanned platforms can now carry multiple types of surveying equipment, allowing data to be collected in a continuous stream throughout the flight for instant upload to a server for immediate analysis.

Small UAVs can be equipped with conventional cameras, ultraviolet and IR thermal imaging cameras, hyperspectral sensors which provide 'big picture' or wide-view information to typically 10mm resolution, and LIDAR scanners – a cross between a laser and a radar that collects ultra-high-resolution data. These sensor streams need to be accurately paired with GPS and geo-location tagging in order to transform the data into useable information, and the information needs to be stored and disseminated as quickly and efficiently as possible.

The explosion of commercial UAV applications with data-driven requirements has prompted the industry to develop ways to process and store the vast amounts of data being produced. One area of UAV use that has been less inhibited by flight restrictions is agriculture, where privately held farmlands are typically exempt from certain regulations governing segregated airspace.

Canada-based manufacturer PrecisionHawk runs a cloud-based platform for storage and analysis of the data collected by its UAVs and is currently working with Alberta-based agricultural consulting company Agri-Trend. The two have integrated their software platforms in order to find ways to collect and analyse agricultural data to help farmers across the US get a better return on investment.

According to PrecisionHawk, the integration of its in-house developed Data Mapper software into the Agri-Data platform will allow farmers to aggregate and analyse data coming from a multitude of sources in order to make decisions more quickly and efficiently. The expectation is to provide growers with full integration of orders, delivery and processing from a range of UAV platforms in 2016.

In January 2015, PrecisionHawk joined forces with Measure, a commercial UAS data services provider, to give clients access to aerial data and analysis. Like PrecisionHawk, Measure is geared towards providing UAV data storage and processing solutions tailored for commercial clients, including oil and gas companies, utilities, farmers, insurers, mining companies, conservationists, public safety professionals and filmmakers. ■

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Amazon's Prime Air could be the kind of platform delivering packages to your front door. (Photo: Amazon)

Open skies?

While some well-known companies have announced their intention to fill the skies with UAVs making package deliveries and providing broadband connectivity, the regulatory reality is somewhat different. **By Gerrard Cowan**

Ambitious plans from Amazon, Google and Facebook to make use of commercial UAS have helped spark a surge of interest in the rapidly growing sector.

This is certainly true of the UK, where the local activities of Silicon Valley giants and a burgeoning homegrown industry have intensified the focus from government and media.

In an interview with *The Daily Telegraph* in August, Jeff Bezos, Amazon founder and CEO, praised the regulatory standards in the UK, saying that 'in the scheme of things, the UK regulatory agencies have been very advanced. The FAA is catching up a little here in the US, but the UK has been, I'd say, a very encouraging example of good regulation. I think we like what we see there.' He is putting his money where his mouth is – Amazon's research and development facility in Cambridge, England, is working on the company's Prime Air system, which it hopes will one day be able to deliver packages to customers.

Amazon isn't the only US technology corporation showing an interest in the UK. Facebook acquired Somerset-based Ascenta in 2014 for a reported $20 million, as part of its Internet.org plan to beam web access from UAS.

But while the Silicon Valley giants seize the headlines, the sector is far broader than a handful of huge companies.

A spokesperson for the CAA told *UV* that currently the regulator has granted 1,036 organisations with permission for aerial work, which is required before a company can conduct commercial activity with a UAV in the UK, and needs to be renewed annually. This figure has 'increased considerably over recent years,' the spokesperson said.

A report by the House of Lords (the upper chamber of the UK Parliament) – 'Civilian Use of Drones in the EU' – said that 2014 'could be described as the year of the drone'. It stated that 'in the UK alone, there are now hundreds of companies, mainly SMEs [small and medium-sized enterprises], using RPAS to provide a range of services, including photography, land surveying, building inspection and crop analysis. RPAS will revolutionise what the aviation industry can achieve and how it is regulated'.

Gary Clayton, chairman of the Unmanned Aerial Vehicles Association, which represents all facets of the industry in the UK, expressed confidence over the growing importance of commercial UAS. 'I fully

believe that unmanned technology will become the backbone of non-passenger aviation, whether that be large systems carrying freight around the world, small systems doing all kinds of things, and everything in between,' he told *UV*.

Cautious approach

The UK government is taking the potential of the growing market very seriously, but is proceeding carefully. In December, it launched a series of meetings with members of the public, designed to gauge attitudes towards the use of UAS. It plans to conduct a wide-scale public consultation in 2016, looking into a range of factors, including registration and licensing. It will publish a government strategy later in the year.

'Drones are an emerging technology with the potential to bring significant economic benefits, but it is important that the public are confident they are operated safely,' said Robert Goodwill, Minister of State at the Department for Transport. 'The government is leading efforts with international bodies to develop a stringent regulatory framework focusing on safety.'

There is a wide range of issues to be tackled before UAS become fully embedded in economic life in the UK and elsewhere. Perhaps most important is the need to develop new technology to overcome present hurdles. Currently, all commercial activity revolves around aerial filming and photography, the CAA spokesperson explained. This can mean mapping, data-gathering, straightforward filming or surveillance. Amazon, however, is interested in transportation and delivery.

'Under the current regulations, using a UAS for transportation/delivery is not a viable proposition, due to the requirement for an operator to maintain unaided visual LoS [line of sight] with the device at all times,' the spokesperson said.

This 'beyond visual LoS' element is key. The small UAS side of the business, ie systems of 20kg or less, is seeing the greatest rate of growth. However, UAVs at this classification currently need to be within the LoS of the operator; they must stay within 500m of him or her and fly below 400ft. Moving beyond this restriction creates major challenges, said Phil Binks, solution architect at NATS, a UK-based provider of air traffic control services.

'As soon as you move away from LoS operations, the operator can no longer be the "detect and avoid" system, therefore the technology on the platform needs to be able to take on that task, and that's a big problem. How do you get the detect and avoid system onto the small RPAS?'

Exemptions sought

To further complicate matters, many of these small UAS would be required to operate in all classifications of airspace, both controlled and uncontrolled. 'For UAS to be used for transportation or deliveries, an operator would need to be given an exemption from the LoS rule,' said the CAA spokesperson. 'Such an exemption could only be granted if we are convinced that the device had collision-avoidance capability.'

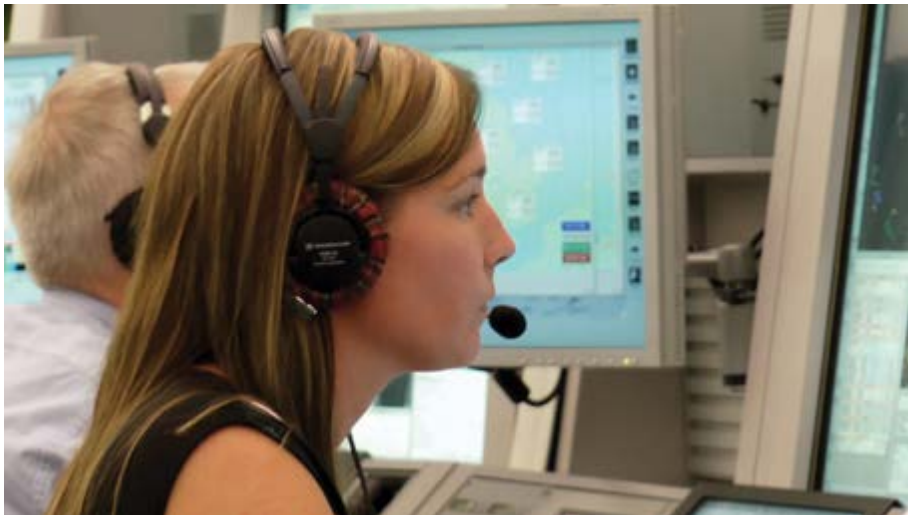
The spokesperson said this was an issue for industry to address, noting that manufacturers are trying to develop autonomous flight control systems to give the vehicles detect and avoid capability. 'However, such a system is probably some way from certification. Ultimately, the timescales are very much with the manufacturers.'

Clayton – who until recently was head of UK communications and security research at Airbus Defence and Space – acknowledged the extent of the challenges. For the systems to operate beyond visual LoS, they will need to be capable of avoiding other air users, as well as ensuring they have no issues with objects like power lines, trees and buildings. 'They may have a map of a street, but if there's scaffolding or other temporary changes that stick out, then that isn't quite the map that they have. So there are quite a few obstacles – all of which can be overcome.'

The House of Lords report set out the LoS problem, but also pointed to a range of other difficulties. 'If a number of RPAS deliveries were scheduled for a similar time in one area, a system to coordinate the traffic of small RPAS in the airspace would be needed,' it stated. 'To guarantee the safety of the operation, the control link between the RPAS carrying the parcel and the pilot would have to be secure. A loss in connection could result in an accident.'

The report said that the market for larger UAS faced many of the same difficulties. 'When scaled up, these challenges are similar to those facing the use of large RPAS to transport cargo, and this helps explain why commercial operations for large RPAS are not yet available in the UK or Europe.'

Air traffic controllers monitored the progress of the CLAIRE flight tests. (Photo: NATS)



New projects

There are a number of projects under way in the UK to investigate the possibility of integrating commercial UAS into airspace with other users. For example, Project CLAIRE (CiviL Airspace Integration for RPAS in Europe) is a Single European Sky ATM Research Joint Undertaking (SESAR JU) programme, designed to test the integration of UAS into controlled airspace. It was overseen by NATS, Thales and the ▶

Netherlands Aerospace Centre, with support from the CAA and the UK MoD.

Project CLAIRE conducted the first ever flight of an unmanned aircraft into controlled and non-segregated airspace using a Thales Watchkeeper. The aircraft left West Wales Airport on a three-hour flight on 30 September and was operated by pilots from a control room at the site. According to NATS, the trial flight and the 'associated safety, regulatory and procedure design work could now pave the way for future use of drones inside controlled airspace'.

It added that 'unmanned air freight, [search and rescue], telecommunications relays and environmental monitoring with UAS the size of conventional airliners are future possibilities'.

Project CLAIRE focused on a large UAV and not on the smaller vehicles that are currently seeing the greatest interest from industry. Ramón Raposo, research engineer in NATS' Research & Development Department, said that operating such small vehicles posed additional difficulties.

'The challenges will be different, because if they want to operate within controlled airspace they will have to carry equipment equivalent to and interoperable with current air traffic management infrastructure, which might be challenging for the size and weight of those UAVs,' he said. 'If you look at the other end of the RPAS vehicles such as the Watchkeeper that we used for Project CLAIRE, it doesn't seem to be challenging for those sort of vehicles to carry a transponder, the standard navigation equipment that any other commercial aircraft would carry.'

Another UK project with perhaps a wider scope than CLAIRE was ASTRAEA, which aimed to enable 'the routine use of UAS in all classes of airspace without the need for restrictive or specialised conditions of operation'.

ASTRAEA – which stands for Autonomous Systems Technology Related Airborne Evaluation & Assessment – was an industry-led consortium, including Airbus, BAE Systems, Cobham, QinetiQ, Rolls-Royce and Thales. The UK government provided half of the project's funding, with the remainder coming from the companies themselves.

The project was launched in 2006 and went through three main stages. The first phase saw the consortium develop synthetic models and draw up a roadmap. This concluded in 2009, and was followed by a second phase that included practical demonstrations of technology to address the major challenges.

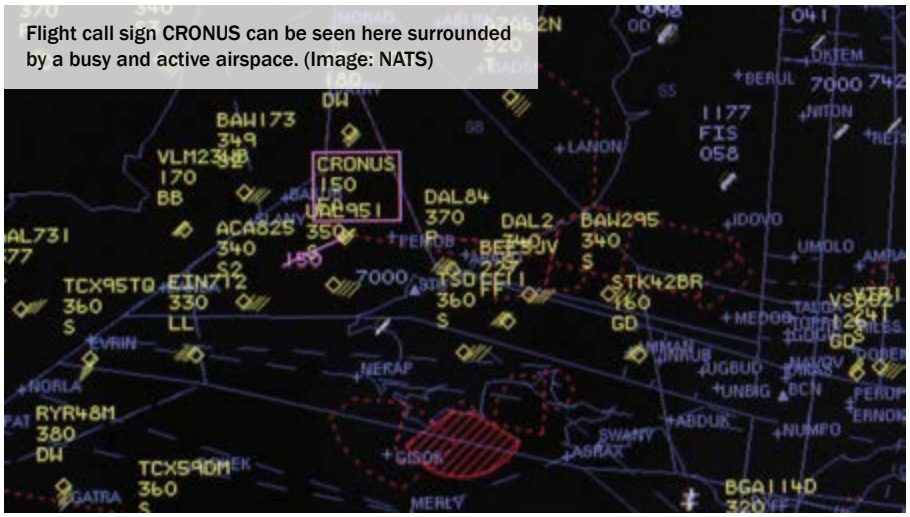
ASTRAEA 3A focused on consolidating the work from earlier stages and laying the regulatory groundwork for part 3B, which would have set out to undertake the flight testing necessary to achieve the target of routine UAS operations in commercial airspace. However, the government declined to provide further funding.

In September, Jo Johnson, Minister of State (Universities and Science) at the Department for Business, Innovation and Skills, said: 'We continue to work with the ASTRAEA consortium and the wider unmanned air vehicle community on how best to support the development of this market and will consider requests for funding support that deliver value for money for the UK.'

Clayton was one of the founding members of ASTRAEA. He said it aimed to 'look at the full gamut of technologies: all the things a pilot would have done'. Although the future of ASTRAEA is uncertain, he is confident that progress will continue to be made in developing UAVs for commercial use. Clayton said that commercial UAV technology is already ubiquitous, pointing to uses in a range of areas, such as inspecting oil rigs and camera work for television shows and advertisements. 'The output is so pervasive that people are just accepting it,' he said.

Binks agreed, saying that NATS held regular discussions with industry over how to support them in their UAS ambitions. He highlighted the media sector, where many organisations wanted to use UAVs instead of helicopters for newsgathering. For now, these organisations wishing to operate within controlled airspace must apply for a non-standard flight plan application, for which they need to give 21 days' notice, or 28 days in some of the restricted areas in central London. 'Well, that's absolutely no good for the media at all – they want to get an RPAS up within 30 minutes or an hour,' Binks said. 'So we are working with certain industries to see how we can address specific issues and support them.'

It may be possible to gradually introduce elements of unmanned technology into a range of areas, thinks Clayton. This would allow the capabilities of the technology to be demonstrated. For example, it could be used to a limited extent in passenger transport, as a means of assisting pilots. It could potentially work as an additional safety aid, with detect and avoid systems



Flight call sign CRONUS can be seen here surrounded by a busy and active airspace. (Image: NATS)

able to supply the human pilot with additional information.

'I wouldn't say that you'd end up with a passenger aircraft without a pilot on board for a very, very, very long time, if ever,' he said. 'However, you might start to see reduced manning on large aircraft, so instead of having five pilots for a long-haul flight you might have slightly less because there's always a backup available.'

Riga rules

Of course, the UK is not alone in pursuing this technology. The projects outlined above had varying levels of input from multinational institutions and corporations. There is a growing body of work being conducted at European level. Major stakeholders in Europe's UAV industry, such as the European Commission, members of the aviation industry, and officials from EU member states, met in Riga, Latvia, in March 2015. They issued the Riga Declaration on Remotely Piloted Aircraft, which contained five guiding principles for the introduction of UAS into daily life, all of which will clearly impact the British side of the industry.

First, they need to be treated as new types of aircraft with proportionate rules based on the risk of each operation. Secondly, EU rules for the safe provision of UAV services need to be developed now. Thirdly, technologies and standards need to be developed for the full integration of UAS in European airspace. Fourthly, public acceptance is key to the growth of UAV services. Finally, the operator of a UAV is responsible for its use.

Violeta Bulc, the EU Commissioner for Mobility and Transport, pointed to the need for a balance between the needs of business and the safety requirements that commercial UAS would have to uphold. 'On one hand industry needs to know which direction the rules are going to make investment decisions,' she said. 'On the other, citizens need to know how we'll uphold their safety, security and fundamental rights, and for them to accept that drones will become more common in their daily lives. As regulators, we have a clear responsibility to address these issues – society expects nothing less from us.'

Work into these practicalities has been taking place at the European level for some time. Project CLAIRE was conducted as part of the SESAR JU, which was launched by the European Commission. SESAR JU is the technological element of the Single European Sky programme, launched by the commission in 2004 to reform Europe's air traffic management system.

UAS are becoming an increasingly important element of this goal, with CLAIRE one of nine projects focusing on the future of unmanned systems in Europe's crowded skies. Three of the SESAR JU UAS projects have been completed, with implications across the continent. For example, as part of Testing Emergency Procedures in Approach and En Route Integration Simulation, a UAV demonstrator was integrated with the air traffic of Bordeaux-Mérignac airport in France. It found that such UAS could currently operate only in airports with fewer than 20 movements per hour.

There is a sense that regulations will need to be harmonised across the continent. The CAA spokesperson said the organisation was 'very active in working with the EASA to develop a common set ▶

The Watchkeeper UAV used for the CLAIRE tests is operated by the British Army, and is pictured below during an earlier flight. (Photo: Thales)

of rules across the EU'. The latter agency has launched a major consultation on UAS policy and rulemaking, to which the CAA will be responding, the spokesperson said.

'We do need to aim towards a European regulation in order to promote the industry,' said Binks. 'The last thing I imagine companies would want is to have a set of regulations to adhere to in the UK, then they operate in France with another set of regulations, then in Germany another set of regulations. We do need to, as we are doing, engage in Europe and develop European standards and regulations.'

European work

The House of Lords report mentioned above was focused on work at the European level. It supported the aim of creating an internal UAS market in the EU: 'The civilian use of RPAS has the potential to bring aviation into all industries. It is important that rules developed by the commission and member states enable growth in the industry and development of technology for the future.'

The report outlined a wide range of recommendations for the development of an EU commercial industry and said there was a need for EU rules on safety. However, it warned that rules for small UAS 'should be flexible enough for member states to respond to, and support local, industry'.

The commercial UAV industry is global, of course, stretching far beyond Europe's borders. The second principle of the Riga Declaration, focused on the development of safety rules, states that 'the essential requirements should be harmonised at the global level to the maximum extent possible'. It calls for Europe to make full use of the cooperation already established in the Joint Authorities for Rulemaking on Unmanned Systems, a body containing members from national and regional aviation safety bodies, as well as ICAO.

Regulatory harmony across the greatest possible geographical range has obvious benefits for participants in the industry, giving them transparency across borders when developing their products. Denis Koehl, senior adviser for military affairs at the SESAR JU, highlighted the potential for transatlantic harmonisation when he spoke to the 11th USA/Europe Air Traffic Management R&D Seminar in Lisbon, Portugal in June. Without increased harmonisation, there was a risk of 'burdening airspace users with the need to carry different types of capabilities and causing them to bear the associated additional costs'.

Likewise, the House of Lords report called for UK and European authorities to work with their American counterparts. It recommended the creation of an online database through which small UAV pilots could register details of flights below 500ft, saying that this had already been explored in the US.

'In order to keep the UK and Europe at the forefront of RPAS developments, we recommend that all parties seek to engage with NASA in the US, which is currently researching the development of such a system,' the report stated.

United front

There is a great deal of optimism in the UK and more broadly for the potential of the commercial UAS sector, among both industry and government. However, it is clear that much has yet to be addressed, primarily in the technological and regulatory arenas.

One of the issues identified in the House of Lords report was what it termed a 'chicken and egg' problem. 'Industry is reluctant to invest in developing the necessary technology without certainty about how they will be regulated, while regulators are reluctant to develop standards until industry comes forward with technology for validation,' it stated.

The report recommended an approach similar to ASTRAEA, with industry and regulators in Europe working together 'to overcome this challenge through shared funding and early joint working'.

In many ways, the current position of the civilian UAV sector in the UK and beyond is reminiscent of the earlier stages of several technologies that are now ubiquitous. The Watchkeeper that was used in Project CLAIRE was able to carry equipment that could not currently fit on a smaller UAV. Still, Clayton has no doubt that a process of 'miniaturisation' will occur.

'It's like any other equipment, it gets miniaturised,' he said. 'I remember not so many years ago I bought the largest disc drive you could ever dream of – you would never need more storage in your life and it cost quite a lot of money. It was a whole 70MB.' ■

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Smaller gaps, ***growing capability***

The Latin America market contains a diverse mix of indigenous and imported unmanned capability and services, but the ratios for some nations are shifting. **By Richard Thomas**

Latin America appears one of the most promising markets for civil security and military-grade UAVs, but despite the significant advances being made in creating national industrial capacity, many countries still look overseas for their platforms and expertise.

At present, platform applications focus on ISR and border security, particularly for counter-narcotics operations. Brazil, Colombia and Mexico have bought UAVs from Israeli OEMs, such as the Elbit Systems Hermes 450 and 900 and Aeronautics Defense Systems Dominator XP.

US companies are also represented among foreign exporters, such as Boeing and its ScanEagle, which first began operations with the Colombian armed forces in the mid-2000s. Other procurement programmes are at different stages of maturity with both European and Asia-Pacific systems.

No surprises

That one of the main roles these platforms are being tasked with performing revolves around the provision of ISR for security services engaged in counter-narcotics operations should come as no surprise.

Alon Dayan, CTO at Mexico-based Balam Security, agreed that combating the drug trade was a key reason for the interest among Latin American countries in unmanned systems.

'In Mexico, they are using this technology to follow drug cartels and intercept communications – they bring a lot of value to the fight,' he said. 'The cartels are growing in capability and some of them are like a military, an army you have to fight.'

Not that UAV and UAS development should solely be for the benefit of the defence and security markets, as the sheer geographical challenge of Latin America lends itself well to the use of such systems in the commercial sector.

Christian Zepeda, general manager of UAS manufacturer Delair Tech Latin America and a Mexico native, certainly thinks so. One example was the proliferation of large-scale infrastructure projects thanks to the cheap natural gas made available by fracking in the US.

These works are often sent through vast unpopulated areas, such as the Sonora region in Mexico.

UAS such as the ScanEagle are well suited to operating in the vast spaces of Latin America (Photo: Boeing)

'If we take the example of Sonora, the north-western Mexican state in which I was born and raised, and compare it to France, my adoptive country, the former has a surface of 180,000km² – roughly a third of France's 550,000km² – whereas its population is only 2.6 million people, almost 25 times less than France's 64 million inhabitants and almost half of these 2.6 million people are in one city,' he explained. 'This is obviously an extremely fertile ground for our industry.

Indigenous ingenuity

From Argentina's Lipán M3 and Guardián UAVs, to the Colombian IRIS, the region is increasing the capability and complexity of its unmanned systems. A 2013 report by the Americas Society and the Council of the Americas detailed the spread of unmanned technology in the region, with some countries able to trace a history of UAV development and operations back ten years and more.

The disparity that first greeted foreign OEMs looking at how they might invest in Latin America and the capability shown by overseas UAV superpowers has reduced somewhat then, as more countries are able to draw on lessons learned with older generation platforms for newer models.

Brazil, arguably the leader in UAV design and development in the region, has been extremely busy in recent years improving its knowledge and technology baseline, particularly boosted by the extensive cooperation with Israeli firms in both procuring complete systems and investments into its own manufacturing capability.

In March 2015, Avionics, itself a partner of IAI, announced it was progressing towards the production of a locally constructed MALE UAV named Caçador. Information released at the time detailed that the programme was made possible thanks to a technology transfer from IAI to Avionics, ensuring a 'successful, professional and highly advanced process'.

The Caçador will be based on IAI's Heron, a platform with proven capability which was illustrated with the news in December that the Heron 1 marked its 70,000th flight hour in support of operations in Afghanistan by Australia, Canada, France and Germany, among others.

> *"In Mexico, they are using UAS technology to follow drug cartels and intercept comms – they bring a lot of value to the fight."*

Brazil is clearly confident that it will meet its national needs and already has experience with IAI models, which have been in operation with the country's federal police since 2010. It is thought that the Caçador will feature an automatic take-off and landing system and be capable of fitting multiple payloads for LoS and BLoS missions.

Interestingly, an IAI subsidiary, European Advanced Technology, acquired a minority holding in Avionics back in 2014, a move that IAI said was part of its strategic expansion into the Brazilian defence market.

Eyeing developments

Elsewhere, in Colombia it has been revealed that the IRIS tactical UAV, itself developed by the government-owned Corporación de la Industria Aeronáutica Colombiana (CIAC), is set to be delivered to the Colombian Air Force this year. A series of test flights were conducted to address flaws with the original model which by all accounts were successfully completed.

Once in operation, the IRIS will likely perform the traditional tasks that platforms of such capability are expected of, such as the aforementioned ISR and counter-narcotics patrols.

Chile has also been at the forefront of unmanned operations in the region and concluded an agreement for the Hermes 900 from Elbit Systems at the beginning of this decade, with around half a dozen thought to have been procured. As far as capability goes, the Hermes 900 is one of the most advanced systems in both the region and worldwide, capable of carrying a maximum payload of up to 350kg, with a mission endurance and operational ceiling of 36 hours and 30,000ft respectively.

Again, the use of these systems primarily concerns border security and assisting in combating the drug trade.

While Hermes is not an indigenously produced platform, having operated such systems for some years, Chile's armed forces will be in a better position to transition into a national manufacturing plan if so desired. A number of companies have been operating in the civil security and commercial UAS sector, such as IDETEC in Santiago, which markets its range of systems for law enforcement, survey and infrastructure monitoring.

In March 2015, an official note from the government of Chile revealed that officials held a meeting with representatives from OEM Mapemaun on its development of an internal security monitoring system using indigenously developed rotary-wing UAS.

Argentine advancements

In Argentina, defence companies have been looking to bolster their own national UAV manufacturing capacity, building on programmes such as the Yarara, which saw the Argentine Air Force (AAF) grant Nostromo Defensa an initial contract in 2011 for three UAVs. The design and production would take place in Córdoba.

A statement at the time from Nostromo said the Yarara would be used as a UAV trainer at the flight school at Córdoba AAF base. The tactical UAV was reported to be able to fly at speeds up to 80kt, with a range of 50km and service ceiling of 9,850ft. Loiter time is stated as a maximum of six hours. According to Nostromo, the platform is suited for a number of applications such as UAV training and tactical ISR.

More recently, the first UAV flight of the national Argentine Air Robotics System (Sistema Aéreo Robótico Argentino (SARA)) programme took place in 2014 following a decision by the Buenos Aires government in charging the National Institute of Applied Research with the development of a multi-system indigenous capability. The flight of the MET-1 in August 2014 took place near Córdoba. The SARA project also envisages the design and production of larger MALE platforms.

Ecuador, Peru, Uruguay and Venezuela also have growing domestic UAV manufacturing capability, again for use in surveillance, reconnaissance and counter narcotics and counter-terrorism. ▶

Without listing all national capabilities in the R&D, production and testing of UAVs, it is fair to say that regional powers in Latin America have both the inclination and skill sets to develop indigenous programmes.

Where there could be limitations is in the sustainment of UAV operations and industry, and this is where foreign OEMs look to leverage their hard-won knowledge and expertise.

Partnering up

In a sector undergoing such rapid change and development, however, it pays to be able to call on those who have been through all the teething problems in developing a UAV from the runway up.

An approach that is growing in popularity involves foreign OEMs engaging in industrial partnerships with local UAS manufacturers. This provides both technological and intellectual boons to the Latin American market, acting as a strong stimulus to the developing capacity base.

In September 2015, Israeli OEM Aeronautics confirmed the sale of a single Dominator XP UAS to Mexico following the completion of flight trials. Based on a DA42 Twin Star commercial aircraft, the MALE platform is well suited to military and homeland security missions, over land and sea.

The deal with the Mexican government was for the platform only and contained no technical support. At the time of the announcement, Amos Matan, CEO of Aeronautics, said that it was the first contract where the UAS was exported to the customer rather than renting it, and the expectation was that it would be marketed to other nations.

Boeing subsidiary Insitu has also been active in both promoting platforms and partnering with local companies, such as Brazil's Santos Lab and its Carcará platform. Back in 2011, Nostromo Defensa and Israeli-based UAV company Innocon joined forces in the development of new UAV solutions for South American markets.

Not last in line

For Dany Eshchar, Aeronautics deputy CEO for marketing, sales and business development, the Latin American UAV market is 'encouraging' and although its countries have not been among the earliest adopters of such technology, they are also not last in line.

'In the last few years they have understood the benefit of UAVs and have taken steps forward to adopt the capacity for their use,' he said. 'They understand the UAV is easy to operate, has low life-cycle costs and is much cheaper [than manned alternatives].'

He told *UV* that among all the countries in Latin America, the key markets for Aeronautics were Argentina, Brazil, Mexico and Peru. These nations were being offered options from across the company's unmanned family, including the Orbiter and Orbiter III tactical UAVs, Aerostar and Dominator.

'We are not ignoring the rest, but these are strategic countries. The markets are maturing and we will have more sales in the next two years,' added Eshchar.

Meanwhile, Zepeda of Delair Tech Latin America is also optimistic over civil uses of UAS in the region. Whether for topographical surveying or infrastructure monitoring, unmanned systems were becoming mature enough to meet requirements.

'Another sector we believe has great potential in Latin America is agriculture, particularly in the Mercosur region due to its vast, highly "technified" farmlands and the technology-friendly business culture that exists there,' he said.

Not that the region is homogenous in its ability to operate such systems, as Argentina, Brazil, Chile and Mexico pull ahead of the rest. In particular, according to Zepeda, the latter two were 'quickly becoming Latin American UAV leaders' and 'epicentres' of industry.

However, it is one thing to know how to operate the systems and another knowing how to interpret the data or organise a thorough maintenance schedule without contractor support. Here lie the limitations in the region, meaning foreign OEMs will continue to play a formative role in any industrial partnerships. ▶

The Brazilian Air Force operates advanced UAVs procured from overseas OEMs, such as the Hermes 900. (Photo: Elbit Systems)

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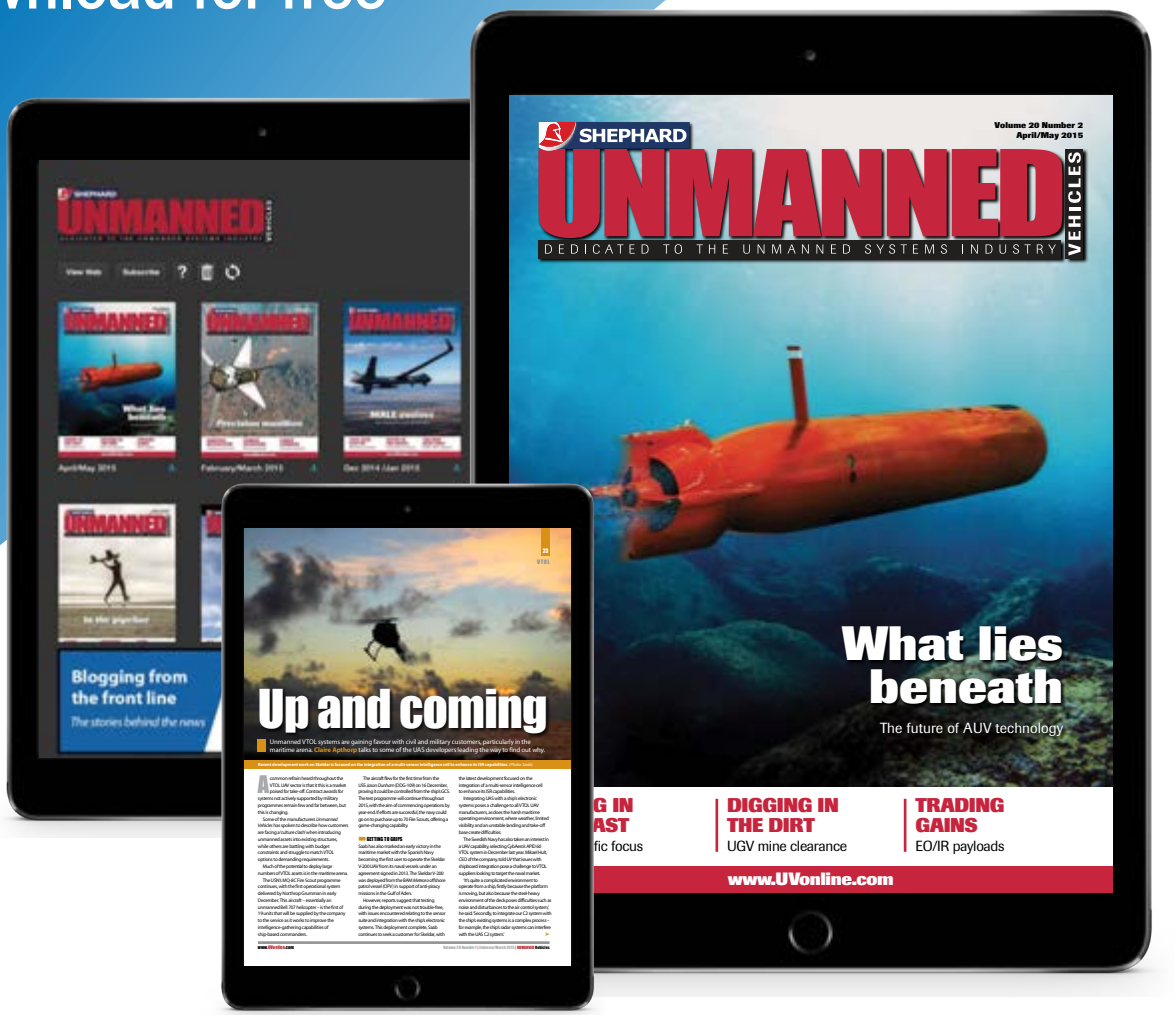

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Argentina's Lipán is a good example of UAS manufacturing capability in the region (Photo: *UV* picture library)

For the agriculture sector, Zedepa said that the 'missing link in the value chain' concerned the lack of analytical models to interpret the UAS' data output into actionable information.

'I talk about a missing link in the value chain because these models depend on the crop, the climate and the soil composition,' he said. 'There is a variety of parameters that need to be considered, a lot of R&D that still needs to be done and even when the general models have already been developed a field-by-field customisation will be needed, requiring a huge number of trained engineers.'

Significant interest

Another example of local/foreign tie-ups include Portugal-based Tekever Group, which signed a purchase agreement with Brazilian UAS manufacturer Santos Lab, acquiring what was described in reports as a 'significant interest' in the company in April 2015.

According to a release issued at the time of the announcement, the new partners would 'join their capabilities to integrate technology, offer new products and join commercial efforts at a global level', with particular focus on the South American markets.

The AR2 Carcará UAV, already then in operation with the Brazilian Navy, would be the first product jointly launched from the partnership. The Carcará includes a water-proof airframe designed and produced by Santos Lab that is specifically aimed at maritime and amphibious operations.

Tekever's role in the platforms production was with the provision and fitting of advanced onboard processing, communications equipment and ground control systems, which the release stated would enable the AR2 Carcará to be fully interoperable with all other Tekever UAS products.

At the time, Ricardo Mendes, COO of Tekever, said that its participation in Santos Lab would preserve it as a strategic company for the Brazilian Security market. The cooperation would also benefit both companies' business strategies.

Gabriel Klabin, CEO of Santos Lab, spoke of a 'win-win' relationship, where as a result the Carcará would be 'a more flexible, versatile and reliable' product.

Aeronautics was also in a position to assist in the growth of the industry from within, said Eshchar, which could potentially include, depending on permissions from the Israeli MoD, the transfer of its own UAV technology.

'We are able to support them in their concept of operation, to build their capability, how to grow their operation, the technology and the infrastructure,' he said. 'The region has big potential, but they have to adopt a [platform] maintenance philosophy and budget management.

'As far as I know, they are mainly using EO payloads [on UAVs]. They are now in the second stage of their use, into the second layer of sophistication. Aeronautics is offering to assist any country to have transfer of technology.'

According to Eshchar, Aeronautics could provide customers in Latin America with alternative payloads for their existing UAV platforms, such as EO/IR, communications, EW or radar.

These partnerships are not just about unit sales and ensuring the customer has the wherewithal to fly the platform, but the nuts and bolts of maintenance, basing and other logistical demands that play such a vital role in sustaining UAV capability.

Bridging the gap

The aforementioned Balam Security currently acts as a bridge between prospective exporters in Israel and importers, particularly in Mexico but also elsewhere in the region.

'We prepare the end user for these totally new technologies [when they] are used to manned aviation, which [means] a complete change of attitude,' Dayan told *UV*. 'Things like adapting runways for UAV use, [construction of] hangars and investing in the time to teach the customer how to use these types of systems.

'It is not so easy. It takes time to get used to it, but we are with the clients every step of the way and have pilots come over from Israel to help train the customer.'

There is, however, risk in all commercial activity as national and regional macroeconomic pressures influence or alter how much a government can afford to spend, curtailing or cancelling previously agreed programmes.

Most recently in January, Elbit Systems announced the decision to 'wind up' activities of its Brazilian joint venture Harpia Sistemas due to what the company termed 'budget constraints' in Brazil. The company was owned in conjunction with Embraer Defesa e Seguranca and Avibras Divisão Aérea e Naval and formed in 2011 to 'explore the [UAV] market'.

A statement from Elbit reads: 'Due to the venture's strategic nature for designing a Brazilian RPAS the companies will continue to develop technologies to meet future demands of the Brazilian armed forces and the civilian market in a new format and agreed on working together in the future.'

It is clear that the Latin American UAV market and industry is embarking on what is likely to be a period of persistent change, replication and innovation as the leading nations begin to produce their own systems. These will be for both domestic consumption among civil security and military agencies, and also for export to regional neighbours.

Dayan summarised: 'There are not now the gaps like there were ten or 15 years ago – they are much, much smaller.' ■

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Nicholas Hill, defence and security director at Plextek Consulting, speaks to Richard Thomas about the sort of innovative solutions that must be found to advance automation, communications and active camouflage capabilities.

Getting creative

From the outset, Hill made clear during a sit-down last year that Plextek Consulting was not a product company, rather that its expertise was focused around the provision of technical and highly specific knowledge for a number of programmes in need of creative thinking.

'It just so happens that unmanned systems is quite an interesting area for us because all the technologies that we work with are fairly critical for them. We don't go anywhere near the platform, but sensing, communications, autonomy and navigation are all things that we work with.'

The UK firm has been heavily involved with Project ASUR (Autonomous Systems Underpinning Research), a DSTL programme that looks at ways for the UK armed forces to use unmanned systems and develop capabilities within the supplier base.

As operators aspire to more advanced uses of such platforms, so the terrain and circumstances in which they could be deployed changes. Instead of scanning a field in clear line of sight, small UAS are increasingly being sought for operations in urban and cluttered environments.

A difficulty in achieving this was that most small UAS only carry a camera in their payload which would usually be insufficient as a navigational sensor.

'In principle, you can do it with a camera, particularly a stereoscopic camera, but they don't provide information for a machine that is very easy for it to deal with. It takes huge processing power to take a stereoscopic image and work out "this is a wall, that is a window, this is something I can fly around",' said Hill.

'So that's one of the reasons we have been looking into the feasibility of providing a miniature radar that you can put on the front of an unmanned system so they can accurately sense its environment.'

The judgement made on how much lighter an active scanning UAS radar would have to be meant that the forward-facing area would have to be no larger than a small smartphone.

Under the ASUR programme, Plextek worked on miniature radar technology working in the 60GHz wavelength, deemed to be effective if a platform was flying in a city street, around buildings or indoors. The company has been awarded a Phase 2 contract by DSTL for small UAS radar technology.

'It's the magnitude of difficulty in that. It's not so much "can it be done", but "can it be done with the battery, weight, volume, that I've got?"'

Urban scenes

Maintaining communications between the operators and platform is made more complex within the urban environment. One solution could be in using multipath reflections, and at 60GHz there 'was a lot of bandwidth to play with', but it was unable to bend around corners.

'You can construct a system that will reflect, however, so if you imagine if a building was between you and the platform, you could bounce the signal off a nearby tower to connect. If you can get the geometry right, you've got a steerable beam. Another thing is that the geometry can be very complex because you might have multiple refractions because the UAS is flying around, so its quite a difficult problem in knowing how to steer the beam and keep it pointed in the right direction.'

> *"It's the magnitude of difficulty. It's not so much 'can it be done', but 'can it be done with the battery, weight, volume, that I've got?'"*

Another ASUR programme undertaken by Plextek has been the development of active camouflage, which although originally was focused on land vehicles, effort was now being put into determining how to apply the technology to UAS. Phase 1 testing last year was conducted on a UAS of similar size to a Desert Hawk.

'Adaptive camouflage isn't like cloaking – you can't make things disappear. It is simply about having a range of camouflage schemes that I can select from. So if you happen to be parked in a desert, forest or a city, you can press a button and get the right scheme to suit.

'Currently, it is looking quite optimistic, although probably I think the way to achieve this is to integrate the panels into the structure of the vehicles. Unlike land vehicles, where it is conceivable to see how to apply these after, as an accessory, I don't think that is going to work with the aerodynamics and weight limitations of a small UAS. You are going to have to integrate it into the structure.' ■

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