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Front cover: The C-Worker 6 USV can be used for offshore and coastal tasks including hydrography. (Photo: ASV)

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Richard Thomas, Editor

Best laid plans

The past month has seen two of the most ambitious unmanned programmes take very different development paths and not in the order one might have imagined.

The US Navy will now transform its all-singing, all-dancing carrier-borne Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) air vehicle into a fuel truck, while the oft-indecisive European pairing of the UK and France appear hopeful of taking the Future Combat Air System (FCAS) UAV as far down the manufacturing line as possible (before its eventual, inevitable cancellation a decade from now).

Disheartening development

For the US, and those keen to see the continued development and growth in unmanned capability, it is a disheartening outcome of a programme that perhaps found itself sandwiched between defence spending belt-tightening and a number of other current or planned procurements, such as the F-35 Joint Strike Fighter and Long Range Strike Bomber.

Continued reduction in planned requirements of the UCLASS resulted in a programme that while industrially possible, was a far cry from the high notions it set out with. The death of the programme, caused by a thousand little paper cuts, will see it known as the Carrier Based Aerial Refueling System (CBARS) and has prioritised near-term problem-solving for its carrier air wings.

Nevertheless, considerable knowledge will have been gained from operating the prototypes, and it should be remembered that the carrier-capable CBARS will still remain a first among all the world's nations in unmanned capability. It's just that it won't be what was first envisaged (where have we heard that before?)

Rude health?

The FCAS, however, is in a comparative patch of rude health, underpinned recently by expansive statements from British and French officials looking to produce an unmanned combat platform to replace manned jets somewhere in the 2030 time frame. Each nation is going to put forward £750 million ($1 billion) to continue the programme, with prototypes expected in or around 2017.

While the requirements here are clearly different from those of the US, the most obvious difference being the lack of sea-borne operations, it is nevertheless the mark of a European defence industry keen to explore some sort of rationalisation in the unmanned realm, as achieved with pan-continental crewed platforms like the Eurofighter Typhoon and Panavia Tornado. There is also something to be said for the different development stages at which both programmes are currently situated.

Whether or not the dreams and aspirations – which may yet include additional European countries eager to share the workload – industrial benefits and capability will be achieved, will only become clear in the fullness of time. There is more than one example in living memory of such collaborative programmes that ran late, over budget, or indeed delivered something a little less than what was first expected.

The long term

It will be interesting to ascertain where the Asia-Pacific region sees itself in the long-term unmanned environment.

It would be inconceivable that aspiring powers there were not examining what capability might one day be explored, although there will be much to see and learn from the US and European programmes, not least in terms of the pitfalls of industrial competition and pesky defence budgets.

Industry is littered with demonstrators becoming garden ornaments and ambitious plans to revolutionise defence given a good dose of political, economic and social reality. For the sake of the simple technological development, it might be nice to see something seen through to the final, bitter end for a change. ■

In the next issue

- Commercial UAS insurance
- UGV bomb disposal
- USV composite materials
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Malaysia selects Fulmar UAV

The Malaysian Maritime Enforcement Agency (MMEA) has selected a Spanish-built, fixed-wing UAV for use aboard new patrol vessels. The winning design is the Thales España Fulmar, and the UAVs will embark on board six new-generation patrol craft (NGPC) that are under construction by local company Destini Shipbuilding and Engineering at Port Klang. The MMEA will obtain six UAVs.

The delivery of the first Fulmar system should occur later in 2016. (Photo: Thales)

The 19kg Fulmar has a 3m wingspan, and its maximum 12-hour endurance offers an 800km range. This will greatly boost the surveillance reach of the MMEA, which is constrained by budget and the limited number of patrol vessels it owns. The carbon-fibre Fulmar is available in both land and maritime versions. It is launched from a catapult, and it can float for up to 24 hours if it has to land unexpectedly at sea.

It is unclear which EO/IR system the MMEA has opted for, but the Fulmar is able to accommodate an 8kg payload. Of interest, the NGPC tender document stated that the shipbuilder, in conjunction with other parties, was responsible for sourcing a suitable UAV that could be recovered by a skyhook.

While the tender requirements seemed to favour the Insitu ScanEagle, the MMEA has opted for this Spanish solution that is recovered by a net. Eastern Sabah Security Command previously tested the Fulmar, but did not select it. Instead, the ScanEagle won out, with platforms seeing intensive use in support of counter-insurgency missions.

The keel for the first 44m NGPC was laid on 18 November and should reach the MMEA in December this year. The ships, based on a Fassmer design, will carry an Aselsan SMASH 30mm main gun as well as the UAVs. The contract for these vessels was worth $93.3 million.

The Fulmar requires a crew of two to operate. First delivery should occur at the end of the year in time for the commissioning of the first patrol boat.

This is the MMEA's first UAV, and it should offer far greater and more cost-effective reach for the agency as it confronts criminal and territorial challenges within Malaysia's EEZ.

By Gordon Arthur, Hong Kong

Patroller to replace French Army Sperwer

Photo: Sagem

The Patroller UAV has finally been confirmed as the replacement for the Sperwer UAS currently deployed with the French Army's 61st Artillery Regiment from 2018.

According to a 5 April release issued by Safran, of which Sagem is prime contractor, French Minister of Defence Jean-Yves Le Drian witnessed the official announcement of the army's new tactical unmanned system programme contract during a visit to the Sagem (Safran) plant in Montluçon. The programme is based on the Patroller UAV, for which Sagem is again the prime contractor, and leads a consortium of 25 local firms also contributing to the programme. The German company Ecarys supplies the ES-15 airframe for the Patroller system. The airframe is capable of carrying a payload in excess of 250kg, with 20 hours of endurance and an operational ceiling of 20,000ft.

Of the deal for 14 aircraft, Martin Sion, CEO of Sagem, said: 'The French MoD's choice of the Patroller certifies its performance and quality, giving Sagem a major advantage in seizing export opportunities for surveillance drones. Several countries have already expressed their interest in the Patroller, especially in Asia and the Middle East.'

The French MoD said that the contract includes delivery of two operational systems for the army, each comprising five aircraft and two ground stations.

Also included are a further four aircraft and two ground stations for training purposes. Additionally, the contract covers a 12-year maintenance plan.

In September 2015, the company announced they will be targeting a potential deal with the Egyptian MoD, under an agreement signed with local manufacturer AOI-Aircraft Factory.

In October last year, Sagem operated a Patroller UAV in homeland security testing as part of Project Airbeam, a European Commission Project designed to develop management systems for large-scale crises.

By Richard Thomas, London

UK rolls out unmanned vessel framework

A 22-page spin-off Code of Conduct contains details on health and safety, the environment and more. (Photo: author)

Leading figures in the UK's maritime industry have grouped together to introduce a code of conduct for the development, design, production and operation of maritime autonomous systems (MAS) and in particular USVs.

The pan-industry code of conduct was quietly unveiled at this year's Oceanology International in London. The agreement represents the first community-accepted code for USVs, which could eventually be rolled out beyond the UK.

For industry, it assists in the generation of best practice and demonstrates a responsible approach to the development and utilisation of USVs. For customers and the wider general public, it highlights that current best practices are being applied and adhered to.

It is the product of the MAS Regulatory Working Group (MASRWG), which was established in August 2014 and currently has over 30 members. The working group reports to the Marine Industries Leadership Council through the UK government's Maritime and Coastguard Agency.

Companies that support the code of conduct include ASV, Atlas Elektronik UK, BAE Systems, QinetiQ and Thales. Other organisations involved include the National Oceanography Centre, the UK Hydrographic Office and Plymouth University.

Residual worry

Speaking to *UV*, a member of the MASRWG said that the code of conduct was a response by industry, academia and government to the proliferation of USVs and the residual worries that still exist about their operation alongside manned vessels.

'A lot of companies that are likely to build USVs were concerned about customers wanting to know their legal status and how they sit within the existing maritime regulatory framework,' he explained. 'It was recognised early on that because of the way that the [IMO] works, getting any new regulation would take time – potentially a decade, or even two.'

Instead of pursuing regulatory changes, the MASRWG has studied whether there is enough leeway in existing definitions and regulations for USV operation. The group has already drafted an unreleased code of practice, drawing on past work by academia and organisations such as the European Defence Agency.

A spin-off of that code of practice is the 22-page code of conduct that was released at Oceanology International. Areas covered by the document include health and safety, the environment, customer information, certification and compliance. The code of conduct, which has two lead authors from industry, is non-mandatory. It is not adopted in any legal framework, but does show intent and could establish legal precedent in the future, according to the MASRWG member.

'In a court of law, a judge may take into consideration if the code is used by anybody,' he said. 'So the idea is, as an individual state, to use our own best practice to drive the debate forward on regulation of USVs.'

The focus on USVs, rather than unmanned underwater vehicles, is driven by the fact that USVs potentially pose a greater hazard to other vessels, especially as they grow in size. Companies such as Rolls-Royce have toyed with the idea of developing large, unmanned cargo ships to increase efficiencies and reduce costs.

'The USV is really the one that's going to shape – a bit like remotely piloted air vehicles – the regulation.'

The next stage will see James Fanshawe, chairman of UK MASRWG, take 500 copies of the code to the next Marine Safety Commission run by the IMO.

By Grant Turnbull, London

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Global Hawk in U2 sensor tests

The USAF and Northrop Grumman have begun flight trials of new sensor payloads for the RQ-4 Global Hawk. The flight trials will be a key part of the service's proposals to boost the ISR capabilities of the platform and eventually have the unmanned aircraft take over the role of the manned U-2S Dragon Lady later this decade.

The current plan is for Lockheed Martin's U-2S to retire in 2019, and its high-performance sensors – the SYERS-2 long-range imaging sensor and optical bar camera (OBC) – to be fitted to the Global Hawk instead. These sensors collect highly sensitive, national-level intelligence for the US, but are currently only on the U-2S.

Northrop Grumman will modify the Global Hawk with a universal payload adaptor (UPA), which consists of a series of attachment points on the underside of the aircraft. This will ease the integration of U-2S sensors as well as future payloads.

A Northrop Grumman spokesperson told *UV* in February that two Block 30 aircraft have now been modified with the UPA at the company's Palmdale facility in California. 'SYERS-2 is expected to fly on a Global Hawk later this month,' the spokesperson said.

Tests of new sensor capabilities for the Global Hawk have been carried out. (Photo: USAF)

An air force official also confirmed to *UV* that SYERS is expected to fly 'in Q1 of FY2016 and planned for demonstration in Q3'.

Follow-on flights of the OBC and a next-generation multi-spectrum sensor are planned for later this year. The OBC is a particularly important capability, as the non-digital imagery from the sensor is still used as part of the Israel-Egypt peace treaty.

Air Combat Command entered into a cooperative research and development agreement (CRADA) with Northrop Grumman to facilitate the installation and flight demonstration of Dragon Lady sensors on the Block 30 aircraft.

The air force official said that fitting Global Hawk with U-2S sensors will allow the high-altitude UAS to deliver 'comparable capability' to combatant commanders.

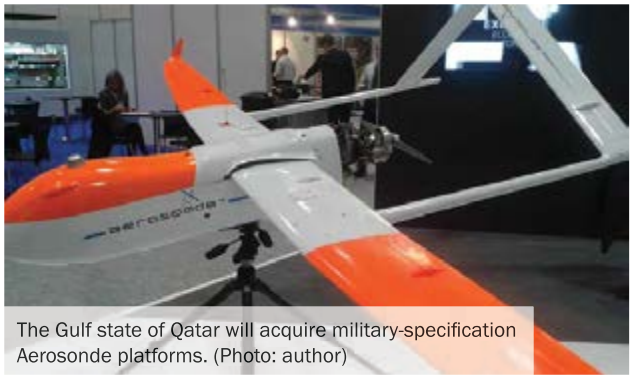
In an interview late last year, Northrop Grumman's VP and programme manager of Global Hawk, Mick Jaggers, told *UV* that once the UPA is fitted, the company 'will rapidly integrate other USAF sensors onto the system as they become available'.

The decision to retire the Cold War-era U-2S spy plane and replace it with an unmanned aircraft has been controversial, with some critics suggesting it will reduce high-altitude ISR capacity compared to the current mixed fleet.

'In the current fiscal environment, the air force simply cannot afford to maintain both platforms. Scenarios were evaluated as to how best the air force can meet combatant commanders' demand, given present fiscal constraints, but all analysis indicated a single fleet is more affordable versus a "mixed" fleet,' said the air force official. 'Retiring the U-2 supports the department's ability to meet fiscal constraints and re-align valuable resources to other high-priority DoD programmes.'

By Grant Turnbull, London

Qatar signs Aerosonde deal



The Gulf state of Qatar will acquire military-specification Aerosonde platforms. (Photo: author)

The Qatari Emiri Armed Forces signed an MoU with Textron Systems Unmanned Systems for an Aerosonde UAS system, valued at 54 million Qatari riyals ($15 million).

Already in service with the US military, the Aerosonde UAS has a long military history and increasingly parapublic and commercial roles. Capable of 14 hours of endurance and 140km line-of-sight range, the system features day/night full-motion video capabilities.

Speaking to *UV* about the MoU, David Phillips, VP small- and medium-endurance UAS, said that the number of platforms to be operated within the delivered system would be defined by the customer, but described it as 'one complete unit' at 'military specification'.

'The system is scalable depending on the operational tempo and how often you need to use it. We see it as a partnership and will work to bring capabilities that serve US troops, and give [Qatar] the same level of capability,' he said. 'We are going to train Qatari students, who are ready to come to our training system in Virginia, to operate the [Aerosonde] system.'

Elsewhere, a number of other MoU's were signed by the Qatari Emiri Armed Forces and companies at the show, including L-3 Communications, which secured an order with Qatar for the provision of 17 MX-25 EO/IR cameras, valued at 126 million riyals. Airbus also finalised an MoU worth a potential 200 million riyals for enhanced C4I capabilities to Qatar.

By Richard Thomas, Doha

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Water power

Critical to naval force missions is adequate planning and preparation, with 'ground study' providing a vital element in route planning, making military hydrography hugely important to navies seeking safe passage of expensive vessels through blue-water and littoral environments. **By Andrew White**

Mission sets for modern navies continue to expand in the contemporary operating environment with force elements required to cover a broad section of capabilities. These range from counter-narcotics, -piracy and -smuggling tasks through to counter-terrorism, counter-insurgency, surveillance/reconnaissance, military assistance and humanitarian aid/disaster relief operations.

Reinforcing the importance of military hydrography, one defence source within the Royal Netherlands Navy explained to *UV*: 'Every commander uses environmental information for the planning and execution of military exercises and operations. Such information will allow him or her to deploy units, weapons and sensors in the most effective way possible. For maritime operations, commanders require hydrographic, meteorological and oceanographic information for localising and clearing sea mines or carrying out amphibious operations, involving troops making beach landings from Royal Netherlands Navy ships.'

Hydrography is best described as the measurement and description of the physical features of oceans, seas, coastal areas, rivers and lakes, but also includes forecasting of any changes over given periods of time. However, blue-water and littoral maritime forces are also utilising the same hydrographic technology to inspect ship hulls, pipelines, cables, harbours and piers as well as during pre-salvage assessments and search and rescue operations.

Technology utilised for such missions now includes a mix of manned and

ASV's C-Worker 5 USV is designed to be a 'hydrographic survey force multiplier'. (Photo: ASV)

unmanned vessels, operated above and below the surface, with the sector currently witnessing an increasing trend towards manned/unmanned teaming between autonomous underwater vehicles (AUVs) and unmanned surface vessels (USVs).

However, many international navies continue to execute military hydrography missions with manned force elements. The Royal New Zealand Navy, for example, showed no particular focus on unmanned technology in the 2014 update of the New Zealand Defence Force's 2011 Defence Capability Plan.

> *"Mature navies continue to consider the integration of military hydrography requirements into MCM programmes."*

In the updated paper, the navy pays attention to the introduction of a new Littoral Operations Support Capability between 2015 and 2020, with a requirement to replace the fleet replenishment tanker, HMNZS *Endeavour*, with a dedicated mine countermeasure (MCM), military hydrography and diving operations support vessel, with no mention of AUV or USV technology.

In December, the Chilean Navy's Hydrography and Oceanography Service acquired an LH-02 *Defender*-class vessel for mapping the sea bed. According to navy officials, the vessel will be used as part of a wider inspection capability for the country's 4,200km coastline. However, there appears to be no appetite as yet for an unmanned capability.

Advanced options

A military hydrography solution – whether manned, unmanned, surface or sub-surface – must be capable of conducting bathymetric surveying and environmental measuring, providing depth recordings along a line of search as well as the identification of additional obstacles in the area. Payloads can include swath and side-scan sonars, towed or fitted to the hull of a vessel, designed to sweep the sea bed and providing a wide FoV. Smaller vessels and boats maintain an advantage over larger vessels with the ability to access inlets and more littoral and riverine areas of interest.

However, the most mature navies in the world continue to consider the integration of military hydrography requirements into MCM programmes, which rely upon similar sonar algorithms and search patterns conducted by sensor payloads on board manned and unmanned vessels, including AUVs and USVs. Indeed, the USN, French Navy and UK RN continue to be heavily involved in such efforts.

Highlighted in the UK's Strategic Defence and Security Review, published on 23 November, the RN's MCM and Hydrographic Capability (MHC) concept continues to be developed, having achieved its 'initial gate' decision in July 2014. This saw the MoD outlining its plan to design, develop and demonstrate a USV-based multi-influence minesweeping capability. This would also able to conduct military hydrography missions and be deployed from *Hunt*-class vessels, including a Reconnaissance Unmanned Underwater Vehicle Hangar for the supporting AUVs on board.

The programme, which centres around the design of an MCM and Hydrographic Vessel (MHV), is currently in an assessment phase to prove the concept to concurrently conduct minehunting, minesweeping and hydrographic missions more efficiently than legacy vessels.

Today, the RN's MCM and military hydrography capability is provided by a mix of eight *Hunt*- and seven *Sandown*-class MCM vessels (MCMVs), fitted with Thales Group-designed Sonar 2193 hull-mounted systems and Sonar 2093 systems respectively. MCMVs have been operational since 2004.

In line with growing trends in inter-agency operations across the contemporary operating environment, the RN also benefits from information gathered by the UK Hydrographic Office (UKHO), which is sponsored by the MoD. The UKHO directly supports the service with the production of nautical publications generated by internal agencies including the Nautical Almanac Office and International Centre for Electronic Navigational Charts.

'Our vision is to be the world's best provider of hydrographic data services with responsibilities for operational support to the RN and other defence customers by providing hydrographic services to support the global mission of our national security forces,' a spokesperson said.

The MoD's Defence Equipment and Support (DE&S) agency explained to *UV* how the MHC programme continued to focus on 'MCM and hydrography [capabilities]... both delivering ▶

maritime geospatial intelligence with broadly similar systems [with] commonality which could be exploited and rationalised in a future capability'.

'A single class of [MHV] mother ship, carrying modular unmanned mission packages, could therefore deliver both capabilities. Operating outside the minefield, the ship will not need the signature control measures of the current MCMVs, so could be much cheaper and, being bigger, will have a greater expeditionary capability,' an official source explained.

In April, DE&S contracted Atlas Elektronik UK (AEUK) for phase one of the MHC programme, encompassing the design of a capability concept demonstrator as part of an initial £12.6 million ($18 million) contract. Phase two will focus on the integration of the USV into the daily routine of a *Hunt*-class MCM vessel, followed by an evaluation process, while a third and final phase will concentrate on an operational evaluation of the system and acceptance tests into service with the navy.

Continental concepts

The concept is being built around AEUK's Atlas Remote Capability Integrated Mission Suite (ARCIMS) multi-role USV, which has most recently been adopted by the German Navy. In December, the German Armed Forces' Technical Centre for Ships and Naval Weapons received an ARCIMS USV system which will be used as part of an assessment of MCM capabilities. The USV can be operated in manned, unmanned and optionally piloted modes.

However, the German Navy is understood to be considering future steps as part of its next-generation MCM capability, which, in line with other such programmes, will feature military hydrography mission requirements.

According to AEUK, the ARCIMS USV provides a 'toolbox of capabilities' for multi-influence minesweeping operations, with the incorporation of remote mine hunting and disposal payloads. Additional features include autonomous mission planning, execution and analysis.

Meanwhile, the Anglo-French Maritime MCM (MMCM) programme continues to drive forward, following a contract award to Thales in March 2015 for delivery of the first phase. An unmanned 'end to end' capability, which includes military hydrography survey capabilities, is expected to be achieved in 2020 and beyond.

Thales, which is teamed with BAE Systems in the programme, is expected to unveil the demonstrator by September 2016, comprising a solution featuring USV, AUV and sonar technology. A second phase is expected to include an evaluation process, although funds have yet to be confirmed for any follow-on contract.

However, the initial contract includes options for a 24-month manufacture and qualification programme with an additional 24-month initial operational evaluation programme by the RN and French Navy.

The MMCM concept is based upon ASV's Halcyon USV, equipped with an autonomous navigation system and obstacle-avoidance sonar technology. The vessel will also tow Thales' SAMDIS synthetic aperture sonar, and will be networked to AUVs equipped with the same technology, allowing the solution to cover a wider area search pattern with the USV before honing in on a subject area with the deployment of AUVs from the USV itself.

ASV is supplying the USV, with ECA Group designing an AUV for the programme and Saab developing a tethered remotely operated vehicle. ECA Group explained to *UV* how the MMCM AUV will be a variant of its A27-M, the largest in its range of products. The company is also developing a launch and recovery system for the programme.

On 15 September, ASV was officially enlisted by Thales and BAE Systems into the MMCM programme with a remit to provide its Halcyon multi-role USV. According to Dan Hook, managing director at ASV, the Halcyon class of multi-role USVs has been developed over the course of a 'long-standing relationship with Thales to offer the ideal solution to the MMCM programme'.

'Developed from the Halcyon design, the more complex and capable mark II offers greater efficiency, stability and an increased payload capacity,' he explained. The programme will see ASV manufacturing two identical systems for evaluation against several pre-defined operational ▶

CUSV, seen here in early prototype form, could expand on its current planned capabilities. (Photo: USN)

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Elbit's Seagull USV could in future have some modular military hydrography capability. (Photo: Elbit Systems)

scenarios, Hook continued, confirming that work on a detailed design had now begun.

'This first official stage, comprising a design study prior to system build, is scheduled to run until the end of 2016. This will also involve working with the end user to define the requirement and place consideration on other external factors. Stages 2 and 3 will include the system manufacture and demonstrations,' he added.

Mission demonstration

Meanwhile, on 25 January, ASV revealed it had conducted a series of 'successful' trials with the Halcyon USV in partnership with Thales, proving the vessel's 'high-speed transit, stability, manoeuvrability and endurance', particularly useful for hydrography missions. The demonstrations were completed in collaboration with the UK's Defence Science and Technology Laboratory in support of a multinational technical cooperation programme.

'Halcyon, fitted with Thales' mission management system and integrated with the ASView control system, operated collaboratively in the trials to demonstrate reliable autonomous operations involving complex behaviours in a range of scenarios and sea state conditions.

'These trials completed operator-planned missions controlled from a remote operations centre, providing operator oversight and control over a communications link. It also showed how a USV can work autonomously with a multi-national squad of AUVs. These successful trials represent a major milestone in Thales' road map to deliver robust autonomous USV operations,' a spokesperson for ASV explained to *UV*.

However, it is easy for military hydrography mission requirements to be lost in and among MCM capabilities, although this fact has not been lost on ASV. Indeed, on 15 March, the company revealed to *UV* that it was introducing an entirely new USV to its product range, specifically designed as a 'hydrographic survey force multiplier' system. Unveiled for the first time at the Oceanology International exhibition in London, ASV officials explained to *UV* how the company had already completed the construction of four C-Worker 5 USVs.

The four vessels will be placed in ASV's global leasing pool of USVs in Q2 of 2016, where they will be made available to international navies and maritime agencies seeking hydrographic mission capabilities in the short, medium or long term. According to ASV, the C-Worker 5 measures 5m in length and has the capability to operate at speeds of 7kts for up to five days without the need to refuel.

'This speed/range combination maximises acquisition effectiveness while minimising launch and recovery operations. As a force multiplier, it can operate concurrently alongside traditional survey vessels, dramatically increasing survey efficiency,' a company spokesperson explained.

The USV is propelled by a marine diesel engine and controlled by ASV's ASView control system. It also has the ability to tow multiple sonar payloads as well as integrate hull-mounted sensors including EO/IR cameras and communications masts.

Hydrographic data gathered from towed sonar arrays can be uploaded onto ASView, which is also capable of navigating the USV. The system is also capable of interfacing with a variety of surface and sub-surface payloads for deployment, operation and data extraction and includes a 'Geo-Fencing' tool which allows the system to acknowledge operating areas and exclusion zones. It also features programmable behaviour should communications be lost during a mission, allowing it to continue with the operation or return to base.

ASView is compatible for operation with LoS communications including UHF, mesh network radios and WiFi, as well as BLoS communication capabilities including SATCOM via Iridium, Inmarsat or V-SAT connections.

'We are undertaking industry-leading research and development to increase the use of safe and reliable vehicle autonomy. Specific focus is in the areas of collision avoidance and operating over the horizon safely. We are working on this both internally and collaboratively with a wide range of defence and commercial technical subject matter experts,' ASV concluded.

Innovative programme

Finally, ASV is also undertaking a £3 million ($4.2 million) research and development programme, in collaboration with the government-sponsored Innovate UK, designed to analyse utility of USVs and AUVs for a variety of tasks including military hydrography.

Addressing the Hydrographic Society in October, ASV officials explained how 'Marine Autonomous Systems' research was being conducted alongside nine other companies from commercial industry and academia, with a view to considering additional capabilities for military hydrography missions.

Topics include over-the-horizon communications, launch and recovery of AUVs from mother ship USVs and the operation of USVs in rough weather conditions. ASV confirmed to *UV* how the research and development initiative remained ongoing.

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Meanwhile, the USN continues to drive ahead with its Unmanned Influence Sweep System (UISS), which achieved critical design review in 2015 with Textron Systems Unmanned Systems as lead contractor. The UISS comprises the Littoral Combat Ship's MCM mission suite and also includes military hydrography capabilities.

According to Textron, the company is currently engaged in preparing for systems integration and test programmes later this year and with ongoing efforts to assemble a sponsoring USV as well as command and control and sensor integration. Outfitting is expected to begin in April, with final delivery to the navy expected by the beginning of 2017.

Additionally, the service is now considering integration of a UAV into the UISS capability set, allowing it to extend communications reach as well as providing situation awareness across the general area of operation for the USV and AUVs. Industry sources informed *UV* how the USN's Naval Sea Systems Command was working with undisclosed industry partners regarding the development of a Technology Demonstrator. It is envisaged that payload space on the Common USV (CUSV) could be capable of launching and recovering a Vertical Take-Off/Landing UAV.

Currently, much hydrographic work in the US is undertaken by the National Oceanic and Atmospheric Administration (NOAA), which announced on 16 February its intention to award an extended maintenance contract to Kongsberg Underwater Technology in support of its EM 302 and Simrad EK60 systems, currently utilised on board the NOAA vessel *Okeanos*.

The EM 302 multi-beam echo sounder is designed to map ocean floors, with the exception of deep trenches, while the EK60 has the capability to concurrently operate up to seven echo sounder frequencies between 18kHz and 710kHz.

Elsewhere, Elbit Systems is now offering a USV which can also be tasked with military hydrography missions, although company officials explained to *UV* how such a capability remained a secondary option behind MCM missions. Marketing the Seagull Multi-Mission USV at the Singapore Air Show on 16 February, company officials explained to *UV* how the system represented a force-multiplying capability for blue-water and littoral navies worldwide.

Capable of also undertaking MCM and anti-submarine warfare missions, the Seagull can conduct military hydrography tasks with a switchable modular mission payload suite. The vessel can be deployed from a port or mother ship and features LoS and BLoS SATCOM communications as well as unmanned and maned modes of operation. Two USVs can be networked together and controlled from a single mission control system.

However, an Elbit Systems spokesperson said that the USV had not been designed primarily with military hydrography missions in mind, rather with more of a consideration for modular use should a customer require it.

Military hydrography operations are supported: by side-scan and synthetic aperture sonars; forward-looking sonar; multi-beam echo sounder; long-range dipping sonar; and diver detection sonar for port and harbour security operations.

Measuring 12m in length, the USV has a maximum endurance of four days and has proven a capability to operate in Sea State 4, although it could survive rougher conditions reaching as high as Sea State 7. A first technology demonstrator of the Seagull completed its maiden voyage in 2015.

The USV can be equipped with payloads including the R2Sonic Forward Looking Sonar system, Klein 5900 towed multi-beam sidescan sonar, as well as other additional supporting unmanned systems including ROVs and mine-neutralising platforms.

Biomimetic future

Future military hydrography requirements could also soon be satisfied by using biomimetic AUVs with the likes of DARPA and the US Office for Naval Research (ONR) developing systems such as the GhostSwimmer.

'Understanding biological systems presents unique opportunities for developing new defence capabilities through mimicry, integration of living and non-living components, or direct use of complex biological systems,' a DARPA spokesperson told *UV*.

The ONR's Silent Nemo programme is in the midst of developing the tuna-like GhostSwimmer AUV, designed for covert operations, including ISR as well as military hydrography. Designed to mimic the oscillating action of the tuna fish propelling through the water, the GhostSwimmer is designed by Boston Dynamics, which was bought out by Google in 2013. The AUV itself is approximately 1.5m in length and weighs 45kg.

Having undergone a test programme at the Joint Expeditionary Base Little Creek-Fort Story, Virginia, in December 2014, GhostSwimmer has already proven the capability to deal with current and tidal conditions in both littoral and blue-water situations. The AUV operated at depths down to 100m below the surface. At present, the GhostSwimmer can only be operated while tethered to a mother ship and is currently being upgraded with obstacle detection and avoidance systems.

In a purely military context, hydrography missions appear likely to continue as a subsidiary capability to MCM operations. However, with advances being made in downsizing of payloads and integration of multiple roll-on/roll-off mission suites, it appears likely that maritime force elements will soon have the luxury to select specific payloads for specific operations.

In the meantime, civil agencies will continue to support the military hydrography requirements of navies as technology demonstrators come to fruition over the next few years. ■

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LEARNING CURVE

When tens of millions of dollars are spent on a UAV, it pays to make sure it is available for operations more often than not, particularly with the growing demand being placed on such platforms by militaries around the world.

By Richard Thomas

The question for militaries is how to get the most operational time out of a platform, and in turn minimise its exposure to training activities, where prospective and newly graduated operators might stress the airframes more than necessary. Then too, it should also be noted that even experienced operators have to contend with technology still being developed and finessed to the point whereby the relatively high attrition rate of unmanned systems can be permanently reduced.

It should be kept in mind that many complex unmanned systems are themselves being developed by manufacturers even as they are handed over the customer, such is the need for and relative infancy of integrated operations. Inducting an advanced UAV, such as General Atomics Reaper or Elbit Hermes variants, carries with it an inherent risk that pilot error, mechanical failure or loss of signal can end with millions of dollars of platform rearranged into its constituent parts.

Mature capability

Although unmanned systems have been around for a considerable time, platform capability has had to mature significantly in recent years in order to reduce the potential for accidents and mishaps by operators, either during training or live operations. Indeed, as *UV* discussed last year during a visit to the Reaper training centre at Holloman AFB in New Mexico, such is the difficulty in flying these large aircraft that the take-off and landing has to be performed ▶

High-end platforms like the MQ-9 Reaper, pictured here at Holloman AFB, are operationally vital and acquired at considerable expense. (Photo: author)

by a separate aircrew on site, who take over from mission operators in the UK and US.

So it behoves operators, trainers and manufacturers alike to ensure, or at least make as much effort as possible, that aircraft are only being flown active and live when necessary in order to reduce the potential for costly accidents and damage.

Dany Eshchar, deputy CEO of Israeli UAS OEM Aeronautics, told *UV* at the recent Singapore Air Show that the more time operators spend with simulators, the less wear unmanned platforms take, thereby increasing how long UAVs can spend operationally deployed.

'A simulator is part of the package [offered to customers],' he said, adding that although the preference would be for real-life training, simulation 'while still synthetic', reduced platform degradation, particularly for newer trainee operators.

One way that this can be achieved is by bringing down the time that trainee and graduate UAV operators are spending on live flight operations, where the action could be undertaken in simulators. This is particularly pertinent among operators who are embarking on a significant increase in the scope of their unmanned capabilities, such as those witnessed in the US.

OEMs are also rushing to meet the demand being placed on UAVs by users such as the US, not just in production of systems, but primarily in addressing the shortfall in trained operators. Balancing out active and virtual training is vital in this regard.

A spokesperson for GA-ASI said it would shortly open an RPA training academy in Grand Forks, North Dakota, 'to reduce stress on all customer resources'. Initial training will be provided to GA-ASI aircrew, with follow-on training to all customers who wish to participate, while software improvements continue to reduce pilot workload.

It was not solely down to the simulated training in maintaining the required level of platform availability, added the spokesperson. Maintenance programmes were constantly being evaluated 'at both organisational and depot levels'.

'If there are trends, we improve the product as needed. Improvements come in many forms, including materials, manufacturing processes, updating repair manuals or training organisational-level or depot technicians. The voice of the customer is a critical input to the health of our aircraft [and] reducing tasks on an organisational level is of great importance to our company.

'Significant analysis is taken to continue to extended scheduled or time-consuming inspections, allowing aircraft to remain flying without returning for scheduled maintenance. This model has worked well over the years, resulting in one of the highest availability rates in the [US] military.'

USAF split

During a briefing at Holloman AFB last year, international training provider CAE revealed that the breakdown for the USAF training curriculum syllabus was as follows:

USAF Predator/Reaper crew training at Holloman AFB is 26% academic, 38% simulator and 36% live. (Photo: CAE)

academic/classroom training set at 26%; simulator training at 38%, and live training at 36%.

According to a CAE official, there had been no real change in live to simulated training percentages in recent years, with pre-2014 figures roughly the same. However, in 2015 the company was able to shift four live training events to the simulators in the event of bad weather, which would still be counted as effective flight operations.

In January, it was announced that the 558th Flying Training Squadron increased its efforts to double the number of RPAs and remote pilot operators, by introducing class sizes of 24 students. The programme is part of a series of efforts to increase the number of operators across the USAF, with nearly 300 expected to graduate in 2016, rising ultimately to nearly 400 per annum.

The 558th provides the USAF's sole undergraduate RPA programme in three courses for officer and enlisted aircrew. Graduates will then move onto more formal training units at Holloman and Beale AFB.

Speaking to *UV* recently, Chuck Morant, VP global strategy and business director, defence and security at CAE, said that a man was still 'in the loop' and the decision had to be made by customers and operators how they wanted to accomplish their training, either virtually or physically.

'That comes back around to the difference of opinion in training, so some customers, when we're talking about militaries, will say: "I have to have that person understanding a 3D world before I teach them in a 2D world". But we have a lot of young people who have grown up in a 2D world, and so now you have to say: "What do I need to augment in that training, such that they will be exceptionally proficient with an unmanned system?"'

This decision will be affected by the expected missions, such as ISR, and the series of actions that have to be achieved in order to get the platform to its intended location to employ its embarked sensors or weapons payload.

'These are very long-endurance vehicles, so do you need to train for any of the potential flight difficulties you might encounter in weather, clouds, or terrain, so can you train that sufficiently in the synthetic environment? And then of course you have the weapon or sensor employment, and now again, can you simulate those very egregious conditions where there are anomalies so that, on a clear day, anybody can do it?

'I think that where a company like CAE excels is that we can take what we've done in synthetic training, for a long period of time, and apply that [knowledge] now from a manned system to an unmanned system; we're used to interjecting all of those different capabilities. You have to look at that in the requirements process.'

Robert Luthy, L-3 Link Simulation & Training's director, air force and navy ▶

strategic development, said that the Predator Mission Aircrew Training System (PMATS), used at sites such as Holloman AFB, enables the USAF to allow MQ-1 and MQ-9 crews to gain initial qualification, mission qualification, continuation and mission rehearsal training.

Such is the demand that an additional 34 units have recently been put on order to add to the 26 in current training operations. This will further add to crew capabilities, without having to put flight hours on the platform.

'The capability already exists for even more training to be transferred to support the air force's goal to achieve 100% of UAS crew training through the use of simulation. What the service has found is that it is much more cost-effective to gain training by using simulation versus operating actual platforms, a situation that parallels the cost benefits that simulation has brought to the air force's fixed-wing training requirements,' Luthy said.

Continued investment by L-3 Link in training environment technologies will 'make it difficult to discern a training flight in PMATS from actual flight of the platform'. This will require integration with the entire battle space, added Luthy, and full concurrency with the platform.

'We typically maintain several training system loads so that operators can fly the current program loaded on the air vehicles as well as programs that are about to be introduced in the field. That way, the crews are fully trained and prepared when new software is delivered to their operational platforms.'

Unmanned operations centres, like this one at Holloman AFB in New Mexico, will want to spend as much time as possible monitoring advanced training and actual operations, rather than basic flight. (Photo: CAE)

Virtual maintenance training is also being introduced for ground crews tasked with keeping the platform in the air. L-3's programme with the US Army enables students to gain instruction on virtual systems to conduct operational checks and repairs with platforms like the MQ-1C Gray Eagle.

'By applying what they've learned, they build on their virtual training using physical replications of simulated hardware aircraft sections. This blended training solution results in accelerated student learning and improved student retention, and produces better qualified maintainers. Ultimately, this provides greater platform readiness and availability for operations,' said Luthy.

While one might have thought that maintaining is very much a hands-on skill, clearly there are benefits for ground crew in knowing how to approach a particular problem and what steps are needed in order to rectify it. As commented above, this approach benefits availability and removes a degree of risk from the management chain.

Italian method

Not that all CAE's customers will look to operate their unmanned systems in the same way as the USAF. Morant pointed out that as the Italian Air Force is acquiring an advanced simulator to assist pilot training for its Predator B fleet, the anticipation was that they would look 'more towards synthetic training'.

'You have customers all over the world who have different views on training, so you have to kind of remember that up front. And that's why we have invoked with [the Italian Air Force] a project for a very ▶

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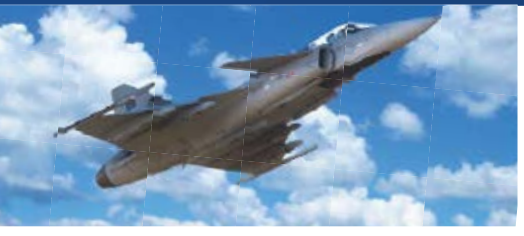

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high-fidelity device that they would actually say is Level D, or zero flight time in our vernacular, for training, and they plan to do the majority, if not all, in the simulator.'

It was in June last year that CAE announced that the Italian Directorate for Air Armaments and Airworthiness (DAAA) had contracted it to develop and deliver a Predator UAS Mission Trainer for the Italian Air Force.

A release at the time said that CAE and manufacturer GA-ASI intended to develop the mission trainer representing the Italian Air Force's Predator A and Predator B/MQ-9. The trainer is due to be delivered in 2017 and allow for 'rapid transition' to flight operations for pilots and sensor operators without further training on live aircraft.

An Italian Air Force official at the time was quoted as saying that the simulator would enable safe and cost-effective virtual training to better prepare Predator crews for operational missions.

Gene Colabatistto, group president, defence and security at CAE, stated in the release: 'For both manned and unmanned platforms, simulation-based training continues to demonstrate its proven capability as a safe and cost-effective solution for maintaining and enhancing mission readiness.'

Meanwhile, Frank Pace, GA-ASI's president, also mentioned that the simulator would 'help to reduce the training load on Italy's Predator fleet significantly' which would free those aircraft 'for increased participation in civil and military operations worldwide'.

There is however a limit to what a simulator can create in terms of a training environment, in so far as its ability is the collective knowledge of those involved in building it. Real-life training can differ from the simulator in that it brings up the unknown, the unexpected, and is essentially benefiting from not being programmed beforehand.

'I think technologically the industry can simulate what they know. It is what you don't know where the constraints that we just have never encountered before come up. But then that's the progressive build of capability, and so every time you have one of those anomalies that you have never modelled before, just add that and it makes it better,' said Morant.

He further explained: 'Until you actually encounter that anomaly in real life, you won't know it's an anomaly. So you look at a flight test programme for an aircraft, you don't know what you don't know until it happens. But I think we can interject enough of those anomalies today that maybe you better prepare somebody for that.'

New frontiers

Being able to synthetically simulate so closely and exactly what an aircraft does, and adding the known conditions, brings customer benefits and helps increase platform availability. At that point, customers can go back to the acquisition process and determine how many aircraft they will need, based on the idea that much of the flight training is offloaded into the synthetic world.

This process of essentially finding the most cost-effective and efficient way to train and eventually deploy platforms that are in such high operational demand marks both the maturing of the industry and the need for technology to assist in preparing crews for live missions and planning.

'I think it will always have to have a balance, and I'm a proponent for both, but yes, you do very much extend the longevity of your platform and you can take and offload a lot of the basic, or even advanced, flight training,' said Morant. 'That's what you want offloaded from your fleet, so that the time you do spend in the air is not straight and level and learning to drop the gear or change radios, but it's the actual mission employment.

'The US customer would tell you that yes, there has been a great increase in the simulated training, because when this started, this phenomenon of UAS training or UAS missions was really basically all live, because you just flew the vehicle and you learned by flying. It's a force multiplier.'

Simulated training, which itself enhances the prospect of using the platform for operations, is in a growth phase, Morant explained, both capability-wise and across the industry as a whole. 'We just have to get more and more comfortable with what goes on. Now it's not uncommon at all for civilian airliners to be on auto-land with passengers on board. That has to be on the check-list for so many landings that they do.

'When that first started, everybody was very [sceptical about] that type of thing, so we will grow. I mean, we joke in the air force about open cockpits and wearing leather jackets and scarfs, and this is just the progression [of technology] and the capability of ourselves as the human in the loop.' ■

FLARES was designed in response to requirements for smaller launch and recovery equipment. (Photo: Insitu)

Fetch and carry

The UAS industry is a byword for innovation, but while attention is often placed on platforms and payloads, developments in the launch and recovery of unmanned systems are helping create new opportunities and capabilities for eager operators. **By Angus Batey**

Despite the fact that aviation managed with runway operations and helicopters as its two main options to launch and recover manned aircraft for most of its first century, the possibilities in the unmanned sector appear to be broader, deeper and are only just starting to be explored.

Taking the pilot (and human passengers) out of the system allows designers of unmanned aircraft to consider options that would be dangerous, if not impossible, for a manned platform to execute. High g-forces experienced during catapult launches from carriers can be exceeded by an unmanned aircraft, and methods of recovery that amount to controlled crashes, with the attendant sudden stops or changes of direction that would put unacceptable physical strain on a pilot, become possible.

Several unmanned systems, such as BAE's now-retired Phoenix or Lockheed Martin's Desert Hawk family, have used different forms of controlled crash landing, novel air-braking techniques and cushioning or impact-dissipation methodologies to land. The key challenge is to minimise damage to both airframe and payload.

Parachute flip

The Bird-Eye family of UAS, produced by IAI Malat, combines a parachute system to slow the aircraft to below stall speed and different cushioning methodologies across the range of aircraft to limit damage to airframe and payload. Some Bird-Eye models use an air-bag system to cushion the airframe as it hits the ground, while others have prong-like shock absorbers fitted. The key difference between Bird-Eye and other UAS that use parachutes to initiate landing is that the deployment of the parachute has the effect of flipping the aircraft onto its back, thus eliminating the risk that the payload – contained in the belly of the aircraft – will come into contact with the ground during recovery.

This landing solution concept 'was created to protect the payload, which is the most important part, and in many cases the most valuable part, of the UAV', said Dan Bichman, IAI Malat's marketing coordinator for UAS. The story of the Bird-Eye, which dates back to the early part of the 21st century, was the result of technical innovation seeking both to respond to customer needs and inform emerging requirements.

'The basic need was to be able to launch and recover from a field,' Bichman said. 'And from there, our engineers tried to find a way. Normally, the easier part is to take off, which the Bird-Eye does either by catapult or hand bungee. The other part is to recover with minimal damage to the ▶

air vehicle. Once our engineers came up with the parachute and airbag or shock absorbers, they then thought about how to protect the payload, and came up with the idea to flip it over.'

Although today one might expect the effects generated by some of the smaller Bird-Eye systems to be achievable with a multi-rotor UAS, such technologies were not available when IAI began developing its system. Additionally, a fixed-wing aircraft continues to offer greater speed and range than can be achieved with a rotary system.

'The newest version, the Bird-Eye 650D, is about 4m in wingspan and 30kg take-off weight, with the same concept for take-off and recovery,' Bichman said. 'We're doing missions with this that you cannot do if you take a rotorcraft with a VTOL system and the same dimensions. Normally, you would have much less payload, would fly slower, and the endurance would be small if compared with the Bird-Eye 650D.'

IAI's Panther family of UAS leverages tiltrotor technology to achieve vertical take-off and landing, then transitions the rotors for horizontal flight. (Photo: IAI)

RAF platform

Even with conventional take-off and landing methodology, unmanned operations can throw different challenges into the mix. When the RAF was considering platforms to meet a UOR for ISR to support ground forces in Afghanistan, questions about launch and recovery were less to do with developing or adopting novel approaches than about the staffing and other human factors associated with UAS operations.

The system eventually selected (the General Atomics Reaper) takes off and lands in conventional fixed-wing manner, but requires a launch and recovery element (LRE – a term denoting air crews, ground crews and infrastructure) to be within visual LoS of the air vehicle. Once the aircraft has been launched, control is transferred to the mission crew, who fly the mission over a satellite communications (SATCOM) data link and can be located anywhere in the world.

By selecting Reaper, the RAF could share SATCOM and other infrastructure with the USAF, which was also operating the type in Afghanistan. The RAF's 39 Squadron were co-located with the main USAF Reaper operating base at Creech in Nevada, and a two-man RAF crew were deployed to the launch and recovery site in Kandahar while UK Reapers were operated in Afghanistan.

'The pros were that it was an established system – it was mature, the conops were developed, the Americans were expert in it, and we could learn as we were doing it,' explained Andy Jeffrey, who, at the time Reaper was procured by the UK, was a wing commander in the RAF and worked as the assistant chief of the air staff's expert on UAS within the MoD.

He became 39 Sqn's first commanding officer when the unit was stood up at Creech to operate Reaper. 'The cons were that we were a very small player in the very big American system. In terms of the numbers of aircraft launched, we were less than 10% of the whole effort at Kandahar. And you lose crews able to man the mission flown from Creech.'

Launch and recovery crews had to have a minimum of 500 flying hours with Reaper before they could deploy to Kandahar. Prior to acquiring Reaper, the RAF had 44 flight crew embedded in USAF Predator and Reaper squadrons, some of whom were absorbed into 39 Sqn, so they had a number of experienced crews available immediately, but the most experienced were deployed to Kandahar straight away.

LRE training would take several weeks, during which time the crew was not as available for mission flying. This was followed by a short period of leave before the crews returned to the UK for mandatory pre-deployment training and then embarked on their four-month tour to Kandahar. After leaving the LRE, crews went through decompression and usually took another short break with family. The process could mean losing a mission crew for up to nine months. While one crew was deployed, at least one other would be in training.

Another potential drawback was that reliance on US infrastructure could limit the ability of UK forces to deploy Reaper in a UK-only operation in which USAF Reapers were not involved. Initially this was not a concern, as the UK's Reaper procurement was only for operations in Afghanistan, but with Reaper now a core system in the RAF inventory, and with a certifiable Reaper airframe expected to form the basis of the ongoing Protector programme, the possibility of operating the system outside the USAF infrastructure is no longer a purely academic question.

'It would be quite easy to set up a Brit-only LRE somewhere, because we have qualified crews and all the equipment to do it,' Jeffrey said. 'The ground control station for the mission element could be anywhere. But could we sustain that operation? You could probably do it for a few weeks, but not much longer. You would like to hope that Protector would have the ability to be independent of the Americans, not just in terms of LRE and infrastructure but also training. But that probably won't happen for a long time.' ▶

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Bird-Eye 650 is launched on a deployable catapult rail, and recovers after a parachute deploys, flipping the aircraft upside down, where shock absorbers protect the airframe from damage when it hits the ground. (Photo: IAI)

Overcoming limitations

Another platform with an unusual recovery method is the Insitu ScanEagle. The system was developed in part to use on board small ships and provide longer endurance and range than would be achievable with a rotary VTOL system. The solution was to launch the fixed-wing aircraft from a catapult and recover it by flying the system into a rope suspended from a crane.

As the aircraft's wing strikes the rope, sending it into a lateral spin, a hook on the end snags on and the recovery system absorbs the energy, slowing it to a stop. The system, called SkyHook, uses the crane to lower the aircraft to the net below.

Although the system is effective and has proven commercially successful, there are obvious limitations. The aircraft requires a certain unimpeded expanse of open sky to launch, and the catapult has a nontrivial footprint. Launching it in certain environments – for example, an urban area or from beneath a tree canopy – would be impossible. Similarly, the recovery concept demands enough clear space for the ScanEagle to make a level approach to the rope, so recovering to any area where there are significant obstacles would be, at best, challenging.

In response to these limitations, Insitu and its partners at Hood Technology are currently conducting flight tests and associated development of an entirely new system.

Flying Launch and Recovery System (FLARES) uses a second multi-rotor VTOL aircraft to carry the ScanEagle to height and then release it. The same aircraft can also carry the SkyHook rope, and becomes, in effect, the top of the crane during the recovery phase. The bottom of the rope is played out using a winch which absorbs most of the impact when the air vehicle strikes the rope, and, once the aircraft's hook has attached to the rope, the FLARES vehicle descends vertically, gently lowering the ScanEagle back on to the recovery site.

'One of the big drivers for us was taking our existing system and making it more expeditionary,' said Andrew Hayes, Insitu's director of advanced development.

'Both commercial and military customers want to have a smaller footprint if possible, so we looked at how we could take our launch and recovery equipment and shrink it down.

'Once we started to come up with the concept of using something like a quadcopter to pick up the vehicle and to hold the top of the SkyHook line, we looked at what that would change in terms of the dynamic of the system,' he continued. 'And what it changed was our ability to operate in very constrained spaces. The only clearing you need is essentially a column of clean air above the FLARES unit. That's applicable in the commercial sense. If you're operating in a built-up area and you're trying to get the vehicle above the buildings to launch it, and also in a military environment or an unimproved area, where, if you have an opening in the jungle canopy above you, you can launch and recover the vehicle.'

The launch phase of the system involves the air vehicle (it does not have to be a ScanEagle, Insitu notes) being attached to the FLARES vehicle and going through its normal pre-flight preparations. This includes the ScanEagle's engine being started, so its propeller is activated before the mated pair of aircraft leave the ground. The FLARES vehicle takes off vertically and flies to the height selected by the operator; it then flies horizontally, imparting momentum before releasing the fixed-wing aircraft.

'That's one of the areas we're exploring,' said Jim McGrew, Insitu's FLARES programme manager. 'What's optimal? We don't need to give the [ScanEagle] vehicle full flight speed before we release it, because we do have altitude below us. However, we found it's better to give it a little bit of forward speed rather than just drop, because it tends to lose more altitude. It also helps to ensure separation between the FLARES vehicle and the ScanEagle. We release it somewhere below stall speed; it quickly accelerates with its own motor and starts to climb.'

Energy management

For recovery, the main difference between current SkyHook operations and the proposed FLARES system is not in the ScanEagle's altitude, but the length of rope above the point at which the platform strikes the rope.

'ScanEagles typically recover, give or take, about 30ft above the ground on the SkyHook system,' McGrew said. 'Currently, using the FLARES system, we recover at a very similar height above the ground. But the multicopter itself is quite a bit higher, and we're still evaluating where the best height is. There's quite a bit of energy involved in capturing an air vehicle, ▶

Insitu's FLARES launch and recovery system in flight. (Photo: Insitu)

particularly when we start getting to the higher-weight ScanEagles. So we've devised a system that manages that energy, and not all of it has to come out of the multicopter. If it had to absorb all of that momentum of the ScanEagle coming in, that would be too much.'

'There's an initial complex mechanism in the winch that holds the tension on the rope for a moment, so the wing hook can engage, and then plays out the rope so that the system doesn't have a huge force acting upon it in a short period of time,' added Hayes. 'That period of time has increased with FLARES, so you can bleed that energy over a large rope over a longer period. Because of the way we've designed the winch, you have a lot less impact force on the ScanEagle than you do with our traditional recovery system, meaning that our impact g-forces are significantly lower with this system, and it puts a lot less wear and tear on everything we're carrying. That's also true of the launch phase.'

Superficially, the FLARES vehicle bears a degree of resemblance to the latest design of the platform developed by online retailer Amazon, as part of the company's Prime Air programme, which seeks to use UAS to deliver packages. The vehicle has both horizontally and vertically aligned rotors, enabling it to launch and land vertically, but fly horizontally. The key requirement appears to be the need to take off and land at a very precise location close to buildings and other obstructions, while still having sufficient speed to quickly carry out a delivery.

UV requested an interview with Amazon but the company declined. A spokesperson did confirm that the platform – known at this stage only as 'the latest Amazon prototype Prime Air drone' – is an internal Amazon development.

'Any time you're thinking about VTOL, there's trade-offs and penalties in weight,' Insitu's McGrew pointed out. 'We have ISR systems with fixed wings that we want to be able to fly for long periods of time. To add the weight of motors and batteries in order to lift it vertically straight up off the ground, and then have to carry that around all day, there's quite a bit of penalty there. So when a company starts looking at that, maybe it works for their business case based on the range they need to go. If you're just lifting a package 10 or 15 minutes away, you might be willing to accept that for expediency.'

Tiltrotor system

FLARES gives ScanEagle a VTOL capability without degrading its fixed-wing, horizontal-flight performance. IAI's Panther family of aircraft uses a tiltrotor system to give a fixed-wing UAS the same capability in a single airframe. The system, which has been in development for around five years, is not operational yet, but Bichman said that the company 'is involved in close work with some customers on different configurations'.

Panther was developed partially because IAI perceived a need for a UAS with a more precise landing capability than the Bird-Eye family (which requires a landing zone of approximately 50m^2) and partially from feedback from potential customers.

According to Bichman, once in production the system 'doesn't have to be much more expensive' than other systems of comparable size and performance. The main expense has been in development of what is a complicated and technologically demanding solution.

'One of the greatest challenges in this development was the tiltrotor capability,' he said, 'and to be able to have a fully automatic system that does the whole procedure of take-off and landing only by pressing a button. I saw some of the first experiments with the system: we had a back-up manual pilot, who was a very skilled and experienced guy, and his recommendation was, "Don't try to do it manually!" Because in most cases you won't be able to do it.'

Automatic, single-button operation – which is also the goal of Insitu's FLARES programme – is a software rather than a hardware challenge for Bichman. The other main difficulty faced by Panther's designers was to provide sufficient endurance from such a power-hungry system. The type's payloads are envisioned primarily as intelligence-gathering sensors and data links, which will be lighter than the kind of packages Amazon and other companies may wish to deliver via their UAS.

There appears to be significant motivation for industry to continue exploring different and novel technologies and concepts for launch and recovery. Emerging requirements, particularly for non-military applications of UAS, will likely require different approaches to take-off and landing. If applications such as package delivery become legally viable, methods of achieving sufficient performance coupled with exacting landing needs seem likely to drive further innovation.

'From my own experience and point of view,' Bichman concluded, 'right now we have what I call the normal UAVs that take-off and land on runways; we have the Bird-Eye family that takes off from launchers and lands with parachutes and either cushions or shock absorbers; and we have the VTOL capability with Panther. I think that's pretty balanced! But we never sit still. We're always looking for new ways and new capabilities, which is what keeps us all the time at the leading edge of technology. And the way I see it, we'll keep doing it.' ■

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Commercial gain

Small UAS are the tool of choice for the vast majority of commercial operators. While the sector faces technological challenges to its growth in a number of areas, senior figures are confident these can be overcome, stimulating further expansion for the fledgling industry.

By Gerrard Cowan

The commercial use of RPAS has seen rapid growth on a global scale in recent years. In the UK, operators must secure a Permission for Aerial Work licence from the CAA before they can use UAS. A spokesman for the authority told *UV* that 1,416 permissions had been granted as of mid-February – more than double the figure from a year earlier. The CAA added 75 to the list in January alone.

A hexacopter in use on a construction site progress shoot. (Photo: Kingfisher)

All of these cover small systems of less than 20kg. However, many are actually under 7kg – systems of this size and below can be flown over congested areas like towns or cities, with the necessary permissions, although they must not fly closer than 50m to a building, person, vehicle, vessel or other structure that is not under the control of the operator.

'It has really taken off in the last 12 months,' said Adam Bailey, vice chairman of the Association of Remotely Operated Aircraft Systems (ARPAS)-UK, a trade body. 'The technology has become easier for people to reach and the cost of entry is less and less. Some people are seeing it as a garden shed business, and corporate entities are waking up to the possibilities as well.'

'A couple of years ago, it was very difficult to do it,' said Gary Clayton, chairman of UAVS, a separate UK trade association. 'Now it isn't. We've opened up regulations and we've got the training organisations. Before, you had the pioneers. Now, it's a well-proven route.'

Bailey is the founder of Kingfisher Aerial Photographic Services, which provides imaging to the building and property sectors. He says that when he joined the industry in 2013, there were only about 120 operators. As the sector has grown, so companies and individuals have become more specialised, with interests in construction, agronomy, media, utilities and an array of other work.

'It is a growing business and you're seeing more and more move into the technical side, like myself in the built environment, or within the agricultural side looking at the condition of crops and land. There are all sorts of specialist technical services – that side is starting to grow,' he added.

Training services

Elliott Corke is director of HexCam, a UK-based UAS training and filming company. HexCam uses small cameras in its work, like the vast majority of other companies in this side of the industry. 'Most of the cameras that we use on the rigs are so capable now at such a small size, that generally there's no need to go over 20kg for any kind of camerawork,' he told *UV*.

In fact, the company rarely uses systems larger than 7kg, with most coming in below this size. However, he collaborates with a network of operators around the UK and has access to their larger systems if he needs them. Corke started his business in 2012, and says that the training side has now grown into the largest part of his work – a strong indication of the rapid expansion of the industry.

'About a year in, people started asking me if I could train them. At first I said no. Eventually I did a training course for a friend and then, because I used to be a teacher, I built a training programme and started offering it, and it's just gone from there. Now most of my work is actually flight training, and I deliver qualifications as well.'

The type of customer who approaches HexCam for its training services is

changing, Corke says, with more requests for training from large organisations that want to operate their own systems rather than hiring freelancers.

'There are still freelancers coming in, but more and more we're getting asked to put together training programmes for large corporate entities putting in multiple pilots,' he explained.

Clayton said he had also noticed this trend, and the commercial UAS sector is evolving in similar ways to other industries, with large organisations looking to do it themselves if it saves time and money.

'It's like if you go to any big company – they have their own in-house plumbers and in-house electricians, they don't necessarily use the local electrician or plumber. It will be the same in this industry, some big companies will have their own in-house capabilities, but they'll still be trained and licensed the same way.'

UAS technology has come a long way in a relatively short period of time. Corke says that when he started working in the sector as an operator in 2012, he 'started out literally with a GoPro [camera] gaffer-taped to an airframe'. In the intervening period, the technology has massively improved, he says. The company uses radio-controlled octocopter and hexacopter drones in its work.

'The camera gimbals have improved, the cameras have improved, the batteries have improved, the drones themselves are getting more and more capable,' he said.

Part of the rapid growth of the business is down to the fact that it is a new industry, Clayton said. Many of the companies or individuals who work in the sector are small, local operators, working within a 30km radius or so of their home bases; this means there is a great deal of scope for new entrants to the market before it becomes saturated. 'If you think of any other amenity, there's lots of them to cover a local area. So at the moment I think it's still growing as far as what the small systems can do.'

Bailey said there was probably going to be a point at which the industry will see a degree of consolidation, in the UK at least. 'I think the industry as a whole has become quite saturated,' he explained. 'At the moment it's driven by SMEs [small and medium-sized enterprises] and micro-SMEs like myself, with less than five employees, and some of them are just single-man bands. The marketplace can only be so large.'

TV exposure

Another factor driving the growth of the industry may be the coverage it is increasingly receiving in the news and other media – people are simply more aware of the existence of the business and the potential opportunities in small commercial UAS, perhaps through stories of the work carried out by Amazon and Facebook and other Silicon Valley giants. Likewise, we are exposed to their usage more often in daily life, with UAS camerawork being used in TV programmes.

'Every time you turn on the television there's footage that's obviously been ▶

taken from unmanned vehicles,' said Clayton. 'Every time you turn on daytime TV and you see a lot of the house-buying shows, they've obviously hooked into the technology, as has everybody else. It's becoming commonplace, and it's something that people are getting into.'

While different countries have different regulatory approaches to UAS, small commercial systems are seeing rapid growth on a global scale.

Attitudes towards the industry have changed in the US, says Brandon Blackburn, CEO of Waypoint Global Strategies, a US-based consultancy firm focused on the UAS sector.

'I think we're at a point right now where the initial proof of concept is in its maturation, people are buying into it, whereas two or three years ago there was still a lot of scepticism,' he explained.

Blackburn said that the aviation sector in general was starting to embrace UAS and that the systems were becoming increasingly omnipresent – this is highlighted by the fact that there are now a number of academic qualifications available in the subject.

'I think we're going to see a more ubiquitous role for UAS in commercial applications over the next three to four years. What's also telling is the fact that [universities] are... offering UAS-focused degrees in the curriculum. So I think that as we see people who are fully trained and experienced enter the workforce, that's just going to continue to be the case.'

Rapid growth

The majority of commercial approvals being made by the Federal Aviation Authority (FAA) are for small aircraft, said Gretchen West, a senior advisor at Hogan Lovells US, a global law firm. West is a member of Hogan Lovells' UAS group in Silicon Valley, and has worked in the UAS area for over ten years.

When she started working in the sector, West said, there were two main users of small systems – the military and hobbyist/modellers community. Now, however, the systems 'are being used for all sorts of different things. They're being used for recreation and for fun or to capture imagery, but they're also being used commercially in a variety of different industries, from utilities to construction to real estate'.

West said the rapid growth of the small UAS sector has created safety headaches. The military users are very aware of the rules of the air, she said, as are members of the longstanding modeller's community, which is governed by associations that educate them about the rules of airspace and has a variety of community standards to govern how modellers operate.

However, with some of the new operators – both new hobbyists and some using drones commercially – 'there's not quite the awareness that these are aircraft... As a community that comes together we need to be really aware and not jeopardise the growth of this industry for others.'

A quadcopter being used for an industrial survey. (Photo: Kingfisher)

She said that none of these dangers were being created intentionally, but the lack of awareness of the rules was a major concern. 'If you're using a tool to measure something on a construction site and you just happen to use a drone or an unmanned aircraft, intrinsically you're not necessarily thinking of that as an aircraft, especially if your background is not in aviation. Some users simply do not understand the rules. It is a big challenge for the industry at large across the globe.'

Corke said more of an obligation should be placed on the end users who hire operators. The users need to ensure that they are looking for the relevant licences, insurance and other documentation before they contract the services of an operator.

'At the moment, with more and more people going into the industry, there's more people who don't know the rules and are flying illegally and in an unsafe manner,' he said. 'As well as us trying to push the safety side, I think there needs to be some way of encouraging end users to ask people for their paperwork.'

Most of the current focus is on smaller UAS, West said. However, she argued that there could be potential for larger systems in future, particularly where the system must stay in the air for longer periods of time. Hogan Lovells is carrying out several studies in this area, she said.

'As this industry shakes out a little and some of the novelty of flying a drone in the air wears off, it will be interesting to see if the focus does shift a little bit. To be able to monitor a railroad, you need to have a long endurance aircraft, and right now most of those are high- or medium-altitude, and are typically much larger systems. It will be interesting to see how the technology converges. Does it stay small, and the endurance extends? There's still a lot of things that need to happen.'

She said that much of the focus for the immediate future would remain on smaller systems, however, with safety aspects playing a major role.

'I think when companies start to think through the business case and what they're going to deliver and the endurance that they need... they might need some larger systems. But I think right now most are focusing on small, and it makes sense because from a safety perspective, the smaller and ▶

HexCam's Elliott Corke flying a DJI Inspire 1. (Photo: HexCam)

lighter the vehicle is, the less damage it can cause if something were to happen.'

Staying power

Challenges surrounding endurance are one of the major technological obstacles facing the small commercial UAS sector, says Bailey, with operators currently restricted to a time frame of about 20 minutes in the air at any one time. Improving this to 40 minutes or an hour or beyond would be hugely useful, he said.

'At the moment, you're restricted by the time you can spend in the air, because you can only put on so many batteries before the benefit becomes negligible. That's where one of the next big steps in drone technology will be. People are looking at the power-to-weight ratios and how we can make power storage more stable.'

This obstacle is not insurmountable, said Corke, and solutions are already emerging to tackle it. Some companies are using hydrogen fuel cells as part of hybrid technologies that can extend flight time to three or four hours, from the current level of 20 or 25 minutes on most systems. Additionally, advances in graphene batteries could make the recharging process much quicker, cutting it from an hour to five or ten minutes, he said.

Perhaps the most serious challenges, however, surround the goal of moving beyond visual LoS. Under current regulatory systems, the operator must keep his or her RPAS within their LoS. In the UK, this is defined as 400ft vertically and 500m horizontally.

'At the moment, we're quite limited in the areas we can cover,' said Corke. 'For example, for large-scale surveys, whether that's in agriculture or in industry, to be able to fly more than 500m from yourself – that would be very beneficial.'

This places obvious restrictions on an operator and the industry generally. There are some ways of extending it – for example, 'extended LoS', when another person is able to talk to the operator over a radio. Corke said this is 'kind of doable at the moment but it makes it awkward, so being able to go beyond visual LoS up to a couple of kilometres would be very, very useful.'

In order for the systems to move beyond visual LoS, they must develop what is known as 'sense and avoid' capability, which would allow them to operate in much the same way as a human pilot, and prevent collisions with other aircraft or structures.

There are other challenges beyond this, however. Clayton highlighted the need to go beyond radio LoS – communicating with the system 'once it gets over a radio horizon. I've still got to communicate with it. So how do I deal with that?'

Industry is working to develop the technology to overcome obstacles surrounding endurance, communications and sense and avoid. There are a number of collaborative projects focused on this and other challenges.

For example, ARPAS-UK is working with a number of other commercial and academic partners on Project AIRSTART, which is investigating the key elements needed to allow UAS to move beyond LoS, including power, communications, and sense and avoid. This is just one example – there have been other projects in the UK in which industry and government have looked ▶

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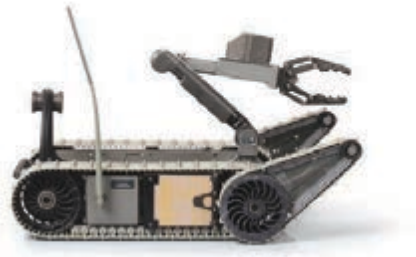

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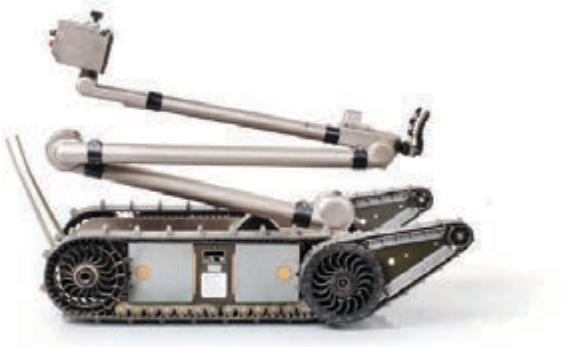

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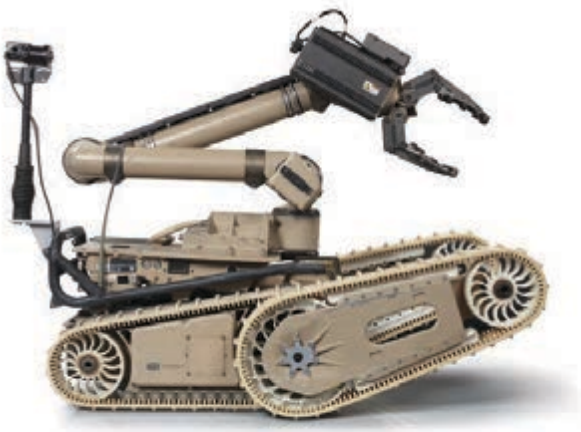

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> *"Once we can prove they're safe, that's when you'll see vast amounts of investment and things will really take off."*

into these issues, such as the ASTRAEA programme. Senior figures in the industry are confident that these obstacles will be overcome, stimulating a new wave of investment into small commercial UAS.

'There's lots of research going on, there's lots of people working in lots of ways. The technology just moves quicker and faster and will get lighter and smaller,' said Bailey. 'At the moment what's missing are the safety aspects. Once we can prove they're safe, that's when you'll see vast amounts of investment and things will really take off, even more so than we have seen already.'

Corke said that moving beyond visual LoS will happen at some stage, although he expects it to first occur in rural locations and then once proved could occur in more congested environments.

Everyday life

Much of the industry's focus is turning to the potential for autonomous systems, in which the human element is almost entirely removed, except for pre-programming the UAS's flight path and precise tasks. West envisions a future in which people will not even notice drones any more – UAS will be a simple fact of life in a variety of industries, and will operate almost of their own accord.

'I like to use the example of a farmer who has a massive field and a fleet of drones, which are scheduled to do the work. They operate at whatever time of day or night and they fly their pre-programmed paths and bring back information processed in real time. The farmer just gets up in the morning, turns on the computer and has a complete data set at the ready and full field maps.'

The rapid pace of technological change in small commercial RPAS is reminiscent in many ways of the early days of the personal computer business. Clayton said that while computers raced ahead in the early years, their development has stabilised in recent times – he expects UAS to follow a similar trajectory.

'We'll get to a point where the small systems can do everything within the parameters they're allowed to work in, and it will plateau. At the moment, however, unmanned systems are just becoming better and better because there's so much more we can do before we start having to get really inventive.'

Regulations around commercial RPAS differ from country to country, with some nations seen as less restrictive than others. In Europe, there is a move towards greater harmonisation, with the systems falling under the remit of the European Aviation Safety Agency. This would be popular with many operators.

'At the moment, the amount of red tape you have to go through if you want to do a job in England that's also based in France is intolerable,' says Bailey. 'Harmonisation across Europe would make it a lot easier.'

'Because legislation is so different in the different countries, what I tend to do if I get a job in another country is find a local operator and get them to do it. I subcontract it,' said Corke. 'Being able to work as I can in the UK in other countries would be beneficial.'

Clayton agreed: 'Harmonisation is a good thing. We may be on an island here but if I was an operator working in the southern Netherlands, why can't I work 15km away in northern Belgium?'

However, despite the obvious potential of small UAS, it is important to remember that there are regulatory and technological limits to what they can do, which will remain the case even if they achieve a longer battery life and the capacity to go beyond visual LoS, Clayton argued.

'The one thing I would say very carefully is that they're not the answer to everything, like any other technology,' he said. 'There's some things they're really good at, for example inspecting church roofs. It certainly saves bringing a cherry picker up a delicate church path or putting scaffolding around a church. That's the sort of thing that they're absolutely brilliant at. But not everything can be done with one technology – they're very good at what they're good at.'

Still, the companies and operators that make up the industry are bullish for its future. 'It's unrecognisable from four years ago, it really is,' said Corke. 'I don't think I would have predicted how fast it would develop. Things come out almost every day – new gimbals, new cameras. You could almost endlessly spend money if you wanted to, so you actually have to be quite careful as an operator on where you draw the line.' ■

The UK MoD has purchased two Zephyr UAVs and assembly will take place at an Airbus site in Farnborough. (Photo: Airbus DS)

HIGH HOPES

The Northrop Grumman Global Hawk remains the only HALE UAV fully operational with a military user, the USAF, and has been for well over a decade. However, companies and militaries alike are partnering up in an attempt to tap into this market and utilise the capabilities it brings. **By Beth Maundrill**

The recent contract awarded by the UK MoD for two of the latest increments of Airbus Defence and Space's (DS) high-altitude pseudo satellite (HAPS), Zephyr 8, shows that despite it being difficult to break through the developmental barrier, these challenges have not hampered the desire for such a unique technology capability.

The department confirmed its intention to purchase two Zephyr 8s on 2 February 2016, and the aircraft will be manufactured at the company's Farnborough site in England. The first prototype of this version of the aircraft was launched in 2015 and has been cleared for flight in military and civil airspace.

The MoD is planning on using the UAV for intelligence gathering missions to support special forces, although it has not specified which kind of payload will accompany the solar-powered HAPS to date. The £10.6 million ($15 million) contract will allow for the two aircraft to be developed under an operational concept demonstrator programme. Initial testing is scheduled to take place in 2017 to explore the capability benefits of the aircraft.

In theory, by working in concert, multiple Zephyr UAVs will be able to provide constant, reliable intelligence capabilities over vast geographical areas, according to the MoD. In this way the aircraft could be used as a communications relay or a data link in the future.

Special surveillance

The platform's primary application is believed to be surveillance for special forces, and during the 2015 UK Strategic Defence and Security Review (SDSR), the Zephyr HAPS was alluded to as Prime Minister David Cameron talked of a surveillance drone which 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'.

The previous version of the HAPS, Zephyr 7, is well known for achieving a world record flight in 2010 with a continuous flight lasting 14 days. The aircraft is able to fly slowly at 65,000ft – typically, a

commercial Airbus A320 reaches an altitude of 35,000ft.

Airbus DS credits the long flight capability to the technology that is used on the aircraft. According to the company, it is the same as that used in its satellites, which are built to operate for up to 15 years without the necessity to replace spares or parts.

Its long endurance can also be credited to the use of solar energy, which removes the need for refuelling. The Global Hawk, on the other hand, uses a jet engine, specifically a Rolls-Royce AE3007H turbofan engine, and has a maximum endurance of 32 hours.

The Zephyr design has been in development for the best part of a decade and the ownership of the design and development of the aircraft transferred from Qinetiq to Airbus DS in 2013. While the design and testing has been under way for some years, the UK is the first to attempt to use the aircraft for military purposes.

The MoD has also embarked on a programme to find suitable technology for persistent surveillance, likely linked to Zephyr. The ministry launched a Defence Growth Partnership (DGP) Innovation Challenge in March 2015 with up to £10 million available to those involved. The initial phase of work that is currently under way is valued at £2 million. The innovation challenge is aimed at focusing on areas which hold significant challenges for UK defence as well as providing opportunities for export.

Google has experimented with high-altitude balloons to provide extended Internet coverage as part of Project Loon. (Photo: Google)

Direct communication

Roke Manor Research was awarded around £1.25 million as part of the project to design a data link that can be used to communicate directly with ground-based cellular infrastructure at a distance of more than 50km.

While the contract did not specify for the technology to be used on Zephyr, Bob Dalgleish, business development manager at Roke, noted that in the development phase the company has specifically borne in mind the SWaP constraints of Zephyr. '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,' he said.

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

The data link will deliver a high-bandwidth communications channel for real-time image and video. According to the company, the system will use COTS 3G hardware, which alone cannot successfully transmit from high altitude to a base station on the ground. To overcome this, Roke will develop adaptive beam-forming technology to intelligently direct the signal to a specific point on the ground to commercial cellular infrastructure or to a dedicated military base station.

Another company that has been awarded a development contract as part of the DGP Persistent Surveillance from the Air challenge is Plextek, which has been tasked with enhancing its research into compressive sensing-based RF emitter location. Peter Doig, business development consultant, defence and security, at the company, said that the project is indeed aimed at HAPS.

Compressed sensing involves encoding and integrating sensor outputs prior to analogue-to-digital (A/D) conversion at a rate much less than Nyquist. Following A/D conversion, the original signal can be reconstructed using specialised algorithms. However, these are computationally intensive.

Plextek has successfully demonstrated compressed sensing algorithms applied to electronic surveillance, and is now researching RF emitter location in frequency and bearing via signal processing operating directly upon samples from a compressed sensing receiver array. The company's innovation is in enabling signal processing, and in particular direction of arrival sensing, in the compressed domain without having to reconstruct the raw signal from the compressed domain first.

'The primary application and key benefit of this work is to significantly reduce the SWaP required by a communications or radar [electronic support measure] payload for a high-altitude, pseudo-satellite platform over conventional approaches or to conversely significantly increase instantaneous bandwidth,' said Doig.

'We are presently finalising the project, however the devised algorithm has demonstrated achieving one-degree bearing accuracy against a range of real-world emitters covering cellular communications, air traffic control and surveillance radar,' Doig added. This technology would allow for a HAPS to have RF monitoring capabilities without the traditional SWaP constraints.

Academic proposal

The University of Sheffield is also focusing its efforts on the SWaP payload for the HAPS. 'My proposal was inspired by the Zephyr unmanned aerial vehicle,' said Jon Willmott, senior lecturer in the Electronic and Electrical Engineering Department. 'Clearly, it has huge potential for long-term earth observation. However, 3kg is the maximum payload that it can take. For example, a typical LiDAR instrument weighs 25-50kg.'

LiDAR technology is primarily used for surveying ground, measuring distance by illuminating a target area with a laser light. 'I wanted my group to get some LiDAR experience because it overlaps with thermal imaging in terms of the technology. I spent a decade in industry designing thermal imaging cameras, before moving to the university and making it my research topic,' he said.

'I proposed to the MoD that we develop the technology that both maps the ground terrain with LiDAR and then puts people and ▶

vehicles into that scene using the thermal imaging "channel" of the instrument.'

Willmott added that the plan is to use 'a combination of good engineering practice, electrically steerable miniature mirrors and 3D-printed metal parts' in order to keep within the weight target. Once achieved, this 'will be particularly good' for surveying international borders and the people moving across them.

One drawback of the Zephyr is its limited payload capacity. While it can support up to five times its own mass, this does not mean that it can carry that kind of weight. As it stands, the total payload capability of the Zephyr 8 is 5kg. Airbus DS has stated that future versions will include increased capacity. By comparison to the Zephyr's limited capabilities here, Global Hawk is able to hold up to 1,360kg. This has enabled it to carry various EO/IR sensors and synthetic aperture radar (SAR).

While not a HALE UAV, the widely used MQ-1 Predator MALE system can handle a 136kg external payload, meaning it can carry some of the most advanced imaging sensor equipment including the General Atomics Lynx SAR, which weighs 37kg and has a range of 80km.

Keven Gambold, CEO of Unmanned Experts, raised concerns about the usefulness of the Zephyr if equipped with an EO/IR-type payload.

'The difficulty of being at 70,000ft is that you are above the weather, which is nice, but you have to look through it all,' he said.

Gambold noted that a small payload can be useful at 300ft on a small UAV but begins to lose its value as an asset at high altitude. 'If Airbus has managed to find a way of creating [a 5kg] sensor that they can make use of then they wouldn't be putting it on a Zephyr, they would stick it on every single thing on the planet, and they would currently own the remote sensing world.'

He said that while the first sale of the Zephyr is a step in the right direction, it may not provide the MoD with exactly the capability it is expecting.

'When they get it up there and realise a camera payload is no good, they are going to change it,' he said.

This could enhance the technology development of the aircraft, as options for data links, relays and repeater and other sensor technology are likely to be explored. 'I'm pretty sure when they get it they are going to love it, but they aren't going to love it for what they bought it for,' added Gambold.

When asked about concerns over the small payload weight, an Airbus DS spokesperson said: 'While precise capabilities that can be delivered are a sensitive matter, Airbus DS has successfully flown and evaluated a range of lightweight payloads, such as EO/ IR surveillance sensors and the data obtained from these sensors has attracted a great deal of interest in the market.

'In addition, Airbus has operated on the Zephyr platform several communication payloads which have achieved extremely useful results. For example, we have been able to provide communications between two combat held radios 650km apart, which is extremely impressive,' the spokesperson added.

'Furthermore, the range of lightweight sensors is growing through both new developments and modifying existing sensors – for example, by removing unnecessary features such as steel casing – to significantly reduce the original weight to meet the Zephyr parameters.'

Looking abroad

To fulfil the general ISR requirement for the Zephyr, Australian company UAV Vision was selected in May 2015 to provide an ISR payload for the Zephyr 8. This will provide a high optical zoom daylight sensor as well as a mid-wave IR sensor fitted with a high optical zoom lens.

The gimbal provided is the CM202, which weighs just 3.5kg – suitable for the Zephyr's payload capacity. It measures 190mm deep by 295mm high. The company has designed the gimbal for large unmanned aircraft or small manned aircraft. UAV Vision says that when paired, the Zephyr and payload from UAV Vision will be able to provide highly stable continuous footage, day and night for extended periods.

Outside of the UK, the Zephyr has not yet managed to secure other contracts, although the OEM has alluded to working with other nations to see where the aircraft could fit in with future requirements. A company spokesperson said at a press event in 2015 that Airbus DS was working with the Republic of Singapore Navy to explore the use of Zephyr to fulfil long-endurance maritime surveillance capabilities. This could involve a ship-launched version of the Zephyr. This would not come without its challenges, as landing the UAV requires a significant runway.

The German military and police are also interested in exploring the vehicle for surveillance use. Following the UK commitment, these nations are likely to

The Chinese BZK-005 UAV is in operation with the People's Liberation Army Navy. (Photo: Gordon Arthur)

keep a keen eye on the development of the Zephyr within the MoD.

Commercial factor

In the commercial sector, HAPS are being explored as a way to deliver connection capability to areas which have little or no satellite coverage to provide access to the internet. The likes of Google and Facebook have begun developing long-endurance UAVs which could fulfil this challenge.

'Facebook and Google are both looking at these HALE systems. That is a great use because satellites are expensive, but with these things you can probably get ten of them for the price of one satellite and get them airborne. Then everybody gets the internet,' said Gambold.

He also noted that it is possible the technology being developed by the two giants of Silicone Valley could be available within the next four years. This could happen before Zephyr has realised its full potential.

Early in 2016, it was reported that Google was testing a solar-powered system at Spaceport America in New Mexico that is designed to deliver a high-speed 5G internet service under a project named SkyBender. The company has been relatively elusive when discussing work on the project.

In 2014, Google bought Titan Aerospace, based in New Mexico, whose flagship project was the manufacture of the Solara 50 solar-powered high-altitude UAV. Before the purchase, it was rumoured that Facebook was discussing acquisition of the company for a reported $60 million.

Facebook is using UAV technology in its effort to connect the whole world with a project named internet.org. The social media giant is working with a team of people from UK-based company Ascenta to develop a suitable aircraft. Founders of Ascenta assisted in the creation of early versions of the Zephyr.

In June 2015, Facebook announced the completion of the first scale aircraft, Aquila, as part of the internet.org effort. The ▶

The Zephyr 8 is the latest iteration of the solar-powered pseudo-satellite. (Photo: Airbus DS)

aircraft is fully solar-powered and has a wingspan matching the Boeing 737 at 42m. The company also stated that it has successfully tested laser technology that can transmit data at up to 10Gbps. The aircraft will fly at around 60,000ft for up to three months at a time.

In a video released by Facebook, details of the project are explained by Andy Cox, engineering lead at the Facebook Aviation team. In order to make the aircraft as lightweight as possible the airframe is constructed out of 88g T700 fibre, which is very resilient and three times stronger than steel.

Eventually there will be a constellation of multiple Aquila aircraft. A ground station will transmit a radio internet signal to a mother aircraft, which will then feed others in the constellation using laser technology, explains Cox. This will result in the provision of radio internet coverage to the ground.

Google is also looking into the use of balloons that provide wider coverage under its Loon project. The balloons float in the stratosphere which are directed by rising or descending into a layer of wind blowing in the desired course of travel.

Google has partnered with telecommunications companies to share the cellular spectrum which will enable people to connect directly to the balloon network from phones and other Long Term Evolution- (LTE) enabled devices. This project began in 2013 with an experimental pilot in New Zealand.

The balloon's electronics are powered by an array of solar panels mounted at a steep angle to effectively capture sunlight. According to Google, each balloon can provide connectivity to a ground area of about 80km in diameter using LTE technology.

Other developments

Outside the realm of solar-powered Zephyr technology and Global Hawk HALE UAVs, there are a few projects that are ongoing and are yet to be mothballed like so many others, including NASA's Helios Prototype aircraft which met its end in the Pacific Ocean near Hawaii, following a break-up mid-air.

China has a variety of projects potentially in development, although typically secretive, and little is known about the details. There is a jet engine HALE UAV, the Xianglong or Soaring Dragon, designed by the Chengdu Aircraft Industry Group. The design has a joined-wing and the few photos that have emerged suggest that the aircraft is at the end of the development phase.

At the military parade in Tiananmen Square, Beijing, in September 2015, China demonstrated its UAV technology including the display of the BZK-005, a HALE platform developed by the Harbin Aircraft Industry Group (HAIG). The aircraft is propelled by a three-bladed propeller and has a cruising speed of 92kt.

It is known that at least three units of the BZK-005 are operating with the People's Liberation Army Navy from Daishan Island near Shanghai since around 2013. The BZK-005 has a maximum take-off weight of 1,250kg and can accommodate an EO sensor payload of up to 150kg. The ceiling of the aircraft is around 26,000ft.

Outside of China, the only remaining HALE UAVs that are still viable are the Boeing Phantom Eye and the AeroVironment Global Observer. According to a Boeing spokesperson the Phantom Eye is currently in 'flyable storage' – presumably awaiting a customer willing to invest in future testing, as to date all investment of the aircraft has been internal.

The aircraft has achieved just 34 hours of total flight time and reached an altitude of 53,000ft. The UAV uses hydrogen internal combustion engine propulsion technology to achieve flight with two propellers. The first flight was carried out in 2012. During the ninth test flight in 2014 at NASA's Armstrong Flight Research Centre, Phantom Eye extended its endurance to more than eight hours. Five of the nine test flights were contracted by the US Missile Defense Agency, which used the vehicle to carry an internal flight data instrumentation payload. Since the 2014 test flight, the Phantom Eye has been resigned to storage, but the company says that it is exploring larger HALE concepts based on the platform's technology. Those aircraft could stay aloft for a week or longer and carry payloads of more than 900kg.

The AeroVironment Global Observer is in a similar state of limbo, awaiting a customer. The first successful flight was conducted in 2010, and in 2014 the company signed a memorandum of understanding with Lockheed Martin to join forces and explore opportunities for the type internationally.

The intention was to target wide area applications such as border surveillance and communications, with an emphasis on providing customers with an affordable option. The UAV has been promoted to work at an altitude of over 60,000ft.

It can be used as a redeployable satellite to provide coverage over an area of up to 1,000km in diameter. It is designated as a multi-mission aircraft, with capabilities including communications relay, ISR, storm tracking, telecommunications infrastructure, wildfire detection or tracking, maritime operations and disaster recovery services.

Since then, no customers have come to light, but the company is ready to offer the UAV to fulfil customer's needs.

With the advent of the Zephyr contract, it could kick-start a new interest in HALE and HAPS technology, while industry and militaries keep a keen eye on the development of only the second HALE UAV outside of China to be commissioned by a military. The development of the Zephyr could pave the way for a resurgence in interest in Global Observer and Phantom Eye alike. ■

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Lockheed Martin's Skunk Works brain trust has a history of coming up with innovative solutions to complex problems. **Richard Thomas** speaks to Kevin Lewelling, manager of the company's rapid operations programmes, about its approach in developing multirole, low-risk and affordable designs.

Cost management

As military budgets worldwide continue to feel the pinch, Lewelling told *UV* that last year the USAF had announced it was launching a series of initiatives aimed at bringing down the cost and time associated with acquiring new technologies.

'The initiatives were bundled together under the banner of "Bending the Cost Curve". These efforts are very aligned with the Skunk Works' approach, which is based on developing trusted, authentic relationships to quickly solve the nation's most pressing needs.

'Generally speaking, our approach to rapid innovation is purposeful and leads to low-risk, affordable solutions. For quite some time, we've been focused on multi-mission applications and integrating open architectures into our platforms, recognising the military is looking for systems that perform multiple roles. We will continue down that path in 2016 and beyond.'

One such programme that has benefited from continued investment in time and resources has been the Stalker XE, which in 2015 successfully demonstrated Group 2 and 3 UAS capabilities on what is a Group 1 footprint. In doing this, Lewelling said that they had now 'broadened the foundation' needed to rapidly mature technologies that will expand SUAS capabilities.

The focus for 2016 was to reduce the operator workload that comes with long endurance and multi-intelligence capabilities, as well as looking for ways to leverage advancements in direct manufacturing to support rapid deployments, he added.

'We have a long-range vision for our SUAS portfolio and we're continuing to execute building block elements of that vision to discretely offer new capabilities along the way. Further developments will primarily be in the way of reducing operator workload, increasing the platform's endurance, continuing to increase the intuitive nature of our ground control software, additional refinement in the system's vertical take-off and landing kit, and we'll be diversifying the types of payloads the system can carry.'

Future markets

Lewelling added that last year Skunk Works integrated many technologies that it thinks will support elements of BVLOS flights in the national airspace system, and in 2016 would continue to expand the 'opportunity space' for BVLOS internationally.

'This would allow the Stalker to perform the types of missions it is best suited for, such as infrastructure monitoring over long distances, search and rescue and fire scouting. So in addition to there being future markets – military, civil and commercial – for Stalker XE, we will also continue to investigate and evaluate new technologies through demonstrations to ensure we stay on the cutting edge.'

It was in ISR missions that the strength of UAS platforms were most easily found however, with Lewelling describing the capability as 'one of the most useful applications' in being able to provide 'better, actionable intelligence to the warfighter'. He continued: 'It provides them the eyes that they don't or cannot have in certain missions.'

Another programme that Lewelling provided updates on was the DARPA Aerial Reconfigurable Embedded System (ARES), which was being carried out by the Advanced Program Pursuits division of Skunk Works. The unmanned VTOL system is designed to be capable of conducting a variety of missions, including cargo resupply, casevac and ISR.

> ***"We're focused on multi-mission applications and integrating open architectures, recognising the military is looking for systems that perform multiple roles."***

The current design sees ARES operate with twin-tilting ducted fans for improved hovering and landing capabilities, with a rapid conversion to high-speed cruise flight. According the DARPA material, ARES would have a useful load capability of up to 1,360kg, with a flight performance similar to light aircraft, and its size enabling use of smaller landing zones compared to similar-sized manned rotorcraft.

'The Lockheed Martin-led team, which includes Piasecki Aircraft, is currently performing Phase III of the programme, which includes detail design, hardware fabrication, ground test and flight test. All detail design is now complete and we are proceeding with fabrication, assembly and ground test of the flying demonstrator,' said Lewelling.

'We think VTOL UAS with modular payload capability holds real promise. This capability would increase force protection and supply throughput to relieve soldiers and manned aircraft of routine resupply, especially in denied environments.' ■

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