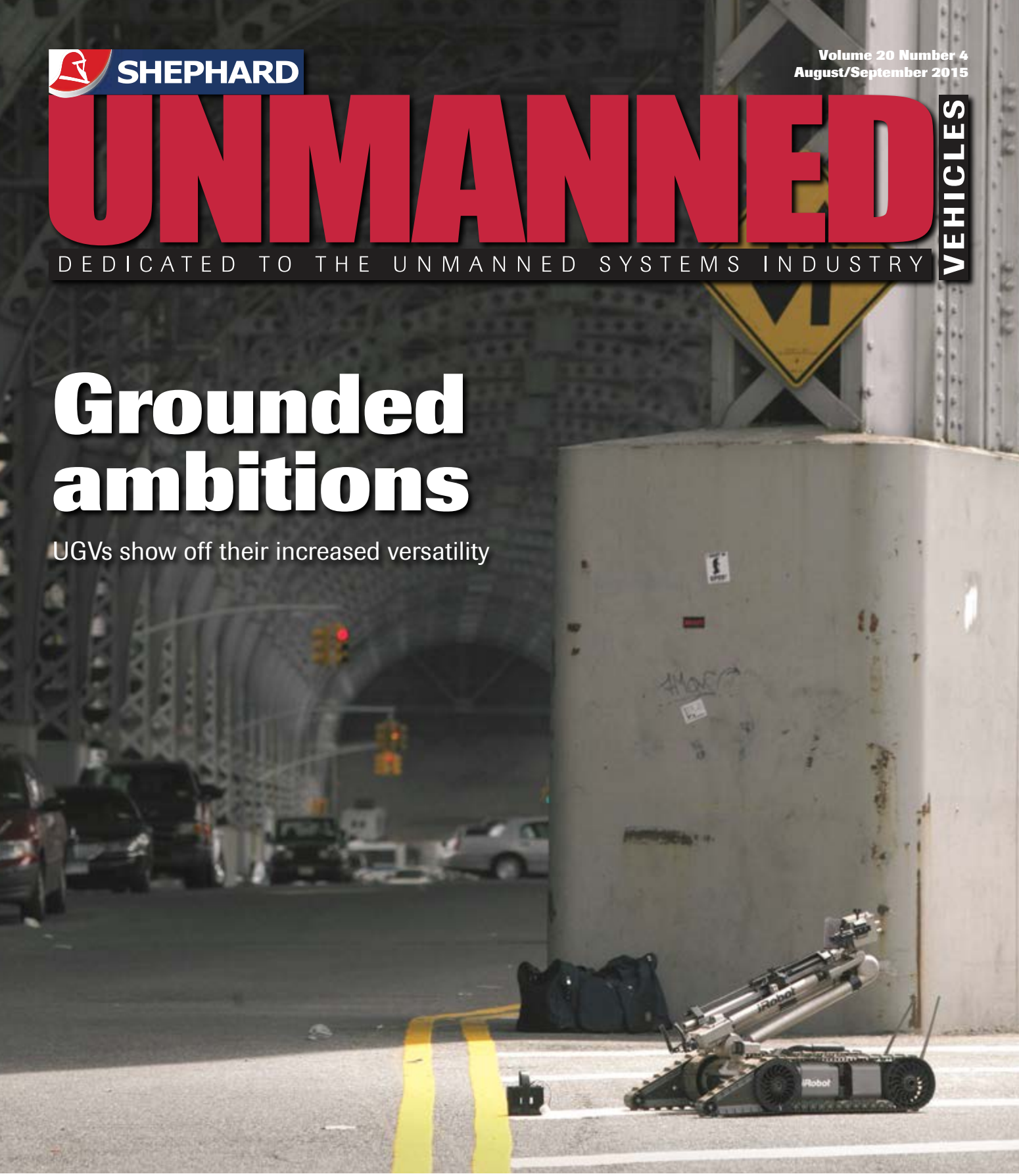
SHEPHARD

Volume 20 Number 4
August/September 2015

UNMANNED VEHICLES

DEDICATED TO THE UNMANNED SYSTEMS INDUSTRY



Grounded ambitions

UGVs show off their increased versatility

CHANGING ROLES

Tactical UAV developments

PLAYING CATCH-UP

Unmanned marine systems

JAMMING SESSION

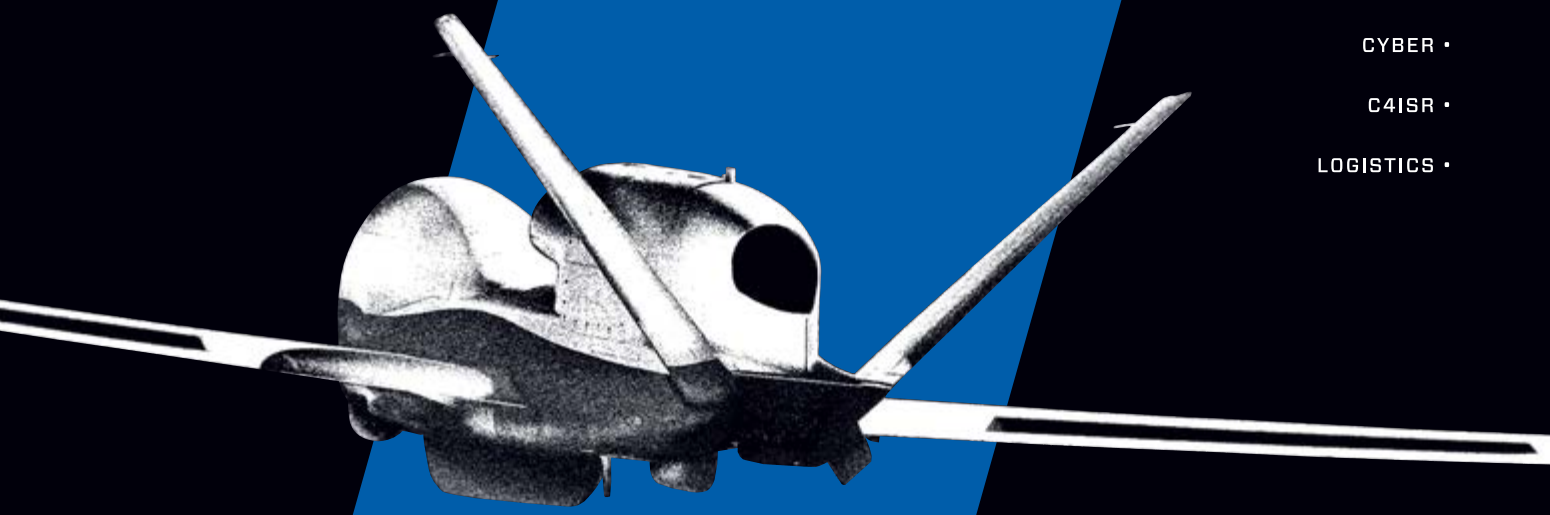
EW payloads

UNMANNED · SYSTEMS

CYBER ·

C4ISR ·

LOGISTICS ·



THE VALUE OF COMMANDING UNMANNED POWER.™

When you can go where others can't,

you gain a powerful advantage.

From undersea to outer space,

Northrop Grumman's advanced platforms

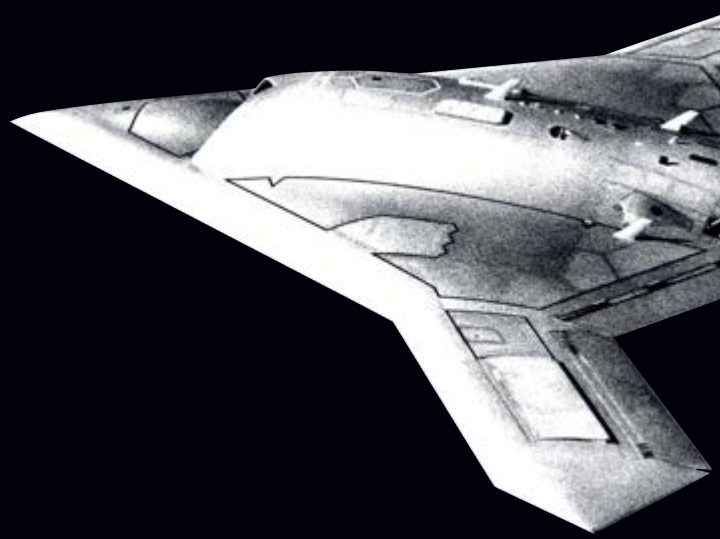
and technologies offer a wide range

of new capabilities for every mission.

That's why we're the leader in

Unmanned Systems.

THE VALUE OF *PERFORMANCE.*



NORTHROP GRUMMAN

www.northropgrumman.com/**ums**

Editor
Richard Thomas
richard.t@shephardmedia.com
+44 1753 727027

Asia-Pacific Editor
Gordon Arthur
gordon.a@shephardmedia.com

North America Editor
Scott R Gourley
scott.g@shephardmedia.com

Staff Reporters
Beth Maundrill
beth.m@shephardmedia.com
Grant Turnbull
grant.t@shephardmedia.com

Contributors
Claire Apthorp, Pieter Bastiaans, Angus Batey, Peter Donaldson, Eugene Gerden, Neelam Mathews, Jonathan Tringham, Andrew White

Production Department Manager
David Hurst

Sub-editor
Adam Wakeling

Graphic Designer
Kam Bains

Commercial Manager
Christian Letessier
christian.l@shephardmedia.com
+44 1753 727003

Editor-in-Chief
Tony Skinner

Managing Director
Darren Lake

Chairman
Nick Prest

Subscriptions
Annual rates start at £65
Tel: +44 (0) 1753 727010
Email: subs@shephardmedia.com
Web: shop.shephardmedia.com

Unmanned Vehicles is published six times per year – in February/March, April/May, June/July, August/September, October/November and December/January – by **The Shephard Press Ltd**, 268 Bath Road, Slough, Berks, SL1 4DX.

Air Business Ltd is acting as mailing agent.

ISSN 1351-3478

Print Buxton Press, Derbyshire, UK

BPA WORLDWIDE

SHEPHARD

The Shephard Press Ltd,
268 Bath Road, Slough,
Berkshire, SL1 4DX
Tel: +44 1753 727001
Fax: +44 1753 727002

www.UVonline.com

3 Editorial Comment
Editor Richard Thomas considers the progress of the unmanned systems sector across the land, air and sea domains.

News

4 Aussie Herons fly in civil airspace
A review of some of the latest developments from around the unmanned systems industry.

10 Attachment theories
The variety of payloads that can be incorporated onto a UGV is steadily increasing as the technology sees a wider range of applications across both the commercial and military markets. Grant Turnbull looks at some of the main growth areas.

17 Once the dust settles
Despite completion of a number of tactical UAV procurements following the drawdown in Afghanistan, the class remains a valuable asset for militaries around the globe preparing for the next era of operations, discovers Andrew White.

27 Support, protect, attack
Technological innovation at the core systems level is resulting in some exciting new capabilities in the field of UAV-based electronic warfare. Peter Donaldson reports on some recent key industry developments.

34 Into the mainstream?
USVs are starting to get noticed by civil and military agencies, as OEMs begin developing platforms that are multi-mission, have greater autonomy and can accommodate more advanced payloads. Claire Apthorp considers their potential utility.

43 Signs of life
The Indian UAS market is looking strong after years of stagnation. Neelam Mathews rounds up the latest developments.

46 Risky business
The growing realisation that unmanned systems can provide a cost-effective and safe method of conducting infrastructure inspections could result in a market boom. Richard Thomas examines where progress is being made.

52 Interview
Tekever Group unveiled the shipborne AR3 Net Ray UAV recently, putting it in direct competition with some established industry players. Richard Thomas talked to COO Ricardo Mendes about the market and the challenges ahead.

Front cover: New payload technology is expanding the range of applications for UGVs. *(Photo: iRobot)*

NEW TOOLS FOR NEW RULES

Visit us at
MSPO 2015
Hall E, Booth E-34
DSEi 2015
S10-140

Performance. Over and Above.

Elbit Systems' UAS family comprises new-generation platforms designed for real-time optronic and electronic battlefield intelligence.
High operational versatility renders Elbit Systems' UAS ideal for numerous missions around the clock.

Full family of interoperable UAS:
MALE · Tactical · Close-range · Mini

Elbit Systems™

NEXT IS NOW™

www.elbitsystems.com

Getting the edge

Progress is very much the byword for this edition of *Unmanned Vehicles*, both in the military and commercial sectors, as planners and developers figure out new ways to use platforms at sea, on the ground and in the air.

More than 70 countries are currently using UAS in some form and this figure will only increase as operating techniques and system capabilities improve and become more varied.

One of the driving forces of this developmental curve has been the conflicts in Afghanistan and Iraq, theatres where multiple nations operated unmanned vehicles in a bid to gain a strategic edge. More often than not, that edge would be information, so platforms on the ground and in the air became dedicated intelligence gatherers, pushing technological boundaries in imagery, analysis and identification.

In a permissive air environment the tactical UAV has become king and is now relied on to provide high-definition EO/IR and EW capabilities as miniaturisation expands the options available to operators.

Much the same is happening on the ground as UGV platforms are being looked at in a modular context, rather than limited to their original design specification, with EOD systems being adapted to provide a range of new capabilities in information-gathering and situation awareness, for example.

Again, this is driven by improved technological capability, miniaturisation (thanks in part to the use of COTS products) and a progressive attitude on the part of industry and clients to explore new applications of unmanned systems.

However, it has not been plain sailing for the maritime sector, which has faced different challenges, in part due to industry not having quite the same military impetus due to the landlocked nature of the Afghan conflict and the prolonged counter-insurgency in Iraq.

As recently as two years ago, sailors in the US 5th Fleet admitted during a media embarkation that they were lagging behind other nations in the use of USVs and UUVs, and were only just coming to terms with the SeaFox mine countermeasures system.

Of course since then we have seen developments in the Common USV programme and the addition of other unmanned platforms to the maritime portfolio. The USN's efforts to integrate such systems is indicative of the industry as a whole in an ongoing game of catch-up.

The benefits, however, may become a little clearer for those operating in a naval environment, given the potential increases in endurance that a USV or UUV can provide the operator, notwithstanding the progress ship-based UAS are making as they are permanently embarked on operations.

There are also a number of 'new' nations to the industry that are looking to establish sufficient infrastructure to design and develop an indigenous unmanned capacity, rather than relying on off-the-shelf purchases from foreign firms.

To this end, in this issue we take a look at the developing Indian market and investigate the recent comings and goings after manufacturers were tasked by the government to find, renew and improve domestic solutions for unmanned military needs (see p43).

This effort is very much a ground-up plan of action, complemented by some overseas procurements, and differing from other national unmanned programmes that have simply been purchased – intellectual property and all – and marketed as a national capability.

Richard Thomas, Editor

RESPONSE

Unmanned Vehicles' editorial team is always happy to receive comments on its articles and to hear readers' views on the issues raised in the magazine. Contact details can be found on p1.

IN THE NEXT ISSUE

- Small UAS
- Data links
- Training
- Radar payloads

Aussie Herons fly in civil airspace

The Royal Australian Air Force (RAAF) flew a pair of IAI Heron UAVs in civil airspace from a commercial airport for the first time during Exercise *Talisman Sabre 2015*.

The aircraft operated from Rockhampton Airport throughout the course of the bilateral exercise.

Wg Cdr Matthew Bowers, commanding officer of No 5 Flight, told *Unmanned Vehicles*: 'It's the first time for us to operate a military UAV from a civilian airport in civilian airspace.'

He explained that the platforms were treated as just another aircraft by civil ATC. The RAAF had previously signed an MoU with Airservices Australia detailing responsibilities and integration for such UAV flights in civil airspace.

The Herons, operated under a three-year contract signed with MacDonald, Dettwiler & Associates (MDA) in October 2014 – and which offers three one-year extensions – successfully flew over unpopulated areas in low/medium-density airspace as part of their first expeditionary deployment. The aircraft served both red and blue forces during the exercise, with missions


Photo: author

typically lasting ten hours while cruising at an altitude of 13,000ft.

'The army loves the capability,' stated Bowers. 'Ground services can't get enough ISR.'

He enthused over the aircraft's capabilities during *Talisman Sabre*: 'Its performance has been outstanding, and controls are in place to ensure safe operations… It's gone off really well.'

The Herons, which have an endurance of 24 hours, carry an IAI MOSP payload with EO/IR cameras, plus an EW package. The platform includes a laser pointer, but this has been deactivated for domestic flights. Bowers said the RAAF would like to add a laser designator, and possibly a radio relay in the future.

MDA provides 'power-by-the-hour' services under a contract designating 1,000 flight hours annually for an initial three years. No 5 Flight comprises about 20 personnel, including five air vehicle operators.

The RAAF has established its own organic Heron conversion course for pilots, with the first iteration having taken place from March to May this year.

The aircraft is seen as an interim capability for the RAAF, allowing the force to retain and expand experience.

Bowers commented: 'The intention is to expand operations outside civil restricted airspace and military aerodromes in preparation for future capabilities.'

Australia will field up to seven Northrop Grumman MQ-4C Tritons beginning in 2021, with the HALE platform intended to operate alongside Boeing P-8 maritime patrol aircraft.

Bowers predicted that the RAAF would eventually acquire a platform such as the General Atomics MQ-9 Reaper.

By Gordon Arthur, Hong Kong

UAV options limited for RN's new carrier

UK Defence chiefs have been tasked by Prime Minister David Cameron to explore ways to project UAVs to counter terrorism, but the lack of a catapult on the Royal Navy's new aircraft carrier will limit embarked unmanned operations.

In a statement released on 13 July –just days after the government pledged to continue to meet the NATO baseline defence spending target of 2% of GDP – Cameron called on officials to invest more in counter-terror capabilities and prioritise resources to protect the UK from evolving threats.

It states: 'The Prime Minister is keen for the defence review to explore how best to work with partners like the US to ensure these ships… will be able to project drones, special forces and strike capabilities [to combat terrorist threats].'

Justin Bronk, research analyst at RUSI, said platforms such as the ScanEagle, already in service with the RN, could operate from the new carrier HMS *Queen Elizabeth*, but the aircraft would be limited to improving situation awareness given that it had 'no kinetic capability'.

He added: 'The US Navy is heading down the strike route, deep penetration, stealth and ISR with the X-47B, and anything like that needs a catapult to get airborne. With Reaper, the wings are too big [to operate from carriers] and it is not structurally marinised. The Fire Scout is probably too expensive and the rotary side of things is already heavily funded with marinising the Apaches and the Merlin programme.'

Douglas Barrie, senior fellow for military aerospace at the IISS, said the UK would have to determine what operational emphasis carrier-borne unmanned vehicles should have.

'It depends on the timescales, there always was an interest from the naval side on operations from the carrier. My impression is that [what is being proposed] is ISR, which is understandable. The ScanEagle fits elements of that requirement, but ideally you need persistence, time on station and radar payload.'

By Richard Thomas, London

NATO CMRE goes passive

NATO's Centre for Maritime Research and Experimentation (CMRE) concluded its participation in trials of two UUVs for passive maritime surveillance in June.

The trial, named Project Perseus, was conducted during 2014 and 2015 in collaboration with Spanish technology company Indra and saw use of a UUV glider and a joint surface/sub-surface unmanned platform as surveillance vehicles.

CMRE scientists and engineers worked to design, develop and demonstrate at-sea concepts of continuous, real-time passive underwater acoustic systems for maritime surveillance. Future plans could see the addition of enhanced monitoring and classification capabilities.

A spokesperson said surveillance demonstrations were made with both the Slocum Glider in 2014 and the Liquid Robotics WaveGlider in 2015.

'For applications requiring a high level of covertness, the underwater glider may be the best choice,' the spokesperson said. 'If on the other hand extreme energy persistence is the criterion, the WaveGlider may be the preferred solution.

'From the technology perspective, we intend to go forward towards an integrated – surface and sub-surface – multi-sensor monitoring capability, with data fusion and multiple classification features.'

The CMRE said the trial saw the use of integrated payloads fitted to the two AUVs to detect and classify fast boats and other maritime threats.

The passive sonar surveillance systems proved effective due to their real-time continuous monitoring capability and the availability of functionalities such as detection, location-finding and vessel classification, the spokesperson stated.

The CMRE added that the technology would help detect anomalous behaviour in marine traffic and in future could be operated within a network to continuously monitor maritime areas of interest.

By Richard Thomas, London

Mexico introduces UAV tech

Photo: DroneTech UAV

Mexico-based company Drone Tech UAV is set to complete the test flight programme of its new aircraft, the AV-1 Albatross, it was announced at the Paris Air Show in June.

While the company was unable to bring the UAV to the exhibition, a video was displayed of the AV-1 conducting flight tests. Once these are completed, Drone Tech UAV will begin a test campaign on its second model in development, the AV-2 Pelican.

'Flight tests on the AV-2 will follow final development on the vertical take-off and landing capability,' explained Arturo Galvan, manager at the company.

While the UAVs are both fixed-wing and run on gasoline engines, they are capable of VTOL via electric motors.

According to Galvan, DroneTech is currently working on the final stages of the VTOL technology for the AV-2 and planned to begin flight tests in July.

The AV-1 Albatross is the larger of the two aircraft, with a wingspan of 5.5m and endurance of up to 60 hours, while the AV-2 Pelican has a wingspan of 3.5m.

'While there is a market for this kind of capability in Mexico, it is a very small market – that's why we have opened an office in the USA.'

The company's US office is in San Antonio, Texas, although Galvan noted that all of the development and technology behind the aircraft came from the company's Mexican site.

'In terms of customers, we have had interest from people within the US, Mexico and Italy,' he added.

By Beth Maundrill, Paris

On the web

Lockheed deploys UTM components
5 August 2015

USMC orders 75 SUGV robots
4 August 2015

Lockheed eyes UAS for JAGM
4 August 2015

China restricts UAV tech exports
4 August 2015

Insitu to build Blackjacks for US forces
3 August 2015

Ferra bags Triton UAS supplier contract
31 July 2015

Transtrex releases UAS restriction system
29 July 2015

Skystar's the limit
24 July 2015

USS *North Dakota* deploys UUVs
23 July 2015

Visit
www.UVonline.com
for the full stories and latest news

Further progress for UK Watchkeeper

The UK's Watchkeeper tactical UAS could operate from austere airstrips by 2017, it has emerged.

During a media briefing at the Thales facility at Gennevilliers on 2 June, Lt Col Craig Palmer, British Army Watchkeeper programme manager, said: 'The next milestone will be reaching full operational capability by 2017, including de-icing and [taking off from] austere airstrips. Developments in a few years could include sensors, data links and bigger engines.'

The army is continuing its development programme, while advancing efforts to integrate the platform into civil airspace and carry out operator training.

Palmer said development had continued following the UK withdrawal from Afghanistan, with some 400 flying hours accrued since operations had concluded. At present, two full systems are in use.

'Post-Afghanistan, the first student will be trained by UK instructors in October 2015,' he added. 'We are building our confidence and now doing army training in the UK.'

Flights are being conducted in civil and restricted military airspace around Salisbury at altitudes of up to 11,000ft.

A total of 54 Watchkeepers had been ordered by the British Army, which aims to operate a total of 13 packages, including trained personnel and support. Pierrick Lerey, strategy and marketing director for UAS and ISR at Thales, said the proposed French Watchkeeper programme would see around 35% of the system built and sourced in France. The UAS itself would be constructed in the UK.

'Watchkeeper is now a modular project and we have strong prospects in the EU and Middle East. The UK programme is funded up to 2042 and we plan to launch a "customer club", where stocks, training and feedback can be shared,' he said.

The platform is a development of Elbit Systems' Hermes 450.

By Richard Thomas, Gennevilliers

Heads turned by UGV concept

Turning heads among the vast range of vehicles on display at the Paris Air Show in June was a concept vehicle developed by loitering munitions manufacturer UVision that married its HERO range to a UGV.

The aim was to demonstrate that it was possible to have the vehicle optionally manned or unmanned, with a single operator controlling both the UGV – on this occasion a modified Tomcar platform – and loitering munition, according to president and CEO Yair Dubester.

'The [UGL-H30] is a concept to show that you can deploy loitering munitions on unmanned ground vehicles, which are becoming more popular, or ships and aircraft.'

With a history of developing unmanned platforms, Dubester said that the UAV market was becoming 'saturated', and saw the opportunity to start the development path to create the HERO family.

'The UAV market is going in two directions – towards larger UCAVs and then the small commercial systems. The main business used to be tactical UAVs, but there are so many companies looking to create their own systems.'

UVision used Le Bourget to display its full six-system line-up of HERO loitering munitions. The multi-operational beyond-line-of-sight systems are capable of carrying out pinpoint strikes and are vehicle or man-portable.

'War has changed – it is now urban, asymmetric and the answer is loitering munitions at very low cost,' Dubester added. 'We worked for four years to develop this family.

'Really these munitions are missiles. You can tell this when it moves, as a missile skids to turn, while an aircraft banks. It is very hard to take a missile and make it fly like an aircraft, which is why we added the fins.'

The smallest of the range weighs 3kg, making it man-portable, and has an endurance of 30 minutes. The system allow targets to be predetermined using GPS, or visually selected when one presents itself. In cases where the attack has to be aborted, the munition can be recalled and another target selected.

The HERO range is also capable of high-speed transit flight and low-speed loitering, depending on the tactical needs of the mission.

By Richard Thomas, Paris

US Army to acquire TSP sensors

Up to 69 Tactical Signals Intelligence Payload (TSP) sensors, manufactured by BAE Systems, could be delivered to the US Army for use in the service's unmanned programmes.

In May, the company was awarded a contract to deliver 12 TSP sensors for the MQ-1C Gray Eagle UAS, with a further 18 recently requested, according to officials at the US Army's Program Executive Office for Intelligence, Electronic Warfare and Sensors.

The total number acquired under low-rate initial production (LRIP) is now 30 TSP units.

Lt Col Xaviera-Chevonne Williams, product manager sensors – unmanned and rotary-wing, confirmed that the procurement of further systems was planned.

'Our army procurement objective quantity is 69. We are on contract to procure 30 TSP systems under LRIP, and the programme plans to procure 39 more when approved for full-rate production,' she said.

Williams added that no alternative sensors were being considered for the MQ-1C programme.

The $70 million indefinite-delivery, indefinite-quantity contract awarded to BAE Systems also covers engineering support services for the army and US Special Operations Command.

The TSP is capable of capturing a 360° aerial field of view, and can detect, identify and geo-locate electronic emitters for operators on the ground to investigate. The system is adaptable to other manned and unmanned aerial platforms.

By Richard Thomas, London

Sense and avoid comes of age

Photo: NASA/GA-ASI

Development is continuing on Honeywell Aerospace's sense-and-avoid (SAA) system, with officials saying the final product would 'probably be another two years away'.

Work began in 2011 as the company looked to get a head start on its rivals, according to business development manager Howie Wiebold, with industry anticipating a US FAA decision on integrating unmanned systems into the national airspace.

The FAA has since begun work on the Airborne Collision Avoidance System for Unmanned Aircraft (ACAS Xu) to determine how best to achieve UAS separation.

'We are leveraging internal product availability and doing as much as we can with the internal capability that we have. This is a continuation of work we have been doing for the aerospace industry as a whole, and focused on safely operating in US airspace,' Wiebold told *Unmanned Vehicles*.

'It is probably going to be another two years away, but we believe it is going to be a discrimination for the UAV and a requirement in future.

'We're aiming to be sensor-agnostic – it could consist of a kind of package with a separate LRU, or a separate card in the motherboard, but the end state is to get a certifiable product.'

PROOF OF CONCEPT

In January this year Honeywell, NASA, the FAA and General Atomics announced that they had successfully demonstrated a proof-of-concept SAA system, following flight tests in November and December 2014.

These evaluated the system, including a sensor fusion algorithm developed by Honeywell, on collision avoidance and self-separation using an adapted Predator B UAV and a variety of other manned and remotely piloted aircraft.

A NASA release at the time stated that objectives of the programme included evaluation of the performance of ACAS Xu algorithms using Traffic Collision Avoidance System (TCAS II) and Automatic Dependent Surveillance – Broadcast (ADS-B) messages.

Wiebold said that most of Honeywell's SAA system was being developed in-house, calling it a 'natural evolution' of legacy work done by the company.

'We are looking at all the different sensors such as ADS-B and TCAS and also the non-cooperative – those that aren't broadcasting,' he explained.

Current plans would see the system applied to Group 3 UAVs, although Wiebold conceded that there could be scope for future development and application to Group 1 and 2 platforms.

A European consortium working as part of a European Defence Agency initiative recently also conducted flight tests of the Mid-air Collision Avoidance System aimed at the integration of UAVs into civil airspace.

By Richard Thomas, London

MULTI-MISSION POWER

EXTENDING HUMAN CAPABILITIES IN THE WORLD'S TOUGHEST ENVIRONMENTS

Textron Systems' platforms are renowned for their multi-mission capability, reliability and performance. They operate EO/IR, communications relay and intelligence payloads within a single sortie. The Shadow® M2 Tactical UAS offers dual-payload and SATCOM options and, along with our Shadow RQ-7B Version 2, can carry our Fury™ lightweight precision weapon to execute the complete find-fix-finish chain. Our Aerosonde™ Small UAS offers both land and maritime multi-mission capabilities within a single, highly expeditionary platform. In the toughest environments and most critical applications, Textron Systems' proven platforms deliver a decisive advantage.

textronsystems.com/unmannedsystems

TEXTRON Systems

INGENUITY ACCELERATED

The variety of payloads that can be incorporated onto a UGV is steadily increasing as the technology sees a wider range of applications across both the commercial and military markets. **Grant Turnbull** looks at some of the main growth areas.

Attachment theories

UGVs come in all shapes and sizes, from large tank-like vehicles to small machines light enough to be carried in a rucksack. Missions are varied, not just because of the different ranges achieved, but the increasing payload options available on the market. New sensors and systems are being developed at a rapid rate for different platforms and mission sets.

The Nerva LG can be fitted with a range of payloads, with a 2D and 3D mapping capability currently in development. *(Photo: Nexter Robotics)*

According to industry opinion, the most prominent activity for UGVs in both civil and military roles remains EOD/bomb disposal. Although their use for EOD predates the wars in Iraq and Afghanistan, they came into their own during both conflicts as US and other coalition forces tackled the IED threat.

The US Army, for example, ordered thousands of robots equipped with cameras and manipulator arms that could locate and disable IEDs in an attempt to keep troops out of harm's way.

In total, the service spent more than $730 million beefing up its UGV fleet. During the height of the Afghan campaign, one of the main suppliers of EOD platforms to the US Army was iRobot. In 2009, the company received its biggest ever order from a military customer when the Pentagon ordered 486 PackBot 510 robots – an 11kg tracked UGV that can travel at up to 9.3km/h – in a deal worth $35.3 million.

NUMBER SURGE

The US also ordered hundreds of Small Unmanned Ground Vehicle (SUGV) 310 robots, a smaller and lighter variant of the PackBot 510 capable of incorporating a number of payloads.

'We experienced a huge increase in usage of UGVs, by both British and US EOD teams, largely focused on the IED threat in Iraq and Afghanistan,' explained Orin Hoffman, technical director, defence and security, at iRobot. 'As part of that, there was a request that started emerging from the field to expand the capabilities of the robot from basic tracked vehicles with cameras and manipulators to be able to do different jobs in support of the EOD mission.

'There was a need in the field to pull wires from the ground and do some digging, so we fielded a kit where the robot would be able to hold a tool-changing device in its gripper and a variety of mechanical tools, including scrapers, shovels and probing sticks.'

The PackBot has eight payload bays, allowing the integration of several systems, including a three-link manipulator arm equipped with a x312 zoom camera, while the gripper has a lifting capacity of 4.5kg across the full range of motion and 13.6kg with the arm in a compact position. There is also an option for a two-link small arm manipulator that can lift 2.26kg through the full range of motion and 6.8kg in a compact position.

SCOUTING AHEAD

Alongside IED detection, there is also increased interest in smaller robots for battlefield reconnaissance. The demands on soldiers during the wars in Iraq and Afghanistan spurred the US Army to buy hundreds of 'throwable' robots equipped with IR optics to see in unlit rooms or tunnel networks.

One of these tiny robots ordered by the Pentagon was the two-wheeled ReconRobotics Recon Scout. The Recon Scout is 14.2cm long, 19.3cm wide and weighs just over 0.5kg. Its IR camera is integrated into the body and, with an optional extendable 'SearchStick', it can be used to look over walls or other tall objects.

It is possible to integrate a mast-mounted sensor on small UGVs, thanks to technology such as the ZipperMast. The mast was developed with the US Army under a small business innovative research (SBIR) contract and can extend up to 2.4m, but may still be integrated onto small UGVs such as PackBot. This is achieved by using three stainless steel bands coiled and placed 120° apart. As the bands unroll they mesh together to form a rigid triangular structure that is strong enough to support a payload of around 4.5kg.

For French manufacturer Nexter Robotics, observation and reconnaissance payloads form the main requirements in the defence sector. The company currently manufactures the Nerva LG system, which has been sold to the French and Dutch militaries. A spokesman told *Unmanned Vehicles* that there are around 20 different payload options for the robot.

For ISR roles, the Nerva LG can be integrated with a 640x480px IR camera and processing unit for automatic intruder alert capabilities. Long-range reconnaissance can also be carried out with the aid of a small pan-tilt-zoom turret. The turret is capable of x36 zoom and can rotate 360° and tilt from 0-90°. The company is also developing 2D and 3D mapping capabilities for its ground robots.

ON THE RADAR

Other manufacturers are experimenting with advanced payloads such as ground-penetrating radar (GPR) for detecting IEDs.

Cobham Antenna Systems has developed a UGV-mounted GPR payload called Amulet, based on its Minehound handheld detector, that it hopes will revolutionise how armies and NGOs across the world tackle the IED and explosive remnants of war threat.

The Amulet system is platform-agnostic and comprises a four-channel QuadPack GPR, an HD camera, a control box and an operator control unit. It is also modular and scalable, so depending on the size of the UGV, multiple QuadPacks can be fitted to increase the platform's swath width.

'You could fit the sensor to any manufacturer's robot and clear a safe path through a compound or a minefield, perhaps to retrieve a fallen comrade,' said Paul Curtis, head of land at UK-based Cobham Antenna Systems.

'One of the objectives that NATO was pushing [in Afghanistan] was to be remote wherever possible, so the logic of putting a detection capability like GPR on a UGV or robot seemed quite obvious – it would remove the soldier from harm's way.'

Curtis told *UV* that the GPR has a 50cm detection swathe and can detect metallic, minimum-metal and non-metallic targets, including mines and IEDs, to a 'tactical depth'. The sensor can be integrated with existing EOD robots to enhance an operator's situation awareness and detection capabilities. Crucially, the payload's low SWaP requirements mean the operator does not have to remove the manipulator arm.

'The ability to do anything remotely depends on the EOD operator having access to the manipulator arm,' he continued. 'If the EOD operator finds a threat and needs to take action, such as pulling soil away, the manipulator arm is the best way to do this. Therefore, when integrating onto an EOD robot, the GPR ➤

shouldn't prevent the EOD operator from having access to the manipulator arm.'

WORKING TOGETHER

With the rapid development of autonomous technologies, the not-too-distant future could see a GPR-equipped robot intelligently scanning and mapping large areas such as minefields. Curtis said multiple systems could cooperate and sensor data might be fused together from other platforms such as UAVs, noting that 'autonomy is a multiplier effect for technologies such as remote search'.

Amulet is still in its early development phase and, as Curtis admits, might be a technological leap too far for the current acquisition and user community, as the remote search concept requires the use of layered high-technology systems. This could change as communities become more comfortable with the remote search capability offered by Amulet.

Google's experimentation with self-driving cars has catapulted autonomous technologies into the mainstream consciousness, and UGVs for security and defence applications are following a similar trajectory. Many systems today are now equipped with a rudimentary autonomous feature known as 'retro-traverse', which means that if radio communications are lost with an operator, it will retrace its last movements until it reconnects to a signal.

The US Army has experimented with larger UGVs featuring semi-autonomous functions, such as Lockheed Martin's Squad Mission Support System (SMSS). This has several modes of operation: follow-me; GPS waypoint navigation; retro-traverse; go-to-point; come-to-me; NLOS remote control/tele-operation; and LOS manual drive. With a payload capacity of 682kg, the SMSS can be outfitted with an array of payloads, including a Gyrocam surveillance system or a roller/rake system for counter-IED missions.

PERSISTENT PERCEPTION

French UGV manufacturer ECA Robotics is also pushing innovation in the field of autonomy.

'The market is mainly focused on EOD, but now we are thinking – and everybody is thinking – about new capabilities on UGVs such as autonomous navigation,' said Patrick Peras, director of the UGV/UAV division at ECA. 'For autonomous navigation, you have to have a good perception of the environment, so you need new payloads such as LIDAR sensors and stereoscopic cameras.

iRobot's 510 PackBot is seeing its role expand to include CBRN missions. *(Photo: iRobot)*

'We integrate [LIDAR] now not only for UGVs, but UAVs. 3D LIDAR is a very accurate system and used to be very expensive, but now the price has come down. We integrate a small LIDAR on a robot and it's perfect for 3D reconstruction and improving the perception and navigation of the robot and to give information about the topology of the area for your operators. People are very interested.'

Peras explained to *UV* that autonomy-enabling payloads would mean a robot could drive to an area of interest in autonomous mode and once it arrives, an operator could take direct control in order to carry out a mission. But, once again, there are barriers to the introduction of self-driving robots, particularly in the French military.

'The main problem is the people, some of the French Army, they don't have any concept of autonomous navigation for UGVs,' he added. 'The military like to have control of their UGVs.'

Currently, ECA Robotics has a range of remotely operated UGVs on the market, including the lightweight Cameleon and a mini-UGV known as the Cobra. For ISR, the latter can be integrated with a x40 zoom colour camera that pans 360° and tilts -55/+90°. Both platforms can be configured for EOD operations (designated the 'E' model) or for CBRN missions ('C' model).

The Cameleon E weighs 46kg and can be equipped with various sensors, manipulators and accessories for EOD missions, such as manipulator arms, water disruptors, X-ray sensors, cameras (day and thermal), a microphone and a fibre-optic link in case of radio jamming.

The company's Cobra Mk 2 E weighs 13kg with payload, and is designed to be quickly deployed in both military and civil environments. In EOD configuration, it is equipped with a mission module consisting of a disruptor payload and an integrated camera.

The Cobra Mk 2 C variant incorporates a 4kg chemical and radiological sensor module that can send real-time data to a 7in ruggedised display device. Once the UGV is configured, it is able to search, characterise and identify dangerous materials, enabling a soldier or ➤


INSITU
It’s Hard to Make the Right Moves When You’re in the Dark
Stay ready. Be resilient. Insitu provides the information advantage for superior decision-making. Our growing portfolio of products and services supports the most sophisticated methods of information collection and processing available, to deliver industry-leading situational awareness and multi-intelligence mission results. In the air, on the ground or subsurface, you will be ready, resilient and capable at every level in every environment.
UNMANNED SYSTEMS
ICOMC2 COMMAND & CONTROL
MEDIA MANAGEMENT SOFTWARE
SERVICES & SUPPORT
www.insitu.com

Cobham's Amulet GPR can help clear a path across dangerous ground. *(Photo: Cobham)*

law enforcement official to take action from a safe distance and determine the best way to handle or possibly neutralise the substance or material.

BUILDING RESISTANCES

iRobot is also seeing a growing trend towards UGVs being equipped with payloads that allow the platform to tackle wider mission sets such as CBRN.

'Historically, our robots have mostly been used by EOD folks – now other parts of the military as well as those outside the military have seen the value of robotics,' Hoffman told *UV*. 'We are now seeing an increasing trend where different and non-traditional robot users are asking to use robotics, but in order to perform their specific missions they need the robots to have certain capabilities that they don't natively have, and we do that by adding payload-based capabilities.'

Hoffman cites the example of iRobot's recent contract award from the Canadian DND for 20 510 PackBots configured for CBRN missions. The company took a base robot system and outfitted it with six different sensors which had already been in use as handheld devices. Using the platform's digital architecture and proprietary software, the OEM was able to incorporate those sensors so they would remain handheld when needed, but could also be attached to the robot for greater stand-off distances if required.

iRobot has even sent its systems into parts of the stricken Fukushima nuclear power plant in Japan, where dangerously high temperatures and levels of radiation have restricted access. The company used its PackBot and the bigger Warrior UGV equipped with a variety of payloads and sensors at Fukushima. The robots could capture video and other data such as oxygen, temperature and radiation levels and then send that information back through fibre-optic cables.

CBRN FOCUS

'Right now, we are seeing a significant interest in CBRN,' explained Hoffman. 'A chemical response team is in a very similar situation to an EOD team – they want a stand-off distance from whatever CBRN event is going on. We have a system that has both the sensors that allow them to do detection from a safe distance and also a dextrous manipulator so teams can actually do some amount of activity downrange with the robot.'

Another company that provided robots to assist with efforts at Fukushima was QinetiQ North America (QNA). Equipment sent to Japan included the company's Talon, a mid-size tracked UGV with a payload potential of around 70kg, and the Dragon Runner micro-UGV. The former can be integrated with a number of sensors specifically for the CBRN mission, including chemical detectors that sample the air for traces of nerve, blister, blood and choking agents.

Like PackBot, Talon was extensively used by the US Army in Iraq and Afghanistan and, according to QNA, has performed approximately 300,000 combat missions. In October 2014, the company unveiled the Talon V robot, the latest addition to the family. The system can incorporate around 70kg of payloads, including a heavy-lift manipulator arm and HD pan-tilt-zoom cameras for day and night operations.

Nexter Robotics' Nerva LG can also integrate radiological sensors, such as the Smart Gamma Probe from Innovation & Measurement Systems or the AP4C chemical sensor from Proengin. According to the former company, some customers also use the robot's generic video interface to install their own sensors, with a micro-camera watching the display. The video images are then displayed in real time as a 'picture in picture' on the operator control unit.

EASE OF INTEGRATION

Developing software and hardware standards that ease the integration of different payloads and sensors is one of the current challenges in robotics.

'At the moment, we rely on "low-level" physical standards, meaning we can interface any sensor/effector which can be operated using USB, Ethernet, CCIR/NTSC videos, RS232 serial link or digital input/output,' noted Peras. 'We developed our own architecture to achieve our own goal, and it now takes less than a few days to integrate and qualify any new equipment in our range of robotic products.

'But the robotics field has to develop and impose higher-level standards at the protocol and capability level. Some tools have been proposed to explore that way, but at the moment none has emerged as the standard for military robotics systems.'

Peras also noted that integrating external sensors and payloads can sometimes be a challenge.

'To integrate a new sensor we have to refine the mechanical structure to receive the sensor and develop the protocol between the sensor and the platform. It's not easy because sometimes the company that manufactures the chemical sensors, for example, does not want to give us the protocol to communicate with their sensor.'

As a result, ECA performs a 'light integration', where a camera is used to display the sensor's display.

The US Army is attempting to overcome these integration challenges by introducing an open standard for robotics development called the Interoperability Profile (IOP). It is hoped this will not only increase interoperability among US UGVs, but also NATO and other allies' robots.

Over a decade's worth of buying thousands of COTS UGVs has led to a 'sustainment burden' because each platform,

such as Talon or PackBot, lacks hardware or software commonality. Sensors and payloads are also quickly becoming obsolete and need replacing.

QNA says its latest Talon V is the first IOP-compliant robot in its class and is also Joint Architecture for Unmanned Systems (JAUS) AS4-compliant.

NEXT GENERATION

The army's strategy will see Talons receive upgraded sensors and payload capacity until a new robot known as the Man Transportable Robotics System (MTRS) comes online in the early 2020s. The hope is that with an open architecture and a thought-out procurement process, MTRS will utilise a common chassis and 'plug-and-play' functionality so it will be easy to swap cameras, sensors, arms or other components as they become obsolete.

At this year's Ground Robotics Capabilities Conference and Exhibition, Scott Davis, PEO for Combat Support and Combat Service Support, said the army would look to enhance software and hardware on existing systems/chassis, upgrade outdated sensors and payloads and increase modularity and standardisation.

'We have invested in making our robots JAUS-compatible,' explained Hoffman. 'We are also working with the government on their IOP standard – that will enable iRobot platforms to be interoperable with new sensors or payload capabilities as they are developed, not just by iRobot but by the government and other parts of the industry. We committed to investing in IOP as a standard to help our government customer make all robots more modular moving forward.'

As more organisations discover the benefits of using UGVs for new missions, the number of payload options available will almost certainly increase. And while the past ten years has seen the procurement of UGVs being driven predominantly by the needs of EOD units, that will slowly change as different organisations, military and civil, discover the capabilities unlocked by using an unmanned system with specialist payload options.

For those with an established UGV fleet, such as the US Army, developing open architectures and increasing interoperability to support payload integration across a large and diversified fleet of platforms will be the next big challenge. uv

RAPSODY

TEKEVER Unmanned System selected for pioneering maritime surveillance

The new unmanned aerial system AR5 Life Ray, developed by the TEKEVER Group, was selected by the European Space Agency (ESA) and the European Maritime Safety Agency (EMSA) to create the first drone-based European maritime surveillance system.

RAPSODY, a project led by TEKEVER, will test the use of unmanned aerial systems in a maritime context through real-world demonstration of two scenarios: search and rescue missions; and pollution and oil spill monitoring. The systems will operate over the Atlantic Ocean, the North Sea and the Mediterranean Sea. This is the first time unmanned aerial systems will be introduced into maritime surveillance missions in Europe.

This is a significant two year long project. The first year will be dedicated to the integration of the various sensors that will board the aircraft, developing on-board sensor algorithms to improve operational performance, as well as optimizing data transmission according to the type of missions that the system will carry out. In the second year of the project, there will be tests and demonstrations that will put the system in real scenarios and prepare it for a fully commercial use.

"The AR5 Life Ray Evolution is one of our larger platforms. With a wingspan of 4.3 meters and a payload of 50 kg, the AR5 is capable of performing 8 to 12 hours missions and has the most suitable design for the RAPSODY project. With the use of satellite communications, our system is geared to perform multiple types of long-range missions, including search and rescue, surveillance and maritime patrol and pollution detection, among others", explains Ricardo Mendes, COO of TEKEVER. "The AR5 is a clear advance in our systems, providing an excellent way to complement maritime surveillance operations, with a lower cost and greater flexibility than manned systems, as well as responding to the huge challenges posed by the European maritime space".

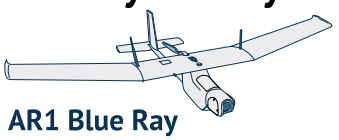
The RAPSODY project is the result of a consortium lead by TEKEVER, which is responsible for providing and adapting the AR5 Life Ray system. There are many advantages in using unmanned systems for maritime surveillance. For example, a reduction of risks associated with the missions, performance which goes beyond that of human endurance, as well as less complexity and a lower cost when compared to manned systems.

AR5 Life Ray Evolution

The AR5 Life Ray Evolution is an unmanned aerial system designed for mid and long-range maritime surveillance missions.

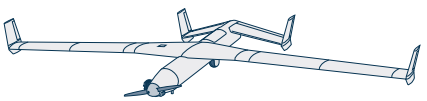
Capable of carrying 50kg in 8 to 12 hour missions, the AR5 provides multiple payload bays and hard points, specifically designed to support a wide range of payloads including, among others, high-definition and infrared cameras, synthetic aperture radars, LIDAR and AIS.

Air Ray Family



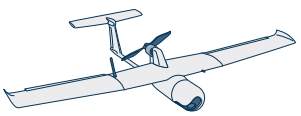
AR1 Blue Ray

AR1 is a fixed-wing UAS, designed for security forces, that delivers advanced information, security, surveillance, monitoring and reconnaissance capabilities in the most challenging urban and rural conditions. AR1 has an endurance of up to 2 hours and a mission radius of 20Km.



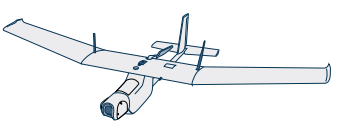
AR3 Net Ray

AR3 is a UAS designed to support multiple mid range missions, including Intelligence, Surveillance, Target Acquisition and Reconnaissance . The AR3 has an endurance of up to 10h, and offers an operational range of 120 Km.



AR4 Light Ray Compact

AR4 Light Ray Compact is designed for Intelligence, Surveillance, Target Acquisition and Reconnaissance missions. With an MTOW of 1,5Kg, the AR4 can fly up to 45 minutes at a cruising speed of 57 km/h and has a mission radius of 5 km.



AR4 Light Ray Evolution

The AR4 Light Ray Evolution is the ideal system for Intelligence, Surveillance, Target Acquisition and Reconnaissance missions, flies up to 2 hours at a cruising speed up to 57 km/h and offers an operational range of 20 km.

info@tekever.com - +351 213 304 300

The Desert Hawk 4 is an evolution of previous variants used by British forces operating in Afghanistan. *(Photo: Lockheed Martin)*

Once the dust settles

Despite completion of a number of tactical UAV procurements following the drawdown in Afghanistan, the class remains a valuable asset for militaries around the globe preparing for the next era of operations, discovers **Andrew White**.

The relentless operational tempo stretching back to the initial invasion of northern Afghanistan in 2001 by US and coalition forces has resulted in an impressive evolution in the design, development and utility of tactical UAVs (TUAVs) over recent years.

In October 2001, special operations forces (SOF) deployed to the north of the country to support Northern Alliance fighters against the Taliban, which had taken control after five years of civil war. At first, SOF teams were supported by tactical MALE USAF platforms such as the MQ-1, while providing their own organic over-the-hill ISR capability with smaller, hand-launched systems.

Subsequent operations in Iraq and Afghanistan in the following years lead to an increasing demand for data generated by a raft of stacked, layered TUAVs providing full-motion video, EO/IR, synthetic aperture radar (SAR) and ground moving target indicator (GMTI) payloads to support dismounted forces in direct action, ISR and military assistance.

EVOLVING ENVIRONMENT

Even with the mass drawdown of troops from the Afghan and Iraqi theatres now complete, the operational environment continues to evolve at a rapid pace, with a reinvigorated Russian threat now flexing its muscles on Europe and NATO's eastern border and the threat of Islamic State, which continues to gain ground in the Middle East and has an eye cast on the northern half of the African continent.

However, as one source from Lockheed Martin described to *Unmanned Vehicles*, lessons learned from the Afghanistan and Iraq conflicts have provided critical information in the employment of TUAVs, with militaries now considering how best to design and deploy such systems in the future.

Indeed, these lessons learned have provided information in a number of key areas, including: operation in hot-and-high as well as cold-weather environments; transportability and logistics; modularity; reliability, configurability and adaptability to meet dynamic mission needs; rapid employment and recovery; security and autonomy; and system signature.

In line with current US Army doctrine, this article will focus on the future development ➤

GA-ASI continues to upgrade the MQ-9 Reaper for future operations. *(Photo: USAF)*

and utility of Tier II (short-range) and Tier III (medium-range) UAS which have supported and continue to support NATO and other armed forces worldwide as the technology continues to proliferate.

TACTICAL INCREASE

Of concern to NATO will be Russia's identification of the TUAV as an area for significant growth, with a strategy currently being implemented to buy hundreds of systems by 2025. Defence sources informed *UV* how the country was seeking to fill capability gaps in Tier II UAVs specifically.

Government-backed companies, including Vega Radio Engineering Corporation and Russian Technologies State Corporation (ROSTEC), are in the process of developing composite airframes, more powerful propulsion systems, signature reduction, counter-jamming data link technology and autonomous navigation subsystems as part of this drive, which is understood to fall under the Russian government's $490 billion armaments programme, due to start in 2016.

In 2014, the Russian MoD announced that it had 50 varieties of UAV in service or development, with further plans to invest nearly $13 billion in this field within the next five years.

Of similar concern to NATO and smaller nation states in the Asia-Pacific region will be suggestions that China's People's Liberation Army is planning to field 'tens of thousands' of UAVs by 2023. These figures were reinforced by a US DoD paper on the Chinese military published earlier this year. It also confirmed that precision-guided munitions were being developed for a variety of UAVs, with an example being CASC's Fei Teng weapon.

ENDURING REQUIREMENTS

One of the most critical requirements to be identified in the aftermath of the campaigns in Iraq and Afghanistan has been the endurance capacity of TUAVs.

General Atomics Aeronautical Systems (GA-ASI), manufacturer of the MQ-1 Predator and MQ-9 Reaper, launched an internal R&D programme to extend the range and endurance of its Gray Eagle design for the US Army following lessons learned in Afghanistan.

'We were successful in developing an aircraft that doubles the endurance and range, increases the internal payload capacity by 50% and provides ease of access to internal payloads for ease of maintenance. The army is considering this aircraft, Improved Gray Eagle [IGE], as an option for future acquisition,' Chris MacFarland, manager of strategic development at GA-ASI, explained to *UV*.

The Pentagon is currently reviewing future requirements for Gray Eagle, and may increase allocations for the US Army's military intelligence battalions (aerial exploitation) from six to 12 airframes each.

'Providing the ability [for TUAVs] to "get there" from long distances away, while still able to "stay there" for extended periods of time offers commanders increased flexibility and survivability, while reducing detectability,' continued MacFarland. 'If the decision is made to purchase IGE, the capability and utility of the army's UAS inventory will be significantly enhanced.'

IGE completed its first flight in 2013, extending endurance by an additional 23 hours compared to its Block I predecessor to 45 hours thanks to the integration of an external 227kg fuel tank and improved Lycoming DEL-120 heavy-fuel engine.

WEIGHT TRADE-OFFS

Further concerns about the endurance of TUAVs in the future operational environment were echoed at the AUVSI exhibition in Atlanta in May, when Lt Col Tory Burgess, US Army product manager for tactical UAS, expressed concerns regarding the upgraded UEL AR741-1102 engine of the RQ-7B V2 Shadow.

Speaking to *UV*, Henry Finneral, VP for tactical UAS at Textron Systems Unmanned Systems, said: 'We are currently upgrading 117 Shadow systems to the RQ-7B Version 2, or V2, configuration.'

The 1102 powerplant is destined to replace the UEL 801, with Finneral explaining how it would increase reliability through alternator and electronic fuel injection improvements, while satisfying power requirements for the Shadow V2, particularly as the larger wing places less reliance on the engine itself.

The introduction of a more powerful, and therefore heavier, engine may lead to trade-offs in the payload and fuel capacities of the aircraft, with the potential for a reduction in either to be necessary in order to accommodate the Block III power plant, Finneral said.

The US Army is understood to be preparing an RfP by early 2017, with downselection expected in the same year.

Endurance requirements are also top of the development list for Lockheed Martin, which is now marketing its Desert Hawk Extended Endurance and Range (EER) UAV as well as the Fury TUAV that has increased its endurance to more than 15 hours.

'Fury is a powerful Tier III, runway-independent UAS that can affordably achieve strategic and tactical missions,' a company spokesman explained to *UV*. 'We have increased Fury's reliability and maintainability by enhancing its low-speed efficiency, endurance and sensor integration. Fury Block 10 is flying today, with changes that have made it more operationally relevant in today's tactical environment.'

By manipulation of its power source configuration, the Desert Hawk EER now provides between two and ten hours of continuous flight, comparing favourably with the 1.5-hour flight time of the first Desert Hawk. The EER variant is also capable of carrying an 8.1kg payload with a maximum speed of 35kt.

PAYLOAD PROGRESS

Undoubtedly one of the most critical aspects of TUAV deployment has been the progression in the capability of payloads, with industry continually developing and ➤

PATROLLER™, THE TACTICAL DRONE *by Sagem*

EXTRA SENSORY PERCEPTIONS

The long-endurance, multi-sensor tactical drone system

The new Patroller™ UAS from Sagem carries a wide array of sensors to address all your surveillance requirements, from real-time intelligence to protection of ground troops. Drawing on nine years of combat experience by our Sperwer UAS in Afghanistan, Patroller™ is a 1-ton tactical drone with 24-hour endurance, an EASA-certified airframe and payload capacity exceeding 250 kg – not to mention extremely quiet operation. It integrates advanced mission-planning, reconnaissance, positioning, automatic target tracking and real-time data fusion functions, plus a NATO-compatible ground station. *"Sagem's new long-endurance drone carries the payload that matches your needs, for extra sensory perceptions!"* **www.sagem.com**

SAFRAN
Sagem

TUAVs could be tasked to assist in maritime patrol operations in tandem with larger HALE platforms, such as the US Navy's MQ-4C Triton UAS. *(Photo: Northrop Grumman)*

enhancing sensors to fill capability gaps identified by armed forces.

'EO/IR payloads continue to be improved with significant military resources going into HD resolution that will reduce workload on the analysis and "prosecution, exploitation and dissemination" side of the RSTA equation greatly,' GA-ASI explained.

As an example, the company has revealed it continues to seek additional payloads for the IGE platform, including a multi-functional EW aerial system and communication extension pod, as the operational environment transitions from the airborne and air defence radar-permissive environments experienced in Iraq and Afghanistan to non-permissive ones as seen in Libya, Eastern Europe and Asia-Pacific.

'We are providing critical support on the analysis of these payloads and their impact on SWaP from the aircraft perspective,' added MacFarland. 'Our role is to support and communicate with the multiple army agencies involved in the development of future payloads to ensure a smooth integration with the aircraft.'

However, according to Matt Moore, head of UAS future business at Thales UK, future TUAV operations will rely upon the deployment of dual payloads, as illustrated by the company's Watchkeeper system which deployed to Afghanistan in September 2014.

GAME CHANGER?

Referring to lessons learned in-theatre, Moore explained to *UV* how the platform's SAR/GMTI payload had been a 'game changer', elevating the role of the UAV from 'tactical to strategic' levels.

'You just don't get that wide-area surveillance with EO/IR payloads,' he explained, describing how SAR/GMTI payloads could penetrate various environmental hazards such as dust clouds.

'With EO/IR, you can't see through them. The British Army in Afghanistan proved how you could cross-cue between SAR, GMTI and EO/IR payloads for detailed identification and tracking, and this will be proven in the future operational environment as our competitors try to catch up with dual-radar payloads.'

The Watchkeeper benefits from a variety of payload configurations, including HD EO/IR and laser capabilities for observation, recognition and precision location, and SAR, which supports high-quality ground mapping, while GMTI detects and tracks moving targets, performed by the I-Master radar.

'Watchkeeper was never designed for a particular campaign, but for expeditionary operations which could include hot and high, icy and cloudy conditions in a very demanding operational environment covering the full spectrum of conflict, including a GPS-denied environment,' Moore explained.

This, he said, could range from peacekeeping operations through to high-intensity warfighting, with Watchkeeper designed to operate in any of these environments or a hybrid combination – as is the direction of current operations. However, Moore asserted that Watchkeeper still had capacity to grow in order to respond to whatever requirements the future operational environment might throw up.

'We are looking to add new capability to our EO/IR and radar payloads,' he said. 'The EO/IR payload remains in programme upgrade and we are considering various upgraded HD payload options. Last year, we introduced a maritime moving target indication mode on board the I-Master radar.'

FRENCH INTEREST

Referring to a 'mission-driven, effects-driven' air system, Moore also described how the company was developing various ESM options for Watchkeeper, with the French MoD particularly interested in COMINT and SIGINT capabilities as part of its upcoming Système de drone tactique (SDT) tender.

Whether the French will pursue a dual-payload TUAV concept has yet to be confirmed, but a flight evaluation programme was expected to start in June, with a preferred bidder due to be selected by the end of the year.

Watchkeeper will be competing against the Sagem Patroller UAV at Istres air vase in France. An Airbus Defence and Space bid called Artemis, featuring Textron's Shadow M2 platform, is also expected to be evaluated.

An initial tranche of two selected SDT systems, each amounting to 14 aircraft, is expected to replace 22 Sagem Sperwer UAVs by 2019, French military sources explained to *UV* at the Paris Air Show in June.

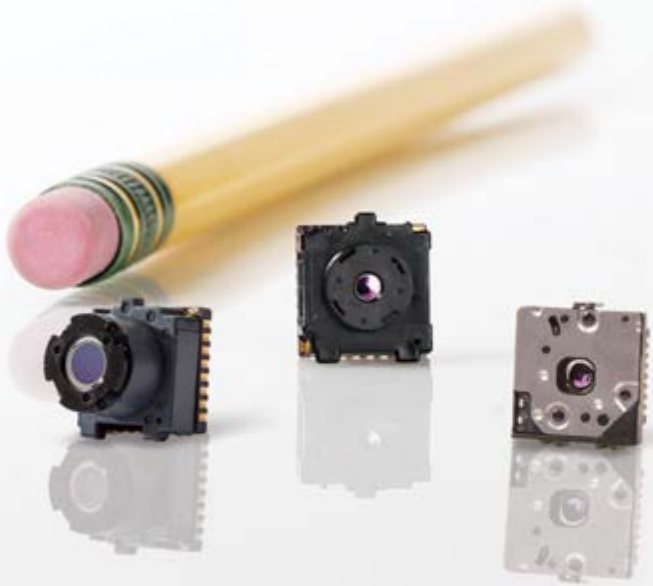
However, doubts about the future of the SDT programme remain, with military sources asking whether the French Army requires an organic TUAV given the air force's selection and procurement of MQ-9 Reapers, as well as the potential for design and development of a pan-European vehicle for 2020 and beyond.

According to Sagem, the Patroller's 'multi-intelligence' capability will benefit French forces. As part of the SDT bid, the OEM has partnered with Selex ES to provide imaging radar equipment and its own Euroflir 410 optronics payload, with data capable of being disseminated to ground users concurrently.

A Sagem source informed *UV* that up to 11 sensors could be integrated on board Patroller, with options including wide-area surveillance radar capability and narrow FLIR sensors.

THIS IS HUGE

FLIR LEPTON LWIR THERMAL CAMERA MODULE



Lepton, the world's tiniest longwave infrared camera module, is the perfect fit for UAVs.

Available in three models, Lepton not only leads the next generation of thermal imaging, it inspires the imagination for what's next.

VISIT FLIR.COM/SHEPARD TO LEARN MORE.

AVAILABLE NOW AT

Digi-Key CORPORATION

AVNET®

ALSO AVAILABLE: LEPTON DEVELOPMENT KITS FOR RAPID PROTOTYPING.

FLIR® | The World's Sixth Sense™

ROUTINE PROCESS

According to Lockheed Martin, consideration of prevalent threats and the potential for worldwide employment of TUAVs has become a 'routine part' of the design process.

The director of business development for unmanned integrated solutions at Lockheed Martin Mission Systems and Training, Jay McConville, explained to *UV*: 'Many enhancements, such as hot-swappable payloads and waterproofing – among others that we are not at liberty to discuss – have been undertaken to address the potential for use in different operating environments. This continuous improvement process is applied across our entire portfolio of UAS.

'EO/IR payloads with advanced image processing capabilities are our primary focus. We continue to assess the state of sensor/effector technologies and focus our internal development activities to leverage emerging capabilities such as communications relay, cyber-electromagnetics, short- or medium-wave IR, targeting support, light detection and ranging and signatures detection in future payloads.

The Fury UAS, in particular, is capable of "multi-int" operations, providing for multiple advanced payload capabilities simultaneously.'

The company's Desert Hawk 4, for example, has been upgraded with a new mission computer and secure mesh networking capability and has also been waterproofed for maritime environments.

Meanwhile, Finneral admits there remains additional capacity to grow the capabilities of the RQ-7B. The V2 configuration is an all-digital Shadow that incorporates the Tactical Common Data Link and Stanag 4586-compliant architecture and communications protocol.

'It includes our Universal Ground Control Station [UGCS] and Universal Ground Data Terminal [UGDT], which are common control elements with the US Army's Gray Eagle and Hunter UAS as well,' he described.

Furthermore, in line with the multi-int development path, a dual-payload variant offers two internal payload bays, as well as

wing-mounted hardpoints for external stores, while a second variant is SATCOM-enabled for beyond-line-of-sight (BLOS) operations.

'With its multi-mission capability, power and endurance, the Shadow M2 can accomplish many of the same mission sets as much larger, more expensive strategic – Tiers IV and V – systems,' Finneral proclaimed. 'We are seeing greater emphasis on broader, multi-mission capability within a single system.'

MULTIPLE MISSIONS

As currently deployed, the RQ-7B Shadow offers multi-mission capability with EO/IR, communications relay and laser designation. Combining these features with the additional interoperability of the UGCS and the encrypted data pipeline made available with the Shadow V2 creates additional capability for more advanced operational concepts, including manned/unmanned teaming (MUM-T).

'While miniaturisation is allowing smaller systems to carry new payload capabilities – ie wide-area surveillance – customers around the world want to ensure that their systems are flexible, configurable and capable of handling a variety of applications through multi-mission capability,' he concluded.

The US Army is understood to be working on integration of an undisclosed SAR payload, with Imsar contracted last year to conduct internal R&D towards this effort. One potential option could be a smaller form factor version of the Northrop Grumman AN/APY-1 STARLite radar.

UNMANNED TEAMING

Moving forward, MUM-T will prove critical to the future deployment of TUAVs, with the US Army in particular seeking to improve interoperability and commonality between manned and unmanned platforms.

Burgess also explained at the AUVSI event how the UGCS and UGDT would help assist in this area, specifically in terms of RQ-7B Shadow and MQ-1C Gray Eagle cooperation with AH-64 Apaches. This, he illustrated, allowed for such benefits as: increased crew survivability of manned platforms; increased lethality thanks to a ➤

A British Army Watchkeeper operating at Camp Bastion. *(Photo: Crown Copyright)*

reduced kill chain; and increased targeting at reach.

In August, the army will conduct further interoperability evaluation tests to exchange data between AH-64s and UAS, with the former capable of controlling the latter's flight plan, sensors and launch and recovery operations.

GOING COCO

Reference must also be made to an emerging trend in the realm of TUAVs that is seeing a number of militaries opting for contractor-owned/contractor-operated (COCO) programmes for the deployment and operation of air frames and their associated payloads.

Moore explained: 'As [military] manpower slips, we are seeing more managed service and availability contracts. Contractors come with skills and the user is able to receive information in raw content or exploited form. This is a cost-effective solution, although some users do like to retain their own core capability.'

US Special Operations Command (USSOCOM) is already implementing such a strategy, with a requirement for its Mid-Endurance UAS (MEUAS) III tactical systems, with the aim for them to be operated globally by contractors physically based in the US during operations. The aircraft will support US Central Command in particular.

UAVs will be launched and recovered in-theatre, although the mission will be controlled by contractors in the US. Requirements call for up to six hours' endurance with maximum range of up to 650km, a USSOCOM solicitation set out earlier this year.

A contract is expected to be awarded in November, with Textron's' Aerosonde, Insitu's Evolved ScanEagle and Lockheed Martin's Desert Hawk IV understood to be competing for the contract.

MEUAS III will support six pre-designated but undisclosed operational areas, providing between 300 and 1,200 hours of near-real-time feed of ISR data per month. This will include LOS and BLOS missions, with both capabilities required to conduct simultaneous imagery intelligence and EW as part of a multi-int package.

MARITIME PATROL

Finally, another expanding role for TUAVs in the future could be that of maritime patrol aircraft (MPA), with unmanned platforms perfectly positioned to execute such 'dull, dirty and dangerous' missions.

The extended endurance and wide-area surveillance capabilities of TUAVs now in development could provide one solution, especially if operated in tandem with manned MPA assets or even larger HALE MPA UAS such as Northrop Grumman's MQ-4C Triton.

TUAV candidates could include Elbit Systems' Hermes 900 and GA-ASI's MQ-9, with the former exhibiting a maritime variant in 2013 at the Aero India exhibition in Bengaluru. The aircraft was equipped with a Selex Gabbiano T200 X-band SAR, EO/IR sensor and supporting ESM payloads.

The MQ-9 has long been touted as a maritime system, with a demonstrator first unveiled in 2006. More recently, the Netherlands expressed an interest in equipping its fleet of four MQ-9 Block 5 air vehicles with a maritime wide-area search system.

A final alternative could be IAI's Heron UAS which has already had the Elta ELM-2022U maritime surveillance radar integrated on board.

Looking to the future, the procurement of new UAS is projected to level off as companies complete large, scheduled production contracts coming off the back of operations in Afghanistan and Iraq. However, the shift to COCO operations is likely to accelerate over the next few years as militaries seek more cost-effective utilisation of TUAVs.

Demand for more ISR capability has not declined and the role of TUAVs is set to proliferate yet further as the technology continues to play an integral role in this area.

As MacFarland summarised: 'In the next ten years, it is unlikely that worldwide ISR demands will decrease, and it will become more of a task to determine what the right mix of sensors and aircraft is to address the need.' uv

WITH SPAN® ON OEM625S, YOUR TRUTH IS ALWAYS PROTECTED.

Now there is another reason to depend on NovAtel precision for your truth. Our SPAN GNSS+INS technology is now available on all NovAtel SAASM receivers, assuring an even more robust continuous, 3D position, velocity and attitude solution. Protect your positioning accuracy with our SAASM-RTK OEM625S and FlexPak-S receivers now. **novatel.com/defense**

NovAtel

2015 AUSA

Annual Meeting & Exposition

A PROFESSIONAL DEVELOPMENT FORUM

Exhibit Space and Sponsorships Available

- Display your products and services to a global audience of more than 28,000
- Participate with more than 500 exhibitors at one of the largest land warfare expositions in the world
- Network with key leaders from the Army, DoD, Congress and the international defense community

12-14 OCTOBER 2015

Walter E. Washington Convention Center
Washington, D.C.

FOR MORE INFORMATION

AUSAANNUALMEETING.ORG

ASSOCIATION OF THE UNITED STATES ARMY

Support, protect, attack

Selex's Sage ESM has been fitted to the Camcopter. *(Photo: Schiebel)*

Technological innovation at the core systems level is resulting in some exciting new capabilities in the field of UAV-based electronic warfare. **Peter Donaldson** reports on some recent key industry developments.

Technologies including fractal antennas, single-chip solid-state digital receivers, small microwave power modules and system-on-chip computers that combine specialised and general-purpose processors are bringing very capable EW payloads within the reach of smaller UAVs, creating opportunities to complement or replace manned platforms in a wider range of roles.

Elbit describes the market as 'continuously growing and dynamic with some uncertainties', depending heavily on meeting new demands and shifting from systems on relatively old manned platforms to new ones on UAVs.

'UAV payloads are expected to outpace the platforms in terms of technological development – payloads and sensors that are capable of delivering intensified EW capabilities and produce quality intelligence,' the company told *Unmanned Vehicles*. 'Advances such as miniaturisation, stronger processing power, higher-capacity storage solutions and broadband data links are expected to meet this increasing demand.'

LINE OF SIGHT

EW is commonly divided into support, attack and protection – Elbit considers that UAVs are likely to make their greatest contributions in the first two categories, with success depending largely on providing a better line of sight to potential targets.

'Electronic support and sophisticated RF geo-location are still providing the greatest contribution, as they might enhance "traditional" UAV EO ISR capabilities with better detection and more accurate localisation, allowing SIGINT to cue IMINT and achieve a more focused capture,' said the company. 'On the other hand, being in a better LOS position than ground-based systems, UAV-based electronic attack is [likely] to be highly effective for a variety of missions.'

Small UAVs (SUAVs) inevitably present SWaP challenges. Elbit points out that placing direction-finding (DF) sensors on such platforms means that antenna spacing and configuration are crucial for optimal reception, intercept and performance, with transmitters and other RF components next in line in terms of the packaging challenges.

WIDE APPLICATIONS

Selex ES offers EW systems for both rotary- and fixed-wing UAVs, from tactical systems all the way up to MALE and HALE aircraft, and reports demand for self-protection suites on high-value machines as well as surveillance and ESM systems for use in the maritime and littoral domains. ➤

The high-efficiency PTXM1000 microwave power module. *(Photo: TMD Technologies)*

The company has integrated Sage, which it describes as a high-end ESM system with capabilities verging on the ELINT realm, into Schiebel's Camcopter 100 VTOL UAV, which has an MTOW of 200kg, and into its own 420kg Falco fixed-wing UAV. The Sage/Camcopter combination flew from a Brazilian Navy *Amazonas*-class offshore patrol vessel for the first time in June 2014. It is currently in Australia for a competition to provide the country's navy with a shipboard capability.

'That is our biggest set of enquiries and where we think there is quite a good marketplace,' said a Selex spokesperson. The company is optimistic that navies will adopt small VTOL UAVs in substantial numbers and network them together with other assets, enabling them to use the detection range advantage gained from Sage ESM systems to cue a variety of other sensors. These might be on other Camcopters or different manned or unmanned assets, including small, non-traditional ISR platforms.

'With good digital receiver technology you are sending some very, very accurate geolocation to other assets who can get closer in,' noted the spokesperson, who added that going forward Selex anticipates growth in border and littoral area surveillance with tactical UAVs such as Falco.

Miniaturising a very capable ESM system allows a small and relatively inexpensive UAV to take on a role that is currently a mainstay of manned helicopter operations at sea.

Sage, Selex points out, has a fully digital receiver that collects high-fidelity information that can be fed into a national database.

Although described as a lightweight system with a typical weight of under 20kg, it is not tiny, and neither are rival EW systems such as the Tactical SIGINT Payload (TSP) from BAE Systems, which is integrated into the US Army's 1,633kg General Atomics Gray Eagle, nor the same company's NANOSIGINT system, which is sized for Group 3 UAVs, a fairly broad category with MTOWs between 25 and 600kg.

As it becomes possible to squeeze more capability into smaller packages, lighter UAVs will be able to help build the electronic order of battle and defend themselves.

OFF THE SHELVES

COTS computer technology plays an important part in the miniaturisation of EW payloads. In building the TSP, for example, BAE Systems chose VMETRO, now part of Curtiss-Wright Defense Systems, to provide conduction-cooled Phoenix VPF1 digital signal processing boards with dual PowerPC microprocessors and dual Virtex field-programmable gate array (FPGA) chips in VME/VXS form. It is a modular and scalable payload with an architecture that is software-reconfigurable to allow for growth and flexibility – as technology and the adversaries' use of technology changes, according to the US Army.

TSP is intended to provide a SIGINT capability to army and US Special Operations Command tactical commanders, improving their situation awareness and shortening the targeting cycle by detecting and identifying emitters associated with high-value targets. The army emphasises that TSP can process 'conventional

signals, standard military signals and modern signals of interest'.

BAE Systems received a contract for up to 30 TSPs, potentially worth more than $70 million, in June 2014, announcing an initial production order for 12 systems under the contract in May.

However, the adoption of COTS computer technology for signal processing is far from the whole story. Besides the rapid evolution of digital components, Elbit points to RF surface mount technology as a key enabler for EW payload miniaturisation, allowing engineers to design receiver and exciter building blocks for many applications. The company also cites wideband software-defined receivers with low power consumption, printed antennas and gallium nitride (GaN) technologies as miniaturisation enablers. The company cautions, however, that not everything is achievable on small platforms.

'There is a practical limit to pack a system to a scale beyond 3:1 with the help of technology,' it noted. 'It takes about a decade to shrink systems to that scale. One should be aware of the functional performance limitations, mainly ones that involve transmitting power and large antennas.'

ANTENNAS TURN FRACTAL

For decades, RF antennas were difficult to shrink because of the relationship between element lengths and the RF wavelengths they can receive and/or transmit efficiently. Selex confirmed that antennas have been challenging to miniaturise for UAVs, particularly at the lower frequencies.

'If you're trying to get down to a C/D-band [0.5-1/1-2GHz] detection in the low frequencies, you have to do something very special with the aerials,' said a company spokesperson. 'You just can't do it when you are right down at the very low frequencies.'

One novel approach to this problem involves the use of fractal geometry in antenna construction. A key characteristic of fractals is that iterative processes form complex patterns of simple shapes that repeat on ever-smaller scales so that they look the same (or at least 'self-similar') regardless of the scale at which they are viewed. Theoretically, this enables lines of infinite length to fit into finite areas. However, real fractal antennas tend to require just a few iterations of the process to produce a compact component with high gain and broadband frequency response.

One company that crafts this technology for EW purposes is Massachusetts-based Fractal Antenna Systems, which says that fractal geometry enables the production of high-performance antennas that are 50-75% smaller than traditional ones.

A key claim is that its antennas offer bandwidths of up to 200:1 and can handle hundreds of watts, meaning that platforms need fewer antennas to deal with existing and new threats. The company further claims that fractal antennas are inherently so well matched to receivers that they can be used without tuning units. It emphasises that antenna performance comes from the geometry of the conductor, rather than through the accumulation of separate elements, simplifying the structure and minimising potential points of failure.

Fractal antennas can be used in ground vehicle, marine, airborne, fixed and personnel-worn applications. Fractal Antenna Systems CEO Nathan Cohen confirmed to *UV* that they are used on UAVs, although he declined to comment further.

COMBINE AND SHRINK

All antennas intercept radio waves travelling through the air and convert them into alternating electrical currents. In passive EW applications such as ESM and ELINT, intercepted signals pass from the antenna system into the receiver that detects them, uses filters to separate out the ones it is looking for (selectivity), amplifies them for further processing and demodulates them, which means extracting the information they contain from the carrier wave.

An ideal receiver would detect all types of signal at all frequencies and demodulate multiple signals simultaneously, even very weak ones mixed with very strong ones – ➤

all in a small, light, cheap, cool and power-frugal package.

For many years, that ideal was unattainable so EW systems used many types of receivers with different strengths and weaknesses. EW receiver types include crystal video, instantaneous frequency measurement, tuned RF, superheterodyne, fixed-tuned, channelised, Bragg cell, compressive and digital.

The big breakthrough came with digital receivers, which can implement any type of filter, tuner or demodulator in any combination in software and therefore can behave like any or all of the other receiver types.

Implementing sophisticated EW receivers in solid-state microelectronics is a specialised job and, so far, remains outside the realm of COTS and inside that of EW suppliers' intellectual property, particularly when it comes to further miniaturisation.

'Our systems engineers design the chips and we've got them right down to wafer size,' the Selex spokesperson told *UV*. 'We have specialist microelectronics engineers who design onto a wafer and then we just get somebody to manufacture the wafer for us.'

The latest result of this process is a prototype handheld micro-ESM about the size of a mobile phone – in fact it uses a mobile phone as a display. 'We've shrunk the Sage box that goes on the UAVs – we've now dropped that by another 50% so it's coming down in size again,' the representative added.

Clearly a handheld device will be light and compact enough to equip an SUAV in modified form and add ESM capability to a larger one, as the spokesperson confirmed. 'We've not yet launched that because it's still in development, but that is the next step and we are well on the way. We have prototyped it.'

The company envisages fisheries and border protection as an initial market and the prototype is functional, but has yet to be flown.

MINIATURE RF DECOY

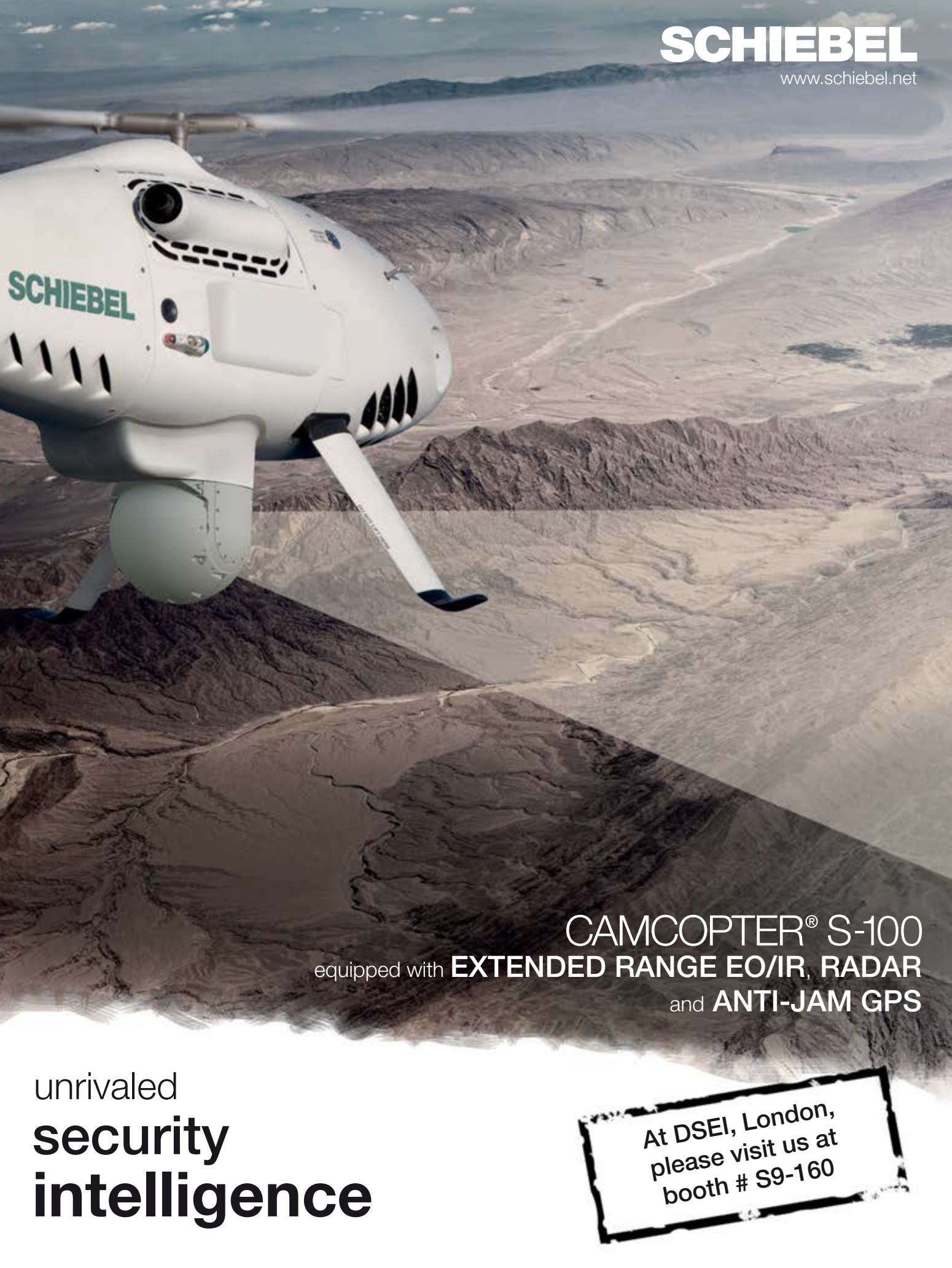
Selex also reports demand for its miniature countermeasures from the UAV sector, in particular its new BriteCloud miniature active radar decoy: 'It's designed for fast jets at the moment, but we are getting some enquiries now for protection of larger UAVs – BriteCloud technology is applicable.'

The self-contained H/J-band fire-and-forget decoy is battery-powered and uses digital RF memory (DRFM) technology that receives, records and retransmits threat radar signals, sometimes in deceptively modified form, using a range of techniques, including Doppler shift and range gate stealing, to attract a missile to the decoy and away from the aircraft.

The inherent capability of DRFM technology enables it to continuously adapt to changes in threat mode and threat type during flight, although it can be reprogrammed by the customer, with EW operational support from Selex available, to optimise it for emerging threats.

Selex emphasises BriteCloud's ability to put significant distance between itself and the launch platform to avoid the home-on-jam vulnerabilities of onboard decoys while ➤

The General Atomics MQ-1C Gray Eagle is equipped with BAE Systems' Tactical SIGINT Payload. *(Photo: GA-ASI)*



SCHIEBEL
www.schiebel.net

CAMCOPTER® S-100
equipped with **EXTENDED RANGE EO/IR**, **RADAR**
and **ANTI-JAM GPS**

unrivaled
security
intelligence

At DSEI, London, please visit us at booth # S9-160

responding rapidly enough to fool the threat, and it can be used either pre-emptively or reactively.

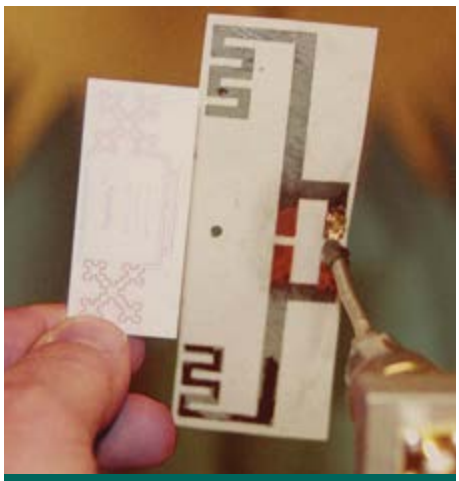
'We've managed to squeeze that down into a package that fits into a 55mm round cartridge not much bigger than a Coke can, and that fits into a standard 55mm chaff and flare magazine.'

Selex is working on a rectangular 218 format version that should be available in 2016.

For SUAVs with limited onboard power, active jamming systems still represent a challenge. Nonetheless, UAVs are likely to make significant contributions to the support, protection and attack aspects of EW.

DEVELOPING MARKET

'This market is clearly starting to develop, and given the number of systems deployed and the level and types of threat that are now becoming apparent, this is none too soon,' said Richard Patrick, business development manager at TMD Technologies, which makes a range of RF components and subsystems including microwave tubes, high-voltage power supplies and transmitters for radar, EW and communications systems. 'However, due to the limitations of the platforms – payload and power in particular – it seems that incorporating additional capability is going to be difficult.'



Fractal geometry has helped drive further miniaturisation. *(Photo: Fractal Antenna Systems)*

Gary Henderson, the company's head of equipment engineering and central engineering services, considers active emitters such as radars and radar jammers the most challenging components to package for SUAVs.

'Providing this power sets the ultimate limit on operating range and mission duration,' he told *UV*. 'The cooling system requirements to manage the waste heat can be a significant contributor to system weight.'

He considers the advent of the ultra-small, microwave power module (MPM) incorporating an efficient mini-travelling wave tube as the most important breakthrough in this area in recent years. The company's own PTXM1000 range of modular MPMs, for example, represents the current state of the art for high-efficiency, low-SWaP EW amplifiers, he said.

'Although solid-state technology has made significant advances on the back of new high-power GaN transistors, they cannot yet compete in applications where size, weight and efficiency are absolutely critical.'

The principal trade-offs relate to size, weight, efficiency and RF output power for a given input power, he told *UV*. EW RF amplifiers need to provide high RF power output over the widest frequency range possible, extending over several octaves to provide maximum protection.

'Traditionally, this was accomplished with multiple amplifiers, each one dedicated to a specific frequency range,' continued Henderson. 'However with the advent of MPMs, this can now be achieved with one small, lightweight amplifier. When designing EW systems for these platforms, the amplifier cooling system is a major consideration as it can often be larger and heavier than the amplifier itself – especially if using a solid-state approach.'

MORE THAN MOORE'S LAW

While the miniaturisation of antennas, receivers and both solid-state and vacuum tube RF transmission technologies has benefited from years of effort and the odd breakthrough, it is the processing side that is most affected by rapid progress in microelectronics. Change is so fast in this area that developers tend to leave selection of the processing hardware until last.

'We design the whole system, wait for the latest processor and then drop it in and put the software on,' said Selex.

However, it is not just the ever-increasing number of switches that can be packed onto a silicon chip that is transforming processing power. Rather, it is the combination of fast general-purpose microprocessors with other devices such as GPUs, which are massively parallel dedicated devices such as digital signal processor and application-specific integrated circuit chips and, increasingly, more flexible and less expensive FPGAs.

The MAP processor from SRC Computers, for example, exploits the inherent reconfigurability of the FPGA by changing its circuitry to optimise it for specific tasks during the mission, although the only acknowledged UAV application of the MAP processor is the Lockheed Martin TRACER foliage penetration radar.

FPGAs can be used alongside conventional fixed-logic microprocessors on the same piece of silicon in tiny but potent system-on-chip (SoC) solutions.

One example of the kind of EW processing application to which FPGAs are being applied is the Automatic Modulation Classification (AMC) system implemented by engineers at the Higher Technical School of Telecommunications Engineering at the Technical University of Madrid (UPM).

The team implemented the AMC as part of a digital channelised receiver on a Xilinx Virtex-4 LX100 FPGA, using only 16% of its available capacity. AMC enables automatic identification of RF signals by processing received data samples in the presence of noise and channel fading. The UPM team tested its system against signals using a variety of different modulation schemes, including binary phase shift keying, frequency shift keying, linear frequency modulation, Huffman, Frank and P4 coding. AMC plays an important role in software-defined radios, intelligent modems, dynamic spectrum management,

interference identification and cognitive radios/EW.

ENTER AI

Cognitive in this context can refer to the application of AI to EW systems that enables them to identify and react effectively to threat signals, eventually including any they might not have encountered before.

An early implementation of cognitive EW technology is Exelis' (now Harris) new Disruptor SRx, an SoC-based family of products that can perform ESM, ELINT, electronic protection (EP), electronic attack (EA) and communications jamming (CJ) functions, switching between them in different phases of the mission. Compact and light enough to fit SUAVs and light helicopters – the modules are about mobile phone size – Disruptor SRx is an open-architecture system that is redefinable in software and adaptable in real time to complex missions thanks to its cognitive capability.

Speaking at AUVSI 2015, Martin Apa, chief engineer for integrated EW systems at the company, said that, based on location and time, the system will determine what it has to do as part of its mission. It if knows that there is a particular threat system in the area, it will know how to counter it.

Meanwhile, his colleague Andrew Dunn, VP of international business development, indicated that this kind of adaptability is just the beginning, and the technology is evolving to shorten the time taken to identify, analyse and counter a new threat.

'Instead of relying on pre-loaded databases, the technology is moving towards: "If I see a threat that I don't know, I am going to use a sophisticated algorithm... to come up with an appropriate response in real time,"' he said.

US academia is also involved in cognitive EW, notably the Georgia Tech Research Institute through its comically named Angry Kitten programme, which combines advanced DRFM technology with cognitive learning algorithms.

DARPA is explicit about this in describing its Adaptive Radar Countermeasures effort, the goal of which is to develop technology that will: isolate unknown radar signals in the presence of other hostile, friendly and neutral signals; deduce the threat posed by that radar; synthesise and transmit countermeasure signals and assess their effectiveness based on observable threat responses.

With EW technology getting smaller as well as smarter, UAVs look set to play a growing role in securing the electromagnetic spectrum for friendly use and denying it to enemies. UV

Into the mainstream

USVs are starting to get noticed by civil and military agencies, as OEMs begin developing platforms that are multi-mission, have greater autonomy and can accommodate more advanced payloads. **Claire Apthorp** considers their potential utility.

Unmanned cargo vessels could ply the trade routes in future. *(Image: Rolls-Royce)*

Recognising that USVs are potentially valuable assets across a wide range of applications, civil and military organisations are set to start investing more in the technology.

One key sector is mine hunting, with a number of navies carrying out development programmes that will see unmanned systems conduct the most dangerous aspects of mine countermeasures (MCM) work in order to protect manned vessels and their crews.

At the same time, although with significantly less fanfare, manufacturers are maturing technologies that will see USVs bring a much wider toolset to naval forces looking to increase the surveillance capabilities of their fleets, while reducing costs and manpower in line with reduced defence budgets, smaller or more streamlined surface fleets and the ever-present requirement to 'do more with less'.

MARKET REQUIREMENTS

Modular USVs enable customers to either gain multiple capabilities from a single platform with interchangeable payloads, or operate mixed fleets of USVs that share a common vehicle base, operator control systems and logistic footprints.

In order to meet multi-mission requirements, ECA has provided a variety of platform configurations within its USV portfolio. For example, its Inspector Mk 2 system can be set up for fire-fighting operations, offshore platform and coastal surveillance or harbour surveillance and protection, while also forming the basis for its MCM and mine identification and neutralisation solutions.

'From our point of view, the growing missions for USVs include MCM, hydrography and homeland security,' an ECA spokesperson told *Unmanned Vehicles*. 'Our customers are looking for multi-mission solutions, and we offer cost-effective solutions that are easily deployable with the possibility to be integrated into existing systems, and can accomplish mixed manned/unmanned operations.'

As the market develops, there are a number of challenges to overcome to boost customer confidence in unmanned technology.

'Customers are still not ready to let a fully autonomous USV sail in the traffic during peacetime operations, however a man in the loop – or even on board – will give confidence to naval users,' the spokesperson continued. 'The challenge [as the market develops] will not be to design the USV, but the intelligence and onboard payloads – the more "brain" and tasks a USV is given, the more importance it will gain among users.'

MANNED/UNMANNED

In early 2014, Israel Aerospace Industries (IAI) unveiled the Katana, a new USV designed for homeland security applications, including the protection of exclusive economic zones, harbour security, patrol of shallow coastal and territorial waters, surface and electronic warfare and offshore platform protection.

The vessel can be equipped with EO payloads, communications systems (line of sight or non-line of sight), radar and weapons systems, providing the user with an early warning situation picture for the classification, identification and tracking of targets, as well as their interception if required.

Katana grew out of IAI's early work in naval weapon testing. In its first generation, it was a simple system fitted with navigation systems and 360° cameras, used to determine the accuracy of missile strikes in marine weapon test ranges.

Today, the platform is more sophisticated, with: autonomous navigation (via pre-determined mission waypoints, with the ability to handle engine and steering malfunction and communication obscuration); a collision avoidance system; sailing control system; and line-of-sight and satellite communications.

It can carry: EO payloads, such as the IAI Mini-POP (a day/night observation system with video tracker capabilities and target geo-location, and a 360° video panorama with motion detection); the ROSY pyrotechnic payload; a surveillance, target acquisition and navigation system radar; a remote-controlled searchlight that can be slaved to the EO payload or to a target on the map; a public address system; and video recording systems.

However, payloads can be added and/or customised according to customer requirements. The system's C2 station is also trailer-based for increased mobility, and it can be deployed on board a mother ship.

SWITCHING IT UP

Katana has been designed to be interchangeably manned or unmanned. In unmanned mode, the vessel can operate autonomously at ranges of around 100m, controlled via a C2 station. In manned mode it can operate as a five-crew combat vessel, with quick transitions between configurations possible.

'Navies and coast guards are conservative customers, and they can be reluctant to make changes when it comes to moving to unmanned technology,' Eyal Sharabani, naval USV director at IAI, told *UV*. 'As a result, there is no market for USVs really. We are having to build it as we go along – go to the customer, show them what advantages unmanned vessels have over manned. We are really writing the book as we go.'

Interchangeable manned/unmanned capability is one of the things that Sharabani believes is an important piece of the puzzle when it comes to encouraging USV uptake by potential customers.

'The dual-mode manned/unmanned is a huge advantage to the customer because it allows the customer to gain two new vessels in one vessel type,' he said. 'When it comes to bringing new vessels into the fleet with different operational and maintenance requirements, it can be a barrier to uptake, but if the customer can keep the same boat and change its configuration to suit the mission, it's a big benefit.'

IAI has demonstrated Katana to a number of potential customers and is now seeing better defined requirements from the market for specific capabilities, including anti-mine and submarine hunting.

'As the technology matures, autonomy increases and we are able to give the benefit of many systems in one vessel – we are able to show that using USVs offers reduced risk to the customer, which will lead to a growth in demand for unmanned technologies overall,' Sharabani concluded. 'Within two to three years we will start to see big changes.'

USV BRAINS

Katana's electronic cabinet, which contains the navigation and payload controls, can be integrated on any kind of vessel, further increasing its flexibility. A similar approach has been taken by Saab with its Bonefish system, where the platform's crux – a flexible mission system – is adaptable across a range of hulls.

With certain hulls suited to various operational contexts – from MCM, surveillance, interdiction and resupply to anti-submarine warfare or search and rescue – having the capacity to easily adapt to different sensors, communications links and hulls to suit the mission allows navies to become familiar with how to use and integrate USVs into their operations.

'Navies are working through the operational concepts of unmanned systems, and whilst there is experience with underwater ➤

The Inspector Mk 2 multipurpose platform. *(Photo: ECA Group)*

vehicles and growing experience with aerial vehicles, surface vehicles are newly emerging,' Derek Rogers, programme manager and engineering manager at Saab Australia's centre of excellence in autonomous vessels, told *UV*.

'One of the advantages of Bonefish is that it is a very flexible mission system adaptable to different boat hulls and this allows navies to experiment and trial the technology, and that is often an important element in successful technology adoption.'

CULTURAL AVERSION

Rogers claims to have not encountered the issue of 'cultural aversion' in discussions with naval customers regarding Bonefish. He believes this is because it is a newer system using mature maritime technology that has had a large market base over a long time and well-defined interface standards for integration with communications and combat management systems, launch and recovery and sustainment systems – rather than a bespoke design that attempts to reinvent the wheel.

'In our initial work we took the approach of designing a hull that could be suited to multiple missions, and additionally we designed a very flexible mission system in order to explore what the market would be interested in,' he said. '[Market information] suggests that multiple-mission USV hulls will come much later, and this is typically true with new technologies – so in the early stages of technology adoption there [is likely to be] interest in hulls suited to very specific missions, typically handling the trade-offs of speed, manoeuvrability, stability and payload, or a combination thereof.

'Our advantage with the Bonefish mission system is that we can tailor it to different hulls and different missions, allowing the experimentation needed in the early stages, and then optimise and militarily harden it at a later stage.'

MORE AUTONOMY

Saab Australia's current R&D effort for Bonefish is looking at higher levels of autonomy. The vessel can be operated via remote control or can follow a series of waypoints, but work is being undertaken to allow a higher level of autonomy to be attained without having to re-architect the design. This includes collision detection and avoidance, mission adaptation, and – eventually – cooperation between multiple USVs.

'In our design we've focused on adherence to collision regulations, and R&D assisting that in the area of collision detection is the precursor to collision avoidance,' Rogers added. 'We'll take a multi-sensor data fusion approach using information from radar, sonar, Automatic Identification System (AIS), optical systems and laser detection systems, for example. Then in terms of mission adaptation – what most people would regard as true autonomy – we also have some R&D under way, but how much true autonomy will be required will be something that will shake out in the market place.'

Further down the road, the programme will undertake integration work with combat management systems and on-water activities, where the goal will be to seek real understanding of how to design truly unmanned hulls – rather than just manned boats without people – and what new opportunities this provides.

With the most frequently discussed operational areas for Bonefish presently being surveillance, anti-piracy and MCM – with anti-submarine warfare and supply increasingly emerging as key capabilities – Rogers said that the feedback he has had from the market thus far has been positive.

'I think most people see USV as "coming" and [the fact] that we've created a very flexible mission system that supports experimentation and refining operational concepts of use has been received positively,' he said.

'Certainly, that we haven't only focused on the technology but have taken into account the regulatory [framework], the economic [market] and even the social considerations has been well received, including meeting with the Australian Maritime Safety Authority and holding discussions with the International Red Cross and navy lawyers, all to make sure we design a complete solution.'

MISSION SETS

Formal requirements in the USV market focus strongly on the MCM mission set. Furthest along the path is the USN, which in October 2014 awarded the sole engineering, manufacturing and development (EMD) phase contract of its Unmanned Influence Sweep System (UISS) programme to Textron Systems Unmanned Systems. The UISS will form the central component of the Littoral Combat Ships' (LCS) MCM mission module, designed for influence sweeping of magnetic and acoustic mines.

Textron Systems was awarded the 30-month EMD contract on the strength of its Common Unmanned Surface Vessel (CUSV), which, compatible with both *Freedom*- and *Independence*-class LCS configurations, will now be further refined, developed and qualified. Work will encompass both the USV and its common C2 software, which is designed for seamless integration into the LCS mission module control station.

The MCM mission set is the most obvious entry point for USVs, because the technology hits the unmanned mantra of 'dull, dirty and dangerous' head-on (see also p46).

'We've got beyond MCM, demonstrated pulling sidescan sonar and using mine neutralisers as well as doing ISR, intercept and interdiction using non-lethal weapons – but we knew that as unmanned technology goes to the maritime surface, mine warfare would be the first entry into the market,' Bill Leonard, director of unmanned surface ➤

ECA GROUP

ECA Group provides
the most comprehensive
Unmanned solutions
in the Air, on Land and at Sea

IT180
Robust and all weather automatic flight UAS for demanding Defence & Security missions

INSPECTOR MK 2
High-performance and multi-mission USV approved worldwide

K-STER C
The most effective sea mine disposal system intagrated by Navies worldwide

A9
AUV providing stability and accurate navigation for several French Navy programs

COBRA MK2 E
War proven multi-mission UGV solution

www.ecagroup.com

make sure

systems at Textron Systems Unmanned Systems, told *UV*.

'But we have designed the CUSV to be multi-mission and reconfigurable so it can perform a variety of mission sets – mine-sweeping one day, mine-hunting the next, performing ISR or a combination of those all in the same mission set. By being "common", it is adaptable to whatever the customer wants.'

FOURTH GENERATION

The 11m CUSV can be deployed from ports, well decks and both LCS classes, and in its current fourth-generation configuration, has been enhanced in terms of speed, range, stability and endurance, with a hull optimised for reduced drag, improved stability and increased strength.

Its payload bay has been tested with four mission packages (sidescan sonar, mine neutralisation, ISR and non-lethal weapons), and the CUSV itself uses the maritime version of Textron Systems' common C2 package, compliant with NATO STANAG 4586, the Joint Architecture for Unmanned Systems protocol and the LCS communication architecture. Additionally, it is compatible with the RSS SeaLancet data link and has a SATCOM capability.

The CUSV has what Textron Systems calls 'sliding autonomy'. The launch and recovery of the vehicle either from port or an LCS mission bay is conducted remotely by a handheld controller, at which point operation is handed off to the universal C2 console, where the system is controlled either from a GCS onshore or on the mother ship.

For general operation, the system is pre-programmed with a mission planning file that enables the vessel to perform its task with a man in the loop. Supervised autonomous operation has also been demonstrated by the CUSV, where the system conducts some autonomous collision avoidance, but generally when an obstacle is detected the system alerts its operator to make navigational decisions.

SWEEPING FOCUS

Of the three phases of MCM (mine sweeping, hunting and neutralisation), the UISS programme of record is presently only concerned with the former.

'Mine sweeping is basically what we call "mowing the ocean", trying to influence mines by simulating certain characteristics of the ships they have been programmed to target, just blindly trying to make those mines go off in the water,' Leonard explained. 'Mine hunting is where a sidescan or synthetic aperture sonar system is used to map the ocean floor, looking for mine-like objects, then either the sensor itself or an operator conducts analysis to determine whether or not the target has the characteristics of a mine.

'Finally, mine neutralisation is conducted after a mine has been identified. A neutraliser – often an autonomous underwater vehicle (AUV) – with explosives is sent down to lay a charge and the mine is blown up.'

While currently only focused on mine sweeping for the LCS mission set, the USN does have mine hunting and neutralisation on its roadmap, and Textron Systems continues to develop capabilities in this area as a nod to future requirements.

'As we execute the programme with the US Navy, we continue to develop and work on capabilities outside the programme of ➤

Textron's CUSV has 'sliding autonomy', allowing changes to operator input. *(Photo: Textron Systems)*

record,' Leonard explained. 'We've conducted work that has seen our CUSV [operate] with an AUV, and we're partnering with many payload and sonar system development companies to bring in their capabilities.'

Currently, the CUSV has undergone three successful reviews – systems requirement review, integrated baseline review and preliminary design review. It commenced a series of critical design reviews in early June, which will allow the manufacturing phase to begin.

The company aims to have a system built by the end of 2015 for integration, test and qualification activities to begin in 2016, prior to handover to the USN for testing on an LCS in late 2016. The contract currently calls for six low-rate initial production systems to be built, with the expectation that the navy will go on to populate the UISS mission module on all 32 contracted LCS, with one system per vessel.

UNMANNED RESUPPLY

At-sea resupply is another growth area. 5G Marine, for example, has developed an autonomous refueller system based on its Marine Handling Craft. The 18m Hercules is designed to provide refuelling at-sea primarily for USV fleets, as well as being a mobile 'filling station' for manned vessels.

The Hercules tanker can be used for: shore-to-ship refuelling; station-keeping, where it stays on station in the theatre of operations; or be pre-programmed to travel from station to station along a pre-planned track to conduct refuelling operations. By allowing vessels to remain on station for longer without having to return to base for refuelling, Hercules acts as a force multiplier, effecting greater range, reduced fuel costs and the coverage of a wider operational area.

Other work in the area of unmanned logistics is being conducted by Rolls-Royce Marine, as it looks to address the requirements of a marine sector seeking greater efficiency. The way to do this, Rolls-Royce believes, is by initially moving certain vessel functions ashore, such as engine and equipment monitoring capabilities – and eventually, the entire crew.

IAI's Katana grew out of the company's early work in naval weapon testing. *(Photo: IAI)*

'Look at the world today and unmanned vehicles are either everywhere or very soon will be, so it would be odd if we didn't see the same trend in the marine industry,' Oskar Levander, VP of innovation, engineering and technology at Rolls-Royce Marine, told *UV*. 'The main driver is economic – making shipping more efficient to give operators better profits, and a logical way to do this is to remove the crew from the vessel.

'You still need crew on land and service teams, but reducing onboard crew will reduce fuel costs as the vessel will be more efficient – no need for a deck house, water production, sewage, refrigeration – the ship becomes lighter, there is more space for cargo and the vessel consumes less electricity. We estimate that there will be a 15% reduction simply by removing the crew, and that will grow if we start actually redesigning the vessels.'

Although the company's work is focused on the merchant shipping industry, Levander said there are obvious synergies with the naval market. Naval forces move enormous amounts of equipment and cargo by sea, and are always seeking to improve efficiencies and reduce manpower requirements. Furthermore, the naval market is, on the whole, driving unmanned technologies within the maritime sector. Therefore, capabilities developed on the merchant shipping side will have benefits on the naval side, and vice versa.

Current focus is on ship intelligence – the technologies required for fleet optimisation, vessel condition management, predictive maintenance, diagnostics, remote support, smart navigation and position, as well as onboard automation, which includes everything from simple automatic reporting systems all the way up to fully autonomous capabilities, and remote control and operation.

RELIABILITY DRIVE

Although the technology building blocks needed to push development forward are in place, there remain challenges to overcome, such as vessel reliability – how to ensure the vessel is functioning for the entire voyage without any kind of human service and maintenance unit, for example.

'That will require a lot of effort and we are developing systems around health monitoring, with a lot of sensors analysing the data coming in and trying to predict the health of the systems to conduct maintenance before something breaks,' added Levander. 'Similarly, [we are] working on how remote control of the vessel would actually work, and if a ship is going to operate itself what is the optimal way to manage that, along with IT security and cyber challenges to prevent anyone else from taking control of the ship.'

Closing, Levander said that the shift to unmanned will be one of the most fundamental changes in the maritime sector, similar to the change from sail to steam and steam to diesel. In the context of wider work with USV technology, it is an exciting time for the market as users become more comfortable with the unmanned concept and begin to exploit its full potential. uv

SEOUL
INTERNATIONAL AEROSPACE &
DEFENSE EXHIBITION 2015

www.seouladex.com

Seoul International Aerospace & Defense Exhibition 2015

Oct. 20-25, 2015 / Seoul Airport

NATIONAL TRAINING AND SIMULATION ASSOCIATION

THE WORLD'S LARGEST MODELING & SIMULATION EVENT

NAVY USMC AIR FORCE '15 ARMY INDUSTRY

INTERSERVICE/INDUSTRY TRAINING, SIMULATION & EDUCATION CONFERENCE

FORGING THE FUTURE THROUGH INNOVATION

Why I/ITSEC?

- 14,000 Attendees
- 526 Exhibitors
- 150 Sessions
- 69 Countries, over 1,900 International Delegates

Albania • Algeria • Argentina • Australia • Austria • Bangladesh • Belgium • Brazil • Bulgaria
Canada • Chad • Chile • China • Colombia • Costa Rica • Czech Republic • Canada • Denmark
Ecuador • Egypt • El Salvador • Estonia • Finland • France • Georgia • Germany • Ghana • Great
Britain • Greece • Hong Kong • India • Indonesia • Ireland • Israel • Italy • Jamaica • Japan • Jordan
Kuwait • Lebanon • Libya • Lithuania • Malaysia • Mexico • Morocco • Netherlands • New Zealand
Nigeria • Norway • Pakistan • Papua New Guinea • Peru • Philippines • Poland • Romania • Russia
Saudi Arabia • Singapore • Slovakia • South Africa • South Korea • Spain • Sri Lanka • Sweden
Switzerland • Taiwan • Thailand • Turkey • Ukraine • United Arab Emirates
United Kingdom • Uruguay • Yemen

A Proud Affiliate Of NDIA National Defense Industrial Association

WWW.IITSEC.ORG ▶ NOVEMBER 30-DECEMBER 4, 2015 ▶ ORLANDO, FLORIDA

A squadron of Heron UAVs is based in Gujarat, which has a 1,600km coastline to monitor. *(Photo: Indian Navy)*

Signs of life

The Indian UAS market is looking strong after years of stagnation. **Neelam Mathews** rounds up the latest developments.

Thanks to the government's push to 'Make in India' combined with some long-overdue action on procurement decisions that had taken a back seat for the past decade, UAVs are high on the agenda for military and security agencies.

Newly forged public-private partnerships are driving growth in an industry that was previously restricted by slow-moving state-sector development programmes.

Given the country's manufacturing boom, 'initiatives of development are being done in India [now] at multiple levels as sources of technology are dispersed, and are not dependent on just one or two OEMs', said Rahul Gangal, partner in the New Delhi office of Roland Berger Strategy Consultants.

India's 6Wresearch has forecast the domestic UAV market will reach $421 million by 2021, although this figure may need to be revised given the increased thirst for procurement. India remains among the top buyers of UAVs, accounting for some 22% of imports worldwide, with Israel as its leading supplier.

MILITARY MATTERS

The Indian Army has commissioned over 45 IAI Herons with a plan to acquire 20 more, while the Indian Navy (IN) currently has two squadrons operating a mix of Herons and IAI Searchers in the south of the country and one in the western state of Gujarat, which has a 1,600km coastline.

'These UAVs will enhance the joint war-waging capability in the region by synergising the capabilities of the army, air force, coast guard and local authorities,' a navy statement said.

The unit in Gujarat allows the IN to patrol the northern part of the Arabian Sea and is well placed for covering the sea lanes of communication from the Persian Gulf as well as providing surveillance for high-value assets.

The Searcher has an 8.5m wingspan and is capable of carrying EO camera, ESM or COMINT payloads. Heron is a larger aircraft with a 16m wingspan and its payloads include a maritime patrol radar.

MALE and HALE UAVs serve strategic needs and are traditionally difficult platforms for countries to develop independently, with access to many technologies being restricted. As neither India nor Israel are signatories to the Missile Technology Control Regime, which ➤

prevents proliferation of UAVs capable of carrying a 500kg payload for at least 300km, acquiring Herons and Searchers makes sense for the IN.

Plans for upgrading the in-service aircraft with 'advanced sensors and a satellite [communications] capability are being discussed', an Indian MoD official told *Unmanned Vehicles*.

An RfI was released in January for a naval shipboard UAV capable of operating from vessel over 50m long with a helicopter deck. 'The navy probably lost its patience waiting for an indigenous programme for a similar product using Chetak helicopters that is facing challenges,' said a source at one UAV OEM. The follow-on RfP for 50 systems is to be released by the end of 2015, *UV* understands, and will be addressed to Indian companies acting as the prime with foreign OEM partners.

The IN has laid down specifications for MALE and HALE UAVs with payloads such as maritime patrol radar, AIS, COMINT, electronic cameras, IR and satellite data links for extended range. The service is also looking at UAV full flight simulators, procurement of which will be carried out under a joint services contract.

SECURITY CHALLENGES

Mini and micro UAVs are critical to meeting immediate homeland security needs, although the challenges are many. 'This is achievable in India as long as major aggregates such as payload, propulsion and inertial navigation issues are addressed,' said Gangal.

While the Indian Army has yet to announce its specifications, RfPs have already been issued in June by the Central Reserve Police Force for two mini-UAVs and the National Security Guard for 12 micro-UAV systems.

International partnerships are also taking shape. The US-India Defense Technology and Trade Initiative (DTTI), an agreement recently extended up to 2025, defines steps to boost bilateral defence partnerships, and now incorporates for the first time a provision to co-produce weapons in India along with the transfer of technology.

One of four 'Pathfinder Projects' identified under DTTI is a next-generation mini UAV named Cheel ('eagle' in Hindi) involving Bangalore-based Dynamatic Technologies and US developer AeroVironment. Dynamatic has been a developmental partner of the Defence Research and Development Organisation (DRDO), working since the 1990s on Lakshya UAV prototypes.

'Under the DTTI Dynamatic and AeroVironment are putting their best-of-breed capabilities to strategically co-develop and co-produce the world's most advanced mini-UAS for global markets,' said Udayant Malhoutra, CEO and managing director of Dynamatic.

The Cheel programme will build upon over two million hours of combat flying that AeroVironment UAS products have undergone in diverse environments including mountains, deserts, jungles, sea and urban areas, he added.

The cooperation programme will leverage AeroVironment's family of small UAS, which includes the Puma AE, Raven, Wasp AE and Shrike.

'Combining Dynamatic's precision engineering capabilities with AeroVironment's innovation and production in small UAS will not only produce an unmanned aircraft system specifically for the Indian market, but will also establish the foundation for a vibrant industry of the future in India,' said Thomas Cunningham, VP for UAS strategy at AeroVironment.

The prototype will be made entirely in India over the next 12 months. The Cheel's design will be an evolution of the lightweight 5kg RQ-11B Raven and 12kg Puma. 'We're going to take the form factor of Raven and features of Puma. We're moving the propeller forward… it will fly higher (longer wings) and is easy to launch,' Cunningham told *UV* earlier this year.

IN THE FRAME

An initiative by Boeing and Tata Advanced Systems Ltd (TASL) in July resulted in a framework agreement to collaborate in aerospace and defence manufacturing and potentially integrated systems development, including UAVs.

TASL has set up a design, development and production facility to manufacture a range of mini-UAVs covering systems weighing a few hundred grams with basic surveillance capabilities and larger models that have more advanced ISTAR functions. One system consists of three UAVs and a GCS, providing continuous surveillance over a designated area. The system is stored in backpacks that can be manually transported over all terrains for immediate deployment.

Airbus Defence and Space (DS) and Kolkata-based Kadet Defence Systems (KDS) recently signed an exclusive strategic cooperation agreement covering the sale and marketing of products and services in the aerial targets field. The two have teamed up initially to offer the Airbus DS Manoeuvrable Expendable Aerial

Searcher UAVs can be equipped with EO, COMINT and ESM payloads. *(Photo: Indian Navy)*

A scale model of the Rustom at Aero India in Bangalore. *(Photo: author)*

Target (MEAT) to the Indian Air Force and Army. The agreement sets out a roadmap for technology transfer, joint product development, local manufacturing and provision of joint services in the Asia-Pacific region. 'This underlines our willingness to find mutually productive ventures in line with the "Make in India" concept,' said Peter Gutsmiedl, head of Airbus DS India.

Avdhesh Khaitan, CEO and founder of KDS, said the arrangement would 'enhance the size and scope of what we can bid on future programmes', adding that India will require at least three of the family of four aerial targets for training and development activities at the DRDO.

He continued: 'Unlike the reusable Lakshya, India's indigenous version, ours is expendable with massive manoeuvres and a high climb rate that will be required by the military in future.' Manufacturing involvement will 'depend on the next contract… Though we expect to start manufacture of some components under the "Make in India" initiative.'

An RfP by the army's air defence branch for Lakshya-type vehicles was released this year, envisaging some 500 sets.

A first transfer of technology for the DRDO's Lakshya high-speed target drone has been approved by the MoD, allowing commercial production by private sector manufacturer Larsen and Toubro. The company already builds launchers for the army version of the aircraft. The DRDO will be paid a royalty for every system sold.

INDIGENOUS TECHNOLOGIES

Last year, government-owned Hindustan Aeronautics Ltd (HAL) approved the creation of a strategic business unit for UAVs. 'We are participating as the risk-sharing partner with the Aeronautical Development Establishment, a laboratory of India's DRDO, on the Rustom 2. We would have all the design rights with us and we would be the production agency where the product is certified,' said a company spokesperson.

Rustom 2 is a twin-engine MALE platform that will be capable of releasing weapons in addition to its primary ISR role.

Other indigenous projects include the VTOL Netra, developed jointly by ideaForge Technologies and the DRDO, which was used by the National Disaster Response Force during the 2013 floods in north India and Gujarat.

The DRDO Nishant is used for reconnaissance and target tracking with four aircraft currently undergoing induction with the army. Panchi is a wheeled-version of Nishant that can take off and land from small airstrips.

HAL, meanwhile, is also working on its own mini-UAVs, such as the Slybird, optimised for operations between 8,000 and 15,000ft with an all-up weight of 3.5kg and a data link range of 10km. The similarly featured Indian Eagle is optimised for flying between sea level and 8,000ft. The 450mm, 500g Pushpak micro-UAS has a data link range of 2km, and an endurance of 20 minutes at up to 320ft. UV

The Marlin AUV has recently been used for commercial inspections in the Gulf of Mexico. *(Photo: Lockheed Martin)*

Risky business

The growing realisation that unmanned systems can provide a cost-effective and safe method of conducting infrastructure inspections could result in a market boom. **Richard Thomas** examines where progress is being made.

In a global unmanned vehicles industry, the dominance of military applications is now being challenged by a growing commercial market that is becoming increasingly aware of the benefits of such platforms, particularly at remote sites – on land or at sea – as well as for infrastructure monitoring and inspection.

Established OEMs are being joined by a host of smaller companies in developing platforms, payloads and data dissemination techniques for the commercial sector.

Aside from the potential financial and efficiency savings, persistence and endurance that unmanned systems can provide for a company, they help reduce the need for employees to undertake 'dull, dirty and dangerous' tasks. Whether having to scale heights, swim depths or navigate the terra firma in between, there has always been human risk in industry.

TOWERS CLOSE-UP

One of the best publicised UAS applications in this sector has been telephone mast inspections. With the significant rise of mobile communications over the past decade and hundreds of thousands of towers and antennas installed across the US and Europe, the workload for construction, maintenance and inspection firms has similarly spiked.

Figures from the Occupational Safety and Health Administration (OSHA) at the US Department of Labor show a total of 91 deaths between 2003 and 2013 from tower-related accidents, with a further 17 people injured.

While the majority of accidents occurred during maintenance, rather than inspections, any time an employee needs to ascend high structures, an element of risk is present.

Responding to *Unmanned Vehicles'* request for a comment on the use of unmanned vehicles for monitoring, the OSHA said it recognises 'the potential of this technology' and was evaluating its use 'to assess safety and health hazards without exposing our staff to hazards that may be present'.

In April, the US government's Federal Register published an OSHA Rfl on injuries and fatalities occurring on communication towers,

either as employer or employee, in a bid to increase safety levels and reduce the number of accidents.

Most of the fatalities (79) were due to falls, while structural collapses killed an additional eight people. A total of three fatalities involved electrocutions, and one was due to an employee being struck by a load while working on the tower.

Falls were also the leading cause of injuries among communications tower workers, with 13 of 17 attributed to that cause.

UNMANNED SOLUTIONS

David Phillips, VP of small and medium-endurance UAS at Textron Systems, told *UV* that the appeal for unmanned platforms was in their ability to remove the operator from dangerous environments.

No stranger to the unmanned industry, Textron Systems has been able to leverage its experience and lessons learned in the military sector into the commercial realm. Potential civil and commercial applications are enormous, according to Phillips.

'These three [dull, dirty, dangerous] mission sets are what drove the need for unmanned systems from a military standpoint, and are also drivers for commercial use of UAS,' he said. '[In addition to infrastructure monitoring], an array of civil applications such as border protection, counter-terrorism and disaster response are feasible for these systems.'

Also well versed in hazardous environments is ground robotics firm iRobot, whose range of UGVs have been extensively used in the nuclear industry to monitor radiation levels and perform tasks previously carried out by human workers.

Officials from the OEM said they were working to increase the range of roles its platforms can perform.

'One market that we've seen most interest from and use from an inspection point of view has been in US and Canadian nuclear power stations,' said Tom Phelps, director of robotics products, North America, at iRobot. 'We have the 110 [PackBot], the 510 and the 710 in with 15 different power stations.

'They are mainly involved in standard tasks such as monitoring radiation levels, waste management, inspection of the facilities and emergency response. They can perform these tasks without the worry of dosing a worker.'

FUKUSHIMA ASSISTANCE

The PackBot 510 was used to assist engineers investigating the structural and environmental conditions of the Fukushima nuclear power plant in Japan. Using hardened electronics to protect against radiation, operators were able to stay outside of the contaminated zones while obtaining valuable information and performing system checks.

The plant's meltdown in 2011 proved again that commercial products can be adapted for use in highly specialised and extreme environments, while suffering no degradation.

The units also did not have to be consigned to the radioactive pile after use, as they were environmentally sealed and could follow the same decontamination process as other equipment from the facility, noted Phelps.

'We will look to develop the existing product line and collaborate with industry leaders to find a better solution,' he continued. 'In the future, we will want more autonomy and to integrate new sensors such as inspection capability for fire or smoke.'

Unmanned subsurface monitoring has also grown significantly in recent times, with AUVs and UUVs being able to offer enhanced capabilities in terms of endurance and detection.

Officials from Lockheed Martin, which introduced the Marlin AUV to market, highlighted the safety benefits of such systems in this area.

'There are many benefits in using unmanned vehicles, like Marlin, for infrastructure monitoring… it eliminates the hazards associated with putting divers in the water; its advanced autonomy requires fewer people at sea to perform inspections; and it reduces risk to operators,' said Rich Holmberg, VP of mission and unmanned systems.

'Fully autonomous operations allow for safer vehicle launch and recovery without the risk of tether entanglement, and provide longer vessel stand-off from production assets than other methods,' he added.

CAPACITY BUILDING

In the monitoring of pipelines, oil and gas installations or other infrastructure, payloads are as important as the platforms they are mounted on – as is a client's understanding of how to best utilise them.

Micro Aerial Projects uses quadcopter UAS to obtain high-resolution aerial images that can then be used to create accurate 3D models of the surrounding geography, enabling customers to inspect their facility, infrastructure or potential sites.

However, despite the clear benefits, some companies still prefer assigning manned capabilities to such duties, according to Walter Volkmann, president of the company.

'Some clients feel that a helicopter is a better solution, but unless imagery is being captured this will just give you a one-off subjective visual inspection – there is no permanent record of the inspection and no means to make any geometric measurements or radiometric analysis,' he said. 'The problem, too, is that folks are generally not equipped to consume or use high-resolution imaging products.

'There is inertia. This new type of sensing and the big data produced can intimidate clients who are used to dealing only with conventional geospatial data, such as low-resolution mapping and vectorised features. You have to be able to extract the essentials from the data, such as soil stability, ground recovery or thermal imaging, and often the end user lacks the capacity to deduce the essentials from such data.'

Progress towards discovering new commercial applications would also be driven by the client, added Volkmann. 'Applications of UAS [in infrastructure monitoring] will be discovered by the clients responsible for the safe operation of the assets. With relevant infrastructure, they could have small platforms continuously monitoring their assets.

'The provision of video and visualisation of high-resolution models are very informative ➤

to planners, landowners, professionals and laymen alike.'

BUSINESS MODELS

Some players in the commercial sector are further along than others as regards incorporating unmanned systems into their business models, although there is a growing move towards the technology as the advantages become clear.

Jeremy Wigmore, CEO of UAS manufacturer Aerialtronics, said that he had seen a 'definite thought process' and a move to embrace unmanned systems.

'At this stage of the market, some people are still going through the research and design stage, but it's like any new technology in that some are using it and others are not.

'Over the past three years, we have specialised in the design and manufacture of quadcopters – this is our market as UAS manufacturers and solution providers. The commercial market is exciting and you will see different payloads and sensors develop in future.'

In June, Aerialtronics revealed the results of a collaboration with telecoms provider T-Mobile in the Netherlands, integrating UAS into monitoring and inspection practices. The tests showed that by using unmanned systems T-Mobile was able to inspect a series of antennas on a sports stadium in just 15 minutes – a process that would have taken a team of technicians a week to accomplish.

The platform, an Altura Zenith, was fitted with thermal sensors and transmitters to collect the data, which could then be quickly analysed by teams on the ground.

Able to operate in poor weather conditions, such as rain or high winds, Zenith has a detachable gimbal allowing for payload changes, and navigates via GPS-assisted flight control for up to 45 minutes.

ESTABLISHED PLATFORMS

Elsewhere, Textron Systems' main platform for infrastructure monitoring comes in the form of the Aerosonde, which has flown tens of thousands of flight hours since the 1990s. The company has a long history in the UAS industry, with its Shadow 200 and Shadow M2 systems operated by a range of militaries around the world.

With over 100,000 flight hours in the past 30 months, Textron Systems' Aerosonde UAS has made commercial customers take notice. *(Photo: Textron Systems)*

Of the Aerosonde, Phillips said it had been used in the oil and gas industry, covering a range of mission sets, including security and infrastructure monitoring.

He said: 'The same features that have made the Aerosonde system so successful over thousands of monthly flight hours for our US DoD customers – more than 100,000 hours over the last 30 months – also has made it an attractive choice for commercial customers.

'[It is] ideally suited to a variety of military and commercial mission sets,' he noted, adding that it is equipped for EO/IR real-time, full-motion video and communications relay within a single sortie, and allows for the integration of additional capabilities depending on customer requirements.

'Textron Systems has worked with customers for a variety of civil and commercial needs, including oil and gas and critical infrastructure inspection and protection, meteorology and scientific research, mapping and surveying, environmental monitoring, and others.'

Phillips said that the system had also been demonstrated for additional applications, such as monitoring national EEZs, while advances in miniaturisation had allowed the company to leverage smaller payloads.

'We have seen interest in a variety of sensor capabilities, including wide-area survey 3D mapping, synthetic aperture radar and LIDAR,' he said. 'All of these, coupled with the range and endurance of the system, allow the customer to observe and cultivate information about vast expanses of terrain, or water, in a very efficient and persistent way. Civil and commercial applications will require a variety of sensor capabilities, and for that reason, multi-mission assets like the Aerosonde are appealing.'

UNDER THE SEA

Further developments are also being seen in offshore inspection, despite the unique environmental challenges it provides. Holmberg said it took 'specific engineering acumen' to design vehicles to operate underwater, for example.

The Marlin AUV is currently one of the leading platforms advancing subsea inspections for the oil and gas industry, conducting structural surveys, pipeline inspections, bottom debris surveys and subsea facility inspections.

By using Marlin, Holmberg said that inspections can be executed ➤

MASTER
THE MARITIME DOMAIN

Textron Systems' unmanned solutions deliver maritime force projection from port to deep water. With a minimal shipboard footprint, our Aerosonde™ Small Unmanned Aircraft System flies simultaneous video, communications and intelligence missions, for comprehensive situational awareness with unmatched reliability. Our Common Unmanned Surface Vehicle (CUSV™) can debark from ports or larger vessels, carrying payloads for numerous mission sets from mine-sweeping to security and intercept. Teamed together, the Aerosonde extends the range of maritime assets even farther for an expanded intelligence footprint. Across military, commercial and civil mission sets — Textron Systems delivers total maritime domain dominance.

textronsystems.com/unmannedsystems

TEXTRON Systems

INGENUITY ACCELERATED

iRobot has had increasing interest in its UGVs for dull, dirty and dangerous work. *(Photo: iRobot)*

autonomously, reducing the need to deploy specialists and trained ROV operators offshore. The most recent demonstrations can be seen in commercial inspection operations in the Gulf of Mexico.

'We created the Marlin AUV system to help industry survey seabed infrastructures and pipelines – it makes inspections safer, better and faster, and offers the clearest 3D view of what lies below,' he said.

According to Holmberg, the platform 'far exceeds' the efficiency of traditional inspection methods by offering an autonomous change-detection capability. Current capabilities include a cruise duration of up to 18 hours, a sprint speed of 4kt and real-time, millimetre-resolution 3D modelling. 'Marlin enables undersea infrastructure monitoring that simply cannot be performed with a manned solution due to depth and mobility considerations – we are effectively extending our reach beyond any manned option,' he said.

The Marlin is launched and recovered using an underwater docking system and normally operates from a vessel or fixed/floating platform, with the movement guided by shore-based or offshore personnel. When configured for offshore platform inspection, it is capable of producing 3D imaging down to a depth of 300m, with an endurance of up to 24 hours depending on the mission, at speeds of up to 4kt.

In inspection configuration, it also features autonomy failsafes (E-stop transponder, fault and leak detection) and sensor payloads (3D imaging sonar, HD video camera, forward-looking sonar) plus onboard mission data recording.

Future developments of the Marlin include a Mk 3 version capable of operating at depths up to 4,000m. In addition to a full spectrum of conventional survey and inspection sensors, the Mk 3 will employ high-resolution 3D sonar and 3D laser sensors to perform autonomous pipeline inspection, deep-water facility inspection and ultimately long-term surveillance of subsea infrastructure from a field-resident docking station.

'Industrial customers now have the option to outsource monitoring and inspection, rather than needing to develop their own in-house capability.'

OUTSOURCING APPROACH

Industrial customers also now have the option to outsource monitoring and inspection, rather than needing to develop their own in-house capability, offering potential cost benefits.

Active in this field is Sky-Futures, whose inspection provision has recently been expanded with a rapid response service for its North Sea business, enabling operators and contractors access to inspection capabilities in 48 hours.

The company has also set up a safety overwatch service to provide real-time video and HD recording of heavy lifting or other topside operations, with clients able to view the progress from the UAV through electronic goggles.

In a statement, Steve Moir, Sky-Futures' engineering manager and leader of the rapid response service, said: 'With ageing assets and the current drop in oil prices, Sky-Futures understands that, now more than ever, preventing loss of production is critical. Our UAV inspection service is available at short

notice, and for preventative routine maintenance of assets, is both safer and more cost-effective than previous techniques.'

According to Sky-Futures, through the use of a UAV, a recent inspection was able to save a client 700 days of rope inspection work, 40 days of support vessel hire and 28 days of work that would have been required during a shutdown. The inspection ultimately negated the need for a rope access visual inspection that the client had planned previously.

RAPID UPTURNS

In the US, a streamlined FAA legislative process for awarding Section 333 exemptions for the use of UAS for commercial purposes has seen a rapid upturn both in the number of applicants and the options for companies looking at such platforms. Over 600 exemptions had been granted by June this year, nearly a quarter of which were intended for inspection purposes.

Elsewhere, more liberal legislative environments in Europe have enabled commercial UAS operators to enter the market and begin to build their own client base, while China's dominance of the consumer market will doubtless spill over into other areas.

As the continued growth of the global UAS industry, worth north of $4 billion in 2014, is matched by developments on the ground and at sea, so too will future commercial opportunities open up.

For the customer seeking such services, the benefits in using unmanned vehicles for infrastructure monitoring and inspection offer up an attractive set of rewards. With huge savings in time, cost, manpower and increased safety, commercial operations are becoming an increasing part of the unmanned portfolio and providing established manufacturers with other revenue sources, away from traditional military use.

'These benefits of using unmanned systems span air, land, sea and undersea operations… Unmanned systems – whether undersea or airborne – help save lives, reduce risk for operators and increase the efficiency and productivity of commercial operations,' concluded Holmberg. UV

A new launch

Tekever Group unveiled the shipborne AR3 Net Ray UAV recently, putting it in direct competition with some established industry players. Richard Thomas talked to COO **Ricardo Mendes** about the market and the challenges ahead.

The Net Ray maritime surveillance UAV, currently being trialled by the Portuguese Navy and National Guard in exercises and for the European Frontex border security mission, is poised to delve into a market where established defence companies dominate the land and seascape, with Boeing Insitu's ScanEagle platform being the main reference point.

Smaller companies, however, have an advantage over large defence firms in being able to respond more quickly to customer requirements or changes in the market, according to Mendes.

'Our product development cycle is really fast and that is something as we scale up we don't want to lose. We have a very stable production process and the [development] process is based on rapid cycles that take a couple of months each, so it is very easy for us to incorporate the requirements and demands that we see on the market or that the customer requires. So even if the current version doesn't satisfy it, future ones will.'

OPENING UP

Having to compete with platforms already boasting an international customer base was both a hindrance and a boon, he added.

'It is very difficult for a small company to open up a new market – it's very different if it's Boeing doing it.

'Besides having a great product, what they did was open up the market and paved the way for companies like us, but by being smaller we have a fast-moving advantage. We are learning a lot and innovating, and of course customers already know what they are looking for.'

The aircraft itself sits in the middle of Tekever's unmanned product range, and was developed after existing customers requested increased range and payload compared to the then existing line-up, while still keeping things relatively lightweight.

At the end of the process, Tekever produced the 14kg AR3 system that is broadly based on its AR4 and AR5 cousins, sharing the same data links and many onboard systems. A 4kg payload, typically a gimbal with EO/IR, could be kept airborne and gather intelligence for 'at least ten hours', although work on the powerplant could push this up to 14 or 16 hours, Mendes said.

JUST DO IT

He explained that the process to determine how best to exploit the operational potential of maritime surveillance UAS was ongoing. 'The best way to do it is just by doing it, and then seeing how useful the information is.'

To this end, the development path of the Net Ray is still in its infancy, and the aim is to be able to meet changing demands and technological advances as time progressed, according to Mendes.

'A lot of improved versions will come out in the next few years as we gain momentum, as we gain experience and as the [Net Ray] starts being used by more navies.'

'With every mission we learn how we can improve the product. So a lot of improved versions will come out in the next few years as we gain momentum, as we gain experience and as the platform starts being used by more navies.'

As the AR3 gets more exposure and develops new capabilities from experience on deployment with the Portuguese Navy in such places as the Gulf of Guinea, so too will it become an alternative to products already in the market place, explained Mendes.

Tekever also has the capacity to increase production according to demand, up to a rate of around ten AR3 systems per month.

'If there is a clear market need and a clear definition of what a product should be for this market, there is a target for us to compete. There is a market, and very strong competition with few competitors. If you look into it, you have helicopter systems, so VTOL, and then ScanEagle and not much more.

'What we are trying to do is make something technically comparable and generate alternatives for the customer where we see opportunities to improve. We believe that the capability should be more on the software side – it should be more intelligent, have a smaller footprint and be easier to integrate within the vessel. That's what we are working towards, targeting that market, but trying to improve on things that we think could be done better.' uv

THE CENTRE OF THE AEROSPACE INDUSTRY

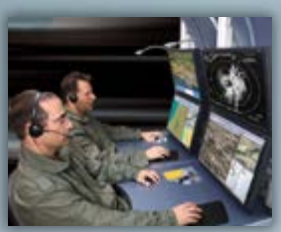
ONLINE VISITOR REGISTRATION NOW OPEN

08-12 NOVEMBER 2015
DUBAI WORLD CENTRAL, UAE

WWW.DUBAIAIRSHOW.AERO/REGISTER

DUBAI AIRSHOW

HERON TP
A powerhouse in the sky



Rely on IAI's HERON TP UAS for utmost versatility and mission flexibility

Backed by over 1,300,000 operational flight hours the Heron TP features:

- Medium Altitude Long Endurance (MALE) mission envelope
- Typical mission payload -1000 kg
- Operational ceiling - 45,000 ft
- Highest safety and reliability
- Operational with Israel's Air Force

IAI

WHEN RESULTS MATTER

www.iai.co.il
info.malat@iai.co.il