THE TRUSTED SOURCE FOR DEFENCE TECHNOLOGY ANALYSIS

ARMADA INTERNATIONAL

SEPTEMBER 2020. Issue 04.

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Publishing Office: Media Transasia Ltd.,
1603, 16/F, Island PL Tower, 510 Kings Road, Hong Kong

Editor-in-Chief: Andrew Drwiega
General Manager: Jakhongir Djalmetov
International Marketing Manager: Roman Durksen
Digital Manager: David Siriphonphutakun
Sales & Marketing Coordinator: Wajiraprakan Punyajai
Art Director: Hatsada Tirawutsakul
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Chief Financial Officer: Gaurav Kumar

Advertising Sales Offices

FRANCE/SPAIN
Stephane de Remusat, REM International
Tel: (33) 5 3427 0130
E-Mail: sremusat@rem-intl.com

GERMANY
Sam Baird, Whitehill Media
Tel: (44-1883) 715 697 Mobile: (44-7770) 237 646
E-Mail: sam@whitehillmedia.com

UK
Zena Coupé
Tel: +44 1923 852537, zena@expomedia.biz

NORDIC COUNTRIES/ITALY/SWITZERLAND
Emanuela Castagnetti-Gillberg
Tel: (46) 31 799 9028
E-Mail: emanuela.armada@gmail.com

RUSSIA
Alla Butova, NOVO-Media Ltd,
Tel/Fax: (7 3832) 180 885 Mobile : (7 960) 783 6653
Email :alla@mediatransasia.com

USA (EAST/SOUTH EAST)/CANADA (EAST)
Margie Brown, Blessall Media, LLC.
Tel : (+1 540) 341 7581
Email: margiespub@rcn.com

USA (WEST/SOUTH WEST)/BRAZIL/CANADA (WEST)
Diane Obright, Blackrock Media Inc
Tel : (+1 858) 759 3557
Email: blackrockmediainc@icloud.com

INDIA
Sanjay Seth
Global Exposures
Tel: +91 11 466 96566 Mob: +91 9818 697279
Email: sseth.globex@gmail.com

TURKEY
Zeynep Özlem Baş
Mob: +90 532 375 0046
Email: media@oz-ist.com

ALL OTHER COUNTRIES
Jakhongir Djalmetov
Media Transasia Limited
Tel: +66 2204 2370, Mobile: +66 81 6455654
Email: joha@mediatransasia.com

Roman Durksen
Media Transasia Limited
Tel: +66 2204 2370, Mobile +66 83 6037989
E-Mail: roman@mediatransasia.com

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WE NEED TO TALK ABOUT PANTSIR

How has electronic warfare made Russia's Pantsir air defence system so vulnerable?
KBP's Pantsir (NATO reporting name SA-22 Greyhound) series short-range air defence system was thought to have entered service with the Russian armed forces from 2005.

IMPORTANT DECISION FOR GERMANY AS A TECHNOLOGY BASE

Sensor systems supplier HENSOLDT has welcomed today's decision by the German Bundestag to develop the new AESA (= Active Electronic Scanning Array) radar for the entire German Eurofighter fleet as a positive signal for Germany as a technology base and for successful European cooperation in the defence sector.

SURVIVABILITY THROUGH DIGITAL STEALTH

Can reprogrammable electronic warfare systems provide protection for tactical aircraft in a dynamic and changing threat environment?

SPACE FOR GROWTH

One year after launching its first three RF sensing and geolocation satellites, Hawkeye 360 is planning a major enlargement of its constellation.

Editorial

AMERICA EXPECTS... BUT WILL THE UK DELIVER?

On Monday 13 July during a visit to the United Kingdom, US Secretary of the Army Ryan McCarthy and British Minister of the Armed Forces James Heappey signed a Memorandum of Agreement (MoA) which establishes the intent to jointly modernise both the British and US Armies.

Heappey stated that "global Britain remains the United States partner of choice." This is perhaps not surprising since an increasing amount of US made equipment has been bought by the British government for the UK armed forces over the last decade and more. Looking at just the Royal Air Force, it has been equipped with the Lockheed Martin F-35B fighter, Boeing's P-3A Poseidon MRA1 and C-17 transport, General Atomics MQ-9A/B Reaper/Protector, RC-135 Rivet Joint, Boeing Apache attack helicopters and CH-47 Chinook transport helicopters and others.

Following the signing of the MoA it now looks like a significant additional chunk of US centric warfighting materiel will be added to the UK's inventory. The Department of Defense (DoD) has already established its 'Big Six' requirements for the US Army.

These fall into six broad categories: Long-Range Precision Fires (LRPF), artillery and long range missiles; Next-Generation Combat Vehicles (NGCV)- manned and unmanned; Future Vertical Lift (FVL) — next generation high-speed rotorcraft; the network - the hub that will centrally coordinate military forces; Air & Missile Defense (AMD); and Soldier Lethality (SL) - improved equipment of all descriptions.

So the UK will be mirroring a good proportion of the US Army's stated requirements over a period from 2023 to 2027. This is how the UK Ministry of Defence (MoD) sees the benefits behind the MoA:

- Networks, the shared development of digital infrastructure to support UK/US operations;
- Long Range Precision Fires, improving the bi-lateral capability development;
- Future Vertical Lift, creating closer affiliation in the development of helicopter capability;
- Soldier and Ground Lethality, building on the existing collaboration to improve the effectiveness of land forces; and
- Assured Positioning, Navigation and Timing (APNT), providing greater coherence in the development of multi-domain technologies.

It is not immediately clear how UK industry will benefit from this joint modernisation, something that will have to be scrutinised closely over the next couple of years.

McCarthy stated at the signing: "This partnership allows costly and complex problems to be distributed and helps protect the industrial base through enabling faster innovation and cost-sharing towards achieving our modernisation priorities.

Speaking about the United States, he stated that "in the last four years we have restored readiness in the US Army; we had only a handful of our Brigade Combat Teams at readiness and today we have just over half of them at the highest levels of readiness".

One of the eye-opening statements that followed was when McCarthy revealed that around $50 billion had been allocated to modernisation over the next five years "to finance our ambition in the midst of flat budget and fiscal challenges that will face us in the years to come." This will be to meet near-peer competition and violent extremist organisations, as well as to replace equipment that has been with the Army over the past 40-50 years - "we just cannot engineer another ounce out of these systems."

In terms of collaborating over joint modernisation, McCarthy said that discussions in the remainder of the year between US and UK representatives would be presenting opportunities for economic as well as military development.

Quite whether the UK Government can afford to keep pace with US military expectations through its expected Integrated Review (replacing the Strategic Defence and Security Review), while trying to recover from the COVID crisis as well taking the economy forward following the withdrawal from Europe, remains to be seen.

ANDREW DRWIEGA,
Editor-in-Chief


US Army

The US Army has returned the MLRS to Europe 13 years after it was withdrawn, now with upgraded software delivering advanced interoperability and faster firing.

SENSOR FOCUSED FIREPOWER

Major General Ken Kamper, Commanding General of the US Army Fires Center of Excellence explains the refocusing of 'fires' from COIN operations to peer-to-peer warfighting.

By Stephen W. Miller

"We are re-orienting Army fires from predominately fighting counter insurgency (COIN) to do all the things field artillery and air defense artillery need to do in large scale ground combat operations," says Major General Ken Kamper, Commanding General of the US Army Fires Center of Excellence (FCoE) and Fort Sill, Oklahoma.

"Our COIN focus over the last 17 years was necessary for that specific threat, but caused a degree of atrophy in our capability to shape the battlefield in depth while simultaneously supporting the close fight during large scale combat operations," he adds.

MGen Kamper, a West Point graduate, has served 31 years in command positions from battery to brigade and most recently as deputy commanding general of the III Armoured Corps. He assumed command at Fort Sill in March of 2020.

The FCoE is the home of both the field artillery (FA) and air defense artillery (ADA) schools training soldiers and marines in tactics, techniques and procedures for the employment of fire support and air defense systems in multi-domain combat operations.

CHANGING DOCTRINE

According to MGen Kemper, "the COIN environment was primarily brigade centric, but our doctrine is steering us towards re-examining our roles at the division level and higher. We must be able to support the close fight while shaping tomorrow's brigade fight today."

"A unique advantage of artillery has been its ability to provided massed firepower from dispersed sites against critical targets on demand," he says. "This capability is an essential requirement as we look at the anticipated nature of future battlefields. This is a skill set that we are focusing on here at the centre and across the Army as we shift toward readiness for large scale ground combat operations."

A critical part of this expanding role is the contribution of artillery fire support teams in planning and executing Joint Fires in support of cross-domain warfare, as today's threats exist on land and in sea, air, space, cyberspace, and the electromagnetic spectrum. "Regardless of domain, we have a role in establishing conditions favourable to allowing joint enablers to dominate in any environment. A large number of these engagements would not only require greater ranges and payloads but refining of targets, fire control and integration of ground and air assets," he explains.

Gen Kemper uses the fighting that has been witnessed in the Ukraine as an example of the renewed focus on "the challenges of peer-on-peer threats and the increased lethality and tempo of operations demonstrated there."

NETWORKED SHOOTING

"A keystone of the Army's approach to the future fires battle is perfecting what we refer to as 'any sensor – best shooter'. The objective is to achieve an integration of networked target detection sensors with available delivery systems. It should then be possible to task the fire mission to the weapon or weapons most suited to serving that target," explains Kemper. "An important aspect in achieving this is refreshing the capability to provide what was referred to as the artillery's general support role."

The Army is increasing the number of its Lockheed Martin M270 Multiple Launch Rocket System (MLRS) and M142 High Mobility Artillery Rocket System (HIMARS) from around 400 to over 600 systems. As part of this new emphasis the Army began to reintroduce the M270A1 MLRS to its forces in Europe with reactivation of two MLRS Battalions, the 1-6 FA and 1-77 FA which was completed in 2020.

Major General Ken Kamper is the Commanding General of the US Army Fires Center of Excellence (FCoE) and Fort Sill, Oklahoma.

US Army Europe reactivated the 41st Field Artillery Brigade in Germany in November 2018 with the the 1st Battalion, 6th Field Artillery officially reactivating on 19 September 2019. The next battalion, 1-77 FA, is slated to reactivate in fall 2020. This is the only US Army rocket artillery brigade in the Europe.

According to a US Army statement on 10 January, the MRLS features a new Software System Suite Version 7.11a. The Strategic and Operational Rockets and Missiles Project Office (STORM – formerly Precision Fires Rocket and Missile Systems) and the US Army Combat Capabilities Development Command Aviation & Missile Center's Systems Simulation, Software and Integration directorate, jointly developed, tested and fielded this government-owned launcher software. "The updated software provides advanced interoperability and faster firing reaction times for the warfighter while also meeting the Army's modernisation priority," stated the release. The 41sty FA can access the systems, modelling, analysis, requirements and test lab at the FCoE in Fort Sill. Jeff Froysland, senior field artillery specialist for MLRS Systems, said that the connection back to the FCoE was were useful: "The SMART Lab provides round the clock software support ... When there is a software issue, our team can troubleshoot in real-time to resolve it."

AIR DEFENCE

Army air defence artillery is also undergoing a true resurgence, especially in the tactical battle space. The relatively

US Army

The 1st Battalion, 6th Field Artillery, 41st Field Artillery Brigade began training with the new M270A1 MLRS in Germany at the beginning of 2020. They can access the test lab in Fort Sill at any time to work through any software issues.


US Army

The Army is looking to operate 144 Interim Manoeuvre Short-Range Air Defense platform (IM-SHORAD) units when they are eventually fully tested and approved for service.


US Army

During Network Integration Evaluation 18.2 at Camp McGregor, N.M., Maj. Gen. Kenneth L. Kamper (right), when he was deputy commander for manoeuvre for III Corps and Fort Hood, Texas.

secure airspace in the COIN environment resulted in the reduction of short range air defense capabilities. Given the current and anticipated future manned and unmanned aerial threats, rebuilding these critical air and missile defense capabilities are a top priority. Programmes such as the Interim Maneuver-Short Range Air Defense (IM-SHORAD) are fielding immediate solutions to meet near term needs while pursuing even more comprehensive approaches and are undergoing fast-track development and testing.

IM-SHORAD had been due to complete developmental testing by June, but this had been delayed due to the COVID-19 virus and challenges with the software development process. It has been designed to deliver 360 degrees of air-defense protection through a mix of guns, missiles, rockets, and onboard sensors. According to an Army statement, a total of 144 systems will operate in four battalions during the initial acquisition phase by the second quarter FY2023.

Gen Kamper particularly emphasises the importance of preparing artillerymen for the intricacies of the next battle. "We need to establish a culture of resiliency that reflects Army values in artillery leaders at every level," he shared. "This means achieving and maintaining proficiency in the fundamentals of artillery tactics and procedures at the small unit, section and battery level. Fundamental field artillery and air defense artillery skills remain equally essential on the future battlefield. The Army is working to restore the capabilities to apply fires at operational and strategic levels. In addressing this gap the Army has identified needs for new equipment, doctrine, techniques, and organisation. The efforts under way in each of these areas are major parts of what makes this a transformational opportunity for the artillery community."

In closing Gen Kamper states: "Though we teach the technical knowledge and tactics necessary to dominate in any domain, those skills are only as good as the servicemen and women that employ them. We have a critical role here at the Fires Center of Excellence, particularly as we turn civilians into soldiers, to really help maximise human potential." A

Tawazun

The Sustain & Enhance Emiratisation in Defence & Security (SEEDS) MoU was signed by Dr. Fahad Al Yafei (right), president platforms & systems, EDGE, and Matar Ali Al Romaithi (left), chief economic development officer of Tawazun Economic Council.

EDUCATION FUELS DEFENCE SECTOR GROWTH IN UAE

The United Arab Emirates government has created opportunities for its own citizens and for international industry partners to create and grow an indigenous defence industry that not only adds value to existing IP, but is an innovator and IP owner in its own right.

By Andrew Drwiega

One of the challenges of starting a new industrial sector in a developing country, both for the national government and for international OEMs and tier industries, is to find enough local 'talent' to stay and grow professionally with the sector as it becomes established.

In the United Arab Emirates, Emiratisation has long been an ambition of the government. With a smaller local population compared to the number of expatriate residents in the country, the aim has been to encourage Emiratis to begin and grow their careers in the public and private sectors.

One organisation that has this as a principle goal is the Tawazun Economic Council, described as 'the defence and security industry enabler responsible for the creation and development of a sustainable industry in the UAE'. Its economic programme seeks to attract both local and foreign finance to fund the continuous development of the sector, while promoting technology and knowledge transfer.

One of its initiatives is called Sustain & Enhance Emiratisation in Defence &

UAE technology and defence group EDGE have now fully acquired the MRO business AMMROC from Lockheed Martin.

Security (SEEDS). In short, it assists international defence related companies to offer internships and job placements to qualifying UAE nationals.

In March this year, the Abu Dhabi based advanced defence technology group EDGE signed a Memorandum of Understanding (MoU) with Tawazun to offer UAE nationals the opportunity to join some of its technology development programmes. Internships and jobs would be offered to high performing individuals allowing them to gain experience working on advanced technology, defence and security projects through the SEEDS programme. The MoU was signed between Dr Fahad Al Yafei, President - Platforms & Systems, EDGE, and Tawazun's Matar Ali Al Romaithi.

Areas of priority identified by the SEEDS programme include systems engineering and architectures, modelling and simulation, component and module technologies, RF sensor technologies and applications and others.

EDGE has over 12,000 employees spread across 25 companies with revenues around $5 billion. The organisation will be recruiting and training UAE nationals from a selection of the country's respected academic institutions including Khalifa University, Abu Dhabi Polytechnic, United Arab Emirates University, and the Higher College of Technology. Their target students are those who are studying for degrees in engineering and computer science.

On 21 July, EDGE announced that it had acquired the remaining 40 percent stake in the Advanced Military Maintenance Repair and Overhaul Centre (AMMROC) from Lockheed Martin/Sikorsky making it a wholly owned UAE company, although a number of commercial agreements will remain.

AMMROC is the authorised regional service centre for Lockheed Martin's C-130 Hercules transport aircraft. In addition it provides MRO services for F-16 and depot MRO hub support for UH-60 Black Hawk helicopter components.

"Lockheed Martin and Sikorsky have played a pivotal role in developing the UAE's MRO capabilities. As EDGE assumes full ownership of AMMROC and continues to pursue the military and civil MRO market with specialist skills, we recognise that such achievements are the outcome of our international partnerships," said Faisal Al Bannai, CEO and managing director of EDGE.

EDGE has five different technology clusters: platforms and system; missiles and weapons; cyber defence; electronic warfare and intelligence; and mission support. Many companies within these clusters are seeking to export their products such as Nimr's JAIS 4×4 infantry fighting vehicle.

PATH TO THE FUTURE

On 13 July, the organisers behind Abu Dhabi's Global Aerospace Summit held a webinar to discuss Technology Transfer and Building the Defence Sector - Challenges and Opportunities.

Matar ali al Romaithi, chief economic development officer, Tawazun, said that in order to develop the defence sector, Tawazun was "looking at three pillars to develop technology in the country and make partners more keen to share their technology and Intellectual Property (IP)."

Firstly he said that investment in people was very important. Then came organisation and legislation to allow development to take place and be recognised. Finally he pointed to the need for the right level of systems and technologies to allow development to take place.

"In terms of technology, the UAE has become very competitive in the region, with educated people...and finding the right way of applying technology," he said. He added that simply buying IP had not been seen as a practical solution. Instead, the UAE Government had "started [by] building manufacturing capability and then evolving the defence industry by attracting the right partners."

"The UAE has been so focused and evolved this process...there is a level of maturity and experience that sets the model for the rest of the region," said Robert Harward, CEO Middle East, Lockheed Martin. He said that IP had to be evaluated in terms of what's its worth and cost, and that there were many stakeholders to consider including governments.

Harward said that Lockheed Martin's policy was to link interns with company engineers and their projects to do "on the job training." He added as that mentoring continued the interns grew into one of the more

NIMR, an EDGE company, manufactures, assembles and sells a range of armoured and unarmoured military vehicles on the export market.

In July, the Emirates Space Agency sent its own space orbiter on a mission to Mars.

important aspects of the IP. The process would allow an Emirati engineer to replace an expatriate engineer.

The development of drones, cited Harward, was not simply a matter of the IP and concept but more how they would fit into the overall defence industry picture as well as the military concept of operations. They had to demonstrate a path from initial concept through to procurement then integration into the military system.

One of the issues faced by developers outside the United States is how to get their products validated and acceptable to the US Government. Once that is achieved, said Harward, the US Government is more able to support and understand that technology and speed up the process for it to integrate into the defence business.

Alan Davis, CEO, Raytheon Emirates, said that there was no limit to where the UAE national aerospace and defence community could go. Raytheon has been in the UAE for 30 years and he said that was just the beginning.

Davies stated that Tawazun had moved offset from a transactional relationship to a value proposition. "We end up investing as partners with technology, match it with training and leadership which allows us to develop new missions, markets and capabilities leading to business outside the UAE."

Back in 2019, Davies had revealed that Raytheon Emirates would be helping to establish cyber academies and a 'cyber range' which would assist the UAE Government to identify, engage and defeat threats as they emerged.

Jay Little, vice president, Collins Aerospace said that he had he preferred the phrase 'localisation' to 'technology transfer.' Little also talked about the benefit of employing local talent "where we can create solutions for local customers" easier than doing it from the headquarters back in the US.

In addressing the question of barriers to effective technology transfer, al Romaithi said that "the link between industry and academia had been missing, particularly with regard to long term planning." However, the Government policy in dealing with international partners not only in hiring UAE nationals through projects like SEEDS, but in ensuring that those people had the right expertise through the educational process to begin, was making them attractive to prospective employers. He added that the mix of international cultures that were well established within the UAE allowed good understanding. The SEEDS programme is making the "human capital grow as we go," reminded al Romaithi.

However, Harward voiced concern that although people were the most important component, there was a capacity issue as they were the hardest. Forming a career path for them that they wanted to pursue in terms of staying for years and growing 'in place' was sometimes a challenge. "When they got to the end of their project they turned around and said they wanted to go and start their own business. But I need you to be committed to this business for five or six years. We have got to make that career path, enticing, realistic and something they believe in because when you talk about capacity we are all competing for that same gene pool."

In terms of identifying technologies that the UAE is prioritising, Davies said that it starts with Defence Technology Security Administration (DTSA) approval. In the US, the DSTA 'administers the development and implementation of Department of Defense (DoD) technology security policies on international transfers of defence-related goods, services and technologies.' "We have already had an audit in the UAE working with the Minister of Defence and have the right procedures to guard both US and UAE technology," stated Davies. This allows UAE industry to continue to have access to that technology.

Davies noted that space is one sector that is going forward quickly, between five and 20 years ahead: "We are going to be focused on regional security, but the technology associated has multiple application." He said that all of the mainstream companies were active in the space sector, and enabling that technology in the UAE would lead to international opportunities. "Nobody is going to get to space by themselves; it is going to be a collaborative effort. Nobody will get to Mars by themselves."

Underlining that fact was the launch on 20 July 2020 of the Emirates Mars Mission which involves sending an orbiter named *Hope* to Mars. Headed by the United Arab Emirates Space Agency through the Mohammed bin Rashid Space Centre (MBRSC), it has been a collaborative effort between the MBRSC and the Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado Boulder, with support from Arizona State University (ASU) and the University of California, Berkeley. It was assembled at the University of Colorado. "This has been a great success at a very difficult time," added al Romaithi, referring to all of the problems caused by the COVID-19 virus.

Little confirmed that the UAE needed to do work at a national level: "We need to do the innovation and technology development locally so it is not ITAR controlled or by another third party but Emirati controlled, so they can control their own destiny around their networked communications and security," he said. "Then they will be able to export their creation."

He added that Collins had technology that was not ITAR controlled through its civil business that could be transferred that could then be the subject of local innovation and subsequently exported. A

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Leonardo

Leonardo's AWHero UAV flying from the Italian FREMM *Virginio Fasan* during the NATO exercise *Ocean 2020*.

BRIGHT HORIZONS FOR MARITIME ROTARY UAVS

Naval rotary unmanned aerial vehicles are a reality. From mine countermeasures to ISR and beyond, the number of players in the maritime market is growing.

By Andrew Drwiega

NATO's *Ocean 2020* Exercise, led by the Italian Navy, was designed to demonstrate how collaborative autonomy between multi-domain unmanned air, surface and sub-surface vehicles could result in information being gathered, and so proving their worth as force multipliers.

Among the objectives of *Ocean 2020* was the improvement of maritime situational awareness through the integration of unmanned systems and Intelligence, Surveillance Target Acquisition and Reconnaissance (ISTAR) capabilities, as well proving interoperability between heterogeneous systems.

Rotary unmanned aerial vehicle (RUAV) assets used included Leonardo's SW-4 Solo and AWHero platforms. The information collected was integrated with existing ship based sensors to create a recognised maritime picture (RMP). Other unmanned assets included surface and subsurface vehicles.

Information was shared with the prototype European Maritime Operations Centre (EU MOC) in Brussels as well as among a number of national MOC's located in Rome and Taranto in Italy, Athens in Greece, Cartagena in Spain and Lisbon in Portugal. Five naval vessels formed the large naval task group including the Italian Naval frigate *Virginio Fasan* which operated the AW Hero.

Roberto Pretolani, Leonardo's RUAV marketing manager, speaking from the Fasan during the exercise, explained that the AWHero is a 200kg class system. "It has six hours of endurance (with a 35kg payload) which can operate datalink at 50 nautical miles (nm)." The RUAV Hero being used during the exercise was equipped with a 10 inch gimbal camera with electro-optical/infrared (EO/IR), and an AIS maritime transceiver, which allows it to integrate into the ships combat management system.

According to Leonardo, the AWHero "is the only rotary UAS in its class going through a military certification process. It represents the company's best technologies combined into one platform: air platform and systems, sensors, datalink, data processing and analysis, and cyber security.

For the maritime ISR mission, it can be fitted with Leonardo's Gabbiano Ultralight Maritime Radar. Weighing 24kg it operates off 450W through a 28VDC power source.

The AW Hero was partnered with the other Leonardo platform, the AW SW-4 Solo optionally manned helicopter, to achieve multi-source data integration. Being substantially bigger, the SW-4 has a MGW of 3.968lb (1,800kg) and a maximum cruise speed of 111kts (206km/h) with up to a five hour endurance with a 100kg payload. The SW-4 Solo took its first unmanned flight in February 2018.

A Leonardo statement indicated that the AWHERO "accomplished all its four planned missions on board the Italian Navy's FREMM *Virginio Fasan*. These including automatic take-off and landing procedures from the vessels' bridge, and in mission terms it detected, tracked and identified the intruding vessel. Data was also sent to an NH90 helicopter during part of the exercise.

V-200 ORDERS

UMS Skeldar has met with success in placing its V-200 UAV with international navies as part of a Naval Group/ECA Group inspired 'toolbox' approach to mine countermeasures (MCM). The Belgian


Leonardo

Leonardo's AWHero conducted four planned missions including detecting, tracking and identifying an unknown vessel.

and Royal Netherlands Navies are equally sharing 12 new mine hunters which will be equipped with a 'toolbox' of unmanned options including air, sea and sub-sea unmanned vehicles in an autonomous mine detection and clearance package.

As well as the UMS Skeldar V-200 rotary UAV, the package includes unmanned surface craft, the USV INSPECTOR125, which can deploy the Autonomous Underwater Vehicle (AUV) A18M, towed T18 sonars for mine detection, as well as SEASCAN identification and K-STER neutralisation robots. Part of the V-200's appeal is that it can also act as a communications relay between various platforms and the host vessel. The contract agreement with UMS Skeldar is for 10 V-200 systems with deliveries expected to begin in 2023.

A standard operating package would comprise two V-200 UAVs and a ground control station. The UAV's heavy fuel engine is manufactured by German company Hirth Engines, which UMS Skeldar acquired in May 2018. This engine gives the V-200 a maximum speed of around 81 knots (150km/h) and a service ceiling of nearly 10,000 feet (3,000m).

This success for UMS Skeldar follows earlier section of the V-200 by the German and Canadian Navies. For both of these customers, the V-200 will provide an unmanned intelligence, surveillance and reconnaissance (ISR) capability.

The Canadian version, acquired in 2019 through Qinetiq Canada will also be made available to Canada's special forces. It will feature an Active Electronically Scanned Array (AESA) radar and Electro-optic infrared (EO/IR) camera.

The German Navy provided UMS Skeldar with its first win in August 2018, through main contractor Elektroniksystem- und Logistik (ESG). The V-200B is now operating off German Navy Corvette Class 130 vessels.

VRS700: DECK LANDING'S BECKON

On 28 July, the second prototype of Airbus Helicopters' VSR700 had its first free flight just over nine months since its first tethered flight. The flight of 10 minutes was made at the test facility near Aix-en-Provence in the south of France, close to the Guimbal factory where the aircraft platform originates.

"This now opens up further testing toward the full flight domain," said Nicolas Delmas, UAS and VRS700 programme director, in an exclusive conversation with AI. "Airbus Helicopter is taking a step-by-step approach to the development of this

UMS Skeldar's V-200 rotary UAV has been selected as part of the naval mine countermeasures 'toolbox' capability led by Belgium Naval & Robotics, a consortium including Naval Group and ECA Group

UMS Skeldar

UMS Skeldar's V-200 UAV has been selected for the Belgium/Netherlands (BE/NL) next-generation offboard mine countermeasures (MCM) programme.

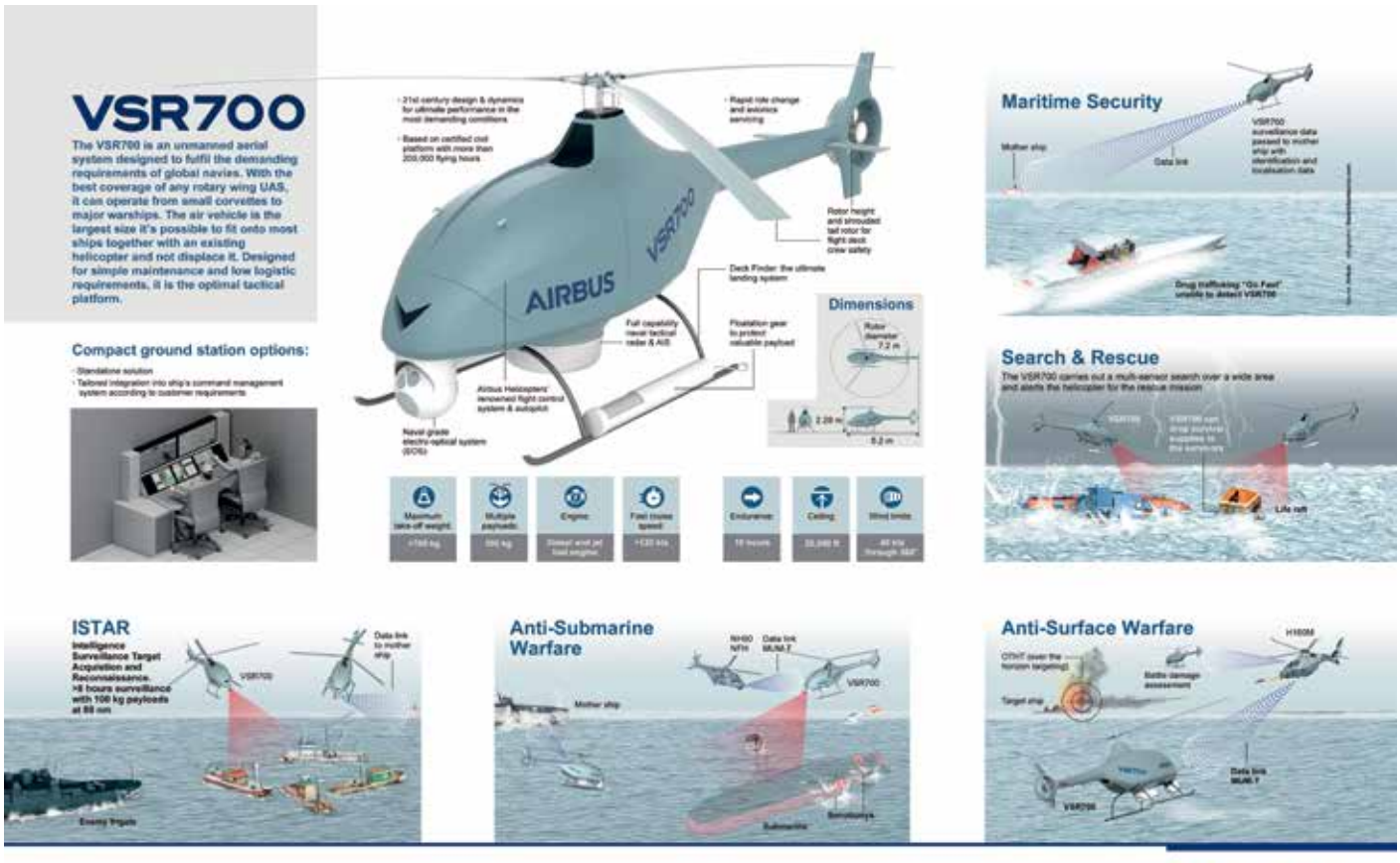
prototype VS700 unmanned aircraft," he said.

Back in 2013, Airbus began optionally piloted trials with its EC145 aircraft which Delmas describes as 'an important first step.' "That is when we started working with the Intelligent Flight Control System (IFCS), one of the key technologies when you are developing drones," he stated.

The selection of the Guimbal Cabri G2 helicopter as the baseline for the development of the VSR700 took place in 2017 after Airbus signed up to a de-risking study with the Directorate General of Armaments (DGA) to develop the UAV for the French Navy.

From 2017 the development programme began to run at full pace and the agreement will last until 2022. "We expect them to trigger the next phase after that," said Delmas, adding that this would then take the UAV capability into full production and service.

The Guimbai Cabri G2 was selected as the platform of choice for the VSR700 because "it was the best compromise in terms of weight, performance, maintenance costs and operating costs. It embodied the



Airbus Helicopters

Airbus Helicopters is making steady progress with its VSR700 UAV towards deck-landing trials with the French navy in 2021.

AIRBUS

segment in which we should be for future rotorcraft drones," Delmas said. He added that "it also has good flight performance thanks to its three-blade rotor, which is especially important when taking off automatically from a ship." The VSR700 is in the 500-1,000kg (1,100-2,200lb) weight class and will be able to carry a variety of naval sensors. Endurance is billed as between eight and 10 hours, depending on the payload up to around 100kg.

The Cabri G2 has already sold over 200 units and has over 200,000 flight hours, which was another factor that led to its selection. "We have not started from scratch. We have tried not to modify the original aircraft and tried not to make something too complex. We want to keep the DNA of the Cabri," stated Delmas.

However some alternations have been necessary. "The VSR shape has of course been redesigned - a drone is not operated in the same way as a manned helicopter," noted Delmas.

"The engine that we have today is an upgrade of the Cabri G2 initial gasolene engine. We have added some specific additions to the management of the engine [using diesel/jet fuel]."

Naval Group is a co-contractor with Airbus on the project, both organisations working for the DGA. "We compliment each other. Airbus Helicopter is fully responsible for the complete unmanned air vehicle including the mission system inside the air vehicle and the integration of the sensors - the first mission we will perform will be ISR. A We will rely on a two sensor configuration for that. We are working with Thales to deliver the datalink to the air vehicle from the ground station and everything that is linked to the performance of the air vehicle."

The actual tactical air vehicle mission system, and how that integrates with the naval vessel's software and onboard mission system is the responsibility of the Naval Group.

There are currently two prototypes that are flying. The first is close to a Cabri G2 and is capable of flying with a safety pilot and is the Optionally Piloted Vehicle (OPV), but has all necessary avionics and software for unmanned flight without any mission systems. "It is the vehicle we can use to test the avionics and new functions," said Delmas. "In the next months the OPV will mainly be used to keep developing all the navalisation part of the UAV; basically it will finalise all the autonomous flight laws so that it can land and take-off from a ship."

The first free flight on the VSR700 took place on 28 July this year at Aix-en-Provence in France.

The second prototype is the most recent VS700, which is not expected to change that much going forward, but the shape has been optimised to house all the electronics and all of the mission systems. This is the aircraft that has flown the tethered and free flights.

"The sea demonstration is planned but we will begin deck landing trails with its VSR700 later in the year, progressing to sea trials with the French Navy in 2021. At the start of 2021 we will implement the full flight domain on prototype 1 then implement the full mission system that will be used for the demonstration. 2021 will be when the full mission system will be validated prior to the demonstration," confirmed Delmas.

In 2022 Airbus, Naval Group, the French Navy and DGA will redraw their contract to allow for additional activities and to assess the 2021. This will lead to a further refinement of requirements leading to the final end product. "We will be using two prototypes to continue with the French Navy, who would still like a capability as early as possible." said Delmas. A second demonstrator for the French Navy's "Système de Drone Aérien pour la Marine" programme has already been confirmed by the French Ministry of Armed Forces as part of the PlanAero. However, the French Defence Ministry's current budget planning does not see the UAV's entry into service no earlier than 2025. But Airbus will have an ongoing contract to further develop the UAS and is in discussion with the government how that end date might be brought forward.

S-100: AT SEA OR ASHORE

Schiebel has been an early leader in developing its customer base with its well know S-100 Camcopter. In November 2019 the company announced that the S-100 had been integrated with the French Navy Mistral class amphibious helicopter carrier *Dixmude*.

In March this year approval was received for Schiebel's newly designed heavy fuel S2 engine, which will allow the RAN to expand its test and evaluation of the aircraft prior to the Sea 129 Phase 5 programme which will result in the selection of the future UAS capability for the RAN´s new Arafura Class Offshore Patrol Vessels (OPVs).

Having already convinced the Royal Australian Navy (RAN) of its technology - *22X Squadron already operates several units for maritime duties - Schiebel has now teamed with Raytheon Australia for what could be one of its biggest wins to date if its bid for the Australian Land 129 Phase 3 is successful. A

UGVs need to augment soldiers' capabilities to perform various tasks. Rheinmetall's Mission Master with its inherent swimming ability assists infantry to cross a water obstacle.

BATTLEFIELD UGVS MAKE STEADY PROGRESS

UGVs will certainly be a welcome addition to supporting soldiers on the battlefield, but the need for complex systems is still being evaluated.

By Stephen W. Miller

The possibilities for the practical use of Unmanned Ground Vehicles (UGVs) has grown appreciably with the availability of a number of enabling technologies. These include more advanced information processing, digitalisation, compact high resolution video cameras, wireless communication, GPS positioning, hybrid power, and longer life batteries to name just a few. Each provides a critical contribution to building a ground platform that can move under its own power from one point to another with minimal human intervention. This potential capability has been recognised by numerous militaries with an eye to addressing a wide range of tasks both in supporting roles and directly on the battlefield.

Simple 'robots' first appeared in the military in the bomb disposal or EOD role to reduce the exposure to danger of the human EOD technician. These were generally used at close ranges with direct control by an operator. Their success brought widespread adoption by military and security forces and encouraged their use in other missions. Currently, UGVs are primarily focused on four applications: logistics carrier/resupply (often referred to as a 'mule'), reconnaissance, combat, and casualty evacuation/MedEvac. Each task has both common requirements as well as unique challenges.

PROS AND CONS

At its current state of development the UGV is primarily a complement to the soldier. They are controlled by, supplement and enhance soldiers capabilities on the battlefield. A logistics 'mule' like the General Dynamics wheeled 8x8 Multi-

Utility Tactical Transport (MUTT) "can carry 546 kilograms (1,200 pounds) of ammunition, water, extra batteries or support weapons, such as the M4 Carl Gustuav recoilless rifle or Javelin anti-tank missile with spare ammunition" stated a company spokesperson. However the MUTT, which is a contender for the US Army Squad Multipurpose Equipment Transport (S-MET), uses a wireless tethering system that is linked to a soldier within line-of-sight. In April 2020, General Dynamics Land Systems UK delivered two MUTTs to the British Army.

Gert Hankewitz, programme director at Finland's MILREM developer of the THeMIS UGV points out, "autonomous travel by a UGV becomes much more difficult when operating off-road and cross-country which is exactly the environment anticipated by the military. The lack of regular and distinct physical markers as found along roadways complicate the independent recognition of obstacles and waypoints. Its ability is further degraded in darkness and limited visibility."

"Even with an operator in the loop, there are still challenges," Hankewitz continued. "Operators can experience orientation and perception issues in controlling a UAS. Being separated from the vehicle it is easy to become confused as to its travel in relation to their position and its location on the ground. An overhead view display of these relative positions can reduce this but adds complexity."

"Another issue is that a remote operator has no sense of the motion and attitude of the vehicle itself," said Mike Powell of Howe & Howe, designer of the Textron Ripsaw UGV. "The operator has no 'feel' for the forces which the vehicle is being subjected to as it responds to commands." This is further exacerbated by the lack of three-dimensional visual perception inherent in camera video images. As a result, neither on-board driving aids nor the remote operator may recognise a drop-off, such as a ditch or cliff, in front of the vehicle. Powell explained that as a result, "operators will unknowingly push a UGV beyond its limits ... and place it in unstable or unsafe situations that can disable it. In field use, roll-overs are the most common accidents that occur."

General Dynamics Land System has developed the 8×8 Multi-Utility Tactical Transport (MUTT); it is a contender for the US Army Squad Multipurpose Equipment Transport (S-MET) requirement and is also being trialled by the British Army.

CHALLENGES

Brigadier General (ret) Alain Tremblay, vice president, Business Development at Rheinmetall Defence suggested that "building a suitable platform with the mobility and durability needed is well within the capabilities of industry today." The company's Mission Master UGV platform is actually derived from the proven ARGOs recreational all-terrain vehicle that is able not only to move with dismounted troops but can even ford water hazards. "Rheinmetall's focus is on addressing the software challenges related to providing the UGV with even rudimentary decision making capabilities. The complexity of this grows as the mission tasking of the UGV changes. The cargo UGV may have lower operational expectations than more demanding missions required of a reconnaissance or armed UGV. Tasking a UGV to autonomously evacuate a wounded soldier needs the added assurance that the vehicle will reliably go where it is directed and safety delivery the casualty. The objective is to provide a UGV with a command that it can execute with little or no human intervention"

AFFORDABILITY

Various nations' militaries are taking different approaches to the use of UGVs. The United Kingdom would like to employ them on mass almost as a consumable, while the United States and Australia seem to be seeking more sophisticated, and therefore costly, systems. In either case price is a major consideration since a basic rationale of the UGV is that it should be fielded in sufficient numbers so as to supplement and/or replace manned systems in some tasks. However, as Tremblay reflects, "they also need to be sufficiently affordable to allow them to be put at risk without concern over losing a high cost asset."

One approach toward moderating the price of the UGV is in providing a common package that can be utilised in each of the roles for which it is intended to be configured. The Milrem THeMIS uses a common platform. Hankewitz explained that it is "designed to be reconfigurable for different roles by adding modules. Further, the system is configured so as to be upgradable by accepting new technologies and improved components such as fuel-cell batteries and software."

Shawn Davy technical director Advanced Programs at Textron Defence, stated that although the company's Ripsaw

The Milrem THeMIS, here configured for infantry support, is designed to accept whatever attachments or systems a user requires which can be mounted to the frame.

UGV "is a fully purpose built system, it uses a modular 'building block type' approach that allows the base platform to be reconfigured to various roles. This can often be managed at the forward operating base.

Thremblay adds; "currently sensors are the single greatest expense in a UGV covering three quarters of their cost. This is a major price driver." In addition, achieving lower production costs could be difficult as the low numbers of systems that are being requested will limit the ability to apply economy of scale savings.

REAL TIME CONTROL

Probability the greatest challenge to the UGV is achieving a reliable, secure and real-time communication link to and from the UGV. Oleg Martyanov, an ARF manager at Russia's Advanced Research Foundation, was quoted by Russia's TASS news agency when he said that his organisation has begun testing the ability of its Marker UGV to respond to the voice commands of its human operator.

However, senior research officer Andrei Anisimov explained at a conference at the Kuznetsov Naval Academy that "modern Russian combat unmanned ground vehicles are not able to perform their assigned tasks in classical types of combat operations." It has been observed that the effective communication range was often limited to 300-400 metres.

Hankewitz makes the point that "radio frequency control links can be naturally interrupted [by terrain for example], suffer delays in receipt, and are vulnerable to active jamming. Any of these circumstances can result in loss of communications and control." This possibility is of particular concern with UGVs which require human intervention or decision making. The armed UGV, like the Textron Defence Ripsaw RCV Mark 5, is designed to mount stabilised weapons up to 30mm calibre offering firepower equivalent to an armoured fighting vehicle. But the ability of any armed UGV to employ these weapons remains reliant on positive man-in-the loop control.

ARTIFICIAL INTELLIGENCE

Ted Maciuba, acting director Robotics Requirements at the US Army Manoeuvre Centre of Excellence shared that "advances in artificial intelligence are demonstrating increased situational awareness and the possibility for greater autonomy in executing some tasks, although critical decision making requires human intervention. The challenge here is in perfecting a reliable soldier to system


TASS

Russia deployed its Uran-9 armed UGV to Syria in early 2019. Armed with a 30mm auto cannon, coaxial machine gun and able to accept guided Ataka anti-tank missiles, it was essentially a remote controlled armoured fighting vehicle. It reportedly encountered problems in maintaining communications links, operator orientation, and its ability to acquire and define targets.

interface that is more intuitive. Achieving better integration within the UGV functions and with the operator are key," he concluded.

TRANSFORMATIONAL

"The UGV has the potential to transform warfare," stated Brigadier General Ross Coffman, director of the US Army Next Generation Combat Vehicle Cross Functional Team. "I am passionate about the potential contributions that they offer. Yet it is relatively new territory, so it is important to determine what works and what doesn't." The Army is conducting a series of field experiments that place surrogate UGVs into the hand of soldiers to attempt to determine just this. "We need to define what level of autonomy is not just technically possible but what level we actually want or need in the UGV," he stated.

Just as the early EOD robots augmented their human technician operators, most concepts for the wider use of UGVs focus on utilising them to undertake tasks that extend current capabilities as an element of a ground operation. The value of the contribution that a UGV would offer in executing the breach of a defended obstacle, providing observation and security in front of friendly units, or conducting forward reconnaissance is unmistakable. The challenge is in how to accomplish this technically but, more importantly, assure its integration and coordination into the broader actions of ground forces. In this sense the UGV may simply be a new element in the tool kit of combined arms. A

This artist's impression of the PAN-1 satellite betrays some of the spacecraft's important characteristics, such as its C-, Ku- and Ka-band SATCOM collection antennas.

PAN'S LABYRINTH

Unravelling the mystery of the US PAN-1 signals intelligence collection satellite, and UCAV strikes in Yemen.

By Thomas Withington

Like any good covert operator the spacecraft has several monikers; USA-207, P360 and PAN, with the last being the most enigmatic, an acronym for Palladium at Night. PAN-1, as the satellite will henceforth be called, zoomed into the heavens atop a United Launch Alliance Atlas-V rocket launched from Cape Canaveral, Florida on 8 September 2009.

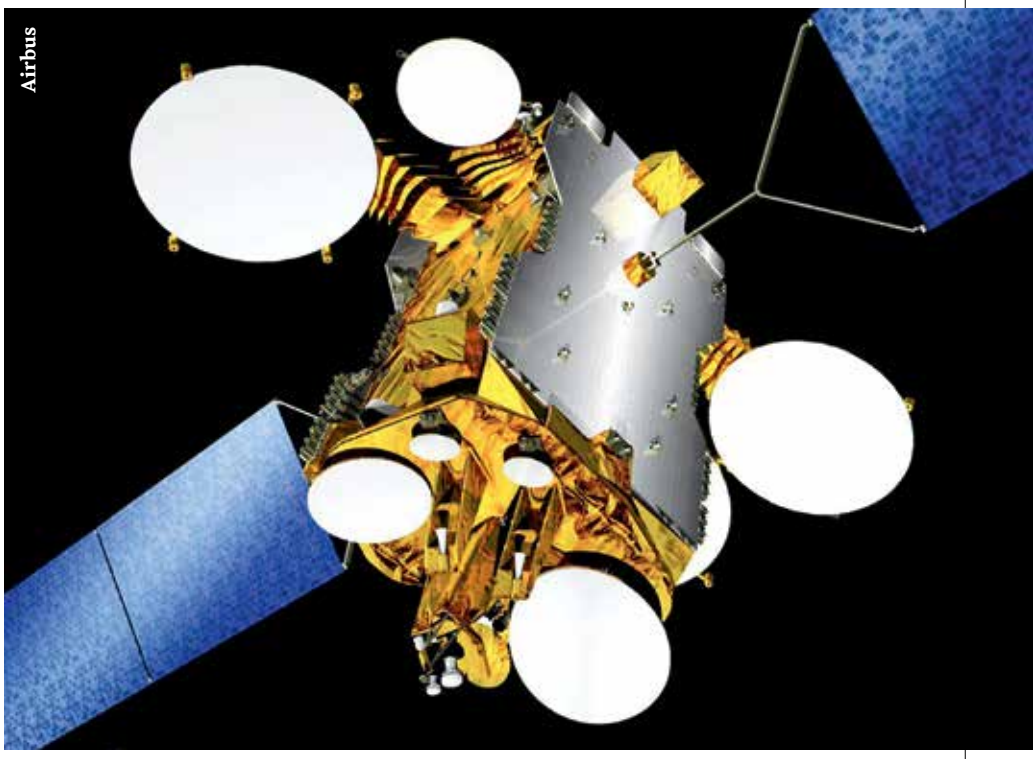
PAN-1 uses Lockheed Martin's A-2100 communications satellite bus. The satellite is in a geostationary orbit where it moves at the same speed as the Earth, around 863 knots (1,600 kilometres per hour). This allows the satellite to loiter over the same area of interest. Initially PAN-1 entered a geostationary orbit over Africa. Satellite watchers noted that the craft was positioned between the meridians of 33 degrees east and 53 degrees east; a position that would cover nearly all the Arabian peninsula and a wide swathe of east Africa, including trouble-spots like Somalia, and the western Indian Ocean. It would be an understatement to say that such areas were of interest to the US intelligence community. Yet the mission of PAN-1 appeared to be slightly more nuanced than simply hovering above some of the world's war zones and listening to the spectrum for the communications traffic from High Value Individuals (HVIs), Pentagon-speak for bad guys. Instead, it appears that the PAN-1 was to hoover up so-called FORNSAT (Foreign Satellite) communications traffic not from Earth but from other satellites, according to redacted documents freely available relating to communications intelligence sharing between the 'Five Eyes' partners of Australia, Canada, New Zealand, the United Kingdom and the United States.

The logic behind PAN-1's mission was fiendishly simple: develop a spacecraft which can be moved in close proximity to a standard commercial communications satellite and, for all intents and purposes, 'overhear' the traffic that they are receiving. Although redacted, the documents noted that the capability in question, assumed to be the PAN-1, would be tasked with "targeting commercial satellite uplinks not normally accessible via conventional means." PAN-1 was launched with a finite amount of fuel onboard allowing the satellite to be moved throughout its

service life, with enough spare fuel for it to eventually be positioned in a 'graveyard orbit' at the end of its mission well beyond the orbital thoroughfares routinely used by operational spacecraft.

The satellite may have been designed to exploit a simple law of electro-magnetics: as a beam is transmitted it widens from its point of origin in a cone-like pattern, like the light flowing from a torch. As a result, a spacecraft like PAN-1 can be moved into the vicinity of another satellite and exploit this phenomenon. By being near the intended satellites, its antennas will be able to receive satellite communications traffic from Earth. Publicly available sources have presented diagrams of the PAN-1 satellite which show its C-band, Ku-band and Ka-band horn antennas capable of collecting COMINT transmitted across the C-band frequencies reserved by the International Telecommunications Union for SATCOM, chiefly the 5.925-6.425GHz uplink/3.7-4.2GHz downlink (C-band), 14GHz uplink/10.9-12.75GHz downlink (Ku-band) and Ka-band (26.5-40GHz uplink/18-20GHz downlink) wavebands.

Keeping track of these bands has meant that PAN-1 has had its work cut out. There is a myriad of spacecraft that carry communications across these frequencies, and since its launch PAN-1 has shown some significant interest in a variety of these satellites. Amateur satellite trackers have kept a detailed log of PAN-1's behaviour. For example, in May 2016, the satellite was discovered in the neighbourhood of the United Arab Emirates' Airbus/Thales Alenia Yahsat-1B/Al Yah-2 communications satellite. This handles Ka-band and Ku-band commercial and military SATCOM traffic. Was PAN-1 collecting COMINT on traffic moving across Yahsat-1B/Al Yah-2? Likewise, the satellite was in close proximity with the Paksat-1 and Hellas Sat-2 birds in November 2010. The Boeing PakSat-1/Pashto-1 was launched in 1998 and leased to the Space and Upper Atmosphere Research Commission, Pakistan's national space agency. Open sources state that the satellite provides C-band and Ku-band communications over the Middle East and Central Asia, and parts of South Asia and Europe. Hellas Sat-2 was built by EADS Astrium/Airbus and launched in May 2013 providing Ku-band coverage across North Africa, the Middle East and much of Europe. Given the coverage that both satellites provided over the Middle East, Central Asia, North Africa and South Asia one can see why the US intelligence community was keen to listen to the traffic flowing across these and other satellites vis-à-vis ongoing US-led counter-insurgency operations following the September 2001 attacks on Washington DC and New York.



One of the target satellites for the PAN-1 has been the UAE's Yahsat-1B/Al Yah-2 with the assumption that the former has been used to collect FORNSAT intelligence from the latter.

TARGETED ASSASSINATIONS

There is an interesting potential correlation between the frequency of attacks performed by US Air Force (USAF) and US Central Intelligence Agency (CIA) Unmanned Combat Aerial Vehicles (UCAV) and conventional airstrikes against targets in Yemen since the PAN-1's launch in 2009. Publicly available figures note that USAF and CIA UCAV attacks, most probably using General Atomics MQ-9A Reaper/Predator-B aircraft, increased in frequency between 2010 (one recorded attack) to 2012 (50 recorded attacks). Between 2013 and 2019 there was an average of 14 attacks annually. How might the PAN-1 be connected to these attacks? Standard interceptions of satellite traffic using ground-based antennas available to the Five Eyes intelligence sharing members may reveal that HVIs such as a known insurgent is using a particular satellite or satellite network to communicate. This will most likely be a spacecraft that they can reach in a line-of-sight range from their location, in this case, somewhere in Yemen. With the satellite network and spacecraft identified, the PAN-1 can be moved within proximity of this satellite so that the former can start collecting COMINT regarding the HVI's transmissions. Importantly, this will allow the satellite to determine the source of these transmissions and hence the possible location of the individual. Such intelligence may provide sufficient detail to determine their location to within a kilometre or so.

Nonetheless, to successfully prosecute what will be a small target, at worst the size of an individual, at best the size of a single vehicle in which they travel, will require a higher level of precision. Traditionally, at least three satellites have been needed to determine the position of an emitter using the Time Difference of Arrival (TDOA) technique. Given that radio signals travel at the speed of light, 161,595 knots-per-second (299,274 kilometres-per-second), by calculating the microscopic difference in time that it takes the same signal to reach each of these spacecraft one can determine the location of an emitter, and hence possibly the person using that

US DOD

The MQ-9 Reaper UCAV has been the platform of choice for the assassination of HVIs in Yemen. Have these attacks been added by COMINT collected by the PAN-1?

device. Recent innovations have shown that this process can be performed with a single satellite; Horizon Technologies' space-based version of its FlyingFish communications intelligence payload being a case in point. It is possible that the PAN-1 may use similar technology to avoid needing more than one satellite to determine an HVI's location.

With the HVI's location determined other platforms like the US Air Force's Boeing RC-135V/W Rivet Joint signals intelligence aircraft can be brought into play. The underside of these jets is festooned with very/ultra high frequency blade antennas enabling the plane's Raytheon Multiple Communications Emitter Location System to determine the position of the HVI with high precision using their SATCOM communications. Equally, other US or allied airborne COMINT gathering assets like the Royal Saudi Air Force's Boeing RE-3A jets are believed to have a similar configuration to the RC-135V/W and could play a similar role. It will then be a matter of tracking the HVI visually as well as electronically either via satellites, inhabited platforms or unmanned aerial vehicles to wait for the optimum moment to strike.

EPILOGUE

What is PAN-1 up to now? Open sources state that the satellite does not appear to have moved from its current position since 2016. At the same time, the spacecraft has not been placed in a graveyard orbit. This seems to indicate that the satellite could be reactivated at a later date should the need arise. Other questions remain. The US National Reconnaissance Agency owns and operates one of the largest SIGINT satellite networks in the world in the guise of its Advanced Orion/Mentor satellites of which seven were launched between May 1995 and June 2016. There is little information about these satellites in the public domain, although it is thought that they are primarily concerned with civilian and military communications intelligence gathering across wavebands of 30MHz to three gigahertz. It is noteworthy that the USA-202/Mentor-4 member of the constellation has been used to collect SATCOM traffic moving across the Thuraya network from Afghanistan and Pakistan after being positioned in close proximity to the Thuraya-2 satellite in 2009 where it remained until 2013. Thuraya's frequencies of 1.525GHz to 1.661GHz would fall squarely within the Advanced Orion/Mentor's remit. If the Advanced Orion/Mentor satellites can eavesdrop on SATCOM traffic why develop the PAN-1 spacecraft? Is it possible that the PAN-1 was needed to plug holes in the COMINT collection gaps the Advanced Orion/Mentor satellites could not cover either because they lacked the necessary payloads, because they were too busy with other tasks or because it would cost too much fuel to move existing Advanced Orion/Mentor satellites to be within eavesdropping distance of the satellites of interest to the US intelligence community. This, like much of the PAN-1 programme, remains shrouded in mystery. We may see declassified documents relating to its mission in the future which may answer some, or all, of these questions. For now PAN-1 seems to be keeping quiet. A

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REVISITING DEFENCE INDUSTRIAL POLICY

Andrew Hunter

The defence industry is often portrayed as a stodgy industry sector where not much changes over time. Its time worn characterisation as 'the military industrial complex,' and the so-called 'iron triangle' between Congress, the military, and defence industry further emphasises its supposedly unchanging nature. But what if this conceptualisation is wrong, and lures us into a dangerous complacency towards the industrial base just at the moment that critical changes are taking place?

The traditional, static view of the defence industry can be hard to reconcile with the pace of change over the last 30 years. The early part of this time period featured massive industry consolidation and the emergence of today's international aerospace primes. This was followed by industry reshaping to respond to the wars in Iraq and Afghanistan and the emergence of highly networked military forces. This era rapidly gave way to a nosedive in the defence sector due to sequestration and defence budget reductions throughout the western world, which was subsequently followed by a period of sharp budget growth in the last four years that may well have already peaked.

A portrait of stasis this isn't, but two factors have supported the idea of defence industry as static: limited and declining competition for major weapon systems and the continued dominance of the big five aerospace primes (Lockheed Martin, Boeing, Raytheon, General Dynamics and Northrop Grumman) with relatively little change in their market shares. Defence industrial policy has also been largely hands-off, with a de facto ban on mergers among the top five defence contractors, but a green light approach to mergers below that level. In fact, mergers, acquisitions, and spin outs have been fairly active at this lower level. The budget bust of 2011-2015 slowed its pace but it has picked up in the last few years with the emergence of new, large prime contractors specialised in defence services and strategic combinations involving major aerospace primes including Northrop Grumman's acquisition of Orbital Sciences Corporation and Raytheon's combination with United Technologies. These deals suggest that the big primes are posturing themselves for major change in their business. I believe these firms are anticipating change with good reason.

One of the most remarkable trends of recent years is the dramatic growth of a new form of government contracting arrangement known as Other Transaction Authority (OTA). OTAs have been around for decades, but they have been used in a very limited fashion by the Department of Defence (DoD) until 2017. The total expended on OTAs in any given year was typically measured in millions, barely visible in a US defence budget measured in hundreds of billions. In the last three years, however, OTA expenditures have grown to become the single largest category of research and development (R&D) spending. In addition, they have expanded usage into both production and operation and maintenance activities. Critically, the vast majority of OTAs are either executed with, or have substantial involvement from, nontraditional contractors. Since OTAs are now the contracting approach of choice for developing new weapon systems, the prospect for newly emergent competitors in defence industry seems not only possible, but likely.

At the same time that OTAs are driving the potential for newly emergent primes, big technology companies such as Google, Amazon, and Microsoft which have long been reluctant to engage closely with the military, are now competing vigorously for government contracts, especially those relating to cloud computing and artificial intelligence (AI). Not only are these firms dominant in their commercial markets, with all the advantages that this dominance confers, they have stockpiles of cash that could allow them to acquire the major defence industry primes. The very real prospect of competition from these firms for some of the biggest upcoming defence contracts suggests the potential for a dramatic reshaping of the defence industry. Before we write off the defence primes, though, it must also be noted that for all the successes that technology firms such as SpaceX and Palantir have had in breaking into traditional defence industry spaces, commercial firms have also started to show their limitations in solving complex problems. From self-driving cars and global space-based internet services to general AI, aggressive technology firms have repeatedly seen their predictions of rapid success stymied. It may be that some particularly hard problems lend themselves to the kind of disciplined technology development that the defence primes specialise in. There may still be a role for these firms at the cutting edge of technology in the 21st century as there was in the 20th century.

If DoD's new investment pattern and developments in industry are signalling the potential for major industry shifts, will DoD leadership remain on the sidelines? Or will it decide to engage with industry leadership to shape the future of high technology in the defence sector? What is needed is a defence industrial policy that welcomes new competitors, drives forward on strategic technologies, manages industry concentration, and preserves critical defence capabilities. A

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