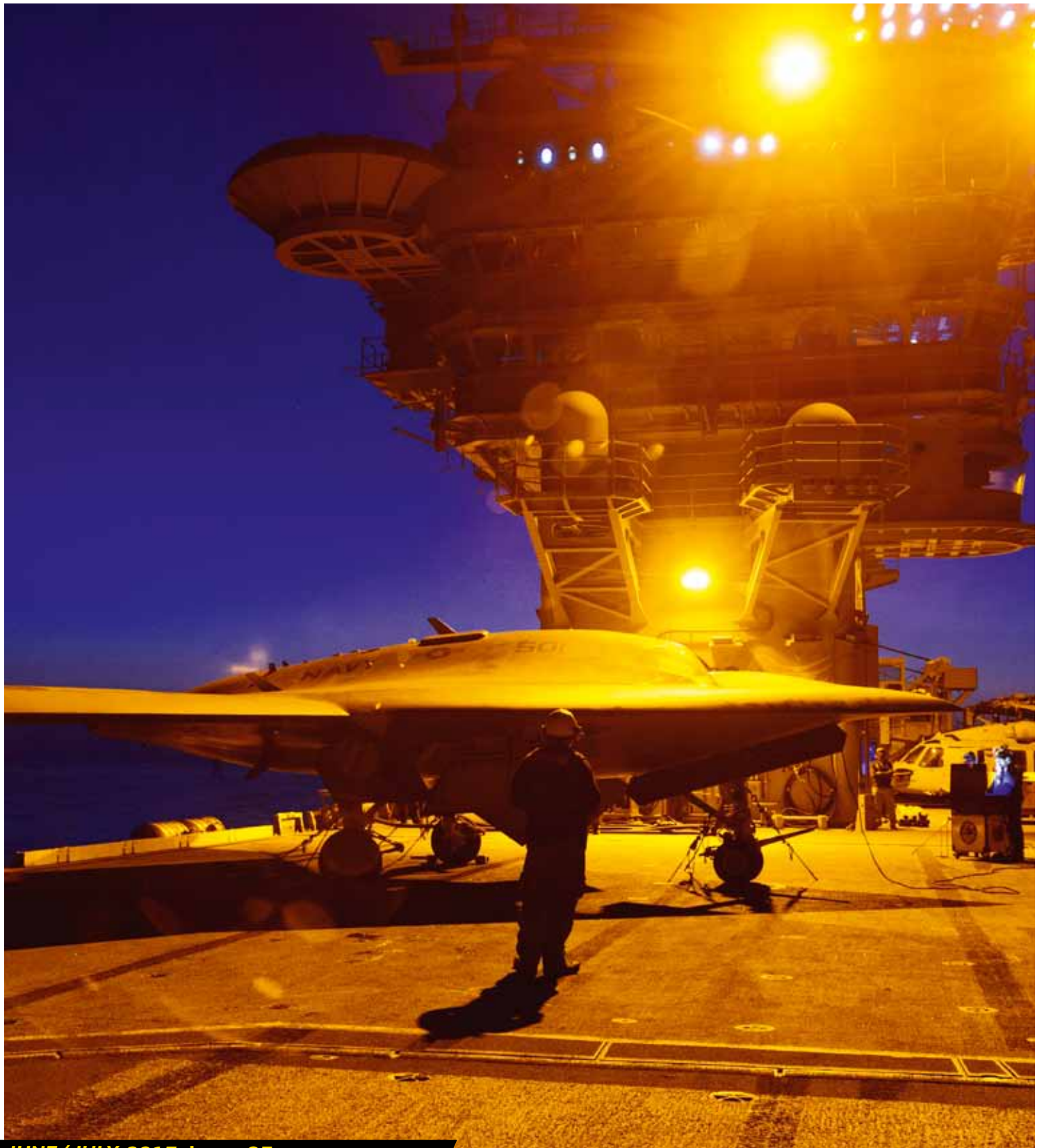
THE TRUSTED SOURCE FOR DEFENCE TECHNOLOGY ANALYSIS

ARMADA INTERNATIONAL



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Editorial

macron economics

On 7th May, France witnessed a famous victory as Emmanuel Macron was elected President of the country smashing his opponent Marine Le Pen from the extreme right *Front National*, winning over 65 percent of the vote, to her 35 percent.

Mr. Macron's victory provoked a collective sigh of relief in many of the chancelleries of power across Europe, not least in that of Angela Merkel. Arguably Europe's most powerful politician, and an ardent supporter of the European Union (EU) Dr. Merkel was among millions of Europeans fearful that a victory for arch-Eurosceptic Ms. Pen could not only bring about the potential collapse of the European project, as distrust of the EU is high in France and Ms. Le Pen had promised a referendum on the country's future membership as an election pledge, but also that her victory could have a seriously adverse effect on French race relations, given the highly inflammatory rhetoric of Ms. Le Pen and her supporters towards France's Muslim population during the campaign.

Away from the EU, Mr. Macron's victory could have strategic implications for France. Although defence was perhaps not as much a priority for French voters as the economic health of the country, or the size of the public sector and public spending, his victory will nevertheless have implications for the French armed forces. Perhaps most importantly, he has pledged to ensure French annual defence spending meets NATO's (North Atlantic Treaty Organisation) non-binding target of two percent of Gross Domestic Product (GDP) annually for its members. This could be tricky as, at the same time, Mr. Macron has pledged to keep France's budget deficit below the EU's annual three percent of GDP limit, while promising to cut corporation tax from 33 percent to 25 percent.

Increasing defence spending will inevitably mean trimming the French state in other areas, and voters might not be keen to see France's generous welfare provisions cut to boost the armed forces, potentially costing Mr. Macron support. That said, he has struck a hawkish tone, promising to stay in the fight against ISIS (the Islamic State of Iraq and Syria) saying during the campaign that his main foreign policy goal was to "kill" that organisation, something that the French armed forces are continuing to do alongside their US-led allies in Iraq and in the Sahel region of Africa. Such tough talk will be welcome words in Washington DC where Mr. Macron and President Donald Trump will be working together to bring about a decisive victory against the ISIS scourge. At home, he has promised extra police officers, up to 10000 in total, to help the domestic counter-insurgency fight. Striking such a robust tone will be welcomed in a significant part of the French electorate given the political violence the country has witnessed over the past two years. Moreover, his efforts could be supported by members of France's Muslim population which has so often taken the collective blame from Ms. Le Pen and her supporters for the actions of a tiny minority. Building trust could help the fight against ISIS at home, as much as increased defence spending will help the fight abroad.

THOMAS WITHINGTON,
Editor

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SAAB TECHNOLOGIES SAAB

Giulia Tilenni

An IRIS-T AAM seen here mounted onboard a Typhoon family fighter of the Italian air force.

SUPERIORITY COMPLEX

The world's air forces deploy a variety of Air-to-Air Missiles (AAM). This article profiles some of the leading European, Israeli and North American efforts for prosecuting within visual range and beyond visual range engagements.

Giulia Tilenni

European nations have been keen to achieve strategic independence in defence technology from the United States since the advent of the Cold War in the late 1940s. Hence, several nations in Western Europe have been developing indigenous platforms such as the Dassault Rafale, Eurofighter Typhoon and Saab JAS-39 Gripen fighter families; all notable examples of this European struggle for independence. True strategic independence in this sector makes sense only if these fighters can employ European-produced AAMs. Diehl BGT Defence's IRIS-T Infrared (IR) and MBDA's Meteor Active Radar Homing (ARH) guided AAMs represent the first two examples of broad European defence cooperation in the air-to-air missile domain. Both weapons were developed within European consortia involving several states and companies, for example, over 200 companies have been involved in the Meteor programme.

IRIS-T

The IRIS-T was developed as a response to a common operational requirement to replace the Raytheon AIM-9L Sidewinder IR-guided short-range AAM. Development of the IRIS-T started in 1996 under German leadership, with that nation covering 45 percent of the costs, and Diehl was chosen as the prime contractor. According to Diehl documents the IRIS-T development phase, which lasted until 2002, included several weeks of trials. Deliveries started in December 2005 and were supposed to end in 2012, although it is likely they are still ongoing. The IRIS-T has been developed as a cutting edge weapon. Its main strength lies in the missile's combination of manoeuvrability and agility and digital integration with a fighter's helmet mounted display. The IRIS-T's technical features, including the optimised rocket motor, provide it with remarkable dogfight capabilities, and it can engage targets within a 13.5 nautical mile/nm (25 kilometre/km) range, at speeds in excess of Mach three. It was reported in May that the missile's manufacturer was developing a fire on-the-move capability for the IRIS-T SLS (Surface Launched Short Range) surface-to-air missile system. The IRIS-T SLS employs the same IRIS-T AAM, and the company has revealed that it has finalised the fire on-the-move concept for the weapon which would include a four-missile launcher mounted on a mobile platform designed in such a fashion as to fire the missiles while the platform is in motion. However, the firm gave no indication as to when this

capability could be ready for procurement along with possible, or existing, customers for such a platform. Furthermore, towards the end of 2016, the Royal Norwegian Air Force (RNAF) commenced flight tests of a new air-to-surface capability for the IRIS-T. During flight tests in September 2016, a RNAF General Dynamics/Lockheed Martin F-16AM fighter launched a missile to ascertain the weapon's capability to acquire, track and hit a fast patrol boat target. Diehl stated in reports that the incorporation of this surface attack capability could be made available via a software insertion.

Giulia Tilenni

The Meteor missile continues is onward march into service, with the RAF soon to induct the weapon into operational service, alongside the French Air Force.

METEOR

Joining the IRIS-T is the Meteor beyond visual range AAM. In April 2016, the *Svenska Flygvapnet* (Royal Swedish Air Force) became the first operator of the weapon onboard the service's JAS-39C/D fighters: "In 2016, Saab introduced an operational upgrade and combat enhancement for the Gripen fighter that is known as the MS20 capability. That (capability) included full integration of the Meteor missile for the Royal Swedish Air Force's JAS-39C/D fighters. They are the world's first and only fighters to be operational with this revolutionary European weapon system," a Saab spokesperson told *Armada*. According to the French ministry of defence and the *Direction Générale de l'Armement* (General Armament Directory) defence procurement agency, the 200 Meteor AAMs ordered by the French government in 2010 (instead of the 300 estimated at the beginning of the programme) should be delivered between 2018 and 2020. Like France, Spain has decided to acquire a smaller numbers of missiles than originally anticipated expecting around 100 instead of 400.

The missile could be carried by the Lockheed Martin F-35A/B/C Lightning-II fighter family: "Prior to the initial operational capability of the Meteor on the F-35 family, the weapon will have already been fully integrated onto the JAS-39, Rafale and Typhoon families and so this previous work will provide a very good basis for integration onto further platforms in the future. It is no surprise then that Meteor has been assessed as compatible with all F-35 variants and is seen as a low risk for integration. The Meteor is planned for integration as part of the (F-35) Block-IV Follow on Modernization Plan," the MBDA spokesperson continued.

But to date the Meteor's integration on the F-35 family is far from taken for granted because of a number of concerns. Firstly technology gaps and differences, namely a fully European product designed for a fourth generation fighter will be mounted on a fully American fifth generation fighter. Software compatibility between the missile and the aircraft are a primary issue, and the US maybe wary of disclosing source codes and features that would help addressing integration feasibility for the weapon.

Besides, although the JAS-39, Rafale and Typhoon families have some network centric capabilities, thanks to their use of NATO's (North Atlantic Treaty Organisation) Link-16 tactical data link protocol, their levels of integration *vis-à-vis* other platforms, and Command and Control (C2) networks, are arguably not as developed as they are on the F-35 family, which was designed from the outset as a highly network centric asset to be integrated into wider US C2 networks.

The UK has already decided to integrate the Meteor on its forthcoming F-35B aircraft due to equip the Royal Air Force (RAF) from circa 2024. It was reported this April that the UK Ministry of Defence (MOD) had awarded a contract worth $52.7 million to MBDA to explore the integration

MBDA

A Meteor missile is seen here onboard a Rafale-M of the French Navy. The weapon is expected to enter French service from circa 2018.

USAF

The AIM-9X weapon has an all-aspect seeker enabling it to engage a hostile aircraft from any angle. Raytheon has benefitted from several recent contracts pertaining to this weapon.

of the missile onboard this aircraft. The missile is already expected to enter service with the Typhoon-FGR4 fighters of the RAF from 2018, media reports continue. It is expected that each of the RAF's F-35B aircraft will accommodate a pair of Meteor missiles on two of the four underwing hardpoints with which the RAF's jets will be equipped. This will be necessary as the Meteor missile will be too small to fit inside the F-35B's internal weapons bay. That said, reports have stressed that MBDA has examined reducing the size of the missile's tail fins to enable it to fit inside the aircraft. This will be achieved by developing fins which although shorter in height will be longer, so as not to degrade the weapon's performance. Away from the F-35 family, work continues on integrating the Meteor missile onboard other platforms. Although the Royal Swedish Air Force has become the first air force to introduce the Meteor into service, with the weapon equipping its JAS-39C/D jets, it was reported in April 2017 that the UK MOD had completed development testing of the Meteor onboard a Typhoon fighter owned by Airbus' defence and space division, which included a simultaneous firing of two Meteor missiles during test flights in Scotland. The conclusion of this testing regime now allows the RAF to commence its operational evaluation of the weapon, which is expected to occur later this year. Similarly, the DGA announced during April that it had completed its final guided firing of a Meteor missile from a Rafale family combat aircraft, which involved firing the missile against an air target during tests performed from the *Armée de l'Air* (ADLA/French Air Force) Cazaux airbase in western France. The conclusion of the test firings marked the completion of the full integration flight test campaign of the weapon onboard *Aeronavale* (French Naval Aviation) and ADLA Rafale-F3B/C/M fighters. The weapon is expected to enter operational service with the ADLA from early 2018.

The April contract represents a second success for MBDA as regards the F-35 family so far this year. In mid-March MBDA announced that it had performed several test firings of the firm's AIM-132 ASRAAM (Advanced Short-Range Air-to-Air Missile) IR-guided weapon using an RAF F-35B at Edwards airbase in California and Patuxent River airbase in Maryland. Meanwhile, in August 2016, the UK MOD awarded a contract worth $238 million to purchase AIM-132 rounds for deployment onboard the RAF's forthcoming F-35B aircraft. This contract followed an earlier contract in September 2015 which covered the development of a new variant of the AIM-132 missile for use onboard the Typhoon-FGR4. This new weapon is expected to enter service with this aircraft in 2018, according to media reports. Reports continued that the F-35B will use the legacy variant of the AIM-132 weapon until circa 2022, and will then presumably switch over to the new AIM-132 variant under development for the Typhoon-FGR4.

NORTH AMERICA

While MBDA is Europe's leading missile design, research, development and production company for air-to-air missiles, its US counterpart Raytheon is similarly heavily involved in air-to-air missile efforts. During the first six months of this year, the firm has been awarded contracts to produce AIM-9X Block-II Sidewinder IR-guided family AAMs under a contract worth $78 million awarded in April. Although these weapons are destined to furnish USAF and US Navy stocks, the contact also covers production for foreign AIM-9 family customers. Moreover, the contract includes enhancements to the weapon's guidance and propulsion systems. Importantly, unlike legacy AIM-9 models, the AIM-9X has an 'all aspect' seeker meaning that it can engage a hostile aircraft from off

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US Navy

An impressive loadout of several AIM-120D weapons seen beneath the wings of this US Navy McDonnell Douglas/Boeing F/A-18D.

boresight angles. Similarly, on 11th May, the US Department of Defence (DOD) awarded the company a contract worth $7 million to extend the operational life of its AIM-120D Advanced Medium Range Air-to-Air Missiles (AMRAAM) ARH guided weapons, used by Australia, Japan, Norway, Romania and Turkey. This contract award followed an earlier US DOD contract option worth $64.6 million covering the upgrade of the weapons' guidance system. A number of enhancements are being rolled out across the AIM-120D fleet in the US and across the weapon's export customers. In January, it was reported that Raytheon and the USAF were working on the development of a new signal processor to equip the weapon with the intention of helping the missile to remain in service until the 2020s and beyond. This year also saw the production of the 20000th AIM-120D weapon.

ISRAEL

While this article has, so far, focused on North American and European AAM efforts, Israel remains an important player in the air-to-air missile domain, alongside Russia and, to a lesser extent, the People's Republic of China. However, space is alas insufficient here to discuss the recent efforts of these last two nations in detail. Rafael Advanced Defence System's Python IR-guided AAM family is the country's flagship product in this regard and is used by at least 17 countries around the world. In March 2016, it was revealed that Israel and India had agreed to establish a joint venture involving Rafael and Reliance Defence for the production of, among other products, air-to-air missiles. While the news did not explicitly state which AAMs could be produced as a result of this effort, it would be of little surprise if Python family weapons were to be included. India is already known to be a user of the Python-4 and Python-5 variants of the missile. The former can perform all-aspect engagement, according to open sources, and entered service in the 1990s, while the Python-5 distinguished itself during Israel's intervention in Lebanon in 2006 to stop the Hezbollah militia from firing rockets into Israeli territory, when the weapon was successful in destroying two Ghods Aviation Industries Abadil unmanned aerial vehicles being flown by Hezbollah. This February it was announced that Vietnam will be joining the Python club, procuring the Python-5 missile which could potentially be used to equip its Sukhoi Su-27/30 and Su-22 family fighters.

OPPORTUNITIES

Although air-to-air combat is rare in the current global operational paradigm, it would be premature to announced its disappearance. The ongoing efforts of Russia to develop the Sukhoi T-50 fighter and the People's Republic of China to realise the Chengdu J-20 fighter, show that US and Western rivals will continue to invest in efforts to overturn the air superiority and air supremacy generally enjoyed by the US and its Allies since the Balkans and Iraq conflicts of the 1990s. Yet such an operational advantage cannot be taken for granted, and the investment being poured into AAM research, development and production indicates that the West is not about to cede this position through neglect.


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UK MOD

Typhoon-FGR4 fighters remain on QRA ready to respond to potential threats to UK airspace. These aircraft are usually equipped with ASRAAM and AIM-120 missiles.

GUARDIAN ANGELS

For 24 hours per day, 365 days per year, the United Kingdom Air Surveillance and Control System (UKASACS) watches the skies of the nation for suspicious activity. Yet plans are afoot to replace the UKASACS with a new system.

Thomas Withington

Official information notes that the UKASACS Force Command is located at RAF Boulmer airbase in northeast England. Subordinate to the Force Command is the UKASACS Control and Reporting Centre (CRC), collocated at RAF Boulmer, which federates ground-based air surveillance radar, naval surveillance radar and airborne surveillance radar to form a Recognised Air Picture (RAP) covering the North Atlantic Treaty Organisation's (NATO) Air Policing Area-1 which, alongside the UK, open sources note, includes Norwegian and Icelandic airspace. The CRC, sources continue, also exercises control over the RAF's Quick Reaction Alert (QRA) fighters tasked with responding to any incursion of UK airspace, or to any aircraft deemed to be acting suspiciously within it. Recently QRAs have been fulfilled by RAF Eurofighter Typhoon-FGR4 fighters, at least two of which are continually held at readiness, fully-fuelled with a mixed weapons load of four MBDA ASRAAM (Advanced Short Range Air-to-Air Missile) infrared-guided Air-to-Air Missiles (AAMs) and the same number of Raytheon AIM-120 AMRAAM (Advanced Medium Air-to-Air Missile) active radar homing AAMs.

The CRC forms the RAP by federating radar imagery from so-called Remote Radar Heads (RRHs). These are reportedly located at RRH Benbecula in the Outer

UK MOD

The RAF's Sentry AEW.1 aircraft form an important part of the overall UK air defence posture, helping to plug gaps in radar coverage and to provide additional radar imagery for the UKASACS.

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Hebrides islands, off the northwest coast of Scotland; RRH Buchan on the northeast coast of Scotland; RRH Brizlee Wood, on the coast of northeast England; RRH Staxton Wold and RRH Neatishead; both on the east coast of England; and RRH Portreath, close to the most south-westerly point of England. These RRHs house a range of radars including the Lockheed Martin Type-92 (RRH Benbecula and RRH Buchan) and the Lockheed Martin AN/TPS-77 (RRH Staxton Wold, RHH Brizlee Wood and RRH Neatishead) and BAE Systems AR-327 Commander (RRH Portreath).

According to open sources, the Type-92 has a design very similar to the firm's AN/FPS-117 L-band (1.215-1.4 gigahertz/GHz) radar which has a reported surveillance range of circa 250 nautical miles/nm (463 kilometres/km). In terms of altitude, the radar can cover an altitude of up to 114,829.4 feet/ft (35000 metres/m). Regarding specification, the AN/TPS-77 shares much of the AN/FPS-117's performance characteristics, with the exception that the AN/TPS-77 has been designed to be transportable, although it is used as a fixed-site radar in the UK. It is interesting to note that the UK Ministry of Defence (MOD) procured the AN/TPS-77 which were installed from 2011 and which are now all operational, so as to mitigate the potential radar clutter which can be triggered by the spinning blades of wind turbines. The UK has established a number of offshore wind farms on the eastern coast of England, hence the need to deploy radars which are resistant to this resulting radar clutter. Finally, the AR-327 Commander is an S-band (2.3-2.5/2.7-3.7GHz) radar that has a reported maximum range of 253.8nm (470km) and altitude of 100,000ft (30480m).

In addition to the radar imagery which is generated by these systems to form the RAP, the UKASACS can receive additional imagery from the RAF's fleet of seven Boeing Sentry AEW.1 airborne early warning aircraft equipped as they are with the Northrop Grumman AN/APY-2 S-band airborne surveillance radar which provides a range of 216nm (400km). This is in addition to the RAF's Raytheon AN/FPS-132 Ultra

Shown here is an AN/FPS-117 radar, upon which the AN/TPS-77's design is closely based. The example in this picture is operated by the Royal Australian Air Force.


UK MOD

High Frequency (300 Megahertz to three gigahertz) ballistic missile early warning radar located at RAF Fylingdales airbase in northeast England. This radar has a range of circa 3000nm (5556km). Beyond the Sentry AEW.1 fleet and the AN/FPS-132 radar. The RAF is able to draw upon radar imagery provided by the UK's National Air Traffic Service (NATS) which provides air traffic services across the UK.

According to official RAF literature, RAF Boulmer either detects an aircraft behaving suspiciously using its own RRHs or from information supplied by NATS. A decision is then taken to scramble the Typhoon-FGR4s on QRA. The airspace around the suspicious aircraft is then cleared by NATS, and RAF Boulmer will control the interception of the aircraft. The literature adds that the ultimate command as to whether to shoot down an aircraft which has remained unresponsive to demands for it to cease its activity rests with the UK Prime Minister. In terms of hardware and software, IBM provided the RAF with the UKASACS Command and Control System (UCCS) which, according to official UK Ministry of Defence documentation, provides the UKASACS air surveillance and air command and control capabilities via workstations, software, servers and networking equipment. Both RAF Boulmer and RAF Scampton in Lincolnshire, also in eastern England which provides a backup facility to the site at the former, host 41 UCCS workstations at each of these CRCs. The reason for the two CRCs, according to an MOD document is: "so that the routine air policing role can be run by either centre giving dual resilience to the system." Also located at each CRC is the Flight Plan Dissemination System (FPDS) which is used to populate the UCCS with flight plan information from civilian ATM.

The overall UKASACS architecture has been modernised via the Project CERBERUS initiative. Officially dubbed by MOD literature as: "an obsolescence driven mid-life technical refresh and life extension to the data handling, processing and display component of UCCS," the CERBERUS effort was led by IBM. Further improvements are now occurring for the UKASACS in the form of the Project GUARDIAN initiative. An undated MOD document provided some important information regarding the intentions of the Project GUARDIAN undertaking. While much of the document is redacted, it is possible to gain some insight into its scope. Whereas the Project CERBERUS effort sought to enhance the capabilities of the UKASACS, for all intents and purposes, the latter initiative, according to the document: "will replace the current Air C2 (Command and Control system) installed at (redacted)." While the document omits the locations of the Air C2 system to be replaced, it is reasonable to assume that this refers to the UCCSs at RAF Boulmer and RAF Scampton. The document continues that, presently, the existing UKASACS architecture employs a: "dedicated voice communications system that connects to the UK defence network of radars and radios," and that Project GUARDIAN: "will deliver the new capabilities of (redacted)." This could mean that the new communications architecture

which will comprise Project GUARDIAN will include Voice Over Internet Protocol communications. Finally, the Project GUARDIAN architecture: "will include the exchange of radar track data between UK command sites and NATO (North Atlantic Treaty Organisation) Command sites in Europe." Currently, the UK is thought to share the RAP generated by the UKASACS with NATO's Combined Air Operations Centre at Uedem in central Germany.

This latter point is particularly important. Much of NATO's European membership is involved in the Air Command and Control System (ACCS) initiative which is being led by the ThalesRaytheonSystems consortium. Put simply, the ACCS initiative is an ambitious programme to replace several disparate Air C2 systems used both to safeguard air sovereignty, and for the planning and execution of air operations, with a scalable fixed and deployable hardware and software architecture used across the participating nations. This will not only standardise the equipment being utilised, but help the alliance develop a single 'Super-RAP' depicting the airspace over NATO's European membership. The inference in the MOD document is that, while the UK has chosen not to participate in the ACCS initiative (*see below*), it does plan to include mechanisms to share its national RAP with NATO to contribute to the Super-RAP.

In terms of time scales, the MOD document stated that the ministry is expected to enact its so-called 'Main Gate' approval for Project GUARDIAN in the May/June timeframe. Main Gate approval is MOD jargon for when the UK government takes the decision to commit the main part of its investment to bring the programme to fruition. Though as the discussion below illustrates, these plans could now be in a state of flux. The document further informed that the Project GUARDIAN architecture will interoperate the current communications systems used by UKASACS, including its Tactical Data Links (TDLs) described in detail below.

Moreover, the UKASACS' predecessor, IUKADGE (Improved UK Air Defence Ground Environment) system which entered service on 1st June 1993 was known to use Marconi's UNITER digital telephone system for its ground-to-ground communications. An undated document published by British Telecom, still hosted on the company's website, advertising the firm's Defence Fixed Telecommunications Service, stated that the UNITER defence secure voice network remains in service. Additional publicly available RAF documents noted that the RAF's Fixed Telecommunications System (FTS) forms a vital part of the UKASACS architecture and provides secure and unsecured voice communications, recorded messages in the form of written orders, data and signals across the UK's Defence Communications Network. The RAF also "ensures good communications between all agencies and authorities" who maybe involved in an interception being led by the UKASACS. As noted above, this could include NATS and the UK Prime Minister's office. Two components form the FTS, a system known as BOXER and UNITER. Documents obtained by *Armada* noted that the BOXER network uses fibre optic, satellite and microwave communications links which entered service with the RAF in 1996, and which are owned by the RAF. UNITER, meanwhile, constitutes the switching and terminal equipment enabling the user to communicate with a receiver.

Meanwhile, a number of tactical data links are employed to connect platforms such as the RAF's Typhoon-FGR4 fighters on QRA to the UKASACS, not least of which is the Link-16 TDL. Link-16 is a NATO TDL standard that provides secure voice and data communications across a frequency range of 969 megahertz/MHz to 1.2GHz. It enables radar track, and other tactical information, to be shared between these aircraft and the UKASACS. Link-16 is also used by the RAF's Sentry AEW.1 aircraft allowing the similar exchange of tactical information. The Royal Navy can share data using NATO's Link-11 TDL. Link-11 is used for the exchange of similar tactical information across high frequency and ultra high frequency (300MHz to three gigahertz). Whereas Link-16 is largely used to support air operations, Link-11 is mostly used in the naval domain. The asset of using Link-11 is that it allows platforms such as the Royal Navy's 'Daring' class destroyers, which are armed with the MBDA Aster-15/30 active radar homing surface-to-air missiles, to enhance the UK's air defence by contributing track information derived from the ship's BAE Systems' SAMPSON S-band and Thales S1850M L-band naval surveillance radars.

THE CRUNCH

As noted above, the MOD was originally

UK MOD

Alongside RAF aircraft, the Royal Navy's 'Daring' class destroyers can feed radar track information into the UKASACS via their Link-11 and Link-16 TDLs.

planning to make its 'Main Gate' decision *vis-à-vis* the Project GUARDIAN procurement in May/June 2017. However, on 18th May, UK Prime Minister Theresa May announced a general election to be held on 8th June. This may well suspend the MOD's decision on proceeding with the Project GUARDIAN procurement until the political landscape is clear after the poll. Secondly, the government has entered a period of purdah until after the election, meaning that the author's requests to the MOD for an update on the current status and future plans regarding the Project GUARDIAN initiative have remained unanswered.

According to Douglas Barrie, senior fellow for military aerospace at the International Institute for Strategic Studies, a London-based think tank, the MOD and RAF will need to take a number of strategic factors into account as they evolve the Project GUARDIAN architecture: "Ten years ago, the design could have comprised a fairly benign system designed to protect UK airspace," he stated. However, Russia has now moved from being an "irascible neighbour to a strategic competitor." Mr. Barrie stated that this strategic change was hallmarked by Russian President Vladimir Putin's speech during the February 2007 Munich Security Conference, in which Mr. Putin railed against a perceived domination of the international system by the United States and its allies, declaring that: "It is world in which there is one master, one sovereign." At the operational level for the UK, and for NATO in general, this emergence of Russia as a strategic competitor has translated into regular flights by Russian Air Force aircraft close to UK airspace, with Typhoon-FGR4 aircraft being scrambled from RAF Coningsby airbase in eastern England in early February to intercept two Russian Air Force Tupolev Tu-160M/M2 strategic bombers thought to be flying close to UK airspace. Mr. Barrie continued that the UK once again faces Russia as a potential adversary much as it did during the Cold War, and that this could require the Project GUARDIAN system to be capable of performing: "surveillance against a range of platforms which include not only inhabited aircraft, but also air-launched cruise missiles, and platforms with a low radar cross section such as fifth-generation fighter aircraft."

Cost is a second consideration for the realisation of the Project GUARDIAN architecture. The UK was originally a partner in the ACCS initiative (*see above*) however late last decade the country suspended its involvement. According to a highly placed source close to the programme, the suspension occurred because the UK did not feel that the ACCS architecture, at that stage of development, met the UK's safety requirements. Despite this, the source continued that the RAF has remained very interested in the ACCS, particularly the theatre missile defence capability which forms part of the overall ACCS architecture. That said UK procurement officials have ruled out the obtention of the ACCS architecture and *Armada's* source continues that the MOD is strongly expected to award the Project GUARDIAN work to the "incumbent supplier," in this case IBM which supplied the UKASACS architecture.

Nevertheless, the decision not to proceed with acquiring ACCS could impose a financial penalty on the UK. *Armada's* source added that, as an original partner, the UK remains committed to sharing the funding of the ACCS realisation, yet in addition to this, it will now have to also procure the Project GUARDIAN architecture, effectively paying twice for a new air C2 system. This could place additional pressure on the UK defence budget following media reports in late April that the UK's Public Accounts committee, a parliamentary body that scrutinises the value for money of UK government spending, that the MOD's ten year procurement programme which commenced in 2012 risks becoming unaffordable. In addition, the UK may suffer financial uncertainty and the possibility of the value of Sterling weakening further as the country prepares to leave the European Union in 2019. This could result in lower fiscal revenues for the government over the 2017 to 2019 timescale, possibly making Project GUARDIAN a hostage to financial fortunes against a backdrop of continuing strategic uncertainty.

US Navy

An X-47B is seen here refuelling from an OmegaAir B707-320; an important step forward in the development of this capability for UAVs.

OVER THE OCEAN

While they are primarily used by air forces, with armies, following closely behind, Unmanned Aerial Vehicles (UAVs) are becoming an asset that naval forces are increasingly interested in operating, although the introduction of them comes with a number of challenges.

Beth Stevenson

The ultimate aim for naval operations is to deploy UAVs from vessels, to provide surveillance around ships and to be used for the overhead watch of an area at stand-off ranges; either in isolation or to provide data to neighbouring inhabited aircraft. Systems that are most synonymous with this role include fixed- and rotary-wing UAVs, ranging from the large, helicopter-derived systems like the Northrop Grumman MQ-8B/C Fire Scout aircraft, to the Boeing/Insitu ScanEagle and RQ-21A Blackjack fixed-wing UAVs, all of which are operational with the US Navy. Nevertheless, enhancements are being made to systems developed in Europe and Israel which are gaining interest both domestically and internationally.

Integration of the UAV into the vessel itself is one such challenge, as is developing a system suited to operating at sea. Typically, rotary-wing UAVs have been used in support of this type of operation, taking technology from naval support helicopters. Rotary-wing UAVs are also easier to integrate into vessels, compared to their fixed-wing counterparts as the former's vertical take-off and landing capability means they require less deck space. That said, a number of technological developments have been made in recent years to integrate new types of aircraft into deck-based operations.

CARRIER OPERATIONS

One such feat was the successful arrested landing of Northrop Grumman's X-47B Unmanned Combat Air Vehicle (UCAV) demonstrator onboard the USS *George HW Bush* 'Nimitz' class aircraft carrier in May 2013. This was then followed by a flight test in 2014 that demonstrated the X-47B's ability to fly from the deck of the USS *Theodore Roosevelt*, another 'Nimitz' class carrier, in concert with a US Navy McDonnell Douglas/Boeing F/A-18C/D Hornet fighter. The final success of the X-47B programme was a 2015 demonstration of its ability to be refuelled by an OmegaAir Boeing B707-320 tanker, and the experience the US Navy gained will ultimately roll into the MQ-25 effort (*see below*). The initiative is now concluded, with the US Navy retaining the two X-47B aircraft in a flying condition for further development, reports in 2015 stated.

To this end, the service is pushing through its Carrier-Based Aerial Refuelling System (CBARS) programme, which will see the service acquire the MQ-25 Stingray UAV. Four contractors are bidding to provide the air vehicle element of the programme, namely Boeing, General Atomics, Lockheed Martin and Northrop Grumman. All four were selected to carry out air vehicle work

under the navy's previous Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) programme; a predecessor effort that sought a stealth UCAV that ultimately got reduced to CBARS. Despite the navy's best intentions, timelines governing the UCLASS effort continued to be pushed back as the service struggled to specify what it wanted from a carrier-based low Radar Cross Section (RCS) UAV. The RCS element was a particular challenge, so the navy instead reclassified the programme as the CBARS, which would concentrate on a refuelling capability to bolster the tasks performed by the F/A-18E/F Super Hornet's on-board the carriers. A request for proposals for the next phase of the work is expected to be released this year, which will cover engineering and manufacturing development, and will follow risk reduction work that each company is on contract to perform to evolve their bids to be CBARS, rather than UCLASS, suited. Ultimately, the MQ-25 will be a surveillance system capable of acting as a tanker, and will use the US Navy's Cobham A/A42R-1 air-to-air refuelling system that is operated on US Navy and US Marine Corps' F/A-18 family fighters. According to US Navy sources, the first MQ-25 aircraft is expected to enter service in the early 2020s.

ROTARY WING

One system that has seen operational success at sea is the Schiebel Camcopter S-100 rotary-wing UAV. Its most recent success was the purchase of one system in February for testing by the Royal Australian Navy, which is a service that is keen to introduce UAVs into its fleet: "One S-100 system, like the one the RAN has ordered, consists of two air vehicles," a Schiebel spokesperson told *Armada*. "The contract we recently signed with the RAN also includes engineering, logistics and operational support for the next three years." The RAN requirement was a highly sought one, as other manufacturers also bid to sell their systems to Canberra. This included UMS Skeldar with its V-200 rotary-wing UAV, which includes a heavy-fuel engine, a feature the company thought would make the aircraft appealing to the RAN, and one that is noticeably missing in the S-100. A heavy fuel engine is an important consideration as it can provide commonality with ship fuel, and other aircraft operated from a vessel while also being potentially safer regarding ignition points compared to other aviation fuels.: "It is well known that to operate on (vessels), the unmanned aerial vehicle in question needs to operate on heavy fuel," David Willems, business development director at UMS Skeldar, told *Armada*: "The S-100 does not operate on a heavy fuel engine. We believe there will be opportunities for our V-200 beyond these trials and well into the future, based on our unmatched compliance for operations with surface vessels and seaborne platforms."

Another market in which they are both competing is in Germany, which has also sought a rotary-wing UAV for integration on its *Marine* (German Navy) vessels for some years. UMS Skeldar has teamed with ESG to pitch to this market, and progress in the navy's programme is expected soon: "Our relationship with ESG is important on a number of levels, not least the fact that they are the prime contractor relationship for a number of opportunities," Mr. Willems noted: "We support their campaign with the VorUMAS (the new name for the procurement of VTOL UAVs for the German Navy)," Mr. Willems continued, adding that the release of a request for proposals for the Germany Navy requirement is imminent. Moreover, he noted that while he cannot discuss in any detail, there are a number of other opportunities the company is eyeing in Germany.

Schiebel, meanwhile, says that it is anticipating the release of the German Navy's tender: "so we will have the opportunity to convince the German Navy that our S-100 is the world's best option when it comes to maritime VTOL (Vertical Take-Off and Landing) UAVs", the spokesperson noted. Skeldar also saw a recent success in Indonesia, with the company seeing its first sale there in February since the firm, which was formed by combining the unmanned assets of Saab and UMS, was formed at the end of 2015. One initial system was sold for evaluation, which the company hopes will eventually lead to more sales in Indonesia: "The V-200 is performing well within the tests and patrol evaluations it is undertaking," Mr. Willems added: "With multi-payload capabilities, a low logistics footprint, commonality of ground control station and the ability to operate on heavy fuel, our Indonesian customer has had very positive feedback so far."

Mr. Willems added that the interest in UAVs is increasing year-on-year, and their potential deployment across the military,

UMS Skeldar

UMS Skeldar achieved a new success late last year when one V-200 system was selected by Indonesia for test and evaluation, ahead of further potential orders this year.


GA-ASI

General Atomics was pitching a derivative of its Predator-C for the US Navy's UCLASS effort, which has now evolved into the MQ-25 requirement that seeks a tanker UAV.

maritime and civilian sectors means there is a larger requirement than ever before for multipurpose unmanned aircraft: "With all our platforms, each one has multiple payload capabilities, meaning they can be used for a variety of missions at any time," he said: "Our customers are particularly benefitting from this capability ... In addition, we are continually undertaking significant research and development based on future requirements. Although there is nothing new to report at this stage, we will be making changes in the next couple of years." The company is also pitching its smaller VTOL UAV, the R-350, for the naval UAV market, which Mr. Willems said is an ideal first UAV for an operator to deploy in this arena: "leading to the deployment of other assets such as the V-200," he noted: "At this stage, however, there is nothing we can mention in terms of potential customers."

India is also a promising target customer for UMS Skeldar, and the company is working with local partner 3F-Advanced Systems to organise a number of demonstrations in-country: "We expect the first sales to be in the military sector," Mr. Willems observed: "Our intentions are therefore to start assembling the V-200 for the local market in India before eventually producing them locally based on required volumes." India is a new target market for a number of different UAV sales following its admission into the Missile Technology Control Regime (MTCR) in 2016, which permits members to export UAVs and missile-related technology that has a payload in excess of 1100 pounds/lb (500 kilograms/kg), and a range of 162 nautical miles/nm (300 kilometres/km), to the nation. Following the MTCR membership, the government of India issued a letter of request to the US in June 2016 seeking approval for the purchase of 22 General Atomics Guardian UAVs for the Indian navy; the Guardian is a maritime variant of the company's ubiquitous Predator family of UAVs. General Atomics could not comment on the potential sale to India due to commercial sensitivity, but the US government does not seem to have issued an acceptance to date.

General Dynamics is looking to move into the maritime market in several areas, and was even integrating a sonobuoy payload capability for the Guardian, which it was developing along with Ultra Electronics. It could not comment on the current status of the development, but it was designed to increase the maritime prowess of the UAV. Other maritime systems that have been integrated include the Leonardo Seaspray-7500E X-band (8.5-10.68 gigahertz) airborne surveillance radar and Automatic Identification System (AIS) interrogators. The AIS is a radio frequency-based transponder system mandated for all vessels with a gross tonnage in excess of 300 tons mandated by the International Maritime Organisation, the United Nations body responsible for regulating shipping, to provide details of a vessel's identification, course and speed.

Furthermore, the company is involved in the MQ-25 development (*see above*), which if successful would be the company's first sale to the USN, which would complete the tri-service success of the Predator UAV family in the US: The MQ-1 Predator and MQ-9 Reaper variants have been in operation with the US Air Force for some years, while the MQ-1C Grey Eagle is operated by the US Army. General Atomics is expected to pitch a jet-powered version of a UAV derived from its Predator-C Avenger aircraft for the MQ-25 competition. Carrier-based operations are new to the company, despite it having a successful line of medium-altitude, long-endurance UAVs used by several NATO (North Atlantic Treaty Organisation) nations.

ISRAELI INGENUITY

Israel Aerospace Industries is also developing maritime versions of its Heron family of UAVs, including a heavy fuel variant, although none of them are carrier-suited. Launched in 2014 during the Singapore air show, the heavy fuel Super Heron was developed as an offering for a Swiss requirement that was ultimately won by rival Elbit Systems with its Hermes-900, but the IAI system is still being marketed by the company: "The Super Heron is one of the Heron's versions and is suitable for every mission including the maritime mission," Dan Bichman, UAV marketing lead for IAI's Malat division, told *Armada*: "The Heron family is constantly improving in many different aspects ... The Super Heron is targeted to the UAV user that need an improved capabilities system and the option of using a diesel engine. The system is relevant to clients all over the world." Additionally, Mr. Bichman noted that the basic version of Heron family can easily be modified to install systems and payloads required to make it maritime mission-suitable: "That way you can easily make any basic Heron a maritime Heron is by installing the suitable systems and payloads," he said.


IAI

IAI says it can add maritime features to its baseline Heron UAV, including a suitable radar, electronic intelligence gathering system and long-range communications

Such payloads includes IAI's ELTA division's airborne surveillance radar for maritime patrol aircraft, such as the firm's EL/M-2022ES X-band product, IAI's Tamam division's Micro Pop optronics sensor, plus electronic intelligence sensors such as IAI ELTA's EL/L-8385 electronic support measure. Additionally an IAI ELTA satellite communications system can help it operate over long distances; in excess of 540nm (1000km) and also at low altitudes in accordance with operational demands: "The maritime Heron (has been) operational for many years with different users around the world, including the Israeli Navy," Mr. Bichman says: "The Heron UAV system is a multi-mission, multi-payload system with long endurance that fits a wide range of operational missions at different heights and ranges, and is capable of operating under extreme weather conditions," he continued. IAI and Elbit Systems are not the only Israeli firms offering naval UAVs. In 2010, the Israeli Navy selected the Aeronautics Orbiter-2 UAV for operation from its surface vessels, such as its 'Sa'ar-5' class corvettes. According to the firm, this aircraft has an endurance of up to four hours, can carry a 3.3lb (1.5kg) payload and has a 53.9nm (100km) operational radius.

SENSING TROUBLE

While platforms are clearly important as regards being able to operate in support of naval missions, the sensors they carry are equally as vital: "It is the combination of platform and sensor that is very appealing to the customers, as it provides all-weather, wide area coverage," the Schiebel spokesperson said regarding the overall sensor/platform package. One provider that has seen lots of success in this area, having tested systems on the S-100 and winning a highly sought after contract for integration of its Osprey X-band airborne surveillance radar onboard the MQ-8C in June 2016 is Leonardo. While Australia has acquired one S-100 system, the sensors have not yet been selected, but Leonardo has previously demonstrated its PicoSAR X-band airborne surveillance radar to the RAN onboard the S-100 in June 2015, so there could be an opportunity there further down the line.


Schiebel

Leonardo has tested a number of systems onboard the S-100, including its PicoSAR radar system that could be of interest to the Royal Australian Navy.

The Osprey radar is being provided directly to the US government for integration on the US Navy's MQ-8C aircraft: "We are still on contract, delivering on schedule, and working with all of the players involved in the Fire Scout programme to make it a success," Brendan Nolan, vice president of sales for radar and advanced targeting at Leonardo's airborne and space systems division, told *Armada*, adding that the navy is considering establishing an indefinite delivery, indefinite quantity contract to cover more sales: "Our main focus is delivering well on the contract that we won. Obviously we look forward to opportunities to support the US Navy or Northrop Grumman in any export activities, but at the moment our focus is to deliver well on the programme."

Mr. Nolan stated that the Osprey radar is a "pivotal change" in comparison to earlier generation radars that are fixed arrays: "(On the) Fire Scout there are two antennae: one either side of the aircraft, which provide a 240 degree field-of-view without any moving parts," he said: "So the installation allows the radar to not be mounted underneath the helicopter, which they often are, which is advantageous for operating in rough sea states." Mr. Nolan continued that the Active Electronically-Scanned Array (AESA) architecture which the radar employs allows the operator to simultaneously carry out multiple tasks: "With AESA you can pulse-by-pulse point the radar anywhere that it can physically see, so what that allows the system to do is clever things like looking in front of the aircraft for weather, (while) doing some ground mapping for target areas to the right, while simultaneously looking out for air threats to the left, for example." He continued that: "The benefits of Osprey really lend themselves to unmanned operations, because you can do so much with what is a very light system, so it's ideally suited to UAVs," Mr. Nolan adds.

MERITOCRACY

While there have been great successes in the deployment of UAVs by the US Navy in the maritime domain, as this article illustrates, there are also significant efforts being made elsewhere. The operational challenges of using any system in the naval environment, never mind an unmanned one, are vast, but industry is looking at a number of technologies that will increase the effectiveness in this domain. With an increased level of safety in comparison to inhabited equivalents by putting fewer aircrew at risk during flying operations, plus the reduction in cost by not using a pilots' valuable time, the merits of using UAVs in a maritime domain are clear, and slowly but surely they are rolling out to sea with a number of different nations.

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BEST SUPPORTING ACTORS

US DOD

The Italian air force has used is AMX-A11A fighters for CAS missions in Afghanistan, with Italian industry examining further CAS technological developments.

The nature of modern day operations means that air strikes are often the primary form of attack used against targets, and traditional battlefields, which generally only involve the two opposing sides but that are away from civilians, reside for now in the history books.

Beth Stevenson

Insurgents today, as they have been throughout history, are integrated into everyday societies: "The guerrilla must move amongst the people as a fish swims in the sea," noted Mao Zedong, the founding father of the People's Republic of China. Practitioners of political violence have the advantage of being indistinguishable from civilians, and relatively safe from large scale bombardments, because opposing forces, notable the US and its allies, want to keep collateral damage to a minimum, to avoid adverse publicity in the global court of public opinion. Close Air Support (CAS) is therefore utilised to ensure that when an air strike has to be made near civilians, the enemy is the only target that is hit. While aircraft now have an array of sensors available to them that allow for a near-perfect situational awareness in the air, pilots do not always know exactly what is going on, on the ground, despite the detail of the intelligence picture they have available to them.

The missing pieces of this intelligence jigsaw can be found by having personnel on the ground whom can provide the information that is missing to the pilot, offering a picture of what is happening on the ground and feeding this up to the aircraft. Typically these personnel are referred to as Joint Terminal Attack Controllers (JTACs) that are highly trained, and responsible for directing air power to the right target. JTACs use a range of different technologies, which incorporate a number of different communication feeds that allows JTACs to transfer the information they have received to a commander, or directly to a pilot.

The US was the first to give the appellation to the CAS/JTAC mission, and the technology used is often US-built. Nevertheless, this does not mean that other nations are not carrying out this type of mission, nor that non-US industry is not also developing similar technology. Italy

is one of the few nations outside of the US that has been recognised for its CAS effort, having flown AMX International AMX-A11A fighters in support of this mission type throughout Italy's operations in Afghanistan supporting the US-led multinational effort against the Taliban and Al Qaeda insurgent organisation there. Information regarding what ground-based technology is used by Italy is limited, but it is likely to incorporate systems developed by domestic industry, while Italian aircraft such as Eurofighter Typhoon-F2000A fighters have been touted for use in this role. Italy is keen to integrate its Typhoons-F2000As in the CAS role, and the aircraft has been used to demonstrate a new key technology that could support this mission set.

REVERSE IFF

To this end, Leonardo has developed an air-to-ground version of its Identification Friend or Foe (IFF) technology, which is a Radio Frequency (RF) transponder-based capability that in the air domain typically allows a pilot to transmit and receive identification data. IFF allows operators to determine if another aircraft is friendly or hostile by verifying the signal it receives as a response to an initial RF interrogation. The so-called 'reverse IFF' approach being employed by Leonardo will now allow an aircraft to communicate with ground-based platforms and formations, in order to verify where friendly forces on the ground are located. Although the company could not provide any further detail at this time, it told *Armada* that one of the system's key applications is in support of the CAS mission, and applying it to the Typhoon fighter family supports a desire by both the operators and industry behind the aircraft to adapt it further to this type of operation: "A reverse-IFF system uses the same concept to interrogate ground forces (as the air-to-air one), allowing a pilot to understand where surface-level friendly forces are located before deciding whether to use weaponry," Leonardo added in a written statement: "The system is called 'reverse' IFF because the aircraft uses its transponder, usually used to reply to interrogations from other aircraft or from the ground, to scan (for RF transmissions from) ground vehicles."

In April 2016, Leonardo announced that it had demonstrated the successful integration of a Mode-5 reverse-IFF system onto a Typhoon family aircraft, providing air-to-ground IFF capabilities. Mode 5 refers to the new IFF protocol that will be expected to be used by NATO (North Atlantic Treaty Organisation) nations from circa 2020. All IFF systems, if they are to be used during NATO operations or exercises, will need to be integrated with Mode 5 compatible IFF systems by then, and the reverse IFF system could be another option for this: "To demonstrate the solution, an Italian air force Typhoon simulated a close air support mission over Pratica di Mare (Rome) airbase in Italy, flying toward and interrogating a number of Italian Army armoured vehicles with its reverse IFF system. As the vehicles returned 'friendly' signals, the Typhoon held off from providing air-to-ground support that might otherwise have caused collateral damage to the friendly forces," Leonardo continued in the statement. It added that NATO is considering the Mode 5 reverse IFF system as one of the possible

US DOD

A US Air Force A-10C ground attack aircraft performs a CAS strike during a training exercise.

CAS technological development is focusing on methods by which forward air controllers and counter-insurgency aircraft such as the EMB-314 pictured here can work together.

short-to-mid-term solutions for air-to-surface identification, which will help it avoid friendly fire when cooperating with coalition forces: "The integration solution ... has shown that it is possible to introduce such a significant capability in a simple, low-impact fashion using the aircraft's existing (IFF) transponder," it added.

COMMANDER FIRE

Thales, on the other hand, is developing technology within Europe for the ground-based operator specifically, namely the Commander Fire CAS Edition,which is derived from other intelligence systems that the company has already developed. Commander Fire is a fully digitised artillery Command and Control (C2) system. In 2012, it became apparent that as a result of the French Army's experience of using the Commander Fire system, it wanted a specific forward observer system in order to help optimise the sensor-to-shooter loop: "in order to (accelerate) the call for fire tempo and guarantee long-range precision strikes with smart ammunition," Matthias Abouothman, product line manager for artillery and intelligence systems at Thales, told *Armada*. Mr. Abouothman added that recent military operations involving the French armed forces in Afghanistan, Libya, Mali and Iraq underlined specific needs for more air-land integration, which is the "criticality of joint coordination" when it comes to CAS missions: "Thus, Thales launched in 2014 the first version of its Commander Fire CAS Edition; a customised hardware integrated on a combat vest integrating full connectivity and offering a dedicated Digitally Aided Close Air Support (DACAS) software suite," he said. Commander Fire systems are operationally deployed in France, Malaysia, Saudi Arabia, South Africa and the United Arab Emirates, although when it comes to the Commander Fire CAS Edition: "our export customers are very keen to stay discrete mainly because of on-going international coalition air strikes against ISIS (Islamic State of Iraq and Syria," Mr. Abouothman added: "The target market is worldwide, as fire support missions include new (weapons), joint coordination, legacy integration," he said, adding that the DACAS market is platform driven, and is also being bolstered by sales of new aircraft that could be used in this role, notably the recent sales of the Dassault

Elbit Systems has carved a niche as a supplier of upgrades to Soviet/Russian and Warsaw Pact era aircraft, such as the L-39, to enable them to be compatible with Western avionics and weapons.


USAF

Rafale family fighter to Egypt, India and Qatar," he added.

The Commander Fire CAS Edition can connect with existing tactical radios to allow its information to be shared across the battlefield. It enables the JTAC to perform voice and data exchanges with the air operations headquarters, army combat units within the area of interest, as well as fixed and rotary wing aircraft directly: "The latest version of the Commander Fire CAS Edition, (and) new hardware and software configurations enabling call for fire in three clicks, will be tested in real conditions (in 2017)," Mr. Abouothman noted.


Danie van der Merwe

In the Brazilian market, Embraer and Rockwell Collins announced in April that they had teamed with Savis and Bradar to work on a number of key defence technologies, including close air support. While the agreement is designed to develop a number of different technologies, the first focus is on radar integration into Rockwell Collins' FireStorm product, which is a wearable targeting system for JTACs that connects different battlefield elements together into one unit. The agreement will see Bradar's radar incorporated into the system, which will increase situational awareness and be able to be used alongside CAS aircraft such as Embraer's EMB-314/A-29 Super Tucano turboprop trainer/light attack aircraft: "This integrated solution provides an option to augment the capability to offer both close air support and troops' call for fire, being able in the future to operate integrated with attack aircraft, such as the A-29 Super Tucano," a joint statement released on 4th April said. While there is a domestic application to this work, the *Força Aérea Brasileira* (Brazilian Air Force) notably operates the A-29A/B, the team hopes that together exports of different technologies including the radar-upgraded CAS system will be more appealing to potential customers.

That work being carried out with less traditional CAS aircraft in mind, such as the Super Tucano and Typhoon families, also illustrates how certain nations want to have control over both the land and air element of close air support operations. Elbit Systems is seemingly taking a lead on modifying older aircraft to be adapted to modern CAS missions, including for the Royal Thai Air Force that has received an upgraded Aero Vodochody L-39 turbofan trainer that supports close air support roles. The Philippines could be another customer for a modified L-39, as the island nation seeks a new CAS aircraft, and Aero Vodochody's systems could be an option, including its new L-39NG, which includes new avionics and a new engine. Elbit installed a new avionics suite onto the L-39 for Thailand, including an advanced cockpit, a debriefing system, and the capability to deploy Western weapons. It added that the system was tailored to be as close as possible to the General Dynamics/Lockheed Martin F-16 fighter family operational concept, to enable the L-39 to perform as a lead-In trainer for the F-16. Elbit also offers the Serpent, which is a portable and lightweight laser designator and rangefinder for laser-guided munitions. This provides forward observers and close air support operators with diode-pumped laser technology, which Elbit says in its literature enables accurate laser designation with low lifecycle costs and reduced battery consumption. The system is also lightweight with a mass of 4.63 kilograms (10.1 pounds) it is optimal for dismounted soldiers, Elbit noted.

Another success of Elbit is the upgrade of the Sukhoi Su-25 family ground attack aircraft which, with its modifications, is designed to provide CAS and engage low-speed air targets: "It features a versatile arsenal of both Western and Eastern weapons, mountable (across) ten pylons," Elbit says. The new Su-25 is equipped with an advanced avionics system, including a weapon delivery and navigation system, and is fully NATO-compliant: "The fully modernised cockpit features two multi-function colour liquid crystal displays, and a head-up display," the company said: "The upgraded aircraft is fitted with protective features, assuring increased survivability even in the harshest scenarios."

These different aircraft offer alternatives to US-built systems such as the Fairchild/Lockheed Martin A-10C Thunderbolt-II ground attack aircraft operated by the US Air Force, which has now become synonymous with CAS aircraft, and ground-based systems are being developed accordingly to complement these alternative aircraft. The US arguably takes a lead in a lot of operations worldwide, so it makes sense that it also takes the lead in integral operations such as CAS execution. However, there are still theatres where the US is not present, and other nations must then take responsibility directing air power to the correct target during these operations. To this end, nations in Europe and further afield are incorporating CAS technology, of which there are many different varieties, and offering different types of system to export nations.

SUITS OF ARMOUR

Helicopter armour that protects aircrew members and passengers from small arms fire is a proven requirement driven by recent, and ongoing, conflicts in the Iraq/Syria and central Asian theatres, meanwhile the drive towards lighter armour will continue.

Andrew Drwiega

Armouring helicopters, more properly defined as adding ballistic protection, to safeguard crew and passengers when flying in war zones has always been a compromise between installing an extra element of protection, while adding weight and thus sacrificing payload. Weight is an ever important factor, nowhere more than during high altitude operations where engine performance decreases due to the commensurate lack of oxygen. Due to the nature of recent Counter-Insurgence (COIN) operations, helicopters, particularly those involved in troop transport, usually fly at 3000 feet (914 metres) or below depending on aircraft type and tactical requirement. This makes them vulnerable to a variety of ground based weapons, from single shot rifles, to dedicated heavier machine guns that double as Anti-Aircraft Artillery (AAA) that can be broken down and transported into remote locations by insurgent groups. Such weapons have in past conflicts,

US Army

Six US Army UH-60Ls and two CH-47Fs simultaneously launch a daytime mission from Tarinkot airfield in south-eastern Afghanistan in 2013.

included the Russian 14.5mm ZPU family towed AAA and DHSK 12.7mm heavy machineguns. When such weapons are present, however, air support in the form of attack helicopters or fighters are usually called upon to eliminate the threat as aircraft ballistic protection against weapons of these sizes is difficult to achieve, much as it is against the explosive power of the surface-to-air missiles used by Man-Portable Air Defence Systems (MANPADS).

A typical Ballistic Protection Systems (BPS) traditionally comprised a dense material which would offer protection, but had the drawback of being heavy and adding a lot of weight around the aircraft. The challenge in recent years has been to produce the same, or better, ballistic protection while using new composite materials that are much lighter and more compact. The development of such light-weight composites have now allowed their use onboard fixed and rotary-wing aircraft: "The key driver for helicopter ballistic protection is always weight, so we operate a continuous research and development process to evaluate new materials and optimise processing and armour constructions to reduce the weight of our solutions," Nick Baird, commercial director at UK-based Permali Gloucester told *Armada*. Over the years, US Army Aviation and the Missile Research, Development and Engineering Centre's (AMRDEC) Prototype Integration Facility (PIF) has evolved an expertise in developing ballistic protection for a range of rotorcraft, particularly the Boeing CH-47 Chinook family heavy-lift and Sikorsky UH-60 Black Hawk family medium-lift utility aircraft. The PIF has focused on the development of new versions of the Hybrid Enhanced Ballistic Protection System and Multi-Hit Transparent Armour Engineered Seams kits for both the older CH-47Ds and the CH-47Fs replacing them. Again the focus of development has been to use composite materials to reduce weight while offering protection for small arms fire up to 7.62mm calibre. On a CH-47D/F, this reduced the weight of the BPS by 2000 pounds/lb (909 kilograms/kg) to the current weight of around 3500lb (1509.9kg). A complete CH-47D/F BPS will usually include cockpit and cabin floor protection, side panel protection and also a Multi-Impact Transparent Armour System for windows, which offers a measure of ballistic protection. A similar reduction in weight was achieved for the BPS of the UH-60 family helicopter. This time around 500lb (227.3kg) was taken off the weight of the legacy BPS system.

The design of the BPS is also something that can be changed to increase protection: "Another key development is shaped ballistic protection, traditionally helicopter armour panels have been flat, but we can optimise the integration of the armour onto the platform by manufacturing shaped or moulded panels (both composite and ceramic) that improve protection and reduce weight. Within Europe, our ballistic protection solutions are in service on helicopters operated by Denmark, Italy, the Netherlands and the UK," said Mr. Baird.

ONGOING NEED

During operations in Afghanistan, NATO (North Atlantic Treaty Organisation) International Security Assistance Force helicopters particularly noticed the weight penalty imposed by BPSs when flying at altitude. Even at their main bases, such as Bagram airbase in eastern Afghanistan was 4895ft (1492m) Above Mean Sea Level (AMSL), while Camp Bastion/Shorabak airbase in the southwest of the country, stood at 2805ft (855m) AMSL.

Once the UK Government decided

US Army

Textron subsidiary Aeronautical Accessories has supplied self-sealing fuel cells and ballistic protection for Bell 407 helicopters acquired by the Iraqi Army.

to commit forces into Iraq (2003) and Afghanistan (2001) the Royal Air Force (RAF) required armour for its troop carrying CH-47D (locally designated as the HC Mk.2 Chinook). This was initiated in 2003 through an urgent operational requirements and Permali Gloucester was selected as the contractor to provide that aircraft's BPS due to its experience with composite materials. A requirement was identified to develop and certify in as short a timeframe as possible a BPS which would protect the cockpit, main cabin and the ramp. Considering the role that the CH-47Ds were to play in re-supplying remote bases manned by the British Army's Parachute Regiment when they were deployed into Helmand Province, in the southwest of Afghanistan, in April 2006, all of these protected areas were to prove vital. Upon the arrival of the Parachute Regiment, the regiment was split into smaller teams and inserted into seven key locations which became know as 'platoon houses'. Unfortunately, their low numbers (around 600 troops) meant that they were severely restricted in their ability to conduct deliberate operations and became hemmed in 'Alamo' style by the Taliban who concentrated greater numbers of insurgents against these specific locations. The eight RAF CH-47Ds deployed at the time were then constantly used to re-supply these outposts on a daily basis, often attracting significant ground fire as they tried to land to offload supplies of food and ammunition and to evacuate casualties. Often they needed the firepower of British Army Air Corps Boeing/AgustaWestland AH-64D (locally designated Apache AH.1) attack helicopters to complete their missions.

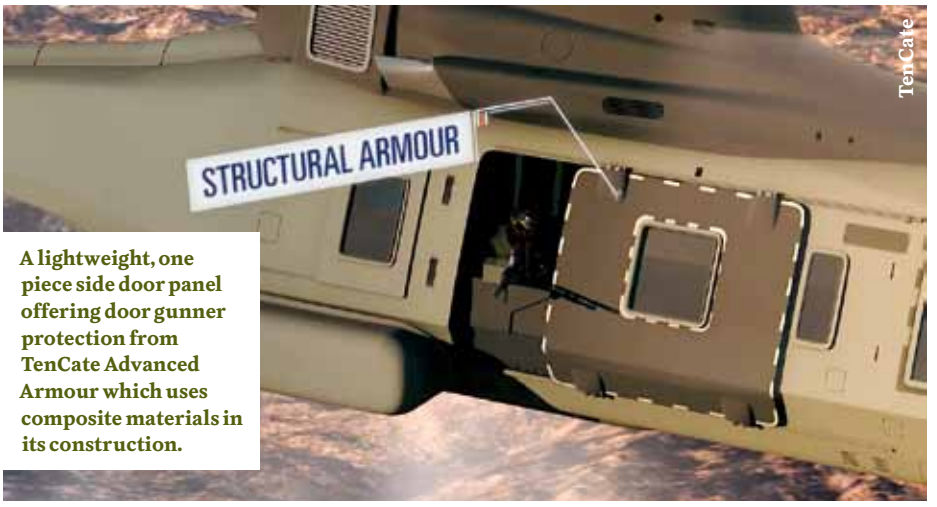
Permali subsequently supplied BPSs to the Royal Netherlands Air Force (RNLAF) for their CH-47D/F and have worked with Boeing to provide options for other export customers. Mr. Baird commented that different operational deployments do not have a bearing on ballistic protection types: "We are not seeing changes to requirements driven by the type of campaign. Requirements are always bounded by weight constraints anyway, so there is a limit to the severity of the threat protection that a helicopter can carry. For passengers in the cabin this is typically small arms protection, often with higher protection (up to heavy machine gun calibre) for the pilot and co-pilot." Confirming that ballistic protection is not 'one-design-fits-all', Mr. Baird confirmed that: "our helicopter ballistic protection is not interchangeable between different aircraft types; the airframe integration is too bespoke and specific ... Armour panels that have been shot usually cannot be repaired," he stated: "Our panels usually have a 'multi-hit' capability, meaning that they are capable of stopping multiple bullet impacts, and retain their structural integrity within reasonable limits. In some circumstances, an impacted panel can continue in service on the aircraft (but with reduced protection) until a replacement panel is available."

IRAQI ARMY

Away from Europe, the Iraqi Army is currently flying 25 Bell 407 light utility helicopters some of which are being used in operations against the Islamic State of Iraq and Syria, as the country strives to push them out of their last strongholds in the north of the country. These aircraft feature ballistic protection for the cockpit floor and crew seats. Around the same time in 2013 that the helicopters were being delivered to the Iraqi Army, a Textron subsidiary Aeronautical Accessories announce that it would be supplying self-sealing fuel cell kits and a passenger ballistic protection system for the Bell 407. The kit included protection for the forward, main and auxiliary self-sealing fuel cells.

The Bell 407 BPS was developed by LifePort, then a Sikorsky company. Developed to protect both crew and passengers, it is also lightweight and coated with a product called LifeGard that effectively seals and protects the armour to increase its durability and provide a

MKU offers a number of products to provide enhanced BPSs for rotorcraft, not least of which is the Polyshield V6 product the firm launched in 2014.



A lightweight, one piece side door panel offering door gunner protection from TenCate Advanced Armour which uses composite materials in its construction.

slip resistant surface inside the cabin. The BPS is made from High Performance Polyethylene (HPPE) fibre and ballistic steel which combines a light weight with ballistic coverage and crew comfort. It is certified in accordance with the US National Institute of Justice Level-III Standard 0108.01 providing a multi-hit ballistic solution capable defeating the 7.62 mm calibre full metal jacket ball rounds.

A GLOBAL INDUSTRY

A report from Research and Markets, a US-based market research report provider, valued the global ballistic protection materials market at around $8.8 billion in 2015, with an expectation for growth at a compound annual growth rate of 5.2 percent from 2016 to 2022. While that is led by personal ballistic protection and vehicle ballistic protection, there is nevertheless a strong requirement for airborne ballistic protection. For example, India's MKU Airborne Systems provides armour for both fixed and rotary wing aircraft and is qualified to the AS-9100 Society of Automotive Engineers' international quality management standard, allowing it to design and develop lightweight armour for aircraft. The company states that its armour can be installed onboard an aircraft without modifying the existing platform. MKU provides aircrew seat, floor and side armour protection within the main cabin, and protection for other vulnerable areas such as a helicopter's chin bubble and side protection for a door gunner. In 2014 it introduced a new product called Polyshield V6, developed in India and Germany. The company stated that this new armour represented a weight reduction of around 40 percent which would translate into additional load capacity for each helicopter so equipped: "The sixth generation technology uses advanced materials and new techniques to develop very light weight armour panels," the firm revealed in a press release announcing the news.

According to Neeraj Gupta, MKU's managing director, the new lightweight panels add only 26.4lb (twelve kilograms) per square metre (10.7 square feet): "Since weight is one of the three major parameters controlling the performance of a helicopter and the only one that can be controlled, this development is very significant" he said during the launch of the Polyshield V6. At the recent Aero India air show held in February in Bengaluru, western India, Mr. Gupta stated that the company was not only able to provide armour for the Indian armed forces, but that it could also deliver BPSs for a variety of rotary and fixed-wing aircraft including Russian Helicopters MI-8/17 family medium-lift utility helicopters; Lockheed Martin C-130 family turboprop freighters; Pilatus PC-6 family turboprop transports; CH-47D/Fs; Messerschmitt-Bölkow-Blohm/Airbus Helicopters BO-105 light utility helicopters and the UH-60 family.

Further south in Australia, CCA Protect has supported the Australian and New Zealand armed forces, and has supplied Australian Army Aviation with ballistic protection for its CH-47D/F and UH-60 family aircraft. CCA has the capability to rapidly produce airborne BPSs but maintains a surplus of components to reduce lead times for manufacturing and supply. Meanwhile, away from Australasia, Armour of America based in Alabama, has provided a number of armour kits for over 300 military and civil helicopters to most of the major helicopter manufacturers over the last 35 years. The company uses computer aided design to develop the kits so that they can be adapted to the design modifications of any operator's helicopter. The main areas of coverage include cabin floor and walls, cockpit, crew seats, gunner stations and transmission walls. Finally, TenCate Advanced Armour uses composite materials enabling the company to pursue a 'built-to-print' and 'built-to-specification' policy, plus designing for the quick installation and extraction of aircraft ballistic panels.

CONCLUSIONS

The need to improve helicopter protection while also ensuring comparatively light weights is unlikely to reduce in the near future. Since their first use *en masse* in combat, notably by the US armed forces during the Korean War of 1950 to 1953, helicopters have been deployed regularly to support counter insurgency operations, as well as conventional warfare. Rotorcraft will continue to be relied upon to assist the entire spectrum of conflict and, because of this, the threat to these aircraft from small arms fire is unlikely to diminish.

THINKING, INSIDE THE BOX

Special forces around the world are keeping a keen eye on technological trends in the artificial intelligence and cyber domains as they seek to maintain operational and tactical advantages over actual and potential adversaries.

Andrew White

Addressing representatives from across the international special forces community in Tampa, Florida in May 2016, during the Special Operations Forces Industry Conference the former director of UK Special Forces (UKSF) Lieutenant General Sir Graeme Lamb warned how commanders must exploit next generation technologies to maintain an overmatch against adversaries. Referring to emerging threats from so-called 'near peer' adversaries, including the Democratic People's Republic of Korea (DPRK), the People's Republic of China (PRC) and Russia, Lt. Gen. Lamb described how the global special forces community must reach the "highest levels of intelligence" in order to empower a shared consciousness of special forces across the battlefield. Highlighting technology types including Artificial Intelligence (AI) to assist in the generation, processing, exploitation and dissemination of Situational Awareness (SA), Lt. Gen. Lamb called for greater proliferation of "operator-to-machine; team-to-machine; and machine-to-machine integration" in order to create a holistic, smart and trusted fusion of knowledge: "It's all in the technology," he proclaimed before describing how special forces should become an: "unconventional force acting unpredictably while doing the unexpected against unknown and emerging threats."

Almost a year on and the special forces community continues to consider such technologies, as was illustrated by the

Revision Military

The US Special Operations Command's TALOS is currently tackling issues associated with the integration of Augmented Reality technology into helmet-mounted displays.

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Future soldier technology is expected to be led special forces with developments including the integration of artificial intelligence to optimise decision-making processes and the exploitation of intelligence.

head of the French Special Operations Command, Rear Admiral Laurent Isnard, who explained to delegates at the SOFINS (Special Operations Forces Innovation Network Seminar) held in Bordeaux, south-west France on 28th March 2017, how the internet had provided unequivocal capability increases to adversaries through information sharing: "Everything has to do with intelligence and decision making," Adm. Isnard explained: "To assess the (operating) environment, we need connectivity and observation. We know everything about (optronics) but our operators are becoming more and more involved in EW (Electronic Warfare) ... We need to find any breakaway technology in radar to identify tunnels and we need to know what's happening behind walls. We are thriving for information and it's this which gives us the edge today. But we need to go further," he urged.

Specifically, Adm. Isnard called for greater use of intelligence by more efficient processing and exploitation of metadata (information that provides information about other information) using AI and other software packages. "If we can't process (intelligence), it is useless," he added. Additionally, he called for greater connectivity across the battlefield, describing how his special forces troops needed to "reconfigure quickly" by becoming more reliant on plug-and-play technology: "We have to connect the operator in middle of desert with his transport plan, including UAVs (Unmanned Aerial Vehicles), boats and aircraft as well as other commandos. We need to be actual in our communications and extremely careful in how we protect communications and data," he asserted while calling for greater usage of autonomous energy supplies.

TACTICAL NEURAL IMPLANTS

How to deliver such efficient processes and technologies? Speaking to *Armada* during the SOFINS event, industry sources described how important 'Hybrid Intelligence' was becoming to the international special forces community: "It's a smart world, hinged around four elements," sources explained while highlighting an operational and training environment encompassing a: "mixed reality of virtual and non-virtual technology, where software meets biology and where deep machine learning can be integrated with human intelligence".

Making reference to future soldier system programmes such as the US Special Operations Command's Tactical Assault Light Operator Suit (TALOS), which seeks to unveil a Technology Demonstrator solution in August 2018, sources described a variety of technology relevant solutions being witnessed across such concepts. For example, one special forces source associated with the programme described ongoing difficulty in managing eyeball focus on virtual and augmented reality icons presented in a soldiers' field-of-view. The TALOS effort is considering the integration of Augmented Reality (AR) into head-up displays for troops which could include a blended fusion of image intensification, infrared and digital display. AR seeks to superimpose computer-generated imagery onto the users' field-of-view: "The market is going to suffer from a problem of seeing an object properly but this is where software will meet biology with things such as neural lace implants. We're almost there," it was explained with reference to body and brain implants. Such a concept is being explored by the likes of Neuralink, of which technology entrepreneur Elon Musk is the founder and chief executive officer, which is attempting to develop brain implant technology to allow for the integration of AI. Put simply, a neural lace can be implanted into the skull and monitor brain functions so as to activate a machine.

ENERGY

Elsewhere, next-generation energy solutions remain high on the agenda for special forces seeking enhanced autonomy and endurance across the full spectrum their operations. Speaking to *Armada*, a company spokesperson from Swedish innovation company myFC explained how future End User Devices (EUDs) such as laptops and tablets could soon be powered for "weeks at a time", thank to the integration of fuel cell technology battery packs. A fuel cell can convert chemical energy into electricity by causing a chemical reaction with oxygen, or an oxidising agent, and positively charged hydrogen atoms. Unable to confirm how mature discussions were at this stage with the special forces community, company sources described how the technology could be harnessed

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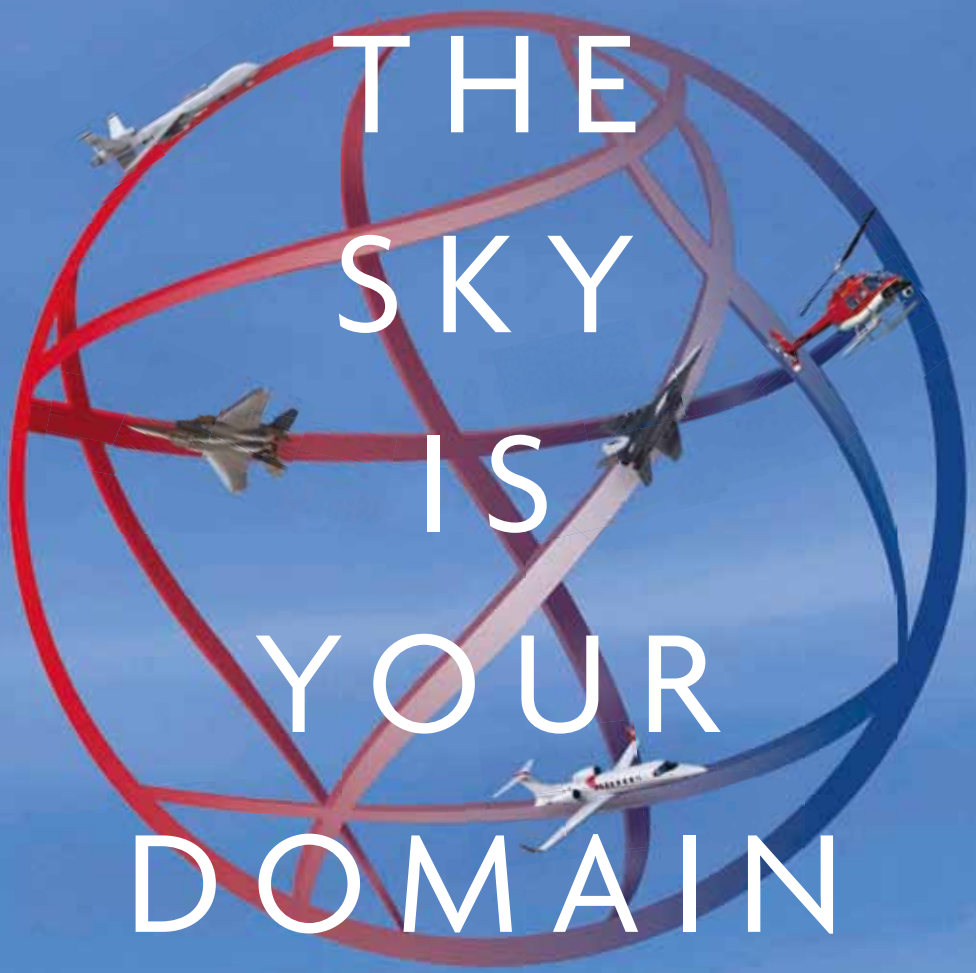

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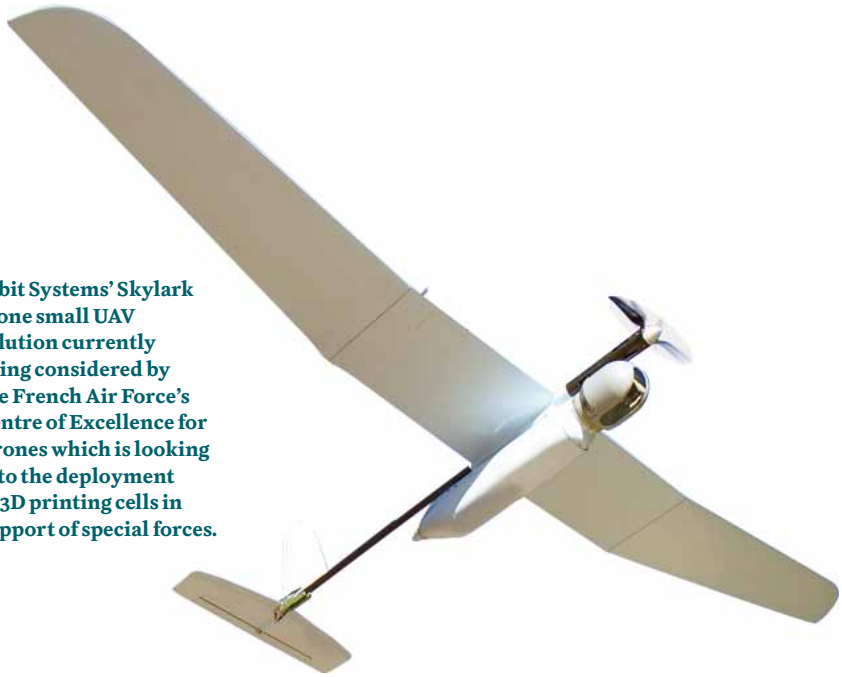

Elbit Systems

Elbit Systems' Skylark is one small UAV solution currently being considered by the French Air Force's Centre of Excellence for Drones which is looking into the deployment of 3D printing cells in support of special forces.

to produce electricity as opposed to more conventional battery technology which can only store electricity: "Batteries can only carry as much energy as limited by the internal energy storage capacity. A fuel cell is a device that generates electricity from a separated chemical reaction – usually the reaction between hydrogen and oxygen," the spokesperson explained. Options include myFC's Powertrekk which relies upon chemical reactions associated with hydrogen atoms: "Hydrogen is the basic fuel for PEM (Proton Exchange Membrane) fuel cells, but these fuel cells also require oxygen. One great advantage of fuel cells is that they generate electricity with no pollution, the hydrogen and oxygen used in generating electricity ultimately combine to form a harmless byproduct, namely water." They continued that: "Fuel cells are scalable and typically put together in a stack in order to obtain wanted power performance for a specific system. Fuel cell systems range from small power units to high power systems like cars or power plants. The technology has also been used in space stations," the spokesperson added.

Meanwhile, Georgia Institute of Technology and Chongqing University, in southwest China continue to explore the development of wearable textiles capable of simultaneously harnessing solar and wind energy to produce electricity on the move. According to the partnership, such a solution could provide dismounted personnel with an integrated solution for the generation of electricity for EUDs: "This hybrid power textile presents a novel solution to charging devices in the field from something as simple as the wind blowing on a sunny day," explained Professor Zhong Lin Wang, from Georgia Tech's Materials Science and Engineering department at the launch of the product in September 2016.

According to Georgia Tech documents describing the technology, the concept relies upon Triboelectric Nano-generators capable of producing electrical power from "mechanical motion such as rotation, sliding or vibration ... The fabric is highly flexible, breathable, lightweight and adaptable to a range of uses. The backbone of the textile is made of commonly-used polymer materials that are inexpensive to make and environmentally friendly. The electrodes are also made through a low cost process, which makes it possible to use large-scale manufacturing," University officials added while explaining how current tests were considering the long term durability of the technology as well as protection from moisture. Defence sources explained to *Armada* how the future integration of such technology into combat apparel would allow for an organic power source for operators conducting long range reconnaissance patrols on foot and without access to vehicles.

3D PRINTING

The international SOF community is also leading the market with regards to three-dimensional (3D) printing techniques for UAV technology which, according to the *Armée de l'Air* (French Air Force) *Centre d'Excellence Drone* (UAV Centre of Excellence), is already in a development pipeline with the French Special Operations Command. Speaking to *Armada* during the SOFINS event Commander Daniel-Frederic Gigan from the UAV Centre of Excellence explained how the technology was changing the way defence organisations can produce objects, with options ranging from UAVs through to perovskite (a calcium titanium oxide material) solar cells printed on plastic. The latter would allow solar panel recharging modules to be printed on vehicles, clothing and infrastructure, providing organic energy sources across the battlefield, defence sources explained. The French Special Operations Command and air force are both currently considering the establishment of an expeditionary 3D printing cell capable of supporting French special forces assisting the Task Force HYDRA effort in Iraq and Syria where French commandos operate alongside Iraqi Army and Kurdish militia against ISIS. Such a move would allow commanders to rapidly model and produce UAVs for special missions: "The Centre of Excellence for Drones has the capacity to develop this capability quickly with our experience in the field and we could do some prototyping in the field in a period somewhere between three days to a week. We are clearly answering a requirement from the Special Operations Command and operational theatres," he claimed. Furthermore, Cmdr. Gigan highlighted ongoing efforts to better integrate AI technology into mini and small UAVs, providing airframes with the capacity to extend autonomous abilities and subsequently, mission effectiveness across the battlefield. He concluded that: "We are structuring our ecosystem so that one day, we can open our catalogue to offer on-the-shelf products needed by our forces. This is why innovation is key." The Centre of Excellence for Drones' current footprint in UAVs is limited to the DJI Phantom series and Elbit Systems' Skylark family UAV, both of which are used for developmental training. However, the centre retains partnerships with multiple UAV specialists including companies such as Parrot.

CYBER MOVES

The advent of the so-called Cyber Warrior

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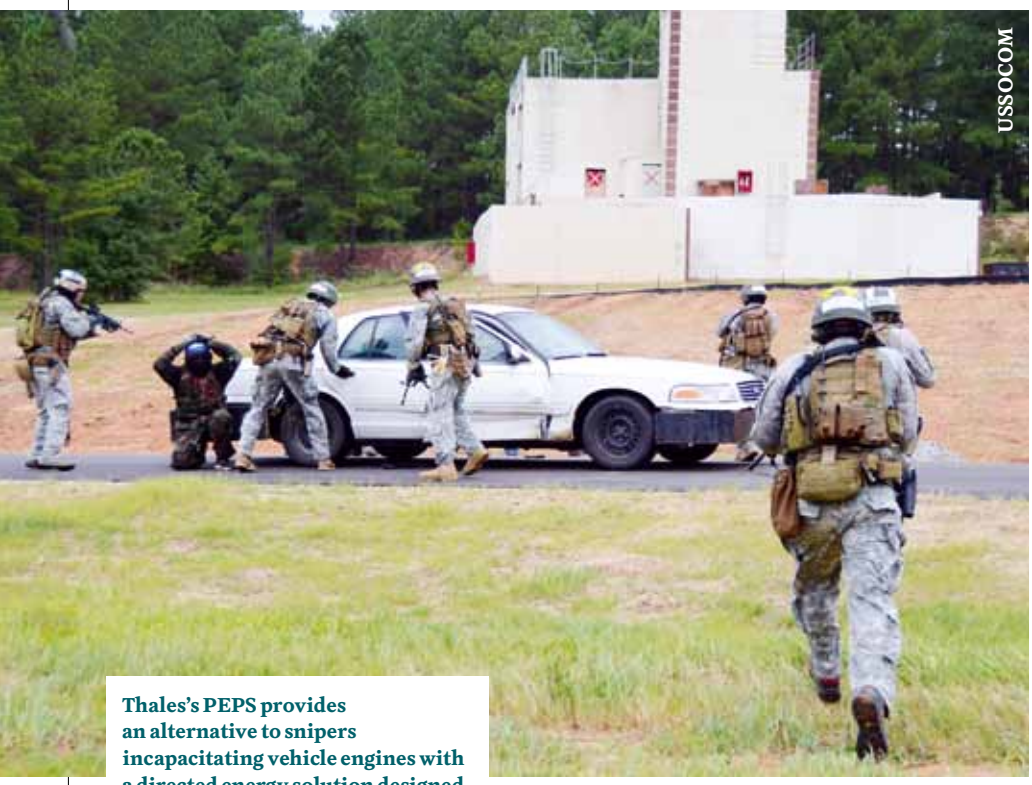

Thales's PEPS provides an alternative to snipers incapacitating vehicle engines with a directed energy solution designed to neutralise the electronics of a mobile vehicle.

continues to gather pace across the SOF community. The Cyber Warrior concept which was first showcased in 2011 by Vincent Viola, the founder of the US Army's Military Academy's Combating Terrorism Centre (CTC) at West Point, New York State. Addressing delegates at the event, Mr. Viola called for USSOCOM to set up a Cyber Warfare Ranger School, providing commanders with a perfect blend of technology and personnel optimised for the future operating environment. It is unknown whether this school has now been established by the US Army, and entirely possible that its existence is classified. Speaking to *Armada* ahead of the SOFINS event, an official spokesperson from the Danish Special Operations Command described how such a concept remains a: "high priority across the Danish armed forces and intelligence agencies." The Command has now stood up dedicated staff officers to consider a future roadmap for the integration of cyber skills into the ranks of the Danish *Jaegerscorps* and Frogman Corps special forces as the threat of cyber and electronic warfare continues to proliferate, the spokesperson confirmed. The news follows the January NATO Exercise CROSSED SWORDS which saw the integration of cyber-kinetic warfare into an Alliance training programme for the first time, according to exercise officials: "The scenario was based on a military cyber-operation. Penetration testers, digital battlefield professionals and members of special forces were tasked with regaining control over a specific military system ... This (unique) cyber-kinetic engagement meant that special forces were used to retrieve physical evidence, including electronic equipment and data storage devices, as they would in a realistic mission in cooperation with battlefield digital forensics professionals," NATO officials described. The exercise saw special forces concentrating on: "evidence gathering and information analysis for technical attribution ... Technical cyber defence exercises typically train information system defence. However, this can only be done with a real-time deployment of opposing forces played by security specialists and penetration testers. These professionals are usually known as the Red Team," officials added.

POLITICAL VIOLENCE

At the tactical level, special forces continue to receive uplifts in technology to better enable them to execute complex operations to fight political violence both at home and abroad. One company which continues to invest heavily in both of these areas, in particular for the French Special Operations Command, is Thales which according to the company's military liaison, Alain Bouquin, is developing two particular next-generation technologies: Speaking to *Armada*, company sources explained how the Portable Electromagnetic Pulsed Source (PEPS) product had been designed to provide a non-kinetic means of halting cars and trucks during vehicle interdiction operations. The special forces community has been considering the development of similar systems over recent years but Thales's latest effort, which disrupts the electronic circuits of the target vehicle bringing it to a standstill, has provided new impetus in this area. One NATO special forces source explained to *Armada* how a PEPS-like solution would provide the capability to stop a target vehicle in a more discreet fashion, compared to using gunfire, and with the added benefit of less collateral damage.

Thales has also developed the Remote Effects by Portable Infrared Laser or 'REPTILE', providing special forces assault teams the wherewithal to cut through metal from a stand-off range of up to 200 metres (656.2 feet), company officials claimed. Speaking to *Armada* during the SOFINS event sources associated with the French Special Operations Command explained the potential benefits of such a capability: "If the course of action to storm a building has been selected, assault teams generally stack up outside the selected aperture for method of entry which can include demolition charges. There have been incidents when operators have been injured using demolitions to breach so the ability to gain entry while stood off at range remains an interesting option," the sources explained.

CONCLUSION

As described by senior special forces officials, the near-term is set to witness considerable capability advances across the community with regards to command and control technology, which in turn will have a significant impact on the tactical *materiel* in use today. There remains little doubt that the advent of AI technology and cyber capabilities will assist in the optimisation of decision-making processes and protection across the battlefield respectively. However, commanders must remain vigilant regarding the overload of information for the human brain so as not to overburden thinking patterns and reactions.

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