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Military Aerospace Focus

- Finnish Air Force
- FCAS/SCAF and TEMPEST
- Defence Procurement in Denmark
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C-390 MILLENNIUM SUCCESSFULLY ACCOMPLISHING MISSIONS

The C-390 Millennium multi-mission aircraft is in-service with Brazilian Air Force delivering exceptional performance and fulfilling all expectations, most notably with support during the Covid-19 pandemic. The C-390 is also the aircraft of choice for Portugal and now Hungary too. Both these air forces have selected the C-390 to meet their own unique and demanding operational requirements. By combining state-of-the-art systems and proven technologies with a worldwide network of reputable suppliers, the C-390 Millennium is a versatile addition to any air force. The C-390 is the most reliable, easy to operate and efficient aircraft in its class.

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The Language of Power for a More Geopolitical EU

Photo: author



It is not only in view of the Israeli-Palestinian conflict that Europeans are trying to orient and mobilise themselves. Commission President Ursula von der Leyen proclaimed a more geopolitical stance for the EU when she took office. The EU intends to play a greater role in global crisis management. According to a survey, this is what the citizens want as well. Last year, 77 per cent of Europeans supported efforts to develop a common EU security and defence policy (source: High Representative Josep Borrell, citing Eurobarometer). Josep Borrell never gets tired of calling for more commitment. At the 6 May meeting of EU defence ministers, he concluded, "We must prepare for the next crises and respond quickly." That involves "making the EU's operational engagement more effective."

The deliberations at the 6 May meeting focused on one of the four main issues at hand: crisis management. A "number of ideas" were "put on the table," the EU High Representative reports. According to rumours, a total of 22 non-papers, describing different perspectives on how to prepare for the next crises and approaches to respond quickly. All more or less focused on the operational aspect of the common security and defence policy: How can CSDP operations and missions be made more robust, agile and efficient? Where should the European Union act as a priority? And how?

Now a new unit is supposed to do the job – although the EU Battle Group has not yet proven its usefulness. Will 'the new entity' help to hide the fact that for the time being a truly global ambition seems to be unattainable?

Fourteen member states, including France and Germany, have endorsed the idea of an EU Initial Entry Force. The approximately 5,000-strong unit (land forces, supported by air force and naval components if needed) would be deployed quickly in the early stages of a crisis. For those familiar with the Common Foreign and Security Policy: old wine in new barrels. As early as 1999, the 'European Headline Goal' gave birth to the idea of international crisis management with a force of 60,000 troops ready for worldwide operations within 60 days (within the framework of the Petersberg tasks in force at the time). In 2007, the rotating EU Battle Group was established to respond quickly to crises. Since then, two battle groups (1,500 men each) have always been on standby for a period of six months on a rotating basis. They have never been used so far. It could form the nucleus for the 'initial entry force' that has now been raised.

Brussels observers believe that the new initiative is a fresh attempt on the road to an EU army. After Brexit, the Union finds itself freed from a fierce opponent of such aspirations.

On the other hand, it is not for lack of ideas that the European Union still does not use the language of power, as High Representative Josep Borrell likes to put it. The EU is proving to be financially strong, to be sure. It has a common budget for defence. Overall, however, it appears powerless. This is not only due to internal differences of opinion among the member states regarding the form of EU foreign policy. As the example, the special conference on the situation in the Middle East on 18 May showed it was not possible to agree on a joint final communiqué. Member states are only – to a limited extent – fulfilling their obligations in terms of missions and operations. This ranges from the lack of deployment of capabilities to individual soldiers. In an earlier interview with our sister magazine +Maritime Security and Defence+, the head of the EU Military Staff, Admiral Hervé Bléjean, referred to capability gaps due to a lack of units and the shortage of personnel in ongoing operations.

Hans Uwe Mergener



Photo: Boeing

Vertical rotary lift aircraft fulfil crucial functions including logistic support, personnel transport, S&R, medevac/casevac, installation/area surveillance and security missions. **Page 46**



Photo: Georg Mader

Larger airborne early warning and surveillance systems on multi-engine aircraft and helicopters have to meet increasing demands to locate ever smaller targets like periscopes or small UAVs. **Page 88**

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Diehl Defence and NIOA to Cooperate

(gwh) Diehl-Defence and the Australian weapons and ammunition manufacturer NIOA have signed a MoU to pursue opportunities to supply, manufacture and support Diehl products for the Commonwealth. The initial scope of the Diehl-NIOA collaboration will cover the 127mm



Image: Diehl

calibre naval guns that will form the core gun system of the new HUNTER-class frigates in the scope of SEA5000 in the coming years. The proposed collaboration between Diehl and NIOA is to support Australian Industry Capability (AIC) and ensure security of supply in line with Australian Government policy.

Rheinmetall is currently establishing a Joint Strike Fighter 25mm ammunition manufacturing facility with NIOA, which is expected to be operational from the end of the year.

British Army BOXER Milestone

(gwh) The countdown to the delivery of the first BOXER Mechanised Infantry Vehicle (MIV) for the British Army is entering the decisive phase. This comes after Rheinmetall announced that welding work for prototype production and the start of series production has begun on schedule at the company's Centre of Excellence for tactical wheeled vehicles in Kassel. Since the contract was awarded at the end of 2019, the four variants of the 8x8 combat vehicle have been developed. Thanks to the modular design, it was possible to integrate qualified solu-



Photo: Rheinmetall

tions as required so now that the development milestones have been reached, production of the first parts can begin.

ARTEC, the consortium of Rheinmetall and Krauss-Maffei Wegmann (KMW) responsible for the development and production of the BOXER, has commissioned Rheinmetall to manufacture the first prototypes. This will involve the installation of components already manufactured in the UK, such as:

- Weapon stations
- Components of the Generic Vehicle Architecture
- The local situational awareness system
- The vehicle emergency lighting system.

Overall, the two consortium partners are equally involved in the production.

After the start of series production in Germany, the majority of production services will be provided in the UK during the further course of production from 2023.

The main production sites will be run by Rheinmetall BAE Systems Land (RBSL) and KMW subsidiary WFEL. The Rheinmetall site in Kassel is actively transferring know-how to its British colleagues at RBSL with regard to welding skills. In total, the British Army is procuring more than 500 BOXER vehicles across the troop carrier, command vehicle, medical vehicle and specialist carrier for around €2.6Bn. Delivery of the 8x8 armoured vehicles is expected to begin at the end of 2022 with the majority of BOXER vehicles for the British Army to be manufactured in the UK.

Stefan Gesmann Appointed MD of Panavia

(gwh) Airbus has announced the appointment of Stefan Gesmann as Managing Director of Panavia Aircraft GmbH by the shareholders of the TORNADO consortium. He succeeded Volker Paltzo on 1 June 2021, who has moved back to Airbus after two years of this assignment.

Gesmann's most recent role at Airbus Defence and Space as Head of System Support Services included the integration of services engineering solutions for various aircraft platforms. He has represented the

Photo: Airbus



company in the German and European Aerospace Industries Association.

With the tri-national TORNADO programme Panavia Aircraft leads one of Europe's largest cooperative programmes for military aircraft. Its shareholders are Airbus Defence and Space GmbH of Germany, BAE Systems plc of the UK and Leonardo S.p.A. of Italy.

AEC Skyline & Milrem Robotics Sign MoU

(jr) Dutch defence company AEC Skyline and Milrem Robotics have signed a MoU to cooperate in the development of unmanned systems. This was signed by Stef Have, director of AEC Skyline Holding and Kuldar Väärsi, CEO of Milrem Robotics, and is to pave the way for joint development, testing and validation of products and software in the fields of activity of both parties, according to the Estonian company.



Image: Milrem Robotics

Under the teaming agreement, AEC Skyline will act as an integration partner for Milrem Robotics products including the THeMIS and MULTISCOPE UGVs as well as the Type-X robotic combat vehicle. AEC will also engage with the Dutch MoD and potential civilian customers, primarily in the Netherlands. With six THeMIS UGVs already operated by the Royal Netherlands Army's Robotics & Autonomous Systems unit under a Concept Development & Experimentation (CD&E) scheme, both parties now aim to position Milrem Robotics' solutions for future requirements of the Dutch MoD, including the use of manned-unmanned teaming.

The parties are looking into requirements that might lead to the integration of new technologies and payloads including (tethered) UAS, sensors and armaments into UGVs. The companies are also analysing how UAS data can enhance AI and autonomous navigation solutions developed by Milrem Robotics and enhance their intelligent functions. The companies have already identified counter-UAS technology and the development of a new integrated user interface as specific areas of cooperation.

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Improved Protection for Turkish LEOPARD 2 A4s

(gwh) Turkey is modernising some of its 354 LEOPARD 2 A4 main battle tanks, which it acquired from Bundeswehr stocks between 2008 and 2013. The tanks, designated LEOPARD 2 A4 T1s, will receive improvements in command and fire control equipment as well as increased protection against threats in current combat environments.

After the first modernised main battle tanks were publicly unveiled in February 2021, the

Photo: SSB



Head of Turkey's Defence Industries Bureau (SSB), Ismail Demir, has now announced via Twitter that mass production of the kits for the increased armour protection has begun at Aselsan. The new protection package has been developed at the Roketsan Ballistic Protection Centre, which has just come into operation. Building on the existing ballistic protection of the LEOPARD 2 A4, protection is increased with add-on modules for turret and hull, with complementary roof protection, heavy track skirts and cage armour. With liners in the hull and turret as well as mine-resistant seats and equipment arrangement, the crew is better protected against the effects of ordnance. A halon-free fire suppression and extinguishing system also contributes to this.

Because of the German Government having imposed restrictions on the export of defence materiel to Turkey after the delivery of the MBTs, Turkey has been looking for a way to increase the number of tanks. As a result, the ALTAY main battle tank was developed, the introduction of which is still awaited.

30mm Gun Turret for STRYKER

(gwh) The US Army is equipping some of its 8x8 STRYKER combat vehicles with unmanned 30-mm gun turrets. In a frame-

Photo: Oshkosh Defense



work contract with Oshkosh Defense (who announced the news) as prime contractor, the US Army Contracting Command has agreed to integrate remotely operated 30-mm SAMSON gun turrets on STRYKER chassis double v-hull infantry carrier vehicle for around €777.6M. The contract also provides for technical system support, logistic support by an intermediate supplier and integrated product support. With this, up to six STRYKER Brigade Combat Teams (SBCT) are to be equipped with 83 converted vehicles each. The first call-off now made, worth around €107M, is for 91 vehicles to be delivered by December 2023 with the entire programme to be completed by 2027.

Oshkosh is working with vehicle developer Pratt Miller – which was acquired by Oshkosh during the bidding phase – and Rafael to execute the contract. For the demonstrator, the SAMSON turret incorporated a Northrop Grumman XM813 gun, an evolution of the BUSHMASTER automatic cannon for use with programmable munitions. The medium-calibre weapon system is considered highly accurate and effective.

The new order to integrate a 30 mm turret into the STRYKER follows the positive experience with the STRYKER DRAGOON, which has been used with the same weapon – albeit in a Kongsberg turret – by the SBCTs stationed in Germany since 2017. It is known from the DRAGOON that the approximately two-tonne turret resulted in reinforced wheel suspensions and wider tyres in addition to interventions in the roof of the STRYKER.

New PMPV Variants

(gwh) Finnish vehicle manufacturer Protolab has announced the introduction of two new versions of the 6x6 Protected Multi-Purpose Vehicle (PMPV), which have been modified based on user feedback to meet the requirements of the Finnish procurement programme.

While retaining the proven mine protection, the PMPV has been given a more powerful engine. There is a choice of engines with 240 kW, 270 kW or 335 kW drive power, which is distributed to the three axles via an Allison gearbox. Front and rear axles are steerable. With a curb weight of 14 tonnes, the maximum payload capacity is for 10 tonnes.

The redesigned interior with more space for C4I equipment includes seating for a crew of two and a group of ten infantrymen. Optionally, different seating systems with two or five point harnesses are available. Crew entry and exit have also been improved and the hatch closure system in all vehicles has been redesigned for easier operation. Com-

Photo: Protolab



fort improvements are to increase the crew's staying power while the vehicle is comparatively narrow at 2.55 m.

Based on the standard configuration, variants for command and control, troop transport or medical operations can be deployed. In mid-2019, Protolab had delivered prototypes of the PMPV for testing to the Finnish Armed Forces.

Russian President Meets Top Brass

(yl) Russian President Vladimir Putin recently held several meetings with high ranking military officials and industrialists to determine: "organisational and economic solutions on strengthening the Army, the Navy and the military-industrial complex" of Russia. The national media disclosed several details of these "working meetings".

The Supreme Commander stated that recent military conflicts have shown the decisive role of various cruise missiles and guided munitions. He stated that the Russian Armed forces have been receiving Kh-101, CALIBER and ISKANDER cruise and ballistic operational-tactical missiles, multiple launch rocket systems, as well as various guided aerial bombs.

Photo: Iskander tactical missile system, courtesy:HPW Holding



The Russian leader mentioned that this weaponry is equal to or surpasses all foreign counterparts with some not having a rival in the world. The weapons were combat tested in Syria to prove their characteristics.

The national leaders in the field of smart weaponry are Tactical Missile Corporation and High Precision Weapons Holding. President Putin also paid special attention

to military transport aviation developments. He noted that well-coordinated work and high readiness of the aircraft fleet largely determines the mobility of troops and the possibility of their rapid deployment over long distances.

He said that a number of the Antonov An-124 super-heavy transport aircraft have been maintained by using “domestic components”. In other words, the Ruslan serviceability has been maintained with no involvement from Ukrainian companies. President Putin also mentioned that state tests of the Il-112V light transport aircraft are almost complete with two vehicles to be handled to the Russian Aerospace Forces (VKS) this year. He stated the production of Il-76 was resumed on a new technological basis. By the end of the year, five newly produced Il-76MD-90A aircraft are to enter service with the VKS.

■ MWTSS Passes Acceptance Testing

(jr) InVeris Training Solutions has announced that it has successfully passed on-site acceptance testing for 14 Mobile Weapon Training Simulation Systems (MWTSS) and an additional 73 EF88 weapon simulators for the Australian Defence Force (ADF). The MWTSS has the same capability as the fixed WTSS but in a single (4.2m x 2.4m) screen mobile configuration that will be deployed to remote locations around Australia, overseas and on Royal Australian Navy (RAN) fleet units. An additional four MWTSS units have been ordered and the currently fielded trial system will be refurbished to the current build standard then returned for use, providing an initial tranche of 19 systems. The MWTSS will be provided in multiple configurations designed to cater for the needs of those units and regions receiving the capability. Every system will have purpose-designed Trimcast™ cases for air compressor, air cylinders, binoculars and ancillaries. Operational units and the RAN will receive the EF88 weapon simulator, also in Trimcast cases, with other systems delivered with F88 weapon simulators in the interim. Units deploying overseas or on fleet units will have a complete spare parts kit to cater for any maintenance issues whilst deployed. The MWTSS replaces the Portable WTSS which commenced trials in 2006 and entered service as an interim solution in 2014. MWTSS will be supported under the WTSS service support contract by InVeris, with instructor courses being conducted from June 2021, commencing at HMAS PENGUIN.

■ Babcock CEO Hosts ARROWHEAD 140 Meetings in Greece

(jr) Babcock International CEO David Lockwood has led a series of meetings in Greece with key industry figures, government officials and supply chain companies as Babcock continues to build international interest in its ARROWHEAD 140 general purpose frigate and bid to deliver the Hellenic Navy's new frigate modernisation programme.

A comprehensive programme of discussions were undertaken as Babcock reinforced the strengths of the offer made by the company and the UK Government to provide the Hellenic Navy with a HYDRA class upgrade programme, an interim frigate capability and four Babcock ARROWHEAD 140 frigates. The ARROWHEAD 140 has already been chosen by the Royal Navy for its Type 31 programme.

The company is committed to supporting Greek industry to build and assemble the new frigates in Greece, reinvigorating the domestic supply chain, upgrading infrastructure, modernising domestic facilities, upskilling and growing local workforces and transferring knowledge and technology.

Babcock officials have also been engaging with Greece-based companies interested in being part of its in-country supply chain and recently held a live online event in Athens, under the auspices of the Hellenic MoD Armaments Directorate.



Image: Babcock

This follows on from previous discussions held in Greece between British Government officials, Babcock and the Hellenic Navy, which included visits to both Greek shipyards. The ARROWHEAD 140 design features a proven hull-form that has been tested in operational environments from NATO and coalition task forces, to national, regional and deployed operations. Babcock's offering provides a design with the scope to adapt to specific operational and layout requirements. This is a modular build, which Babcock, as part of the Aircraft Carrier Alliance, has proven effective through the construction of the UK Royal Navy's Aircraft Carriers – assembled at its facility in Rosyth, Scotland, which is also the site for construction of the UK's Type 31 frigates.

■ Luxembourg Procures 80 Multi-Purpose Tactical Vehicles

(gwh) Luxembourg's Defence Minister François Bausch has presented the plan for the procurement of 80 protected armoured Command, Liaison, Reconnaissance Vehicles (CLR). Earlier, the governing council had approved the planned expenditure of



Photo: Mod Luxembourg

€367 million, which still has to be approved by parliament. The new vehicles are to replace the protected HUMMER and DINGO 2 vehicles in 2024/2025. The 42 HUMMERS have been in service since 1996. The platform, radio and weapon are outdated, protection is inadequate. The 48 DINGO 2s have been in service since 2010. The radio and weapon system are obsolete. The aim of the procurement project is uniform equipment at company level and closer alignment with the privileged partner Belgium in order to achieve advantages in deployment, training and logistics with interoperable and compatible equipment for the next 15 to 20 years. Belgium equips its forces with French SCORPION vehicles. Luxembourg wants to follow suit. The only vehicle of the SCORPION family to be considered for the Luxembourgian requirement is the GRIFFON multipurpose vehicle, although it weighs more than twice as much as the vehicles to be replaced. For the procurement, Luxembourg has called in the NATO Support and Procurement Agency NSPA. Within the given ceiling of €367 million, about one-sixth (€61 million) is earmarked for the procurement of the platforms, one-third (€122 million) for electronic equipment including radios, jammers, sensors and armament, and about 50% (€184 million) for logistic support in operation.

■ BAYRAKTAR UAV for Poland

(Korhan Özkilinc) The Polish Minister of Defence, Mariusz Błaszczak, and the CEO of Baykar, Haluk Bayraktar, have signed a contract for the purchase of 24 BAYRAKTAR TB2 UAVs (four squadrons, each consisting of 6 TB-2s), in the presence of Turkish President Recep Tayyip Erdogan and his Polish counterpart Andrzej Duda. Under the terms of the contract, the UAVs will be equipped with Roketsan MAM-L and MAM-C anti-tank missiles while some will have an SAR radar. This is in addition to the training simulators while Poland will also get an unknown

number of mobile stationary mission control stations. The first UAVs will be delivered in 2022 and the last at the end of 2024.



The UAV is capable of performing its tasks continuously for 24 hours at an altitude of 27,030 ft with a range of 150 km. Powered by Rotax engines that produce nearly 100 hp, it has a top speed of approximately 70 kt and a maximum weight of 630 kg. BAY-RAKTAR TB2 UAVs are also operated by Ukraine, Qatar, Libya and Azerbaijan.

Hanwha Targets UK MFP Requirement

(jr) Hanwha Defense has announced that it has begun formal discussions with UK partners to arrange for a 'Made in the UK' variant of its K9 Self-Propelled Howitzer. The K9 is operationally proven and will be put forward by Hanwha Defense for the UK's Mobile Fires Platform (MFP) programme to equip the British Army with a new artillery capability.



The K9 is currently in service with the ROK and armies around the world, including India, Norway, Finland and Estonia. In September 2020, the Australian Army selected the K9 as its preferred solution for the Protected Mobile Fires platform in its LAND 8116 programme, with a final contract due to be awarded in early 2022.

Hanwha Defense intends to replicate the successful industry participation model used in India and Australia. The company is also committed to transferring related technology and know-how to the UK, enabling its UK partners to access a global market which is believed to be in excess of 600 vehicles. Talks are already underway with Lockheed Martin UK, Pearson Engineering, Horstman Defence Systems and Soucy Defense, along with other UK defence industry partners. As part of the MFP programme, Hanwha Defense will contribute across the UK to intro-

duce specialist training and new skills for the long-term development, manufacture, maintenance and support of the British Army's advanced version of K9.

Tests and evaluations for the newest version of K9, dubbed the K9A2, are already in full swing to increase the artillery's key capabilities, including the maximum rate of fire and automatic ammunition loading functions. The K9A2 development has been led by Hanwha Defense and the Korean state-funded Agency for Defense.

The proposed UK version will be fitted with advanced technologies, such as an unmanned turret, mine protection kits and composite rubber tracks. Furthermore, an automated resupply capability will be introduced using Hanwha's robotic K10 ammunition resupply vehicle. An RFP for MFP is due to be released in 2022 and Hanwha Defense will be revealing its team for this programme at DSEI and other shows between now and then.

RUAG Receives SAR for Engine Contracts

(jr) RUAG has received Source Approval Request (SAR) approval for maintenance and repair work on J85-GE21 engines for the US Government. Only suppliers with SAR approval are taken into consideration for tenders and contracts with the US DoD. With SAR approval for complete engines in the field of F-5 services, RUAG will continue to secure its strategic partnership with its customers in the long term and provide high-quality services. This will be valid for several years. RUAG secures its know-how and expertise thanks to its international assignments, thereby creating synergies for its clients in Switzerland.



First Australian BOXERs Delivered

(gwh) The Australian Defence Force has taken delivery of the first tranche of 25 BOXER CRV 8x8 wheeled armoured reconnaissance vehicles. In 2018, the Australian Government signed a supply contract with Rheinmetall Australia for 211 BOXERs in seven versions for €2.7Bn under the Land 400 Phase 2 armament project. It is agreed that the BOXERs

will be delivered in two tranches: Tranche I (Block I) with 25 vehicles until the end of 2020 and Tranche II (Block II) in the period 2022 to 2027.

Tranche I has now been delivered, comprising 13 multi-purpose and 12 reconnaissance vehicles, the latter with turret and 30 mm gun. This will enable the Australian Army to reach the first stage of operational capability as planned. The vehicles were handed over at the purpose-built Military Vehicle Centre of Excellence (MILVEHCOE) in the presence of Australian Defence Minister Peter Dutton. Phase 2 of the project is now beginning



for Rheinmetall. Currently, 30 Australian employees from Rheinmetall Australia are working at Rheinmetall sites in Germany and learning about production. The 2018 contract also provides for know-how and technology transfer, so with the start of Tranche II, production will be gradually transferred to Australia. The plan is that from vehicle No. 31 (in May 2023) onwards, production will take place entirely in Australia.

In Tranche II, 121 reconnaissance and 15 command and control vehicles are planned, alongside 29 vehicles for joint fire surveillance, 11 recovery vehicles with a winch system and 10 repair vehicles with a crane.

The MILVEHCOE is the central point of the Australian Industry Capability (AIC) programme with regard to the BOXER. Here, Rheinmetall will manage the Australian development, production, testing, training and support of the BOXER vehicles and associated training systems. Development, production and integration work within MILVEHCOE is well underway, while the equipment and facilities at the main production facility have been installed and are being commissioned. Knowledge transfer for full BOXER production in Australia is expected to commence once commissioning of the BOXER production line at the MILVEHCOE is complete.

Patria 6x6 Tours Latvia

(jr) Patria has announced that the joint Finnish/Latvian 6x6 vehicle development programme is proceeding as planned, with a successful Demo Tour in Latvia and increased interest in the programme. The



Photo: Patria

demo tour was held in Latvia during May, where the Patria 6x6 vehicle was presented to the Minister of Defence and the Latvian armed forces, who tested the mobility features and capability of the vehicle under conditions that correspond to the vehicle's operational environment.

More than a hundred people from the Latvian military got a chance to test the vehicle, as well as its loading capacity for special purposes. Representatives of the Finnish Ministry of Defence and the Finnish Defence Forces also attended the event. The demo tour culminated in the Industry Day with the Latvian defence industrial base, which has an essential role in the vehicle programme. Security of supply, including local industry participation, is part of Patria's business model to enable a cost-effective supply chain.

Currently, the programme is in the Research and Development (R&D) phase, which means engineering and development work, so that the basic vehicle platform, versions and the total system, including the support system, are developed further according to the specific needs of participating countries. At this phase, the vehicle has also been successfully tested with many different capability tests, including challenging winter conditions in Lapland, Latvian environment, and the overall usability of the vehicle.

■ Dutch Multi-Mission Radars for Norway

(gwh) The Norwegian Armed Forces will receive five GROUND MASTER 200 Multi Mission Compact (GM200 MM/C) radars for immediate fire support and air defence, the Dutch MoD has announced. With support of the Dutch Government, the Royal Netherlands Army initiated the procurement of the radar systems on 25 May 2021, with an option for three more. The systems, manufactured by Thales Netherlands, will be delivered from late 2023 to late 2024. The Netherlands had already ordered nine GM200 MMs for its own armed forces in

2019, to be delivered from the end of 2022. The GROUND MASTER 200 MM/C is a radar with 4D AESA technology with independent radar coils to simultaneously detect several targets. The radar is suited for weapon detection, air surveillance and air defence, automatically detecting, tracking and classifying multiple UAVs, rockets, artillery, mortars, missiles and aircraft.



Photo: Defensie

■ New GALILEO Satellites Ordered

(gwh) The European Satellite Navigation System is being expanded with 12 new satellites after the European Space Agency (ESA) announced that it has awarded Thales Alenia Space (Italy) and Airbus Defence &

WARMATE

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Critical intelligence and high precision strike with low collateral effect

- Multiple safety levels
- Mission abort capability
- Silent propulsion
- Ruggedised, mobile ground control station
- SWARM attack capability
- Interchangeable warheads
- EO/IR vision for day and night operations
- Multiple flight modes
- User-friendly
- Flight readiness in under 5 minutes
- Statistically confirmed accuracy of targeting - 1.5 m CEP
- Flight duration 70 min.



WB GROUP 

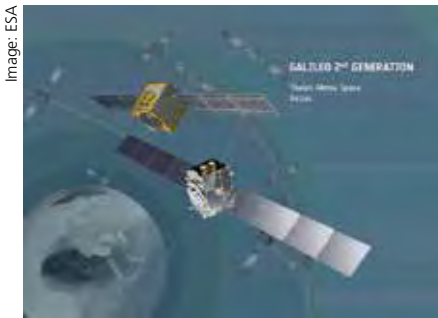


Image: ESA

Space (Germany) two similar contracts worth a total of €1.5Bn to build two independent satellite families with a total of 12 second-generation GALILEO satellites. The contracts could only be signed recently, after an appeal against the award was rejected by the courts.

GALILEO is Europe's civilian global satellite navigation constellation, currently the most precise satellite navigation system in the world, providing metre-scale accuracy to more than two billion users around the globe. With improved accuracy, the new generation should be able to provide decimetre-scale precision positioning to all users. These second-generation GALILEO satellites (G2) are expected to revolutionise the fleet. They complement the 26 first-generation GALILEO satellites in orbit today and the 12 "Batch 3" satellites currently in production and testing. The first launch of these Batch 3 satellites will take place later this year. The new G2 satellites are being built to a short timescale, with their first launch expected in less than four years.

■ MQ-9 Fleet Upgrade for Italy

(jr) The Italian Air Force has partnered with the US Government and General Atomics Aeronautical Systems, Inc (GA-ASI) to provide a mid-life update for its fleet of MQ-9 remotely piloted aircraft and ground control stations as part of a Foreign Military Sales agreement. Announcing the news, GA-ASI said that the Italian Air Force's mid-life modernisation programme will include updates to the MQ-9s which will improve them from Block 1 to Block 5 configuration. The latter includes a significantly increased electrical power capability, improved landing gear and the latest versions of the GA-ASI LYNX multi-mode radar and electro-optical sensors from Raytheon.



Photo: euro-sd.com

■ Hirtenberger Defence Europe Passes First Article Acceptance Test for ELAD with armasuisse

(jh) At the First Article Acceptance Test, Hirtenberger and the Swiss procurement agency armasuisse conducted, a full test of the ELAD system's functionality, accuracy and handling, during which the system design proved to be functional and ready for use.

ELAD (ELectronic Aiming Device) supports setting up and aligning a mortar system. It simplifies the setup process of the weapon and replaces the conventional components such as the aiming circle, target optics (periscope), aiming rods, and target line checker/collimator. ELAD significantly reduces the

Photo: Hirtenberger



time from moving into the firing position to firing the first shot. The time-consuming setting up of the mortar is no longer necessary, while the precision and first hit probability are increased.

The integrated display provides the operator with relevant data without any restrictions in terms of weapon operation. Also, a large number of data interfaces (Bluetooth, cables, etc.) enables integration with future or existing battlefield management and fire control systems for Switzerland. ELAD can be used to integrate new and established weapon systems into the digital battle space. ELAD has fewer training and personnel requirements. It can be used under a wide variety of conditions, can work without GPS, and can be easily be integrated into existing logistics.

■ Terma Radar Selected for Indonesian Navy Hospital Assistance Ships

(jh) Terma was recently awarded a contract to supply a SCANTER 6002 radar for the latest Indonesian Navy's Hospital Assistance Ship (BRS). The award follows a contract signed in 2019 to supply a similar radar for the BRS WAHIDIN SOEDIROHUSODO, delivered in January 2021.

Hospital ships are vessels designed to act as floating medical treatment facilities for humanitarian missions or for use in war zones. The Indonesian Navy's BRS was built in Surabaya by the Indonesian state-owned shipyard PT PAL and is 124 meters long, 21.8 meters wide, and able to host more than

600 people including crew, troops, and patients. According to PT PAL, the BRS can accommodate medical personnel to carry-out operational missions equivalent to those of a regular hospital. The BRS will be fitted with polyclinic facilities, emergency rooms, a radiology unit, and more.

Photo: PT PAL Indonesia



■ TORNADO Modernisation in Germany

(gwh) Now that the German Parliament cleared the way for a comprehensive obsolescence and vulnerability elimination of the combat aircraft's self-protection equipment, the Bundeswehr's TORNADO multi-role combat aircraft fleet will receive a state-of-the-art radar warning suite by 2025. To this end, the NATO Eurofighter and Tornado Management Agency (NETMA) has concluded a corresponding contract worth €102.3M with the prime contractor Panavia Aircraft, which provides for the adaptation development and integration of components in the period 2021 to 2025.

Under a subcontract, Saab will deliver modernised radar warning equipment for around €40M, which will provide future-proof processor performance and extend the service life of the TORNADO's radar warning system. According to Saab, the warning equipment provides aircrews with superior situational awareness in the electromagnetic spectrum, even in challenging scenarios. Saab was first awarded a contract to renew radar warning equipment for German TORNADOs in 1999.

Photo: Bundeswehr



■ MBDA SEA CEPTOR for Type 31

(jr) Under a contract awarded by the UK MoD, MBDA's SEA CEPTOR system will protect the Royal Navy's new Type 31 frigates. The system will allow the Type 31 to simultaneously protect both itself and vessels near it from attack by air- and seaborne threats,



Image: MBDA

including high-speed manoeuvring missiles, hostile aircraft and fast inshore attack craft. The new contract includes integration of SEA CEPTOR with the Type 31's systems, along with delivery and installation of ship hardware for the Type 31 programme. Designed and made in the UK, the contract forms part of the Portfolio Management Agreement (PMA), a partnership initiated in 2010 between the UK MoD and MBDA on sovereign complex weapons design and production. The PMA delivers military equipment for the UK Armed Forces and has secured over 4,000 jobs at MBDA UK while generating savings worth over £1.2Bn. SEA CEPTOR is currently in service on the Royal Navy's Type 23 frigates, and will also protect the new Type 26 frigates. The UK MoD maintains a common stockpile of CAMM missiles for both the Royal Navy and British Army, with the system having been selected by a growing list of other nations for both naval and land-based air defence.

■ Russian Industry Update at HeliRussia

(yl) The HeliRussia exhibition was held from 20 to 22 May in Moscow, making the show one of the very few international events held against the background of the current pandemic. Apart from being a meeting point for the rotorcraft industry, HeliRussia-2021 gave a real chance to receive a fresh portion of information on Russian defence exports. On the first day of the show, Rosoboronexport CEO Alexander Mikheev (pictured) disclosed several figures. According to him, over the last 10 years alone, Rosoboronexport has offered and successfully delivered over 850 helicopters worth about \$20Bn to more than 35 countries. He also mentioned the total volume of the Rosoboronexport current portfolio is \$52.1Bn.



Photo: Yury Laskin

The national state exporter has already supplied to customers about 23 per cent of the total volume of weapons scheduled in this year's plan. Mikheev stated that in 2020 Rosoboronexport sold military products worth about \$13Bn and has already signed contracts for \$4Bn in 2021.

The company booth at HeliRussia 2021 presented the most popular export models of the Russian-made military and dual-purpose helicopters, one being the Mi-17V5 military-transport rotorcraft. According to Mr. Mikheev, more than 270 of this type have been delivered over the last decade.

Other items presented by Rosoboronexport included:

- An upgraded version of the Ka-52 attack helicopter,
- Mi-28NE new generation attack helicopter with round-the-clock capabilities,
- Mi-35M and Mi-35P gunships,
- Mi-171SH special forces support helicopter,
- The new Mi-38T medium assault/transport helicopter.

Mr. Mikheev also stated that "the first deliveries of S-400 TRIUMPH anti-aircraft missile systems to India will take place in October-December this year". He added that Indian personnel training is on schedule.

According to Mr. Mikheev, Rosoboronexport promotes Russian military drones for export only after they are adopted by the Russian Army. He also mentioned that Russia's anti-terrorist operation in Syria helps promote the country's defence equipment to the world market.

■ US Army to Test SRT

(jr) AM General recently received a Firm-Fixed-Price (FFP) contract from the US Army to provide two HUMVEE 2-CT HAWKEYE Mobile Howitzer Systems (MHS) for the service's characterisation test, the company said in a press release.

AM General and its strategic partner, Mandus Group, have been integrating the Soft Recoil Technology (SRT) onto light, mobile, transportable and survivable platforms without sacrificing firepower. According to AM General, SRT is a disruptive technology that will reduce the firing loads for direct and indirect weapons systems, enabling combat systems to meet emerging requirements. The technology is ready now and can be deployed on existing weapon platforms for an immediate effect on the battlefield. Soft recoil enables reduction in overall system weight, making systems more agile and responsive to benefit the supported manoeuvre commander.

The HUMVEE 2-CT (M1152 two-door cargo

truck) that serves as the mobile platform, will come with a standard 14,100 lb. gross vehicle weight, 205 hp engine and antilock braking system (ABS). While the US Army conducts characterisation testing of the 2-CT HAWKEYE MHS over the next year,



Photo: AM General

AM General and Mandus Group will continue to refine the technology for integration of the soft recoil technology onto other mobile platforms. Scaleability is already being tested with a 155mm prototype. The group is also exploring integration onto other existing and future combat systems.

■ LM-LowProfile Laser Modules for Portugal

(jr) The Portuguese Army has awarded Rheinmetall an order for 1,500 LM-LowProfile laser modules. The contract, booked back in October 2020, calls for delivery of the devices in three lots with delivery to be completed by the third quarter of 2021. The order is worth a figure in the low single-digit million-euro range. In carrying out the order, Rheinmetall is cooperating closely with its local sales partner, NT Group Portugal.

Developed by Rheinmetall Soldier Electronics of Stockach, Germany, the minute LM-LowProfile laser module is designed for use on compact assault rifles, but is also suitable for other small arms. The device, weighing around 160 grams and being 85 mm long, can be attached to any standard assault rifle via a standard interface as defined by MIL-STD 1913/NATO STANAG 4694. Owing to its low height (25 mm), it can be used in combination with daylight optics, nor does it interfere with the line of sight. Adding a tactical weapon light further enhances the laser module's operational effectiveness. Rheinmetall has already supplied the Portuguese Army with a weapon light in an earlier order. Delivery is already underway. This is the third order from Portugal in three years.



Photo: Rheinmetall

■ HENSOLDT to Develop Collision Warning System for Drones

(jr) HENSOLDT is vigorously pushing ahead with the development of a collision warning system for civil and military drones. This comes after the radar sensor as the core element of a collision warning system was successfully tested in flight as part of the ProSA-n (military) and KoKo2 (civil) study programmes. Work on the software required for interaction with an autopilot is well advanced. As early as this summer, a demonstrator of the collision warning system is to prove in flight tests that the sensor performance and the software-supported avoidance logic correspond correctly with the autopilot. Since the beginning of the year, HENSOLDT has also been involved in the European Detect and Avoid System (EUDAAS) programme, in which several European companies are developing a concept for bringing large military Medium Altitude/Long Endurance (MALE) drones, such as the EURODRONE, into European airspace. HENSOLDT's "detect-and-avoid" radar uses the latest Active Electronically Scanning Array (AESA) technology, which allows multiple detection tasks to be performed simultaneously and enables very rapid target detection. The scaleable radar can be used in large military drones as well as on board smaller civilian drones.



Photo: HENSOLDT

■ New Generation ACRO Red Dot Sight Introduced

(gwh) The pioneer for red dot sights, Aimpoint from Sweden, has further developed the electronic ACRO reflex sight. The sight enables aiming with both eyes even in difficult environmental conditions (humidity, snow, dust). The 47 x 33 x 31 mm ACRO sight weighs 60 g and is mounted on the gun. For the new generation, the LED emitter that produces the red aiming dot has been improved and is powered by a reinforced CR2032 battery for up to 50,000 hours (more than five years) at setting 6. The LED, which can be dimmed to match the ambient light, provides a sharp 3.5 MoA (Minutes of Angle) dot. This means that the dot covers an area of approx. ten centimetres in diameter on a target at a distance of 100 metres. The inner reflective lens system is protected by

protective lenses on the front and back. The intensity is adjusted in ten steps by two buttons on the left side of the housing. If necessary, the view in and out can be covered with protective flip-up lens covers.

The ACRO sight with fully enclosed optical channel was developed for use on pistols, but can also be used with standard interfaces (e.g. PICATINNY rail) on rifles and long guns. The design parameters refer to firing tests on a semi-automatic pistol. The ACRO sights proved that they can withstand the shocks, vibrations, temperatures and material stresses that occur when firing over 20,000 rounds of Smith & Wesson cal 40 (.40 S&W) ammunition.

The ACRO-P2 professional version is intended for use by military and security forces and offers greater resistance to external influences as well as six adjustment options for day use and four for interaction with night vision devices.



Photo: Aimpoint

New PBS TJ80M-Propulsion Unit for UAVs

Czech aerospace company PBS is introducing the new PBS TJ80M turbojet engine modification, which offers an increased thrust of 1,280 N while retaining the same weight and outer diameter with reduced fuel consumption.

In the middle of 2018, PBS Velka Bites (PBS) introduced the PBS TJ80 jet engine, which provides a 900 N thrust in a relatively small body.

The continuous development of PBS turbojet engines resulted in a significantly upgraded PBS TJ80M that will be unveiled in the second half of 2021. PBS TJ80M features a modernised compressor stage, a modified axial turbine, and a new fuel system. The result of these modifications is an increase in engine thrust by 42 %, from 900 N to 1280 N, while reducing the specific fuel consumption. The PBS TJ80M turbojet engine has an electrical output of 2.3 kW/28 V, 12 kg weight, and only 235 mm diameter.

In the scope of this project, a new spark plug of only 18 mm height is being developed which, due to smaller installation dimensions, facilitates integration with the engine. New control algorithms

have been implemented to full exploit the engine's thrust potential.

As a 100 % "ITAR-free" propulsion unit, PBS TJ80M, is offered for a wide range of unmanned aerial applications.

The "M" version constitutes the first stage of the modernisation programme. PBS will direct its development activities

to further increase thrust and introduce a saltwater version for landings in saltwater and continued use thereafter.

PBS offers additional services, such as optimisation of the air inlet channel, UAV fuel system, or integration of PBS engine control with the UAV control system.



Photo: PBS

The turbojet engine PBS TJ80M

Military Aerospace Expertise and Exports from Israel

Eugene Kogan

Local domestic military aerospace expertise has been honed over a period of almost 60 years. Israel's procurement of US-built fighter aircraft and Israeli technicians and aeronautical engineers developing subsystems and avionics for the jets has enhanced their skills and expertise.

Rafael Advanced Defence Systems' cooperation with Raytheon has taken military aerospace expertise to the next level. The triple combination of buying from the United States, developing subsystems locally, and teaming up with the US has contributed to successful arms exports from Israel. The Ministry of Defence International Defence Cooperation Authority (known as SIBAT) realised in November 2019 that the international arms market was undergoing serious changes and certain adjustments would be needed in order to remain competitive and increase the market share of Israeli defence companies.

Strategy

In the late 1950s-mid 1960s, the Israeli Government realised that it needed to build its own domestic aerospace industry, have the necessary pool of technicians and aeronautical engineers and also to invest in R&D. The decision made by the Israeli Government in the late 1960s and the mid-1970s to acquire US-built fighter aircraft with extensive Israeli modifications has further enhanced the country's military aerospace expertise. At the same time, Israel Aerospace Industries (IAI) was spearheading a campaign in manufacturing UAVs for both domestic and foreign markets. Elbit and Rafael joined IAI several years later and have achieved major success both with Israel and abroad since then.

It should be stressed, however, that the Israeli procurement of the US-built fighter aircraft has become a mainstay of the Israeli aerospace industry and has turned



Photo: IAF

The IAF F-35I ADIR on its first flight with the Israeli Air Force on 13 December 2016

Israel into a major US ally in the Middle East and a test site for American fighter aircraft under combat conditions. The Israeli aerospace industry's modifications of the F-16I STORM and F-15I THUNDER have led to further modifications of the F-35 LIGHTNING II Joint Strike Fighter (JSF) and the F-15E STRIKE EAGLE known as the F-35I and F-15I, respectively. Although the F-35 LIGHTNING II JSF programme is owned by Lockheed Martin and physical or data system modifications to the aircraft are not allowed, Israel, as the only F-35 JSF partner country secured a number of contractual rights from Lockheed Martin that make their F-35I variant optimised for conflicts in the Middle East. In addition, Israel is the only F-35 partner country with a domestically operated maintenance regime since the volatile political situation in the Middle East requires a rapid domestic-repair capability. As a result, Israel may need rapid

onsite repairs to keep their F-35I fleet in the air. That is exactly where properly trained Israeli personnel and their skills come into the picture.

Another example is how IAI, together with the F-15I manufacturer Boeing, has improved avionics and aircraft weapon systems. The aircraft has a number of indigenous features such as a central computer, a GPS/inertial guidance system, and an Elbit Systems display and sight helmet (DASH). The aircraft initially carried the AIM-9L SIDEWINDER and PYTHON infrared-guided short-range missiles but it currently carries the single PYTHON. In 2016, Israel announced the start of an upgrade programme meant to keep the F-15I relevant for the coming years. The upgrade includes a new active electronically-scanned array radar and updated avionics.

Finally, in August 2011, Raytheon and Rafael teamed up to market the IRON

Author

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Photo: Oren Rosen / Wiki CC



An IRON DOME launcher at the Israeli Air Force exhibition at Ramat David AFB on Israel's 69th Independence Day

IRON DOME air-defence system in the United States. Mike Booen, Vice- President of Raytheon Missile Systems' Advanced Security and Directed Energy Systems product line, said that "IRON DOME complements other Raytheon weapons that provide intercept capabilities to the US Army's Counter Rocket, Artillery, and Mortar initiative at forward operating bases. IRON DOME can be seamlessly integrated with Raytheon's C-RAM systems to complete the layered defence." Raytheon and Rafael are also teaming up on the DAVID SLING air-defence system, which is a mobile, land-based missile defence programme.

As a result, the triple policy of procuring platforms from the United States, developing components, support systems and avionics for the US-built fighter aircraft and, finally, teaming up with Raytheon, has proven to be successful in the long run. Long-term cooperation with the United States, together with successfully developing its own weapons systems, has opened global markets to Israeli defence products. Figures for the last four years show considerable success for Israeli arms exports.

Arms Exports 2016-2020

Figures published in March 2017 by the Ministry of Defence International Defence Cooperation Authority showed that exports of weapons systems and technologies totalled US\$6.5Bn. The MoD figures indicated that 20 per cent of arms exports in 2016 came from companies upgrading aircraft and avionics systems, the leading sub-sector, followed by observation

and electro-optic systems (18 per cent), missiles and air-defence systems (15 per cent), land systems and weapon stations (13 per cent), radars and electronic warfare (12 per cent), intelligence and cyber technologies (8 per cent), and UAVs (7 per cent).

A country breakdown of arms exports in 2016 clearly shows that the Asia-Pacific region was the main export target for Israeli companies. Exports also increased to the European market, as well as the markets in North America, Latin America, African countries and India, in particular. In a landmark decision, Eli Cohen, Minister of Economy and Industry, signed a range of new regulations in June 2017 making it easier for Israeli defence companies to work together rather than com-

pete on the world markets. At the same time, they were able to compete successfully on the domestic market.

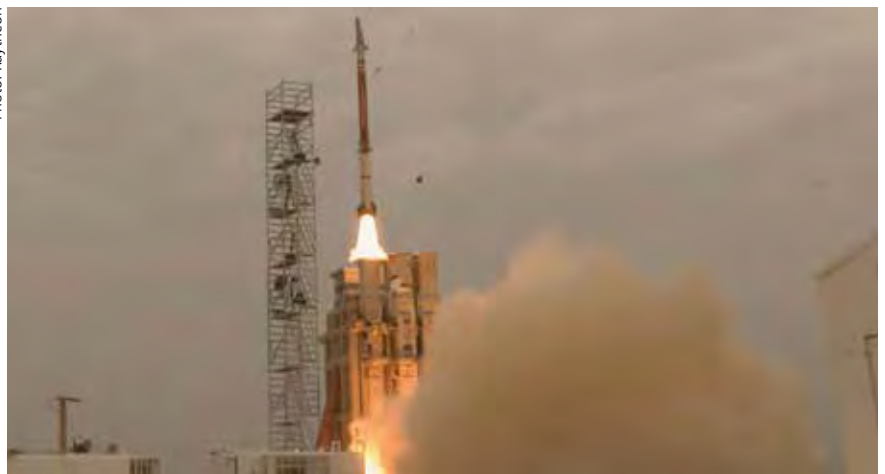
The MoD SIBAT figures show that arms exports increased to US\$9.2Bn in 2017. The figures indicate that the bulk of arms exports; namely, 31 per cent, consisted of missiles and air-defence systems, followed by deals involving exports of radar and electronic warfare systems (17 per cent), upgrading of weapons platform and avionics (14 per cent), dry ammunition (9 per cent), communication systems (9 per cent), and observation and electro-optics (8 per cent), etc. The geographical distribution of Israeli exports remains unchanged since 2016.

The MoD SIBAT figures also show that arms exports decreased to US\$7.5Bn in 2018, of which offensive missile and missile defence systems accounted for 24 per cent of arms exports, UAVs for 15 per cent, radar and electronic warfare systems for 14 per cent, upgrades and avionics for 14 per cent, and weapon stations for 12 per cent.

The SIBAT figures indicate that arms exports decreased to US\$7.2Bn in 2019. For instance, ten years ago Israel was a world leader in UAV sales whereas today's major markets for Israel are in radar and electronic warfare systems. Israel has also successfully entered the missile market in India where the two countries have established several joint ventures.

SIBAT reports that radar and electronic warfare systems comprised 17 per cent of the sales in 2019; missiles, rockets and air-defence systems comprised 15 per cent, manned aircraft and avionics amounted to 13 per cent, observation and electro-optics were at 12 per cent, weapon sta-

Photo: Raytheon



The DAVID'S SLING system forms a crucial element of Israel's multi-tier layered missile defence architecture to provide mid-tier regional missile defence. DAVID'S SLING offers terminal-phase, hit-to-kill defence against tactical ballistic missiles, medium- to long-range rockets, enemy planes, drones and cruise missiles, including SCUD missiles.

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Image: IAI

A variant of the STUNNER hit-to-kill missile; the highly advanced SkyCeptor interceptor is developed to defeat short- to medium-range ballistic and cruise missiles and other advanced air defence threats.

tions and launchers comprised 10 per cent and UAVs amounted to 8 per cent. The geographical distribution of Israeli arms exports has not changed since 2016. Nonetheless, Israeli arms exports have increased to India. After Russia, Israel is the second exporter of arms globally. Although SIBAT has not yet released figures for arms exports in 2020, it is known that sales for Elbit Systems were US\$4.6Bn. IAI sales were about US\$4.2Bn while Rafael Advanced Defence Systems recorded sales of US\$2.7Bn. This has all taken place despite the COVID-19 pandemic. As a result, arms exports in 2020 are likely to be at a similar level to that of 2019 and may even surpass them. The lack of new market inroads for Israeli arms exports has led to a reassessment of the Israeli arms export policy. In order to increase the country's global arms exports, certain adjustments were made and they are presented below.

The Crucial Blueprint

According to Brigadier General (Res.) Yair Kulas, SIBAT Director, a number of new emphases were introduced to the agency plan that was revealed in November 2019. Kulas added that "As part of the efforts to expand the deals between countries, the share of the SME defence enterprises

will be ensured; namely, if major contractors such as IAI, Elbit Systems or Rafael Advanced Defence Systems get an order from a foreign country as a part of a deal mediated by the Government, the large company is obligated to transfer 20 per cent of the contract to subcontracting by an SME company. It is important for us that the SME defence enterprises situated in the country's periphery will be involved in the production and not left out." Furthermore, Kulas said that "We have learned that there are countries with whom, if the Ministry does not take an active role, there will be no deals with Israeli companies. We are aiming at these countries, among others. The new focus includes Asian countries, in particular, though ties with Israel have had a low media profile thus far. The Ministry is considering appointing a military attaché in one of these countries to expedite processes leading to defence deals between Israel and other countries. The Ministry will pay the most attention to this in the coming years; however, at least with respect to defence exports, to countries in Europe [and NATO members]. An up-to-date mapping conducted by the Ministry in late 2019 cited 41 countries around the world [are] considered important targets for Israeli defence companies. Half of the target countries are in Europe."

The demand for missile defence systems and border-patrolling UAVs in Europe, together with other conventional threats coming from Russia, are driving defence investments and this opens up these markets to Israeli defence companies. Another interesting geographical area that until now was closed to Israel, but has recently opened up following the signature of the Abraham Accords, includes Bahrain and the United Arab Emirates. Both are likely to become very important targets for Israeli defence industries with the potential export of the IRON DOME and DAVID SLING air-defence systems. In conclusion, the recent adjustments made to the Israeli arms export system are likely to bear fruit in the coming years. Military aerospace expertise acquired under combat conditions and tested on the battlefield provide an extra edge to Israeli defence systems. The US angle means that the two countries' aerospace cooperation continues and benefits their technicians and aerospace engineers. The SIBAT emphasis on exporting arms to the EU and NATO member states, in particular, has set the tone for the coming years. It does not mean, however, that other markets will be ignored, but SIBAT has established clear priorities and plans to follow them in the coming years. ■

Real-time Monitoring of System Performance and Predictive Maintenance Support

The SCHLEIFRING Condition Monitoring System is an active system that provides data reflecting the overall status of the slip ring unit as well as information about the environmental influences during operation in the field based on the fusion of versatile sensor data.

The system is able to assess and represent the condition of complex slip rings. The data of all sensors can be collected and processed with an intelligent algorithm that calculates the slip ring condition based on SCHLEIFRING's comprehensive expertise in the area of transmission technologies.

The collected data subject to evaluation consist of temperature, real-time clock, shock and vibration, revolutions, humidity, monitoring of the leakage and noise.

The Condition Monitoring System provides warnings, status indication or information about necessary maintenance processes to the customer.

Customer Interface/Protocol

The physical connection between the implemented system and the dedicated customer interface is provided via RS485 – Modbus protocol.

Benefits

- **Full Transparency** – System data and performance status are available anytime in order to respond rapidly in case of failures and to analyse common faults.
- **Data Driven Decision Making** – Make best decisions: The Condition Monitoring System in the slip rings provides data and information for appropriate and best decisions. Individual temperature and pressure sensor limits can be set based on the system's capacities to set off an alarm accordingly.
- **Reduce Unplanned Downtime and Increase Efficiency**

The Condition Monitoring System prevents unplanned downtime and increases system efficiency.

It continuously collects data for the operator to identify warning limits and potential problems.

In addition to the current configuration, the Condition Monitoring System can be expanded with additional types of sensors. You have specific challenges for condition monitoring on your system?



Photo: Schleifring GmbH

Get in contact. We look forward to responding to your needs!



SCHLEIFRING

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www.schleifring.de

Technical Data for Slip-Ring Applications

Hardware	Location	Function	Range
Temperature Sensors	Brush Block Power and/or for other contacting technology	Temp. Power-BB	-40°C to 125°C, +/- 2°C
Temperature Sensor	At the bearing	Bearing Monitoring	-40°C to 125°C, +/- 2°C
Acceleration Sensor	Mainboard	Vibration and Shock	+/- 8 G
Real Time Clock	Mainboard	Real Time Clock	Date, Time
Hall Effect Sensor	Chassis Beside Module	Revolution Counter	1000 rpm
Magnet (for Hall)	Attached to Module	Revolution Counter	1000 rpm
Encoder	Inside Slip-Ring	Revolution Counter	1000 rpm
Humidity / Temperature Sensor	Slip-Ring Housing Interior & Exterior	Internal & External Ambient Temp. / Humidity	-40°C to 105°C, +/- 0.5°C 0 to 100 % rH, +/- 3 %
Microphone	Brush Block	Acoustic frequency analysis	0 – 4,8 MHz
Digital Pressure Sensor	Channel of Leakage Tank	Monitoring of the Leakage	0 – 350 mBar (diff.) , +/-10mBar
Mainboard	Inside Housing of Condition Monitoring Attached to Slip-Ring Unit	SOM-Module	Ambient Temperature Inside the Slip-Ring -40°C to 70°C
Interface Connector (MIL)	Housing Condition Monitoring	Customer Interface	ModBus RS485
Connection Cables	Between Components	Connection of Components	n/a

Beyond the Pandemic Effect

Terrorism and Counterterrorism in 2021

Dr Andreea Stoian Karadeli

The year 2020 marks a global shake-up in almost every aspect of our societies, and the post-pandemic domino effect is still unfolding. The full impact of the COVID-19 quarantine and lockdowns will only be seen in the long term. So far, some of the immediate impacts have completely changed many of the pre-2020 paradigms while influencing others, such as terrorist and extremist trends.

Since the beginning of the pandemic, terrorist groups have both suffered from the virus just like any of us, but they also grabbed the opportunity and used the crisis as a tool for further propaganda, manipulation and control. As the domino starts to unleash, many long-term effects of the pandemic prove to create direct and indirect facilitating factors for extremism and radicalisation, through perpetuating quarantines, more time spent in the online environment, unemployment, uncertainty, economic struggle, unequal healthcare access or growing conflicts. While some scholars and practitioners rushed to match "COVID-19 and extremism as the perfect storm", we should be cautious in order to neither overestimate nor underestimate those two threats. All in one, 2021 has already brought to the table many challenges that defined some interesting trends unfolding this year.

Photo: NATO



Some experts fear that the increased time spent on radical websites could lead to more acts of terrorism.

The Terrorist Threat in 2020: Terrorism vs. COVID-19

Based on data and analysis published by the United Nations, most terrorist groups, regardless of their ideological motivation, have "successfully exploited vulnerabilities in the social media ecosystem to manipulate people and spread conspiracy theo-

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ries" regarding COVID-19 to reinforce their narratives and incite violence. This is a fact that has been observed and underscored since the first months of the pandemic, while the real threat is the increasing vulnerability of available audiences, not the exploitation of the virus per se for existing extremist narratives. Terrorist propaganda has existed in the online realm for a long time and has proven difficult to eradicate or even contain, especially in recent years. The pandemic has not only provided terrorist groups with an interesting topic to play on, but it may have also created the perfect environment for them to test the new means: a vulnerable audience stuck at home during the lockdown, bored, lonely, and uncertain about the future. Nevertheless, the relationship between the pandem-

ic, its lockdowns, and side effects still needs to be discussed to understand its relevance in terms of rising radicalism and terrorist attacks on the global stage. First of all, we must acknowledge that the Internet has been at the epicenter of extremist propaganda for a long time. The pandemic has forced people of all ages to work and study from home, increasing time spent online and decreasing social contact outside of virtual networks. Experts have warned of an increase in terrorist attacks by perpetrators exposed to extremist content and radicalized during the lockdown. But such an assumption is too simplistic. Moreover, the data have shown no evidence of this predicted rise in terrorism; at least for now. It is true that there is a time lag between radicalization and mobilisa-

tion to violence, and it is quite common for people to follow this path within a short period of time. But this can also happen over the long term and be triggered by a specific personal event or development on the public stage.

Is there a Lockdown Effect?

In addition to the experts' warnings, we need to further examine the pandemic's impact on terrorism in 2021 and in the years ahead. We also need to understand

social media since April 2020, representing growth of more than 1.4 million new users per day. The amount of money spent on online consumer purchases in 2020 exceeded US\$2.4Tr, an increase of more than 25 per cent compared to 2019. Statista reports that the average e-commerce shopper spends more than US\$700 per year to purchase consumer goods online. The pandemic has had a significant impact on online travel spending, with annual sales dropping more than 50 per cent between 2019 and 2020.

More Time Spent Online

There is still little research and few data to determine pandemic activity on extremist websites by existing or new members. Researchers at Simon Fraser University found a significant increase in online activity on far-right forums, but no significant increase in membership. Nevertheless, the available data do not conclusively indicate a dramatic increase in the number of people engaging with violent extremist and terrorist content online, nor do they say anything about the



General assumption of COVID-19 vs Terrorism direct effect in 2020

whether existing trends in terrorism and counterterrorism emerged because of the pandemic or whether they were simply amplified by the short- and long-term effects of the COVID-19 crisis, while their roots go back much earlier than December 2019. As outlined in previous reports, the COVID-19 pandemic was expected to create a perfect lineage of events related to the terrorist threat. Therefore, the lockdown imposed to stop the spread of the virus is believed to expand the target audience and increase their vulnerability to extremist propaganda. As a result, more people will tend to respond to the terrorist message, engage with online groups, and become further radicalized, leading to an increase in terrorist attacks in both the short and long term. The pandemic lockdown has indeed increased the use of the Internet for various purposes: Work, education, leisure, and social networking. Based on data published in the April 2021 Global Digital Overview, there are over 4.72 billion Internet users in the world today, 332 million more people than in April 2020, and the average global Internet user spends nearly 7 hours online each day. Social media usage also continues to grow, with 4.33 billion users worldwide in April 2021, representing 55 per cent of all people on the planet. The number of social media users has also increased by 13.7 per cent in the last 12 months. More than 520 million new users have joined

As the online audience expands and time spent in the virtual environment increases, the propaganda of all terrorist groups expands, leveraging the COVID-19 theme. Although the audience has become broader and more diverse, its susceptibility to extremist propaganda is questionable. For the vast majority who do not already sympathise with violent extremists, terrorist content is unlikely to change their pre-existing attitudes. More time on the Internet does not automatically increase the risk of radicalization. However, in the case of individuals who have a slight inclination toward the extremist path, the "side effects" of lockdown and along with visiting extremist online channels can facilitate the user's isolation from the surrounding context and inclusion in closed "echo chambers" of like-minded individuals where extremist beliefs and attitudes can be further reinforced. This path can lead to radicalization, but is not a recipe for an act of terrorism.

duration or depth of that engagement. The data may also be deceptive, as searching for extremist content on Google is not in itself evidence of radicalization. Moreover, Google routinely redirects this traffic to counter-extremist materials, which is why many people are presented with counter narratives designed to avert their radicalization. In addition, investigations cannot distinguish the activities of users or track users who have multiple accounts on different platforms. Certainly, terrorist groups have increased their online presence, especially among right-wing and anti-government groups on social media, but that does not necessarily mean an increase in the number of followers and supporters. An analysis of these groups' online activities would demonstrate a wide variety of themes and narratives, not all of which include calls to violence. Many of these groups are little more



Sources: "Digital 2021: Global Overview Report" <https://datareportal.com/reports/digital-2021-global-overview-report>



than subversive discussion forums, with inconsistent messages and vague goals that form an interesting network of symbioses. It is too early to define the extent to which all of these groups and their propaganda pose a risk for radicalisation and participation in terrorism. In the case of networks that openly promote violence, social media companies have continually evolved their strategies to shut them down as quickly as possible, and there are now more efforts than ever to counter terrorist and violent extremist activity online. Therefore, the presumed "missile effect" of the "shutdown - vulnerable audience - increased online engagement - increased radicalization - terrorist attacks" line of impact has yet to be proven.

A List of Risk Factors

On the other hand, the lockdowns may add to the list of potential risk factors for radicalization: insecurity, social isolation, unemployment, mental illness, social, psychological, and geopolitical circumstances. Regardless of whether they increased during the lockdown, none of these factors is necessary or sufficient for someone to turn to terrorism, and they lose their intuitive appeal when we consider how many people have similar experiences and yet do not turn to extremism, violent or otherwise. Considering that the pandemic has already resulted in losses and trauma, disruption of daily living habits, psychological suffering, and generally high levels of insecurity in vari-

ous areas, the short-term psychological effects of this crisis include panic, anxiety, frustration, boredom, and a pervasive sense of loneliness. In addition, the economic, social, political, and cultural consequences of the pandemic at the macro level could create or amplify a range of negative states of mind, including inward-looking emotions and, more to the point, outward-looking emotions (such as contempt, anger, resentment, and hatred), which at the micro level could make a greater number of people more susceptible to extremist narratives. At the individual level, personal trauma, such as job loss, could create insecurity and despair. All of these elements, compounded by the pandemic, may lead to vulnerability of online audiences and make some easy targets for extremist propaganda. Therefore, the assumption that the lockdowns will create a vulnerable audience that will engage with increasing extremist online propaganda and become further radicalised and capable of planning and executing a terrorist attack is in fact dependent on many different variables. In other words, the lockdown and the short- and long-term effects of the pandemic may create vulnerabilities in the growing target population, and based on existing and intensifying grievances, some may further engage and radicalise. But there is no direct pathway linking the COVID-19 crisis to radicalisation and, by extension, an increase in terrorist attacks. The pandemic may have helped spread the extremist message and reach a larger

audience since the early months of 2020, but this will not become apparent for years to come and will require a higher level of vigilance on the part of national and international authorities. Furthermore, beyond the "lockdown – online radicalisation" debate, one year into the pandemic, the security focus has also shifted towards the health sector. While the West has been battling COVID-19, salafi-jihadi groups have been planning a resurrection in Iraq and Syria, while extending their bonds in South Asia and Sub-Saharan Africa. Many of the fake caliphate's lost soldiers have gone underground and have even travelled to other conflict zones or to their Western countries, waiting for the right time to act. Many of the current unrests around the globe have common actors in the persons of the foreign terrorist fighters that were previously engaged in Syria and Iraq. Furthermore, right- and left-wing terrorist groups have also increased their online and physical activity, while sending their representatives to conflict zones such as Syria and Ukraine. The domestic terrorism threat has become a widely acknowledged threat, pushing for more rules and regulations to be passed in order to counter the spread of right- and left-wing extremism. Still, beyond any of the trends discussed, we must understand that, as our society goes through fundamental change, every element of our global system gets its own reset; and terrorism might also get its turn soon, if it has not started already. ■

India to Stop Importing Tanks, Corvettes, Helicopters

Suman Sharma

From December 2021 on, India will cease importing complex defence equipment. The Indian Government just issued a “Second Positive Indigenisation List” of 108 items to promote self-reliance and defence exports.

Denis Leary once said, “One thing that’s great about firefighters: If they don’t have the equipment they desperately need, they don’t have the help, they don’t care. They’ll do it on their own.” The above seems to reflect the driving principle behind India’s defence manufacturing mindset, elucidated by its recent pitch to achieve self-reliance in weaponry.

In a big push for ‘Self-Reliant India’ otherwise known as “Atmanirbhar Bharat” in the vernacular, the Indian Government has released an extended list of defence items to be procured domestically, thereby banning imports of those items as per the timeline given against each item. Labelled the “Second Positive Indigenisation List” of 108 items, the latest list comprises complex systems.

India is among the world’s top five arms importers, as per SIPRI’s latest findings. Having fought five wars with two belligerent neighbours, in what began during the Cold War, India’s domestic defence manufacturing industry never really took off in the way it should have, ending with huge imports, mostly from the erstwhile Soviet Union. Everything from submarines, tanks and fighter jets were Russian. Small steps were taken in the 1950s with the laying of the foundation for homemade weapons, though with little or no success. This was followed by sanctions gripping the nation post nuclear tests, which only accelerated the need for self-reliance. This demand has only intensified over the years, more so last year during the eight-month stand-off at the Indo-China border in northern India’s eastern-Ladakh sector amidst the COVID-19 pandemic.

Aimed at achieving self-reliance, this Indian Government move is expected to boost the active participation of the public and private sector to fulfil the twin objectives of indigenisation and defence exports. As per the provisions listed in the DAP 2020 (Defence Acquisition Procedure) all the listed equipment will be procured domestically from Indian manufacturers.

SP Shukla, Group President Mahindra Defence stated, “The promulgation of the second positive indigenisation list brings together a range of systems, sub-systems and platforms which collectively strengthens the foundation for ‘Atmanirbhar Bharat’ The second list, aimed at reducing dependence on foreign military hardware, focuses on weapon systems which are currently under development or trials and are likely to translate into firm orders in the future. Like the first list, the second one also targets



AATMA-NIRBHAR BHARAT

“Atmanirbhar Bharat” or “Self Reliance”, is Modi’s clarion call, echoing Gandhi’s vision of a self-reliant people capable of producing and exporting its own products.



In an address to the nation on 12 May 2020, Indian Prime Minister Narendra Modi observed that in order to fulfill the dream of making the 21st century India’s, the way forward is through ensuring that the country becomes self-reliant.

import substitution of ammunition which is a recurring requirement.

Defence Secretary Ajay Kumar stated, “Great news for the Indian Defence Industry. With 101 items notified in August 2020 and 108 items notified now, 209 items not to be imported by Armed Forces from specified dates.”

The exhaustive list prepared by the Ministry of Defence (MoD), and to be hosted on the MoD’s website, underwent several rounds of consultations with governmental and private manufacturing bases to assess future capabilities of Indian industry and provide the continuous impetus towards self-reliance in defence by providing an excellent opportunity for ‘start-ups’ and the MSMEs (Medium Small Micro Enterprises).

Defence Minister Rajnath Singh, who announced the target of US\$25Bn by 2025 for defence manufacturing in India, has mentioned over the last few years the Government’s hope of the industry acting as

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A T-72 AJEYA tank of the Indian Army. Starting in 2025, the import ban on the 1,000-horsepower engine will apply to this tank.

an engine for growth. Out of US\$18.5Bn allocated for capital acquisition for defence in this year's budget, the Government has reserved more than 60 per cent, approximately US\$10Bn for domestic procurement.

Jayant D Patil, Senior Executive Vice President, Larsen & Toubro Ltd, and President of SIDM (Society of Indian Defence Manufacturers), the largest industry body, says, "Due to COVID-19, the list is late by two months, as it was expected in March. But some real big-ticket items have found their way onto the negative list. All kinds of tanks and numerous tank systems now won't be imported. That's one extremely positive statement."

Patil expressed satisfaction with around half of the items having made it from a list of 250 given by SIDM. He said "we are absolutely clear that there will be a third list and a fourth list also", as "that clarity existed even when the first list came".

According to estimates, the Indian Armed Forces are projected to spend around US\$130Bn in capital acquisition in the next five years.

Indian Defence Industry

The top five private defence manufacturers in India are the Tata Group, Larsen & Toubro Ltd, Bharat Forge Kalyani Group, Mahindra Defence and Reliance Naval & Engineering Ltd. Insiders confide that, "It is affirming that Indian Industry has capabilities as well as a track record of having done a lot of indigenous development and the list is just a formalisation of the track record and capability of what industry players have done and are capable of doing." Though there have been arguable debates over the years about a non-level playing field in awarding defence contracts, which mostly go to the Government-owned units,

this initiative by the Government puts behind the possibility of anyone in the MoD's decision-making chain and the armed forces expressing displeasure at the indigenous product and wanting to import it as a deviation from the embargo list. As with the previous list, this too has a lot of complete platforms, system of systems, equipment and major building blocks for platforms.

In some of these cases, it will involve fully capable Indian players who may be able to design and build them on their own, but if they end up being the single vendor, then the MoD's conservative thinking might dilute the categorisation to be more broad-based. This would in turn promote competition as opposed to how Governments worldwide 'hand-hold' even single companies with differentiated capabilities to harness their strategic goals. While on the face of it, this will allow other weaker Indian players to participate by teaming up with foreign OEMs and produce in India, thereby enhancing continued dependence on foreign OEMs for ToT (transfer of technology) as such arrangements will be nothing more than ToTs and licenced production. Thus, the legacy problems the sector is facing will continue.

According to industry estimates, both lists by themselves are expected to yield orders worth approximately US\$55Bn in the coming five-six years.

The Two Lists

Baba Kalyani, Managing Director of Bharat Forge, Kalyani Group, says, "The second indigenous positive list further reaffirms the Government's resolve to promote 'Atmanirbhar Bharat' in defence and aerospace and provide a big boost to companies that have made significant investments in technology, product and capability development in this strategic sector."

The first list, termed the 'Negative list of 101 items' was released in August 2020, which listed an embargo on imports planned to be progressively implemented between 2020 to 2024. The first negative list for defence imports included small ticket items such as towed artillery guns, short-range surface-to-air missiles, cruise missiles, offshore patrol vessels, electronic warfare systems, next-generation missile vessels, floating docks and anti-submarine rocket launchers. An industry insider not wishing to be named, mentioned that, "There are no major Request for Proposals (RFPs) against last year's first list, yet."

It is noteworthy that recently, the MoD-led Defence Acquisition Council (DAC) cleared the RFP for the construction of six submarines valued at approximately US\$6Bn. Labelled 'Project 75i', this submarine deal becomes the first acquisition under the Strategic Partnership model under which Indian manufacturers (both private and Government-owned) lead the project by teaming up with foreign OEMs of their choice in a joint venture. Last year's embargo list mentions the Indian Navy's expected demand to be placed for submarines with an indicative import embargo date of December 2021, where it is expected to contract the six submarines.

The 'Second Positive Indigenisation List' comprises complex systems, sensors, simulators, weapons and ammunition including helicopters, next generation corvettes, Airborne Early Warning and Control (AEW&C) systems, tank engines, Medium Power Radar for Mountains, MRSAM Weapon Systems and many more similar items to fulfil the requirements of the Indian Armed Forces. This second list is planned to be implemented progressively with effect from December 2021 to December 2025.

It also has the highest number of items (totalling 49) that will not be allowed to be imported after December 2021, including next generation corvettes, some variants of single-engine helicopters, wheeled armoured platforms, border surveillance systems and armoured engineer recce vehicles, etc. By end-2022, the import of another 21 items will be barred. A separate list of 17 items such as the mountain weapon locating radar, the smart anti-airfield weapon (SAAW) Mk-I and loitering munitions have been identified for an import ban from December 2023 while the ban on 13 items will be applicable from December 2024.

The import ban on eight other systems and weapons, including the anti-material rifle (AMR) 14.5 mm, and the 1,000 hp engine for T-72 tanks will come into force from December 2025, according to the MoD document. ■



Viewpoint from New Delhi



Photo: Suman Sharma

India's Balanced Response to the Israel-Palestine Gaza Conflict

Suman Sharma

India's lack of open support to Israel during the 11-day Gaza conflict in May be-

tween Israeli soldiers and the Palestinian militant group Hamas, which recently ended in a ceasefire, was taken with a pinch of salt by the Israeli side.

Rony Yedidia Clein, Deputy Chief of Mission of the Israeli Embassy in India said in a virtual interaction, "Israel believed India did not show "public expression" of support for the country, unlike some other nations", adding, "When we spoke with our Indian counterparts, we found an understanding from them, although they did not go public, (or) have such public expressions of support as other countries did. Just imagine what would have happened if rockets had been fired on Delhi as they were fired on Jerusalem on the first day of the campaign? Every country has the right to defend its sovereignty and its citizens." Israel's Prime Minister Benjamin Netanyahu tweeted his gratitude to 25 countries which did not include India. "Thank you for resolutely standing with the flag of Israel and supporting our right to self-defence against terrorist attacks," read the tweet, showing the flags of the supporting countries. Meanwhile, the Palestinian Ambassador to India, Adnan Mohammad Jaber Abualhayjaa, thanked New Delhi for "strongly supporting the cause of the Palestinian people."

Ambiguity on India's silence was reinforced by her nuanced and balanced statement at the UNSC in what appeared deft craftsmanship in semantics and has been open to interpretation by various geo-political watchers. As we unbox the well-drafted statement, India's 'balancing' act becomes clearer. Whether India has a leaning towards Palestine or towards Israel has always fallen in the realm of the grey.

Owing to its vast Muslim population, and dependence on the Arab world for oil, India's historic long-standing relationship with Palestine begins with New Delhi's support to "the right of Palestinians to self-determination". The Palestine policy of the Indian Government has remained consistent since the Cold War following which full diplomatic ties were established with Israel in 1992, at the post-Cold War Madrid Conference, bringing in the new world order, as the Soviet Union disintegrated.

"Since the early 1990s, India's position on Palestine is clear, even before BJP came to power and the Congress Narsimha Rao Government tilted towards Israel and there was a shift in the policy on Palestine. The traditional position on Palestine became closer to the non-aligned movement. India's transactions with Israel are mostly military, which helps Israel. This realist position is harmful

for India's image," says Mohammad Makram Balawi, President of Asia Middle East Forum.

The two statements made by Ambassador T.S. Tirumurti, India's Permanent Representative to the United Nations, dated 16 and 27 May 16, seem to express parity for both sides, but appear to lack an emphatic stance by India against the extensive rocket bombing by Hamas inside Israel, as well as the disproportionate shelling of Gaza by Israeli forces which claimed approximately 230 lives including 60 children. Casualty figures on the Israeli side would have been much higher had it not been for Israel's 'Iron Dome' missile interceptor, which successfully thwarted 90 per cent of Hamas rockets.

India's statement observes, "We reiterate our call for all parties to observe maximum restraint and avoid acts of violence, provocation, incitement and destruction. These incidents have once again underscored the need for immediate resumption of dialogue between Israel and Palestinian authorities. The absence of direct and meaningful negotiations between the parties is widening the trust deficit between the parties."

In its statement, New Delhi begins its recognition of the conflict from the Al-Aqsa mosque, hyphenated with the Temple Mount, thereby invalidating exclusive control of the region by any one community. The Indian statement furthers its recognition from the mosque and not from the time Hamas rockets bombed Jerusalem, which is much earlier.

The tightrope walk carried out by India in calling for restraint, and a resumption of talks between both sides places the layered Indian statement in the complex whirlwind of competing geo-politics. With the fulcrum being 'balance', the Indian statement seems to be addressing several factions.

With defence imports largely forming the cornerstone of the India-Israel relationship, India's call for a democratic process in Palestine also stresses dialogue with the legitimate Palestine leadership, thereby discrediting Hamas.

New Delhi's voting pattern at the UN so far has been in favour of Palestine, but in 2019, India for the first time, in an unprecedented move shocked the world by voting in favour of Israel at the UN's Economic and Social Council (ECOSOC) to deny observer status to a Palestinian human rights organisation named 'Shahed'.

The prevarication in the concluding sentence, "I reiterate India's strong support to the just Palestinian cause and its unwavering commitment to the two-State solution", appears calculated, and demands meticulous perusal. As per the global discourse, Israel may be winning the war, but Palestine seems to be winning the perception war.

Finnish Air Force Modernisation Plans

Georg Mader

Separated by a 1,300 km long border, Finland lives with the permanent presence of its neighbour Russia. Unlike other European nations that share similar airspace environments, militarily non-aligned Finland is not a NATO member. However, Finland is a member of the European Union and one of NATO's Enhanced Opportunities Partners.

Separated by a 1,300 km long border, Finland has lived with the permanent presence of its Russia neighbour for decades. But unlike other European nations that share similar airspace environments, neutral or non-aligned Finland is not a NATO member. However, Finland is a member of the European Union and one of NATO's Enhanced Opportunities Partners. Together with its Baltic neighbour Sweden, however, Helsinki has searched increased political proximity to the Alliance in recent years, while the Finnish Government is still balancing a fine line between membership and Putin's empire. Against this background, the 5.5 million nation's leadership is close to decide on a considerable US\$ 10 bn. renewal of its fleet of fighter aircraft.

During the Cold War, Finland was as a border state between the West and the USSR. In exchange for staying neutral, Russia did not meddle with Finnish domestic affairs and along walking that fine line, the Finnish Air Force (Ilmavoimat or FINAF) introduced Western-built aircraft (Folland Gnat, Fouga Magister, BAe Hawk), Eastern makes (MiG-15, MiG-21) and neutral ones (Saab Draken). During the 1990s, when Russia and NATO maintained a more peaceful relationship, Finland stayed remarkably distant. The manpower of the military was not reduced and conscription was maintained. Finland believes in a strong military, of which the Finnish Air Force (FINAF) is a crucial element.

Under its current Commander MajGen Pasi Jokinen, the service branch today has approximately +2,000 uniformed and civilian personnel, in addition to accepting approximately 1,400 conscripts annually. In case of a national crisis, there is a reserve force of around 38,000 available. Of course, the FINAF monitors Finland's air space on a 24/7 basis. Long- and medium-range surveillance radars that were acquired in 1988 and are now being upgraded and other sensors generate a



Saab participated in the HX demonstrations with a GRIPEN E trial aircraft equipped with Iris-T and METEOR-missiles and an electronic attack jammer pod.

situational picture covering Finland's territory and adjacent areas. With the perception of a though graduated, but more or less continuous threat from Russia, air-defence plays a major role in the FINAF's philosophy and activities of the Russian military in the Baltic area are subject to permanent observation.

Finnish HORNETS

In 1992, Finland ordered 64 F-18C/D HORNETs which were delivered between 1996 and 2000. These were not initially designated F/A-18s as they did not have a ground-attack capability. In a standing quick-reaction-alert rotation, these continue to serve with two units: Lapland Air Command's Fighter Squadron 11 at Rovaniemi Air Base and Karelia Air Command's Fighter Squadron 31 at Kuopio-Rissala Air Base. A third unit, Satakunta Air Command's Air Combat Centre also operates some F/A-18s at Tampere-Pirkkala Air Base." A third unit, the Air Combat Centre, also operates some F-18s at Tampere-Pirkkala. If the need arises to adjust the readiness level either in peace time or in the event of a crisis, aircraft

may be dispersed to road bases and other remote operating locations. In a crisis, the Air Force shifts the focus on defensive counter-air fighter missions and air defence C2 - for all three Finnish services. Since their service introduction, these legacy aircraft - 55 single- and seven two-seaters - have received two major upgrades between 2006 and 2010 and between 2012 and 2016. Carried out with scheduled maintenance-terms at Patria's Halli facility, the first upgrade (MLU1) was to revamp the aircraft's air-to-air capability, which involved the integration of a helmet-mounted sighting system and the AIM-9X SIDEWINDER IR-guided missile. MLU2, the second mid-life upgrade, subsequently enabled the integration of a wide range of air-to-air and air-to-ground capabilities. The air-to-ground weapon suite includes the Joint Direct Attack Munition (JDAM) precision-guided bomb, the AGM-154 gliding Joint Stand-Off Weapon (JSOW) medium-range glide bomb and the powered AGM-158A Joint Air-to-Surface Stand-off Missile (JASSM) 270 km-range standoff-missile (70 systems). The LITENING electro-optical targeting-pod was



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An F-35A LIGHTNING II and an F/A-18E/F Block-III SUPER HORNET during the so-called HX Challenge earlier this year

also introduced, together with modern self-protection, communication and information distribution-systems. Nevertheless and beside all efforts, the FINAF legacy F-18 fleet – after 30+ years of operations – is nearing the end of its service life by 2030.

Finnish HAWKS

On 16 December 1980, the first of 50 BAE-HAWK Mk.51 jet-trainers (HW302) arrived in Pori and assumed the role as a ‚flying classroom‘ to prepare pilots for the fast jet cockpit. In 1993, seven additional HAWK Mk.51A were acquired. And in 2007, a batch of 18 former Swiss Air Force HAWK Mk.66 with a quite low amount of flight hours and with analogue cockpits complemented the fleet. These were upgraded with new avionics and, in some cases, with two-way datalinks, with the support of BAE Systems at PATRIA Aviation between 2011 and 2013. As a result from this upgrade the entire frontline HAWK Mk.51 fleet of 32 aircraft upgraded with glass-cockpits will be part of the FINAF fleet until the mid-2030s. Currently no new LIFT-trainer is therefore pursued. Kauhava was the homebase for the FINAF jet-training school, but in 2014, all HAWKS – two former Swiss aircraft were lost in 2013 - were transferred to Tikkakoski where the Air Force Academy is located. The Kauhava airfield and garrison were handed over to a private owner. The aircraft remain to be a crucial element of the FINAF's training concept. Throughout Europe the type is well known via the FINAF display team, the MIDNIGHT HAWKS. The Finnish Air Force celebrated the 40th anniversary of the Hawk in Finnish service in December 2020.

Other Valuable Assets

Today, the Air Force Academy is currently transitioning from Valmet L-70 VINKA basic trainers to 28 German-built Grob 115s that formerly served in the RAF as "tutors" and were acquired via Babcock Aerospace. Like the HAWKS, they were modernised before entry into service between 2016 and 2018. Before entering service, they received an avionics- and communication-systems upgrade with state-of-the art digital displays and a cockpit-layout compatible with the other aircraft operated by the FINAF. Since 2005, preliminary and basic pilot training services have been contracted to PATRIA. As a strategic partner of the Finnish Air Force, PATRIA is responsible for aircraft and engine heavy maintenance, repairs, upgrades, structural modifications and system development.

Medium airlift capability is provided by three Airbus (CASA) C-295M tactical airlifters, although one of them is used as an ELINT- (Electronic Intelligence) and COMINT- (Communication Intelligence) platform. On 12 February 2018, the FINAF announced that Lockheed Martin's DRAGON SHIELD system was now operational on the aircraft. Lockheed Martin modified this Airbus C-295 cargo aircraft



The logo of the HX programme depicting the five contenders

to accommodate the containerised roll-on-roll-off surveillance system. The Finnish defence forces were also provided with ground stations and communication terminals to support the airborne system. In addition, there are three Learjet-35s, used for light transport, photography, air sampling and maritime surveillance duties. Last but not least, six Pilatus PC-12NGs are covering light personnel- and cargo-missions. All three types are operated by the Satakunta Wing at Tampere-Pirkkala Air Base. To cover pre-planned heavy-lift needs connected to scheduled deployments, the Finnish MoD has a share in NATO's Multinational Heavy Airlift Wing (SAC) at Papá/Hungary, providing global strategic airlift for humanitarian, disaster relief and peacekeeping-missions in support of EU, UN and NATO (PfP) with three C-17s since 2009.

With respect to helicopters, all rotary wing assets were transferred to the Finnish Army Aviation (Suomen Maavoimat) at the end of the 1990s. After replacing ex-Soviet Mi-8s in 2010, the 20 NH90-TTHs (Tactical Transport Helicopter) ordered in 2001 and introduced between 2008 and 2015, are the main type of Utti Jaeger Regiment's Helicopter Battalion. In addition, the Army operates seven Hughes MD500 light helicopters.

Exercises and Cooperation

In recent years, Finland and Sweden have deepened their bilateral defence cooperation. In 2018, the two Nordic countries signed a Memorandum of Understanding on defence cooperation. Finland and Sweden aim to boost their defence capabilities and their ability to conduct joint operations together, ultimately increasing security and maintaining stability in the Baltic Sea region and the High North. Both nations' air forces have participated in each other's main air operations exercises, focused on national defence, already since 2016. Politicians from both nations are keen to foster a closer military relationship, because of Russia's increasingly aggressive posture in or over the Baltic in recent years – resulting in various encounters with pairs of armed Su-27s (once twice a day) and various Russian multi-engine platforms. There is also the perspective of fostering stronger working relationship with third parties, specifically with NATO. Every second year since 2013, Finland, Sweden and Norway have co-hosted the Arctic Challenge Exercise (ACE), which has attracted a lot of participants from several nations. In 2021, Norway is the lead

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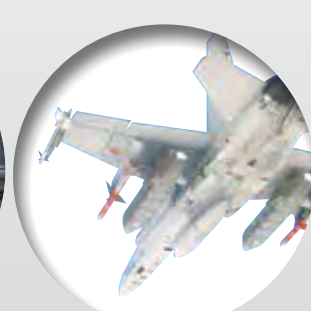
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TORNADO



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F-18



Dassault's HX offer for the RAFALE F4 is believed to include the option of locally-built airframes.

nation. In addition to Finnish F/A-18s, Rovaniemi Air Base currently hosts German Eurofighters and U.S. KC-135s participating in ACE21. In 2019, Ruska 19, the Finnish Air Force's annual main air operations exercise involved 4,500 personnel (including ~2,000 reservists) and up to 28 F/A-18C/Ds and 14 HAWKs. The Swedish Air Force participated with eight JAS 39C/D GRIPENs and an S100 ARGUS AEW&C aircraft. Missions were flown primarily out of the Tampere, Kuopio, Rovaniemi and Jyväskylä air bases. Aircraft were also dispersed to temporary bases, established at the airports of Halli, Joensuu, Kajaani, Oulu, Pori and Vaasa. The Swedish aircraft operated from Kuopio in Finland and Luleå in Sweden.

HX Programme

Despite the economic pain generated by the COVID-19 pandemic, Helsinki has increased its annual defence budget by 54% to US\$4.88 billion to prepare for the initial costs of replacing the legacy F-18C/D fleet in the scope of the so-called HX-programme (H = HORNET, the letter X is typically used to indicate a candidate for replacement). Based on the latest BAFO bids (Best-and-Final-Offers) submitted by 30 April 2021, Helsinki is expected to make a final decision for new fighters at a value of €9Bn later in the year. The MoD and the FINAF have received US-backed bids for the Lockheed Martin F-35A LIGHTNING II and Boeings F/A-18E/F Block-III SUPER HORNET and EA-18G GROWLER, as well as offers from three European companies: Dassault's RAFALE F4 from France, the multinational Eurofighter consortium offering a Tranche-4-like TYPHOON (with the UK in the lead) and Sweden with the Saab JAS 39E GRIPEN. Saab is also offering two GlobalEye AEW&C multi-mission aircraft. In January 2020, a so-called HX Chal-

lenge was carried out at Pirkkala Air Base in central Finland, with tests performed under Finnish winter conditions in order to verify data previously supplied by the manufacturers. During two weeks of testing, the contenders flew 40 missions and also participated in simulated exercises to display their capability in operating in combat scenarios as part of Finland's defence system. Subject to the demonstrations were sensor-ranges, as well as their resolution and ability to maintain tracking while targets used manoeuvring or employed countermeasures. They also served to determine the workload and speed associated with preparing the weapon system to attack a ground target and - in case of a long-range attack – employing standoff weapons if the aircraft can be provided with more specific target-data by a datalink. The sorties were also used to measure each of the fighters' capability to identify and locate

electronic signals and produce situational awareness of the target area. Saab sent the two-seat GRIPEN NF demonstrator and a GRIPEN E trial aircraft equipped with IRIS-T and METEOR-missiles and an electronic attack jammer pod, while a GlobalEye took part in separate trials in the south of Finland. The other bidders sent various single- and two-seat aircraft from operational USAF, USN, French and RAF-wings. Finnish media reported, that only two of the four expected USAF F-35 arrived for evaluation, one of which promptly broke down and could not participate in the tests.

Coinciding with the BAFO deadline, the four contenders released statements and held online-media-briefings to support their pitches, with some promising industrial-participation packages of varying degrees that would boost job growth in Finland. Like before in Switzerland, however, Dassault did not release statements along this line. The magazine Air Force Technology reported that Dassault had offered Finland the ability to operate the aircraft independently from France and potentially build the airframes in country. For a general regional economic as well as security-policy-related dimension, Sweden's bid for the GRIPEN E is especially notable. Not only is Saab proposing only fully combat-capable single-seaters in denial of the need of a national OCU, the country's top officials have publicly assisted Saab's Campaign Director Magnus Skogberg in making the paramount case for extending the Sweden-Finland alliance into a de-facto singular operational air space covered by GRIPEN-type

Photo: Eurofighter



The Eurofighter TYPHOON was the first of five contenders to start a series of flight evaluation trials.

aircraft that commanders could use interchangeably across both nations to ward off an invasion. Boeing rightfully points to far reaching commonalities with the FINAF's legacy HORNETs while offering meaningful long-term opportunities for the Finnish industry, associated with options for the next-generation, multi-role F/A-18E/F Block III and the unique EW warrior EA-18G GROWLER, according to a Boeing spokesman. He stressed that (what also applies to the requirement in Switzerland): "You could have a HORNET flying today and a SUPER HORNET flying tomorrow, while around 60% of existing HORNET tooling can be used to support a new SUPER HORNET – (thus) increasing potential cost savings."

Lockheed Martin touted the advanced capabilities of its F-35, dangling the prospect of offering high-tech job opportunities in Finland that "no other competitor can offer," Bridget Lauderdale, F-35 Program Vice President and General Manager, said in a statement. The company also says it is offering the most affordable jet, "a fifth-generation fighter at the cost of a fourth-generation aircraft. Our production work will continue for more than 20 years, and the F-35 sustainment work will continue into the 2050s - not only will Finland support its own F-35s, but it will directly support the global fleet of F-35s through the production of major components." Obviously, Finnish analysts can be expected to check all this with a fine comb. The industrial participation obligation for HX is set at 30% minimum of the total contract value.

BAE Systems, speaking on behalf the Eurofighter consortium, announced that if Finland were to select their aircraft, "80 packages of in-country work for Finnish companies would be generated. The Government will influence the future programme and product, ensuring the aircraft is tailored exactly to Finnish requirements. With 570 aircraft delivered across Europe and Middle-East, the TYPHOON will remain the backbone of Europe's combat air capability for decades to come." Finland was also invited to join the UK's ECRS Mk.2 AESA-radar programme, bringing Finnish expertise into its future development. However the FINAF may wish to receive a mature AESA.

Other Interesting Aspects

Finland wants fully combat-capable fighters and therefore places a considerable lot of emphasis on the aircraft's ordnance. The Saab offer includes several weapons systems, including MBDA's



The current HORNET fleet of the FINAF consists of 62 F-18CID.

The single-seater C version includes the ASPJ (Airborne Self-Protection Jammer) jamming pod ALQ-165.

METEOR, IRIS-T, SPEAR and KEPD350/TAURUS. TYPHOON also comes with SPEAR, MBDA's AIM-132 ASRAAM, METEOR BVRAAM and the STORM SHADOW air-launched cruise missile. In case Finland selects either the SUPER HORNET or the F-35A, their – US-Government backed - offer includes a modern version of the AMRAAM, the AIM-120C-8, as mentioned during a media conference at the US Embassy in Helsinki in late May. This is quite a step up from the FINAF's current C-7, though how much exactly would come along remained unclear. Most likely the C-8 is a re-named -D, the weapon responsible for the recent test that the USAF described as "the longest known air-to-air missile kill." Exact ranges are obviously both classified while depending on a number of launch parameters. Also coming along from the US in the near future is the AIM-260 JATM (Joint Advanced Tactical Missile). While "commercial details" made it impossible to include that with the BAFO-bids, it looks like a rather progressive development timeline that will see the JATM overtake AMRAAM in production by the mid-2020s. The US Navy will be the first to integrate it on F/A-18E/Fs – and it is no secret that the FINAF has expressed to stay as close as possible to the standard of the main operator of any fighter they buy.

A strike-weapon expected to handle the long-range strike-mission could be the Lockheed-Martin made missile formerly known as JASSM-XR. It would provide a significant increase in range in comparison to the current range of 370 km of the AGM-158A. The JASSM-ER/

AGM-158ERB2's range is quoted to be 1,852 km. In a combat environment, these stand-off weapons would unlock more strike-planning options, including guaranteed stand-off range against all Russian air defences (current and likely planned), as well as the possibility to re-route time-critical flight paths of the cruise missiles around hostile defences.

The EW Capability Aspect

A charming factor constituted by Boeing's inclusion of the EA-18G GROWLER in its proposal, is that the dedication of the platform to electronic attack brings not only the computing power of the specified EW processor unit (kind of an armament element itself), but also the dedicated second crew member. When a new or previously unidentified signal is encountered, it can be processed in flight, assigning an identifier to it. When the aircraft lands, the new SIGINT result can be downloaded ready for the threat library. Boeing is believed to offer this capability as an exclusive. But while the complete absence of "hands-off" black boxes and total independence on the mission is a main selling point of the European contenders, Boeing takes a somewhat different approach - out of necessity. The SIGINT-data would be owned by the Finnish Government, but the processing of acquired mission data is easiest to handle through US infrastructure, where Finnish personnel can be negotiated to be embedded at key functions. EW aspects were also subject to a controversial discussion between the two US contenders at the aforementioned media briefing at the US Embassy. ■

“International cooperation is supported by the highest leadership of the Government.”



Photos: Georg Mader

Interview with Major General Pasi Jokinen, Finnish Air Force

My personal expectation is that the sensor suite and computing power of the new platform will be more up to date, and this will provide potential for growth in the future as well.

ESD: Is an F/A-18 upgrade programme likely to be necessary before the new aircraft reaches IOC?

Jokinen: With regards to the HX project, there is no need for an additional upgrade programme for the F/A-18. We have already conducted two major Mid Life Upgrades (MLU1 & MLU2). Primary weapons, avionics and communication systems of our F/A-18s are up to date. The aircraft provides a platform for several mission areas and is capable of conducting multirole operations. Software development will be continued in order to ensure operational effectiveness until the HX is in service.

ESD: Your pilot training is based on the HAWK and Live, Virtual and Constructive (LVC) Simulation. Are you content with what the HAWK can provide in this respect?

Jokinen: I am very content with the current capabilities of our HAWK-based flight training system. The HAWK will have a significant role in pilot training until the late 2030s. With a datalink equipped glass cockpit the HAWK is a tremendous training effectivity multiplier, providing an affordable training solution for the F/A-18 and later for the HX. Some of the current fighter training missions can be adopted to the HAWK training syllabus in the future. The LVC-configured Hawk can also provide advanced threat, and blue air simulation when needed. Software and also to some extent hard-

ESD: As a combat pilot, how do you assess the MiG-21's capabilities if compared to the DRAKEN?

Jokinen: The MiG-21 had a small cockpit and a lot of switches inside. Aerodynamically it was a great aircraft to fly. Its short range air-to-air missile (AA-8) capability was not that bad in the beginning of the 1990s. The plane was physically very small and this made it very difficult to detect in aerial combat before entering merge.

I'm unable to do a comparison as I did not fly the DRAKEN.

ESD: Regarding the HX programme - but independently from the preferred bidder selection expected this year - what is the status of the evaluation programme? What advantages do you expect the selected aircraft to offer over the current F/A-18 fleet?

Jokinen: The status of the programme is solid. The Finnish Defence Forces' evaluation teams are currently analysing the Best and Final Offers (BAFO) that the manufacturers have submitted. Teams working on various capability areas are conducting their analysis & evaluation phase. There are multiple activities going on including wargames, polling panels and delphi surveys.



At present, the Finnish Air Force operates 55 single- and seven two-seated F-18C/D Hornets. In the background one of three Airbus (CASA) C-295M tactical airlifters, one of which is used as an ELINT- (Electronic Intelligence) and COMINT- (Communication Intelligence) platform

Patria NH90 LDG/SRCH Light – Modern LED Landing Light

Patria LDG Light is a modern landing light solution, optimal for the NH90 helicopters' requirements. Designed to provide improved performance and maintainability to the original equipment manufacturer, the landing light is a single configuration solution with improved reliability, white light power, IR power, turn rate and power consumption. It exceeds current NH90 operating and performance characteristics providing LED life of at least

12-24 months and with high repair and replacement costs. Patria's NH90 LDG/SRCH Light solves these resource problems with easy replacement of the landing light and less needed maintenance during its lifetime. Patria's knowledge and competence has already been put to practice by providing Finland a national maintenance capability for current legacy OEM lights. Patria has been able to deliver a turnaround time of 70 days per

Patria NH90 LDG/SRCH Light is a one-configuration solution as opposed to the two-configuration offered by the OEM, replacing all two landing lights and two searchlights, also HID light. Due to the simple configuration, the installation, maintenance and replacement is merely a normal line maintenance task with a plug and play installation kit. The installation also requires no H/C system modification.



Photo: Patria

10,000 hours. Certification basis is FAR29 Amendment 31, which is acknowledged by the Product Certification Program.

As a strategic partner for Finnish Defence Forces, Patria has been participating in a proof of concept evaluation to meet the user requirements. Patria aims to achieve an exclusive distributor position to modern landing light solutions by providing cost-effective, certified NH90 landing lights with superior performance for all NH90 operators globally. Patria will be an official service centre to support, maintain and repair these NH90 landing/searchlights in the future.

The current NH90 landing lights face difficulties with long turnaround times of

light compared to over 300 days per light by the OEM. The cost of Patria's maintenance has also been significantly less than the OEM's maintenance cost.

In addition to the improvement of reduced resources, Patria NH90 LDG/SRCH Light provides significantly improved white light power which is three times more powerful than the OEM light. The modernised LDG/SRCH Light also offers ten times more IR power than the OEM light, while IR visibility for the naked eye is minimal. This improvement enables better operational capabilities of the NH90 during the night, which emphasises the comprehensive positive effect of the new LDG Light.

Patria NH90 LDG/SRCH Light is a Form Fit Function product, i.e. has the same functionality and working logic as the legacy OEM light. This means that there are no changes or restrictions to the existing NH90 flight manual. The modernised landing light provides contactless hall-type position sensors to eliminate exposed microswitches, brushless motors, lower power consumption and surface temperature in a competitively priced package with EMAR compliant maintenance, repair and life cycle support.

Product deliveries will start in the second half of 2022.
For further information, please contact systems@patriagroup.com.



The Finnish Air Force celebrated the 40th anniversary of the HAWK in Finnish service in December 2020. Shown here is the FINAF display team, the MIDNIGHT HAWKS.

ware development will be carried out on the HAWK fleet after the HX decision to better replicate HX pilot interface. In the event that HX programme should lead into solely a single seat fighter, the level of fidelity in HAWK training scenarios and Fighter Lead-in Training (FLIT) exit levels become even more important.

Back in 2000s when the Finnish Air Force (FINAF) started the glass cockpit modification, the starting point and the ideology was to match the F/A-18 symbology and features as closely as possible. This enabled easier transition for FLIT graduates to the F/A-18. Later on in 2018 when the former F/A-18 datalink radios were integrated with the HAWK, the platform turned out to be a game changer. Nowadays FINAF's training LVC network is one of the very few operational LVC networks at FLIT level in the world.

Situational awareness cannot be emphasised enough when determining the must-have assets to excel in any modern or future air warfare scenario. Therefore, tools for building situational awareness, such as fighter link and simulated radar, were in the first wave of features integrated together with the datalink. Later on, a simulated Radar Warning Receiver (RWR) and better teaming options were added to the mix. Ground-based simulators and threat generators can join the same network adding the V and C elements of the LVC. Already tested in the labs, the next Operational Flight Profile (OFP) update brings simulated long-range missiles, which enable effective Beyond Visual Range (BVR) training scenarios.

FINAF is already experimenting with a possible upgrade to the current HAWK

cockpit layout, which includes but is not limited to a large area display, adding another mission computer and helmet-mounted cuing system. Obviously, Full Mission Simulators (FMS) and tactical simulators alongside with part task trainers shall follow and most of the time actually lead the update schedule of the flying platform. Time and future budgets assigned for training platforms will tell how far the development process will end up.

ESD: Is a replacement for the HAWK anticipated?

Jokinen: The plan is to fly the HAWK until the late 2030s. Currently, we are happy with the HAWK, and no replacement programme has been launched. The fact that the HAWK has proven to be a reliable and solid flying platform since the 1980s is the foundation to build on. Together with support from BAE Systems and Rolls-Royce, the continuous efforts of the Finnish Defence Forces Logistics Command to procure required spare parts help us to reach the end of 2030s. However, we need to observe the big picture of our pilot training. After the HX FOC phase, a comprehensive study of our pilot training system will be conducted. It will be done at the end of this decade, and it needs to cover all the phases of our flight training system.

ESD: Many years ago, the FINAF took in the former Swiss Air Force HAWK Mk.66s, which were very early analogue-cockpit aircraft. Did Finnish industry upgrade them to match your own HAWKs? Are these now flying in the FINAF?

Jokinen: Yes, the Swiss HAWK procurement and upgrade programme was an extremely successful one. Prior in-country knowledge of a similar platform proved to be a huge asset in the adoption phase. FINAF has upgraded all 18 purchased Swiss jets together with 16 older models to the same glass cockpit configuration; nowadays our flying HAWK fleet includes 32 aircraft. The Finnish company Patria, a strategic partner of the Finnish Air Force, has been responsible for the upgrade programme. Patria is also capable of developing the aircraft software.

ESD: Including the FINAF, the Finnish Defence Forces cooperate and train extensively with NATO partners and air forces. What are the benefits for the FINAF – and are they, according to your observations, broadly recognised in Finland?

Jokinen: There are of course many benefits depending on the point of view. The

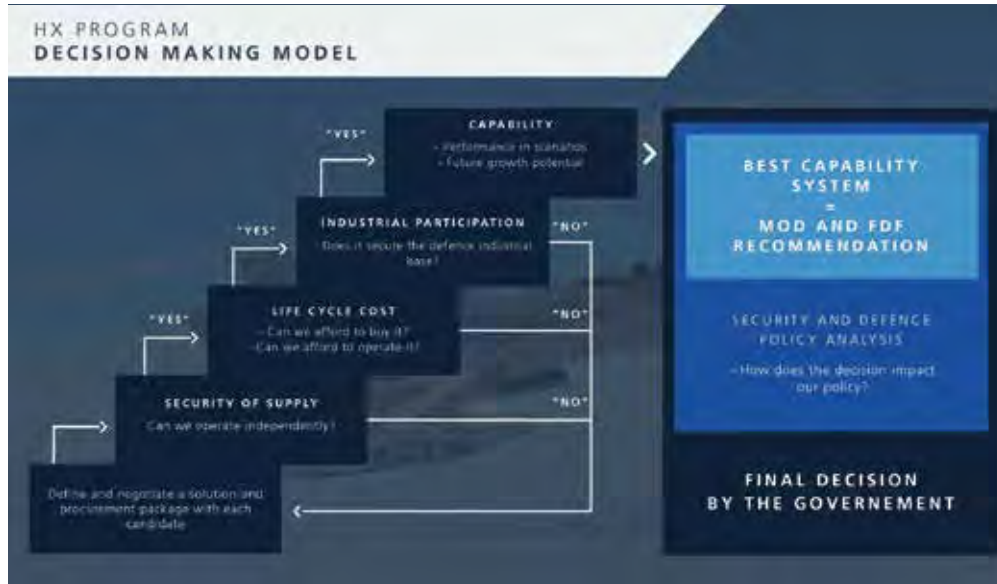
HX PROGRAM TIMETABLE AND PHASING



modern security environment requires international cooperation and training to meet up with various threats to national and global security.

Most importantly, participation in international activities develops our capabilities which are required in our core task - national defence. This is accomplished by sharing information between our partners and benchmarking our ways to operate. We have absorbed many good practices which have been adopted in our TTPs (Tactics, Techniques and Procedures), while still maintaining our strengths and flexibility. Benefits include also the enhanced interoperability and connectivity with partner air forces. This enables us to train better and conduct even more complex exercises.

In the FINAF, we have a standardised training plan for international activities. We have been in exercises abroad, and we also conduct cross border training regularly with our neighbours Sweden and Norway. International cooperation is supported by the highest leadership of the Government and the Defence Forces. As Finland is a democratic state, also different opinions do exist. However, international cooperation, crisis management and peace-



keeping operations enjoy broad support among the general public and decision-makers in Finland.

ESD: Are there any plans regarding future transport aircraft and helicopters beyond your current fleets?

Jokinen: Currently, there are some ongoing upgrades, like the SES (Single European Sky) update for the C-295M fleet. It enables our aircraft to better operate in European airspace.

We are studying and updating the capability requirements of our current utility and transport aircraft fleet. However, there are no plans to replace them in the short term or procuring additional aircraft. We do not deploy globally. Therefore, the international crisis management and peacekeeping operations define our air mobility requirements.

The interview was conducted by Georg Mader.

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Agility Prime: US Air Force Pursues eVTOL Aircraft

Sidney E. Dean

The US Air Force recently launched Agility Prime, a non-traditional programme seeking to accelerate the commercial market for advanced air mobility vehicles. Agility Prime is the Air Force's effort to support the booming commercial investment in eVTOLs. The military's attention to this area of technological development is due to its numerous military applications.

In February 2020, the United States Air Force (USAF) initiated the Agility Prime programme as “a non-traditional programme seeking to accelerate the commercial market for advanced air mobility vehicles.” The immediate focus of the programme is DoD-sourced investment in development and testing of so-called flying cars, both manned and unmanned. Such vehicles have been studied for years with an eye to civilian “Urban Air Mobility” (UAM) applications in urban environments, from high-end executive airlift between high-rise buildings (“air taxis”), to deployment as infrastructure surveillance aircraft. Such aircraft also have military potential.

Agility Prime is financed through AF Ventures, USAF's venture capital fund, and managed through the Air Force's technology innovation organization AFWERX. USAF has invested US\$25M in Agility Prime for 2021 alone, with additional funding planned in future years. By supporting commercial technology ventures, the military hopes to further advances in military-capable technologies at considerably lower cost – and with greater flexibility – than could be expected through a dedicated military prototyping programme.

For industry, the DoD incubator function – including the outlook for an initial market – has boosted the ability to focus on products which might otherwise be considered a poor investment risk. “Our partnership with AFWERX and the Air Force has been transformative,” wrote JoeBen Bevirt, CEO of Joby Aviation, in a December press release. This cooperation “has given us access to facilities, resources, and equipment that accelerated testing and allowed us to prove out the reliability and performance of our aircraft.”

To ensure swift results, the programme is geared toward technologies which are approaching commercial readiness within a roughly 36 month window. Agility Prime is

Photo: Air National Guard photo by Staff. Sgt. Sean Komegay



Photo: Air National Guard photo by Staff. Sgt. Sean Komegay



The electric vertical take-off and landing (eVTOL) HEXA over and at Camp Mabry, Texas, in August 2020



Photo: U.S. Air Force photo by Senior Airman Jacob T. Stephens

A LIFT electronic VTOL aircraft sits on a trailer at Austin-Bergstrom International Airport, Texas, in March 2021. The eVTOL was transported from Ohio to Texas by the 79th Rescue Squadron.

currently in the middle of the “air race to certification,” a three-phase path to military flight certification and potential procurement of one or more operational systems. The “air race” is scheduled to run through December of this year.

Technology Goals and Military Applications

The immediate goal of Agility Prime is to mature technology capable of producing electrically powered vertical take-off and landing (eVTOL) aircraft. This type of aircraft is considered particularly suitable for urban operations. Electric power systems would significantly reduce noise and heat signature compared to combustion engines. As eVTOL aircraft are expected to utilise smaller rotor systems than conventional helicopters, they would also display improved aerodynamic properties in confined urban terrain, and have a significantly reduced risk of rotors catching on buildings, trees or power lines. They would also be easy to operate, even by personnel with no pilot training. Operating modes will include manned, remotely controlled, and autonomous.

AFWERX is coordinating with the Air Force Warfighting Integration Capability group to develop up to 20 potential mission profiles for USAF, but also for the US Marine Corps and Coast Guard. Potential applications being discussed include short-range cargo transport/battlefield resupply, search and rescue, medevac, installation security, and reconnaissance. Previous suggestions have included special operations and urban assault.



Photo: U.S. Air Force photo by Senior Airman Jacob T. Stephens

Airmen offload a LIFT electronic VTOL aircraft from an HC-130J Combat King II at Austin-Bergstrom International Airport, Texas. This transportation test provided 79th Rescue Squadron Airmen a better understanding of how eVTOL vehicles can potentially integrate into military capabilities in the future.



Photo: Beta Technologies

A bird's eye view of the Beta Technologies ALIA eVTOL

Photo: Beta Technologies



Cockpit simulator of the Beta Technologies ALIA 250 eVTOL

Photo: Elroy Air



The Elroy Air CHAPARRAL on the landing pad

Photo: Joby Aviation



The Joby S4 tiltrotor eVTOL in horizontal flight mode

Leading Contenders

Some 27 companies have proposed their flying systems for Agility Prime. To date, the Air Force has identified six of these firms as viable partners for the eVTOL programme:

Beta Technologies

Beta Technologies' ALIA aircraft has a capacity of six people and a projected range of 450 km. The company's ALIA-250 variant is already on the commercial market. Private transport firm Blade Urban Air Mobility ordered 20 units in April of this year. Courier service UPS has ordered 10 units of the cargo-configured variant, with an option for 150. Deliveries under both contracts are to begin in 2024, with operations beginning in 2025.

Elroy Air

According to the manufacturer, the optionally manned CHAPARRAL will have a payload capacity of 165 kg and approximately 500 km range. First flight of the prototype was in August 2019. The company has established a chain of charging stations along its proposed test route between Springfield, Ohio and Plattsburgh New York, a distance of circa 1,000 km.

Joby Aviation

The S4 is the largest eVTOL aircraft being considered under Agility Prime. It carries a pilot plus four passengers, making it suitable for tactical operations. The S4 has six tiltrotors, which transition from vertical to horizontal mode once operational altitude is reached. Joby's goal is a speed of circa 320 km and around 250 km range on a single battery charge. In December 2020, the S4 became the first Agility Prime aspirant to receive USAF's military airworthiness certification.

LIFT Aircraft

The single-seat HEXA has a cumulative payload capacity (passenger and cargo together) of 165 kg. Propulsion is achieved through 18 small rotors attached to a honeycomb-shaped frame above the egg-shaped cabin. The carbon-fibre fuselage sits atop four perimeter floats, which allow the craft to land on water as well as land. The 196-kg LIFT cites a target speed of circa 130 kph. Mission endurance is currently only 15 minutes. The HEXA was the first of the competing prototypes to be featured at a flight demonstration for USAF leaders in August 2020.

Moog

The SUREFLY quadcopter seats two. Each of the four propeller arms has an electric engine powering two contra-rotating propellers. The SUREFLY is the only hybrid system among the featured prototypes; the electric engines are powered by a gas turbine, switching to a battery pack for the final flight phase. Endurance and range are given as 90 minutes and 110 km, respectively. The initial design has a payload capacity of 180 kg. An advanced concept aims to increase this to 300 kg.

Phenix Solutions

The twin-bladed MONO 550 can fly for 90 minutes, with a top speed of nearly 150 kph and a range of over 220 km.

Liquid Piston

For military applications, the eVTOL concept has one downside. Reliance on electric propulsion limits the flexibility to operate in austere environments. Even if portable field generators are available, recharging batteries will also take longer than refuelling conventional helicopters, potentially reducing operational tempo and increasing vulnerability. In March, AFWERX awarded Liquid Piston Inc. a Phase I Small Business Technology Transfer contract for the firm's X-Engine. This miniaturized rotary internal combustion engine could be paired with an on-board generator to charge an eVTOL's battery in flight, or connect directly to the electric drive engine.

Testing Programme

Since eVTOL systems will all be relatively short-ranged, they will need to be trans-



Photo: Joby Aviation

The Joby S4 tiltrotor eVTOL in flight



Photo: Workhorse Group

The Workhorse Group sold its SUREFLY assets to Moog in late 2019 because the programme was losing money.

ported to their operational zone. In March 2021, USAF's 355th Wing (Davis Monthan AFB, Arizona) transported a LIFT HEXA via C-130 to prove the craft is robust enough to survive tactical airlift and be operational after offloading. Preparing and loading the eVTOL took 40 minutes, but once a routine is established, the procedure should take 15 minutes, according to the loadmaster in charge of the test.

In May 2021, the 355th Wing will deploy HEXA for Operation Bushwhacker, an annual exercise held in the Arizona desert. The eVTOL prototype will be tested for its suitability

for austere, hostile environments. Missions will include combat S&R, aerial resupply, and security surveillance over airfields. USAF's 621st Contingency Response Wing at Joint Base McGuire-Dix (New Jersey) plans to start integrating additional ORBs into exercises by the end of this year. This will allow USAF to assess training and maintenance requirements as well as operational suitability. USAF expects to transition ORBs to an acquisition programme in 2023.

Next Steps

Assuming that Agility Prime proves successful, AFWERX plans to adopt the concept to researching other dual-use technologies. High-priority fields would include fuel-cell technology, artificial intelligence, and virtual reality training systems. The recently established Space Force is considered a likely beneficiary of future Prime programmes, which might develop satellite-refuelling capabilities, facilitate a space-based internet, or simplify space-debris removal. "It has to be an area that has strategic importance, both to the commercial sector and to the government sector," said Colonel Eric Felt, head of the Air Force Research Laboratory's space vehicles directorate. To be relevant, the programmes must be chosen so that the government's unique science and engineering capabilities make an actual difference to the existing civilian research project, Felt emphasised. ■

Photo: Liquid Piston Inc.



LiquidPiston has announced the adaptation of its X-Engine technology for the US Air Force to use in unmanned aerial systems (UAS) as well as "orbs" - urban air mobility (UAM) vehicles.

FCAS / SCAF and TEMPEST: Programme Status Reports

Giulia Tilenni

FCAS/SCAF and TEMPEST will continue to be among the most important European cooperative programmes for the coming decades, and probably the most important in the aerospace sector. If political differences between France and Germany continue to put the first at risk, the second is finally gaining momentum due to significant investment.

Over the last decade, most European countries have been faced with the dilemma of modernising their air forces. On the one hand, there is the need to replace their fleets of the EUROFIGHTER TYPHOON (UK, Germany, Italy and Spain), the Dassault RAFALE (France) and the Saab GRIPEN (Sweden) all of which reach the end of their operational service lives in a couple of decades. On the other hand, there is a willingness to acquire some form of strategic autonomy from the US and, maybe more importantly, to preserve the importance and the market share of their aerospace companies on the international market.

Remaining in the technological race is far from an easy task for European countries and their companies since 5th generation aircraft have brought a new, revolutionary approach to air combat missions. The cutting-edge F-35 flies higher and further than its predecessors, and its remarkable features, namely fully fused sensor information, effectively transform the pilot into a unitary decision-maker focusing on limited, yet essential decisions. Pilots receive comprehensive intelligence from the battlefield, rather than raw information to be aggregated and analysed, and are thus in charge of choosing the best solution among those automatically proposed by the system. The Multifunction Advanced Data Link allows for data sharing with the other platforms involved in the missions, such as modern and legacy strike aircraft, and aerial and ground-based platforms.

European companies have not gained any relevant experience in produc-

Photo: Airbus



By teaming sixth generation manned fighters with unmanned platforms, the FCAS will provide European air forces with capabilities well beyond existing fighters.

ing 5th generation fighters. British and Italian companies are part of the F-35 programme, but with only a limited role. Dassault though, has been able to autonomously deliver on a fighter programme from the design phase to series production. But RAFALE is a 4th generation and a half fighter. Saab has gained some relevant know-how thanks to its GRIPEN, but lacks the infrastructure and required knowledge to fully develop a fighter in-house.

Nevertheless, political and industrial considerations have convinced European countries to join the race for 6th generation fighters. London, Rome and Stockholm are all betting on TEMPEST, due to be produced by a group of British companies with an Initial Operating Capability scheduled in 2035. Paris and Berlin, to be joined by Madrid in the next research phase, chose the FCAS/SCAF (Future Combat Air System/Système de Combat Aérien du Futur), due to be operational in the 2040s.

Both programmes will be based on a similar philosophy, which mirrors that of the F-35: the creation of a system-of-systems consisting of manned and unmanned platforms, weapons, sensors, and other force elements to allow for a rapid, continuous and large-scale information exchange across a network of distributed capabilities operating within the air domain and/or across the others.

TEMPEST: the Relaunch of British Defence Investments

The launch of the programme was announced during the 2018 Farnborough Air Show, where a first full-scale concept model was unveiled. However, the key milestones came in September 2019, when Italy and the UK signed a Declaration of Intent to collaborate in the Tempest Future Combat Air System (FCAS) at DSEI, and in December 2020, with the signature of the Memorandum of Under-

Author

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standing that includes Sweden. The MoU covers cooperation for R&D and the joint conceptualising of the programme, to be equally shared among the three countries which plan to launch an international Concept and Assessment Phase later this year and to enter the full development phase in 2025.

The TEMPEST, a fighter foreseen to be at the heart of the programme, will likely be a manned/optionally-manned aircraft to feature several key technologies such as a Multi-Function Radar Frequency System (to be developed by Leonardo UK) and the “wearable cockpit” (BAE Systems and MBDA UK). Rolls-Royce is working on advanced combustion system technology to provide unprecedented levels of electrical power and the thermal load that the new fighter will require. Last year, Michael Christie, BAE Systems Director of FCAS and the senior representative on “Team Tempest”, said that this team, consisting of the RAF’s Rapid Capabilities Office (RCO), the UK MoD and the above-mentioned companies, was in no rush to fly a demonstrator or to lock down the design. Rather, the team preferred to focus on developing the relevant technology and capabilities through model-based

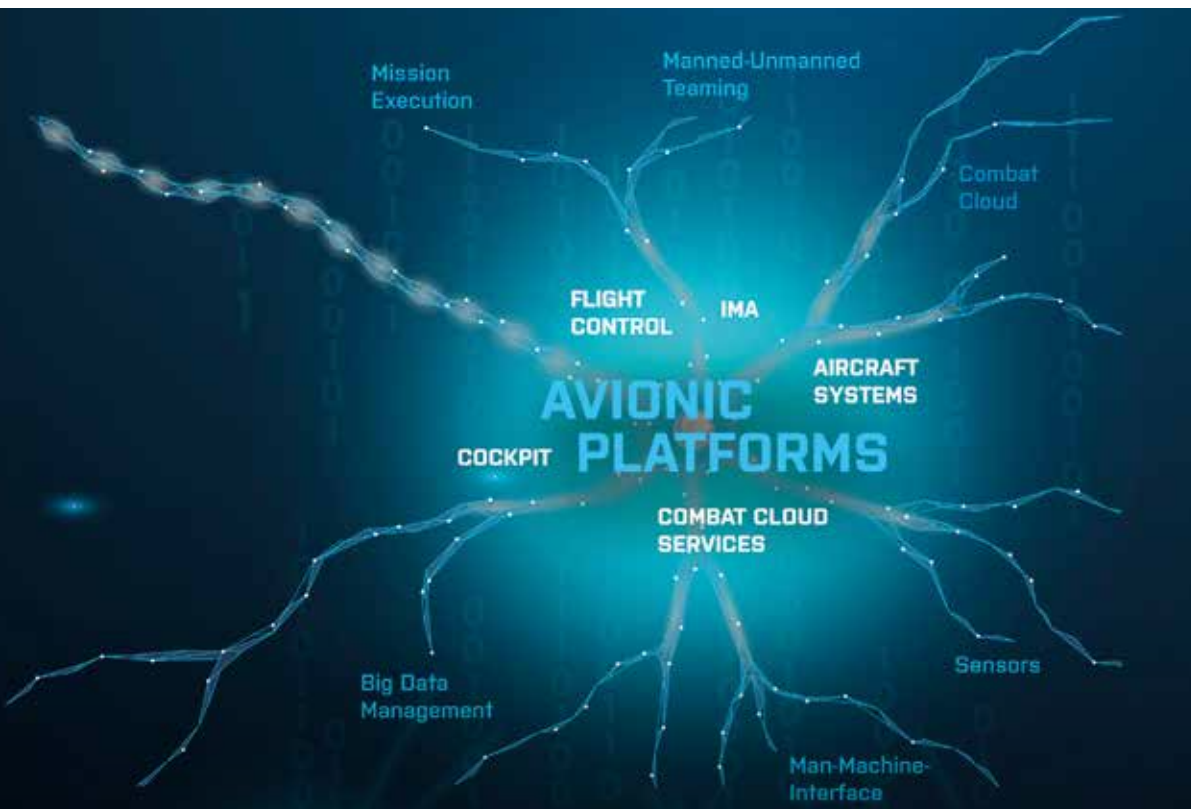


Image: Airbus

At the heart of FCAS, manned New Generation Fighters teaming with unmanned Remote Carriers as force multipliers will form the Next Generation Weapon System or NGWS.

system engineering and design. The final demonstrator might therefore differ from the 2018 mock-up, as shown again in March during Prime Minister Johnson’s visit to BAE System’s brand-new facility in Warton, a first-of-its-kind factory of the future that will participate in the production of the TEMPEST FCAS. The wider system will likely include swarming UAVs based on the Lightweight Affordable Novel Combat Aircraft (LANCA), to be compatible with both the

TEMPEST and the F-35, and aimed at providing increased capability, protection, survivability, and information to combat aircraft. In addition to the industrial commitment, London has recently reaffirmed the political and military importance of this programme with the allocation of more than £2Bn over the next four years for the next phase. Conversely, the level of concrete engagement of the other partners is uncertain.



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Image: MBDA



Artist's impression of an FCAS in Luftwaffe colours

Relevant Italian stakeholders recognise the programme as a determining factor for military and industrial capabilities. The presence of Italian Air Force low-visibility roundels beside the RAF ones on the mock-up shown during PM Johnson's visit to Warton show that collaboration is ongoing. However, the Italian Defence Policy Document for 2020-2022 (Documento Programmatico della Difesa 2020-2022) does not al-

locate any funds to the TEMPEST, but only for the "TYPHOON to TEMPEST" transition aimed at using the technology developed within the TEMPEST framework to upgrade the TYPHOON. Similarly, the lack of the Swedish roundel somehow contradicts Mr. Christie's official declarations about the conclusion of an "extremely successful" collaborative working definition project with Sweden and Saab.

FCAS/SCAF: a Testbed for Franco-German Defence Cooperation

In February 2020, representatives of France, Germany and Spain signed the contract for the combat demonstrator of the Next Generation Fighter (NGF), part of the more comprehensive FCAS/SCAF programme. Paris and Berlin agreed on the equal funding of an 18 month-long, €155M -worth contract study, named Phase1A. Spain decided to join in Phase1B, a later stage dedicated to the development of a demonstrator. The three were required to reach an agreement before the end of April to rapidly launch Phase1B and try to comply with the initial schedule, which originally planned the trials of the NGF's first demonstrator in 2026. It is important to secure the Bundestag's green light for this total of €4Bn-worth of investments before the elections, also taking into consideration that presidential elections will take place in France in 2022.

After several months of intense negotiations, France, Germany and Spain finally found an agreement on Phase1B on 17 May.

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Intellectual property rights were the most sensitive issue to solve. France claimed an initial convergence on the “best athlete” principle, according to which Dassault Aviation would have obtained the lead in the NGF programme in light of its relevant experience on fighter aircraft. With Spain entering the programme, however, Airbus’ participation exceeds 50 per cent, thus convincing Berlin to ask for full access to all co-funded research. As Dassault refused to share the know-how acquired in the last decades with the development of RAFALE or the nEU-ROn demonstrator, participating countries finally decided to list all intellectual property rights that must be shared as necessary for the completion of ongoing cooperative projects. However, the full list is still undisclosed at time of writing. On 29 April, Safran (France) and MTU (Germany) announced the creation of a 50/50 joint venture named European Military Engine Team (EUMET GmbH) and the partnership with Spain’s ITP Aero, a Rolls-Royce Group-owned corporate entity. Safran will be placed in charge for the design and integration on the NGF’s engine, with ITP leading the development of some components, including the low-



Photo: Giulia Tileni

The FCAS/SCAF mock-up at the 2019 Paris Air Show in Le Bourget

pressure turbine and nozzle. MTU will lead the engine service activities. EUMET will also oversee the integration of the Safran M88 engine, which already powers the RAFALE, into the first flying demonstrator.

The demonstrator will finally be completed in 2027, according to the recent deal among participating nations.

Final Considerations

The idea of pursuing two European programmes for developing a 6th genera-

tion aircraft appears unsustainable and inefficient at first sight. Last summer, Dirk Howe, then CEO of Airbus Defence and Space, said that “maintaining two programmes in Europe could be a “bad solution” for the UK and the EU, repeating the 1990s’ error of Europe having three combat aircraft developments in parallel: EUROFIGHTER, GRIPEN and RAFALE”. More recently, Joël Barre, French Director General of Armaments, stated that a future rapprochement of the two programmes would be “good thing” and indeed, numerous considerations could

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SATNUS Technologies for FCAS

(jh) SENER Aeroespacial, GMV and TECNOBIT-GRUPO OE-SIA set up a joint venture named SATNUS Technologies SL to lead the technology development for the remote carrier elements of Europe’s Future Combat Air System (FCAS). The joint venture has been incorporated with identical capital shares of the three companies in accordance with the workload distribution for the individual phases of the programme. Supervised by the Spanish MoD, SATNUS Technologies, S.L intends to coordinate all activities related to the remote carrier technology pillar. The participation of the consortium is to support Spanish participation in this technology sector, assigning Spain a crucial role in the Next Generation Weapon System (NGWS). Within the remote carrier segment, the three companies will be coordinating with the Spanish industrial team as defined by the Directorate General of Armaments and Material (Dirección General de Armamento y Material - DGAM). The consortium expects that both military and civilian applications will be able to take advantage of the research initiatives and results.



support this intention. In military terms, the two programmes are responding to similar requirements: the development of a next generation fighter, part of a system-of-systems that includes legacy and new assets, such as remote carriers, and establishes a new decision-making cycle thanks to remarkable technical features. On the industrial level, merging the TEMPEST and the FCAS/SCAF into one programme would prevent competition among European companies, thus reinforcing their position on the international market and potentially opening new export opportunities. Politically speaking though, the creation of a unique programme would respect the plans by Paris and London to gain strategic independence from Washington. The fact that the UK might finally cap the acquisition programme for F-35B to 48 aircraft, far short of the 138 originally planned, would rep-

resent an important step towards further autonomy from the US. The development of a unique European programme would finally justify and strengthen Franco-British technological cooperation, expected to continue beyond Brexit, with a positive impact being brought to their political relationship. However, an in-depth analysis provides an alternative point of view. The cooling of relationships between the US and EU Member States under the Trump administration convinced a number of European countries of the need to push defence cooperation forward. This was the case for Germany as well, as the idea to launch joint defence cooperative programmes with France demonstrated. Cooperation on the FCAS/SCAF programme, and the ensuing modernisation of the German Armed Forces, reinforces the country’s international weight and the competi-

tiveness of its national aerospace companies thanks to knowledge-sharing with French partners. On its side, France knows full well that Dassault is the only European company capable of fully developing a fighter aircraft, but also that it would be impossible to afford the costs of a new fighter programme alone. This consideration, together with the concept of “grandeur” upon which French foreign policy is based, forces the country to present the FCAS/SCAF as a potential European programme, to be eventually merged with TEMPEST. But, obviously, under French leadership. This is a perspective that is a long way from receiving the support of European partners, which do not necessarily consider France a trustworthy ally when it comes to defence and foreign policy. Belgium, Norway, Poland, the Netherlands and Denmark all decided to procure the F-35 rather than RAFALE, despite the fact that they will be unable to exploit all of its specific features. A political choice that reaffirmed their ties with Washington. Moreover, a UK that has just regained its full independence from Europe thanks to Brexit would accept - with difficulty - a collaborative European effort under a French lead. As per these political considerations, it is unlikely that the two programmes could eventually be merged into one that is unique. In addition, as Richard Berthon, the UK Defence Ministry’s Combat Air Acquisition programme director, said last year, having two programmes in Europe would maintain “a degree of competitive pressure on our industries” without creating a monopoly on the supply of fighter aircraft. Indeed, the recent US industrial experience confirms that the creation of a monopoly is not totally successful, with Northrop Grumman re-entering the race in aircraft production to somehow mitigate Lockheed Martin’s position on the market. To sum up, the development of two competing programmes in Europe will be beneficial for aerospace companies and serve the interests of the different member states. However, the completion of the two programmes cannot be taken for granted due to major variables: the fact that industrial consortia have proven ineffective so far (as the A400M and the TORNADO both demonstrate), and the need for long-lasting political willingness from all partners. The continued skirmishes between France and Germany on the one hand, and a lack of adequate Italian and Swedish funding and industrial cooperation on the other, are potential obstacles. ■

Photo: Giulia Tieni



A mock-up of the Airbus remote carrier at the 2019 Paris Air Show in Le Bourget

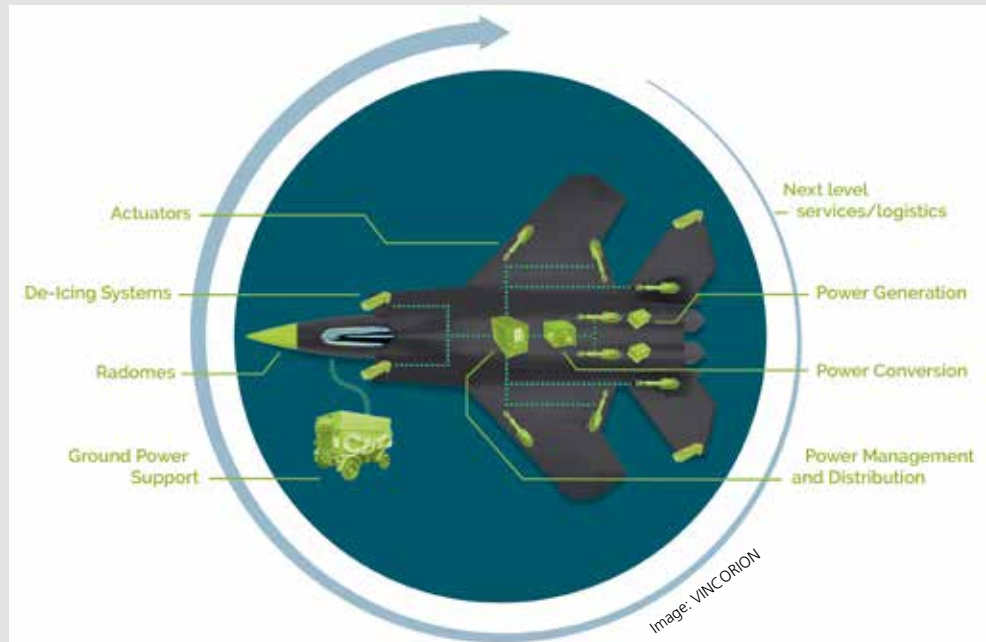
Powering Up the Future Combat Air System

The Future Combat Air System (FCAS) is the largest European defence project and is currently in the final stage of decision-making with respect to the project's objectives, organisational structure and workshares between the participating partners. These decisions have an immediate impact on small and medium-sized companies all over Europe. As one of them, mechatronics manufacturer VINCORION is preparing for the challenges that represent nothing less than a quantum leap for Europe's defence capabilities.

To strengthen European unity in the fields of technology, military deterrence, and economics and politics, Germany, France, and Spain need to make a joint commitment to FCAS. As a 6th generation fighter, FCAS is forcing the European defence industry to skip the development of a 5th fighter generation. Besides, the aim is to secure key technologies in Europe such as communication, crypto & network-enabled operations, artificial intelligence, sensors, stealth, and electronic warfare. This expertise needs to be developed quickly and simultaneously, which poses enormous challenges for the European defence industries. The expectations for FCAS are correspondingly high.

"We are aware of these challenges and are ready to make our contribution to FCAS," says Stefan Stenzel, Managing Director of VINCORION. The company was founded in 2018 as a brand of Jenoptik Advanced Systems and represents the mechatronics division of the German Jenoptik Group. With production facilities in Wedel, Essen, and Altenstadt, the company looks back on more than six decades of worldwide business experience and expertise in engineering, manufacturing and support for electromechanical applications as well as electronics within the aerospace industry, security and defence and transport sector, including rail, vehicles and airports.

During this time, the German mechatronics manufacturer has built a reputation as a long-standing partner to the European defence industry and has had a hand in all the major aircraft launched in recent decades. As such, VINCORION implemented tailored solutions in aircraft ranging from the F-104 as an early generation fighter to the Eurofighter as a 4+ generation fighter, sup-



German mechatronics manufacturer VINCORION focuses on specific technology clusters to contribute to 6th generation fighters like FCAS.

porting these platforms across their entire life cycle to maximise operational readiness.

A High-Voltage DC System for FCAS

"We believe that establishing a high-voltage DC electrical system architecture and integrating high-power equipment will become a key challenge for FCAS in the context of electrical power generation, conversion, distribution, and management," said Stenzel. VINCORION benefits from having already developed safe high-voltage DC electrical power systems with both primary-stabilised DC buses and conventional buses. These systems have already been integrated with several of the latest military vehicles.

"Based on our experience and existing products, our capabilities can help facilitate a low-risk approach in areas such as electrical power generation, power conversion, power distribution, and power management, electrical ground power support, actuators, electrical deicing systems, radomes, and next level services."

VINCORION's products range from electrical power systems, generators, rotary and stationary converters and inverters based

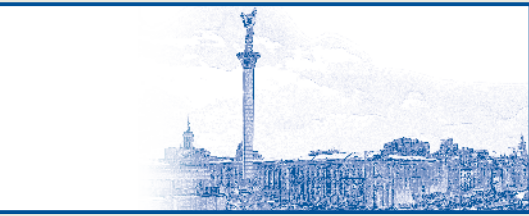
on power electronics, composites, sensor platforms, heated components, rescue hoists, radomes, and electromechanical propulsion and stabilisation systems to services such as maintenance, obsolescence management, and logistics.

Critical Success Factors Remain at the Political Level

Key factors that will determine whether the implementation of FCAS is successful, however, are not in the hands of companies, but rather at the political level. "We are delighted with the positive results of the project over the past few months and are pleased to have been involved in FCAS from early on," says Stenzel. "Reliable, long-term political commitments are essential to ensure FCAS' success, however."

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Viewpoint from Kiev



Photo: author

The Clock is Running to Arm Ukraine

Reuben F. Johnson

The 6 May to Ukraine visit by US Secretary of State Antony Blinken and his meeting with Ukrainian President Volodymyr Zelenskiy was an important demonstration of US backing for the independent nation's more than seven-year military conflict with Russia. Early April saw a ratcheting up of tensions with Moscow, with US intelligence sources looking at Russian troop mobilisations and deployments on the border and projecting Russian President Vladimir Putin ordering an invasion within 72 hours.

The conflict was averted for now after an 11th-hour phone call between Putin and US President Joe Biden. The proposal that the two would meet for a bilateral summit sometime in June is proving complicated, however. A site for that tête-à-tête has yet to be named and more than one former White House National Security Council (NSC) official has commented that the venue can be as important as the substance of the discussions themselves. For various reasons, "neutral" sites like Switzerland or Austria seem to be leading candidates. While these are all hopeful signs for the government in Kiev, the situation remains far from stable. One local business news service editor wrote that "the lure of a one-on-one summit is expected to keep Putin on his best behaviour," but only temporarily. Local residents began their summer holidays in May, as if to hedge against the possibility that a summertime invasion would make two weeks at the beach impossible.

Some 80,000 to 100,000 Russian troops remain on Ukraine's eastern border and in the south in Crimea. Those troops were ordered to be withdrawn to their regular bases by 1 May, but they also left most of their heavy equipment behind – leaving open the option of a snap re-deployment.

That anxiety is further exacerbated by the 19 May announcement that US President Joe Biden had conceded to pressure from Germany and has decided against sanctioning the German company in charge of the joint Russian-European Nord Stream 2 gas pipeline project. "This is the big nightmare for us – opening the door for Berlin to shut off the gas valve to Ukraine but still maintain deliveries to the rest of Europe," said a local defence specialist here in Kiev who spoke to ESD. "It is a perfect example of Germany being far more interested in its relationship with Russia than it is with the rest of Europe."

"We are aware that Russia has withdrawn some forces from the border of Ukraine, but we also see that significant forces remain there, significant equipment remains there. We are monitoring the

situation very, very closely," Blinken was reported to have said to President Zelenskiy. "And I can tell you, Mr. President, that we stand strongly with you. Our partners do as well. I heard the same thing when I was at NATO a couple of weeks ago. And we look to Russia to cease reckless and aggressive actions."

Ukraine, for its own part, has also taken actions following Blinken's visit – long overdue in the eyes of many – to set red lines against Moscow's continuing efforts to interfere in Ukraine's internal affairs.

On 11 May, Ukraine's Prosecutor General Iryna Venedyktova announced indictments against two pro-Russian members of parliament, Taras Kozak and Viktor Medvedchuk, on charges of attempted theft of natural resources in annexed Crimea, in addition to charges of treason. Subsequently, the Ukrainian Security Service (SBU) raided the Medvedchuk residence.

This announcement caps activity that began February when sanctions were imposed against the two lawmakers and Medvedchuk's wife, Oksana Marchenko. In addition, Zelenskiy banned three pro-Russian television stations owned by Kozak and suspected of being controlled by Medvedchuk.

The big question now is what will be Russia's next move? On 12 September, Russia will begin its annual "Zapad" military exercise with Belarus. This raises twin spectres of either an invasion conducted under the camouflage of the exercise, or Russia permanently deploying troops in Belarus – leaving Ukraine surrounded on three sides.

On 11 May, MP and member of Zelenskiy's own party, Servant of the People, Yelyzaveta Yasko wrote on the Atlantic Council's site: "Neither Ukraine nor the country's international partners can afford to sit and wait for the Kremlin's next moves. Instead, the Western world must now acknowledge the urgent need to strengthen Ukraine militarily... Boosting Ukraine's ability to defend itself is the best way to deter Russia and should be a strategic priority for the entire Western world."

This action would require, as others have proposed already, supplying Ukraine straightaway with US Excess Defense Articles (EDA) items like used F-15C/D aircraft and other platforms – to be followed by the delivery of new-build weaponry from US production lines. In the meantime, the clock is running on the West showing Putin the costs of invading this former Soviet vassal state would be too high for Russia to bear.



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Vertical rotary lift aircraft fulfil crucial functions including logistic support, personnel transport (including aerial assault), search and rescue (S&R), medical/casualty evacuation (medevac/casevac), installation/area surveillance and security missions. North American and European armed forces are pursuing innovative new concepts to satisfy future rotary lift needs.

Simultaneously, they are upgrading helicopter and tiltrotor fleets with improved variants of existing models to sustain and enhance capabilities until new systems become available. These measures are driven by two factors. On the one hand, enhanced offensive capabilities of potential adversaries require upgrading the fleets to ensure continued operational viability and survivability. On the other, recent advances in technology now enable development and fielding of significantly more capable aircraft, an opportunity nations ignore at their own peril.

US Military Future Vertical Lift Programme

The United States armed forces are currently pursuing the Future Vertical Lift (FVL) programme to develop a “family” of rotorcraft to include attack, scout and utility variants. One of these variants, the Future Long-Range Assault Aircraft (FLRAA) is intended to carry infantry squads into battle; additional tasks will include S&R, casevac and logistic support. It will primarily replace the UH-60 BLACKHAWK family, of which the US Army alone operates some 2,000. While FLV will supply aircraft for the Army, Marine Corps and Special Operations Command (with procurement open to the Navy and Air Force as well), the programme management lies with the US Army. The FVL programme emphasizes dramatic increases in speed, range and endurance at range when compared to legacy platforms. This is largely driven by the global commitments of the US armed forces, which must operate in a broad range of environments. The Army is seeking an objective top cruise speed of at least 280 knots, and an objective operational radius of at least 300 nautical miles; the US Marine Corps has specified even higher

Photo: Bell-Textron



The Bell-Textron V-280 tiltrotor carries a crew of four plus 12 passengers.

Photo: Bell-Textron



Concept of the Bell-Textron V-280 VALOR tiltrotor in the casevac role. The V-280 cruises at 280 knots and has a 500 nm operational range.

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Image: Bell-TeXtron



While the US Navy has no current plans to procure the FLRAA, Bell has proposed a carrier-capable variant.

Photo: Boeing



The Boeing-Sikorsky DEFIANT X compound helicopter features two co-axial rotors and a pusher propeller.

Photo: Boeing



This concept image shows the DEFIANT X with sling-loaded 155mm howitzers.

performance objectives. Meeting only the Army guidelines would nearly double the real-world performance capabilities of the UH-60. This emphasis on speed and range reflects the anticipation of a potentially major conflict in East Asia, which would require unprecedented mobility for the US rotorcraft fleet. Speed and agility will also enhance survivability against increasingly sophisticated air defence networks.

But while speed, endurance and survivability are important, raw power is not the only or even the decisive consideration, cautioned FLRAA programme manager Colonel David Phillips. The rotorcraft must be fully networked and interoperable with other aircraft and ground forces operating in a multi-domain battlefield. Modularity and open-systems architecture will be essential for maximising flexibility, keeping on-board systems up-to-date, and reducing operating cost. Given the large number of aircraft the Pentagon plans to procure, life-cycle affordability is also a major consideration. However, details regarding manufacturing cost estimates will not be made public for the time being, the Army announced in May.

FLRAA Development, Testing, Procurement

In March 2021, the two industry competitors – Bell and the Boeing-Sikorsky team – were awarded contracts for the FLRAA competitive demonstration and risk reduction (CDRR) phase 2. CDRR phase 1 began in March 2020 and provided risk reduction by completing requirements derivation, trade-off analysis and preliminary conceptual design, Colonel Phillips said in early April 2021. During phase 2, the Army is also working with the contractors to integrate major subsystems and weapons systems on the candidate airframes. Simultaneously, the Army has also initiated contract solicitations to other firms for open architecture avionics and mission-management systems applicable to the entire FLV programme. “Crucial to the success of FLRAA’s objectives is the deliberate integration of a Modular Open Systems Approach (MOSA) into its requirements, acquisition and sustainment strategy,” an Army statement said. “MOSA is a critical enabler for improving lifecycle affordability, directly aligning with Army Aviation objectives to achieve sustained affordability and deliver continuous capability upgrades against future threats.”

The Army provided both industry contenders with a draft Request for Proposals in December. The final RfP will be

delivered this summer, an Army spokesman stated in late April. It will incorporate feedback received from the contenders as well as military stakeholders.

Brigadier General Wally Rugen, director of the FVL programme, explained the military's approach going into the RfP. While the FLRAA is intended to be a multirole aircraft, "we really are focussed on our air assault mission configuration" and achieving "transformational reach," Rugen said in October. Priorities will be placed on troop capacity and other requirements needed to conduct that mission. Beyond that, the RfP will provide considerable leeway to industry rather than including "a ton of mandatory attributes," he said. What remains essential is seamless interoperability with other elements of the FLV family and other partner forces, so that the FLRAA can exploit breaches made in enemy defences.

A development contract award is expected in 2022, which will immediately initiate the engineering and manufacturing development phase of the programme. Flight testing of a production-level prototype scheduled to begin in 2026. The current objective is to enter the production and deployment phase in 2028, and field the FLRAA to the first operational unit in 2030.

NATO (Europe) Next Generation Rotorcraft Capability

European NATO partners are also seeking enhanced vertical airlift solutions. A NATO working group on future rotorcraft requirements was established in 2013, leading to formation of a Next Generation Rotorcraft Capabilities Team of Experts in 2018. In October 2020, five nations signed the (non-binding) Letter of Intent to actively pursue the Next Generation Rotorcraft Capability (NGRC). The initiative is designated as one of NATO's High Visibility Projects, reflecting its significant contribution to joint operational effectiveness. The five initiators of this programme are France, Germany, Greece, Italy and the United Kingdom. Other nations are eligible to join the project over time, subject to approval by the current signatories.

The initiative's goal is to develop and build the next generation of medium lift multi-role helicopters to replace current inventories, most of which include models designed between the 1960s and the 1980s. Recent NATO estimates cite a need for European members to replace circa 930 medium lift helicopters in the 2030-2045 timeframe.



Photo: Boeing

The DEFiant X's rigid, counter-rotating rotor blades are designed to minimise the risk of stalling.

By jointly pursuing research and development, the industries of the participating nations will be able to leverage one-another's capabilities and speed achievement of the common goal. According to a 13 April NATO press statement, "through NGRC Allies will benefit of advances not only in airframe or propulsion technology, but also the digital infrastructure of the capability in order to make sure the capability will be ready to serve Allied forces for the next decades." Adjustments to operational concepts will also be considered during the design phase. Given its recent inception, NGRC's timeline is behind the Pentagon's FLV programme. The

partner nations are currently working toward defining a common set of requirements for the new aircraft. The multinational requirements working group is headed by the British MoD. Once a statement of requirements can be agreed upon, the partners can proceed to signing a binding Memorandum of Understanding (MoU) which will include cost projections, funding and work share between the nations, and a formal timeline; this is not expected before 2022. Once the MoU is signed, the programme will progress through a series of concept-development, design and testing phases. The current goal is to equip forces with the next generation rotorcraft beginning in the 2035-2040+ timeframe.



Photo: Leonardo

The NGRC remains open to all possible rotorcraft configurations. With the AW609, Leonardo has demonstrated the capacity to develop a European high-performance tiltrotor aircraft.



Photos: Leonardo

Leonardo defines its new AW169M Light Medium/Intermediate class helicopter as the next generation multirole helicopter.

NGRC Requirements

While formal requirements must still be hammered out by the multinational team of experts, the NATO working group's original 2018 final report stressed the need for a common next-generation rotorcraft to be modular, so that individual nations could tailor their aircraft to meet their unique requirements. Modularity was also predicted to ease maintenance and result in reduced life-cycle costs. One consideration is building the aircraft on one airframe but in three configurations – basic, improved, and robust – allowing nations to assemble fleets in accordance with their operational requirements and budgets. Open architecture for all on-board systems should facilitate scalability and the ability to configure aircraft according to mission requirements.

Some insights were revealed at the January 2021 Next-Generation Military Rotorcraft Conference hosted by the Royal Aeronautical Society (RAeS), which discussed developments on both sides of the Atlantic. Royal Navy Lt. Commander Andrew White, secretary for the NGRC programme, explained that affordability and commonality rather than performance will be the focus of the requirements debate. "We don't necessarily see that it has to be superfast," said White. "We've kept the requirements relatively broad so that it could be a conventional [helicopter] or it could be a tilt or compound and we'll let industry come back to us with what is the best way for that aircraft to be designed so it will meet our requirements."

One thing is already clear: Europe's military helicopter market is dominated by two firms, the Franco-German-Spanish Airbus and the Italian-British Leon-

ardo. Any multinational development programme will require both firms to form the technology core, supported by major European avionics and engine suppliers such as Safran. This was addressed in January by Jerome Combe, Airbus Helicopter director of policy and strategy. Speaking at the Royal Aeronautical Society Next-Generation Rotorcraft Conference, Combe pointed to Airbus and Leonardo jointly sharing 80 percent of the world's civilian helicopter market. "[With the NGRC] we think that there is a real opportunity for Europe to align and to think about what really should be a European next-generation rotorcraft, adapted to European needs, using European know-how, and [that delivers] sovereignty for European industry."

Additional Projects

Other, more limited helicopter procurement programmes are already well advanced, both in North America and Europe. Several of these programmes display a healthy transatlantic aspect, with US forces buying European aircraft and vice-versa.

MH-139 GREY WOLF

The United States Air Force (USAF) is procuring up to 84 MH-139A helicopters to replace the UH-1 Huey. While built by Boeing, the MH-139A is based on the Leonardo HH139. A major factor in deciding the contract award was the considerably lower life-cycle cost of the MH-139 when compared to competing aircraft (estimated to be US\$1Bn less over

Photo: Airbus



The Airbus H175 "Super Medium" class multi-role helicopter has many attributes desirable in a next-generation helicopter, including modular re-configuration capability, a large internal and external carrying capacity and nearly six hours flight endurance.



Photo: Airbus

Hélicoptère Interarmées Léger – HIL

The French armed forces' HIL programme is geared to procuring a single joint light helicopter to replace five different types currently operated by the army, navy and air force. Airbus received the award in 2017. The selected aircraft, the new H160M, is a modular multi-role helicopter which can be configured for light attack missions, reconnaissance and surveillance, command and control, infantry or special operations transport/support, and S&R. Despite the designation as "Léger," the aircraft's size and performance characteristics are closer to a medium helicopter. All services together will procure 169 aircraft. First flight is scheduled for 2023. Delivery of the first production units is now expected in 2026, or one year earlier than originally planned. Performance is considerably upgraded from the older models the HIL is replacing. This includes a digital cockpit, greater fuel efficiency from the two Safran Arrano engines, a considerable reduction in noise level through introduction of curved Blue Edge rotor blades and a shrouded Fenestron tail rotor, and reduced maintenance requirements. High availability and reduced maintenance costs were considered a major factor from the beginning of the design phase.

Airbus began assembly of its RACER (Rapid and Cost-Effective Rotorcraft) high speed concept demonstrator in April. It features a central main rotor and two lateral "pusher" rotors. The design is optimised for cruise speed over 216 knots, and promises a 15 percent reduction in fuel consumption.



Photo: U.S. Air Force

The MH-139A GREY WOLF before its unveiling and naming ceremony in December 2019. The aircraft is set to replace the US Air Force's fleet of UH-1N HUEY aircraft and has capability improvements related to speed, range, endurance and payload.

30 years). The first operational unit was delivered to USAF in March 2020. The helicopter will be used to transport security personnel at strategic missile bases, and for S&R missions.

PUMA Replacement

The 23 medium-lift PUMA helicopters of the British Royal Air Force will likely be retired in 2025, well before either the FL-RAA or the NGRC will be available. One solution would be procuring an existing aircraft for the interim until the next generation systems are available. While the RAF has not yet initiated a replacement programme, firms are already vying for the contract. These include Airbus, which has proposed a solution based on the H175, while Leonardo has suggested the AW149.



Photo: Airbus

Derived from Airbus Helicopters' civil H160 rotorcraft, the H160M (cockpit seen here at the 2019 Paris Air Show) incorporates cutting-edge technologies to deliver excellent performance and mission capabilities.

Photo: Airbus



The HIL programme, for which Airbus Helicopters' H160 was selected in 2017, will replace six helicopter classes currently operated by the French armed forces.

Photo: Crown Copyright/RAF



The British RAF is replacing its older CH-47 CHINOOK heavy-lift helicopters – with CH-47 ER (Extended Range) CHINOOK helicopters.

Photo: USMC



The CH-53K heavy lift helicopter features so many system upgrades and performance improvements over the predecessor CH-53E that it is frequently considered a de facto new aircraft. The lift capacity is nearly triple that of the baseline CH-53E.

fleet (acquired in the 1980s) with a newly built CH-47ER (Extended Range) variant which displays considerable performance enhancements (CHINOOK Capability Sustainment Programme). Deliveries are expected to be complete before 2030.

The German armed forces have identified an urgent requirement to replace their 70 outdated CH-53G heavy lift helicopters, with an objective delivery timeframe of 2023-2030. It was determined that only Boeing's CH-47 CHINOOK or the new Sikorsky CH-53K variant could meet requirements and be delivered in time. In September 2020, the MoD abruptly cancelled the procurement programme for a replacement, citing budgetary restrictions. Replacement currently remains on hold.

Buy American?

One vital question raised at the January 2021 RAeS conference was: will European NATO partners continue with developing their own NGRC aircraft once FLRAA enters service, or will they buy into the US programme? The latter would have the benefit of potentially fielding the new rotorcraft sooner (although American production capacity will probably be stretched just to meet initial US demand), and would maximise interoperability between American and European allies.

However, much speaks against European procurement of FLV systems. This begins with the political and economic reality that a fully European NGRC will create jobs, invigorate technological innovation, and enhance European industry's global competitiveness. Additionally, FLRAA and other FLV systems might well have higher price tags than European aircraft, especially since the US systems are designed to performance specifications which some European nations might not require.

What remains essential is full interoperability between FLV and future European rotorcraft – a goal evidently shared on both sides of the Atlantic. As Lt. Cmdr. White emphasized, NGRC is intended to be complementary to the American FVL. "With FVL, we're working closely with the US (...) so that we can tie this to FVL as we move forward, and the US are very much involved in NGRC," White said. Realising this partnership will be less a question of precisely matching speed and range, and more a question of seamless networking. Since the market for avionics, sensors and communications systems is already transatlantic, there should be no excuse for not ensuring full interoperability at the earliest possible stage of development. ■

Air-Launched Weapons – Smaller, Smarter, Further

Tamir Eshel

Over the century of aviation, military airpower has changed dramatically. In the First World War, pilots and gunners used pistols, guns and dropped small bombs by hand from aircraft made of wood and cloth. In the thirty years that followed, bombers and weapons have become more sophisticated and powerful.

The sleek and shiny Enola Gay B-29 bomber that took off from the Mariana Islands in the Pacific Ocean to drop the first atomic bomb on Hiroshima, Japan, was the climax of this trend. Following World War 2, as fighter and bomber aircraft became ever more versatile and complex, so too were the weapons they carried. Bombs could navigate and optimise the attack profile by determining strike angle; smart fuses enabled proximity or delayed action, improving terminal effect with a conventional warhead, thus achieving maximum lethality without reverting to a nuclear option. With added propulsion, weapons also became more independent and have enabled airstrikes from a stand-off range, thereby reducing the risk associated with enemy air defences.

These changes have taken place over at least two decades, as militaries and defence companies struggle with the high cost of weapon development and acquisition. During the Cold War, armaments were developed as complete weapon systems, regardless of the cost of acquisition and fielding. The fall of the Berlin Wall brought the arms race to a stop, but the long war that began in 1991 has created a demand for affordable and effective aerial weapons that air forces can afford both from the economy of battle, crew safety, and collateral damage risk. The packaging of strike and reconnaissance capabilities with affordable, precision attack weapons, mostly small-sized bombs, rockets, and missiles, has addressed these needs. These techniques were perfected in recent years, with the extensive employment of drones for surveillance and attack.

However, as Iranian-backed non-state organisations entered the fray, large drones have proven relatively vulnerable to air defence weapons. They were forced to climb higher to operate above the ceiling of enemy fire. Although they were safer at these



Photo: SAAB

The Ground-Launched Small Diameter Bomb (GLSDB) is a long-range, all-aspect, precision-attack, ground-launched weapon developed by Saab.

heights, drones are less capable of delivering the detailed imaging they obtained at the lower level.

The advantages offered by the integration of drones and aircraft brought small and precise weapon systems designed for manned-unmanned teaming. These capabilities leverage the benefits of the unmanned platform that remove the risk of flying close to the enemy. Short decision cycles enable engagement in time-critical targets, with manned aircraft processing the information and employing weapons from the drone or other platforms launched from a stand-off range.

Doing More With Less

Since the collapse of the Soviet Union, the absence of near-peer forces has enabled Western armies to dominate the war zones they operated in, primarily due to their total air superiority. They could concentrate massive airpower, but since the irregular forces turned to urban guerrilla warfare and merged with the civilian population,

targets have become elusive and rarely present themselves to enable aerial attack.

To fight against such forces, airpower relied on persistent surveillance and developed short targeting cycles to address time-critical targets. Drones often performed reconnaissance missions since helicopters and surveillance aircraft proved too vulnerable flying at low-level while carrying out direct attacks. Other attack missions were carried out from high altitude by strike aircraft with a versatile weapons carrying capability.

In recent regional and local conflicts in the Middle East (Syria, Iraq, and Yemen), Libya, Ukraine, and the Caucasus, all sides have turned to weaponised unmanned aerial systems to achieve decisive actions.

The increased threat from enemy air defences, particularly against vertical-lift aircraft and gunships, required changes in the weapon mix carried by low and slow flying platforms. This included increased precision and lethality, as enabled by turning the standard BAE Systems' 2.75-inch rockets into the Advanced Precision Kill Weapon System (APKWS-II). This low-cost solution

Photo: AFRL



The XQ-58A VALKYRIE is designed for high speed and agile manoeuvrability. Depicted is a VALKYRIE deploying an ALTIUS 600.

enables existing assets (helicopters, rocket launchers, and on-board fire control systems) to become more effective by engaging targets precisely at the maximum range (about 6 km) with minimal exposure. Since APKWS-II relies on the 2.75-inch standard, it is already cleared for operations on quite a few aircraft and helicopters, including UH-1Y, AH-1W, AH-1Z, Bell 407G, AH-64, Tiger, MH-60R, AV-8B, OV10, F16, and A10C. The weapon is undergoing integration on other manned and unmanned platforms, including MQ-8C, V22, AH-6, A29, F18, CN235, and AT-6. APKWS is currently fielded or selected for use by 12 air forces, including the US, UAE, Iraq, Qatar, the Philippines, Tunisia, Czech Republic, Thailand, Greece, India, Morocco, and Mexico.

Another new capability added to helicopters is the Common Launch Tube (CLT) developed by Systima Technologies. This tubular carrier launcher can host and deploy different aerial weapons that meet its dimensions and interface. This includes missiles, glide weapons, bombs, and sensors (such as unmanned aerial vehicles). Originally developed to meet special operations needs, CLT has been integrated with military transport aircraft (C-130), assault (UH-60), and scout (OA-6 and MD969) helicopters, enabling them to deploy a variety of new weapons and air-launched sensors without the need for lengthy integration processes.

The CLT can launch a rocket-powered weapon forward by aerial, ground, or naval platforms. It can also be used for 'cold launch' by ejecting the weapon backwards on aerial platforms. The rocket ignition or wing deployment is delayed to separate safely from the launching platform in this method. Typical weapons already deployed from CLT are Raytheon's AGM-176 GRIFFIN missile and Dynetics' GBU-69 Small Glide Munition (SGM) Stand-Off Precision Guided Munition (SOPGM). The latter offers an

all-azimuth launch capability. At the same time, its deployable wing provides a significant stand-off range resulting in a large weapon footprint and a corresponding increase in armed overwatch area. Sensors deployed from CLT include the ALTIUS 600 mini-drone and COYOTE loitering weapon. CLTs offer a versatile weapon carrying capability on several aircraft. CLT stacks are carried on the AC-130 gunship, enabling aft-ejection of weapons from the open load ramp. The MD696 light attack helicopter also uses a seven-tube stack configured for the aft-ejecting of weapons sideways, while the UH-60 or Unmanned Aircraft Systems (UAS) uses forward launch. SOCOM also plans to equip its future 'Armed Overwatch' light attack aircraft with CLTs to provide special operations forces with close air support.

The Air Force Special Operations Command (AFSOC) has developed the Tactical Off-Board Sensing capability (TOBS). For this mission, the ALTIUS 600 produced by the Area-I company is used. AC-130 gunships deploy the drones from CLTs to al-

low the crew to see the battlefield from afar or when their on-board sensor views are obscured. The drone's live video feed is transmitted back to the gunship, where operators can manipulate picture framing, zoom levels, and positioning. The miniature drone remains overhead, maintaining a continuous scan for any surprises or threats until the weather situation improves and is no longer needed. AFSOC considers this capability affordable at a cost of US\$100-150,000 per drone.

Like many other systems in SOCOM's arsenal, the ALTIUS-600 gradually transforms into a versatile platform assuming additional missions. The mini drone weighs between 10-12 kg, depending on payload. It has a range of 450 km, with four hours of mission endurance. It carries different loads for reconnaissance, signals intelligence (SIGINT) missions, or a small warhead when used as a loitering weapon.

Strike Further

Other airpower enhancements include extended effects beyond the line of sight; this is enabled by guided missiles such as the SPIKE LR, ER, or NLOS. To launch their missiles, helicopters no longer have to expose themselves to the enemy. Fired from a 'defilade' position behind a hill, the missiles ascend to acquire and home in on their target using a data link to receive updates, confirmation, retargeting, or abort commands. Helicopter pilots rely on intelligence and targeting provided by other elements over the battlegroup shared network to operate these missions. Modern operational concepts also include the integration and teaming of manned and unmanned assets (MUM-T), where the helicopter aircrews use drones and joint attack teams on the ground. This concept was recently

Photo: via author



A MiG-31K carrying Russia's first operational air-launched land-attack hypersonic missile known as the Kh-47M2 KINZHAL

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implemented in the South Korean MUM-T as part of the Light Attack Helicopters (LAH) reconnaissance helicopters expected to enter service in 2023 which will operate loitering missiles as integral weapons. This MUM-T concept is part of the LAH development pursued by Korea Aerospace Industries (KAI) in cooperation with IAI.

Photo: BOEING



Minimising Collateral Damage

With improved precision, extended range, and higher survivability rates, guided air-launched weapons offer an increased probability of kill (PK). With better chances of mission success, warheads become compact, and facilitate smaller, lighter weapons. Such warheads offer target-focused lethality to reduce the risk of collateral damage and safety radius, enabling air support to strike closer to friendly forces. Some warheads are designed for scalable effects, matching the explosive impact to the mission profile. They are designed to minimise lethality and fragmentation beyond a certain kill radius by using composite materials and frangible bomb cases. This is particularly important for weapons used in urban areas.

Guided weapons designed to strike with high precision may cause collateral damage when they bounce from a hard surface. To avoid this risk, advanced multi-purpose and concrete penetrating bombs are designed with materials and geometries to minimise bouncing and move inside hard structures in straight lines. Modern fuses are equipped with 'void counters' to delay the warhead activation until the bomb

Boeing is developing a long-range version of the Joint Direct Attack Munition (JDAM) called the Powered JDAM, adding an engine to extend its range by 20 times the conventional glide version of the weapon.

reaches a specific floor or room inside the building or underground bunkers.

In the past, these capabilities were reserved for powerful and strategic weapons and cruise missiles, but today they can be used with standard weapons like the Joint Direct Attack Munition (JDAM). Boeing is also developing a long-range version of the weapon called the Powered JDAM, adding an engine to extend its range by 20 times the conventional glide version of the weapon. The new weapon combines a 500-pound warhead, a wing kit, and a propulsion module into the same form factor as a 2,000-pound bomb. Once fully developed, the weapon would offer a lower-cost alternative to cruise missiles for stand-off attack, adapting a conventional bomb for attacking targets in a contested battlespace.

Powered JDAM aims to take the proven JDAM and make it effective in anti-access, area-denial environments, so it has the range to stand outside that engagement

zone. The system could also be used as a decoy. Currently, decoys use the AD-160 Miniature Air Launched Decoy (MALD) to mimic the signature of an attack aircraft or a group of aircraft, causing enemy radar and air defences to engage the decoys and expose themselves to an attack. Fitting a weapon with a decoy payload enhances this capability offering a more versatile kinetic-non kinetic attack capability.

Unlike tactical strike weapons, larger and powered cruise missiles offer the strategic 'Deep Strike' capability. They employ low-level flight and low observable techniques to evade enemy air defences, penetrate and open breaches in Anti Access Area Denial (A2AD) arrays protecting the enemy airspace. Follow-on strikes employ tactical strike weapons that are also launched from a stand-off range. The modern designs use compact and networked armaments to saturate enemy defence and deliver precision effects using swarm behaviour.

Photo: BAE Systems



Platforms qualified for carrying BAE System's 2.75-inch APKWS munitions

Smaller and Smarter

With aerial weapons becoming smaller, aircraft loadout is increased, enabling a small number of aircraft to carry out large attacks. Small air-launched weapons are equipped with glide kits to strike targets at distances of 100 km. Designed around the 250 lb weight class, the Boeing GBU-39 Small Diameter Bomb (SDB), Rafael SPICE 250, and Safran/Diehl HUSSAR employ specially designed quad-launchers that carry the weapon, interface with the aircraft's armament control system, and provide a datalink to update the munitions in flight. A fully-loaded Cobham Mission Systems' BRU-61/A SDB quad-launcher weighs 1,460 lb which favourably compares with a single 2,000 lb bomb, offering 4x strike capacity to maximise weapon loadout even with smaller aircraft.

To extend the range even further, powered versions of those small gliding weapons are under development - the SPICE-250 ER from Rafael and MBDA's SPEAR III are two examples. Both are equipped with a small turbojet to sustain the weapon's flight to 140-150 km, a range considered beyond the effective range of most surface-to-air missile systems.

Both weapons use a two-way data link for in-flight retargeting and abort functions. Both are versatile but reflect different conceptual approaches to guidance and targeting. SPEAR III uses inertial and GPS guidance for mid-course navigation and millimetric wave radar or infrared or a semi-active laser seeker for the terminal attack. Independent of GPS navigation, SPICE 250 uses inertial navigation and electro-optic scene-matching, and employs Artificial Intelligence (AI) algorithms for autonomous navigation and terminal attack. The EO sensor also facilitates Automatic Target Recognition (ATR), Automatic Target Acquisition (ATA), and Moving-Target-Detection thereby enabling the SPICE to engage mobile and relocated targets.

The ATR feature enables the SPICE 250 to learn the specific target characteristics of the mission using advanced AI and deep-learning technologies. Before or during flight, the target type, location, and strike attributes are defined for each weapon, either by the automated mission planning or by the pilot. The weapons fly towards their targets, using their INS for initial navigation. When approaching the target area, they use their ATA and ATR modes to detect and recognise their assigned targets and determine precise aim-points. Each weapon homes in on the pre-defined target, either autonomously or with a human-in-the-loop, aided by the ATR algorithm.



Photo: MD Helicopters

Systema Technologies' Common Launch Tube (CLT) can host and deploy different aerial weapons.

"This future capability will offer users the unique combination of a combat-proven system with unparalleled state-of-the-art technologies, while taking advantage of existing infrastructure, without the need for a new integration," Alon Shlomi, VP, and head of Rafael's air-to-surface systems directorate said. "The significantly-enhanced stand-off range will enable pilots greater operational manoeuvrability, safety, and mission assurance," he added. Another family of intelligent weapons is under collaborative development by MBDA and the Tawazun company of the UAE, as announced at the IDEX 2021 defence exhibition. Currently, at the pre-development phase, the joint team will study several concepts before reaching its development. Originally the SmartGlider family included two basic glide vehicles – light and heavy platforms. SmartGlider Light is designed as a low-cost weapon that allows first-day-entry of heavily defended airspace by saturating and destroying enemy air

defences. SmartGlider Heavy relies on the same concept but features a significantly larger warhead capable of delivering large penetration warheads. This allows for the engagement of a wide range of complex fixed targets. Six SmartGliders will be carried on each 'Hexabomb Smart Rack' (HSL), enabling the deployment of intelligent, networked, and autonomous weapons to carry out swarm-like attacks. MBDA is also studying developing a compact cruise missile known as SMART CRUISER, based on a powered version of the weapon.

The Networked Swarm

The next step is connecting the individual weapons to achieve a Networked, Collaborative, and Autonomous (NCA) attack. In the past two years, the Golden Horde programme at the US Air Force Research Laboratory (AFRL) explored intelligent guided weapons as part of the 'Horde Vanguard' programme using specially modified Col-



TAURUS KEPD 350 E, shown here on a German Eurofighter TYPHOON, is a modular standoff weapon for precision strikes against hardened and high value targets.

Photo: MBDA

laborative Small Diameter Bombs (CSDB). The weapon completed the flight test programme at White Sands Missile Range, New Mexico, in May 2021.

During the third and last phase of the flight test, two F-16s from the 96th Test Wing Eglin Air Force Base simultaneously released six CSDB weapons. Four were released from one aircraft and two from the other. During their flight, all weapons established radio communications with each other using the L3Harris Banshee 2 radio network. A ground station also participated in the network, delivering in-flight target updates (IFTU). This phase of the test demonstrated the ability to scale up the number of nodes required to accomplish the mission.

Such IFTU messages are sent from outside the weapon swarm, and direct the swarm to pursue another target. It demonstrated the ability of Golden Horde weapons to interface with the larger Joint All-Domain Command and Control network (JADC2), a capability considered critical for future NCA operations. The final test objective had two weapons perform a synchronised time-on-target (STOT) attack on a single target location. "The Golden Horde team is blazing an exciting new path for air-delivered weapons," said Maj. Gen. Heather Pringle, AFRL commander, adding that "These technologies are completely changing the way we think about weapon capabilities, much like the laser-guided bomb did several decades ago. Golden Horde and technologies like this will enable the Department of the Air Force to overcome many of its current and future challenges, and we're just beginning to unfold all the possibilities." The next phase, called the Colosseum, rapidly integrates, develops, and tests transformational NCA weapon technologies for future warfighting opportunities.

While the Air Force doesn't appear to have any current plans to field the CSDBs themselves as operational weapons, further developments of the technology that it is now trialling as part of the Golden Horde programme could find a way into frontline weapons. The AGM-158 Joint Air-to-Surface Standoff Missile (JASSM), the ADM-160 Miniature Air-Launched Decoy, and the GBU-53/B STORMBREAKER have all been mentioned in the past as potential candidates for this swarming technology.

Weapons for Multi-Domains

The 21st century battle planner can no longer rely on total aerial superiority, at least not in the first phase of a conflict. Instead, air and naval forces are required to operate within a challenging battlespace, dominated by anti-access area-denied



SPICE 250 uses inertial navigation and electro-optic scene-matching.

capabilities. To fight in these conditions, forces employ a Multi-Domain Warfighting doctrine where each force is prepared to engage the enemy's critical elements, with or without the support of other forces. Fighting in the Multi-Domain battlespace of the 21st century requires land, naval, and air forces to act and overmatch the enemy in all domains. To do that, weapons that were designed for a specific purpose are transformed for use in other domains.

Several weapon systems are already associated with this trend, including the AGM-176 GRIFFIN missile enabled by the multi-purpose CLT as a launcher, versions of the SDB and AARGM missiles, turned into the Ground-Launched Small Diameter Bomb (GL-SDB) and Ground-Launched Advanced Anti-Radiation Guided Missile (GL-AARGM) by using rocket boosters to reach the initial altitude, and the APKWS rockets that have now been adapted to operate on ground vehicles using the FLETCHER multiple launcher system developed by Arnold Defence. Another example is the MBDA BRIMSTONE guided missile that uses a canister as a carrier launcher deployed on manned and unmanned combat ground vehicles.

These weapon systems were initially developed for aerial platforms and converted to land and naval domains. Other weapons, primarily missiles and rockets, were con-

verted from the land or naval domains for aerial weapons. These include the Kongsberg /Raytheon Naval Strike Missile (NSM) and Elbit Systems/IAI RAMPART guided rocket. According to some assessments, the Russian 9M723 (ISKANDAR) surface-surface missile has been adapted into the first operational air-launched land-attack hypersonic missile known as the Kh-47M2 KINZHAL. In 2019, the missile reportedly entered operational deployment with Russian MiG-31 strike fighters and was also planned to equip part of the Russian Tu-22M3 long-range bomber force enabling a 2,000 km strike range.

Multi-domain capability also relates to air-launched weapons able to engage the enemy in several domains, such as kinetic and electronic attacks. There are several examples of such weapons, particularly in the loitering weapon class. The ALTIUS-600 can carry the MoRFIUS high-power microwave emitter, developed by Lockheed Martin as a counter-drone weapon. Using Elbit Systems' electronic attack payload, the ALTIUS-600 can be fitted with a powerful mini-generator and MicroSpear electronic surveillance and attack system.

The MINI HARPY from IAI also uses a combination of a warhead, a passive electronic seeker, and an electro-optical sensor to detect active enemy radars and other emitters. The EO sensor is used to guide the loitering weapon to attack a target even if it ceases transmitting. Another example is the SPEAR RF from MBDA which can be used as part of a swarm attack by SPEAR III missiles to engage enemy air defences with an electronic attack. At the same time, other SPEARs pursue their targets kinetically.

Attritable or Expendable?

Throughout their evolution, air-launched weapons have been designed as expendable assets. Yet, in recent years developers and users consider some of their unmanned platforms as expendable (i.e., missiles and other 'suicide' weapons) or 'attritable', meaning they are regarded as expendable if they do not survive the battle.

Attritable weapons are already part of the development of future air combat systems in the US and Europe. A ground-launched long-range aircraft, the XQ-58A VALKYRIE is designed for high speed and agile manoeuvrability, enabling it to carry different sensors, weapons, and payloads to perform various missions with maximum operational flexibility to the war fighter.

The XQ-58A, developed and built by Kratos Defence, addresses AFRL's Low Cost Attritable Aircraft Technology (LCAAT) programme with the goal of breaking



Image: Diehl Defence

The Safran/Diehl HUSSAR missile employs specially designed quad-launchers that carry the weapon, interface with the aircraft's armament control system, and provide a datalink to update the munitions in flight.

the escalating cost trajectory of tactical manned aircraft through low-cost procurement. It is designed to be significantly cheaper to buy and operate than traditional piloted or unpiloted aircraft. It is the first example of a class of unmanned aerial vehicles developed through this cost- and time-saving process.

In Europe, this capability is considered for the future air warfare plans as part of the Future Combat Air System. The Remote Carriers concept is being developed by MBDA and Airbus as part of FCAS, the sixth-generation aircraft which is the manned element in the programme expected to begin test flights in 2026.

Acting as force multipliers, Remote Carriers are unmanned aerial vehicles (UAV), designed to reduce the risks for manned aircraft by taking over specific air operations' roles in high-risk environments, thereby providing new air warfare capabilities and teaming in combination with and coordinated by other manned air assets.

Remote Carriers

Several types of Remote Carriers are being studied, including expendable swarms, possibly followed by more sophisticated attritable assets, providing a wide scope of potential missions to better support a

safer penetration of manned aircraft into a hostile environment. Capable of "Cross-Platform Mission Management", the Remote Carriers will complement and augment manned fighter aircraft capabilities performing in close cooperation though with a high degree of automation and autonomy to improve mission performance in high intensity conflicts and increase the combat mass to better compensate limited numbers of sophisticated manned fighter aircraft.

Designed as large, unmanned platforms that join a combat manned-unmanned formation, the stealthy or supersonic horde of remote carriers will be launched from combat or transport aircraft, from the ground or surface ships. They will cooperate with other armaments and platforms, equipped with networking, infrared, and radio frequency sensors with data fusion and AI to enable automated target identification in complex environments.

In the foreseeable future, remote carriers deploying swarms of large and small guided missiles, supported by electronic attack weapons, will be able to carry the fight into the highly defended target space, enabling manned aircraft to stay out of range of air defences while managing the battle from afar. ■



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PANTSIR-S1M Short-Range Air Defence Missile and Gun System

The PANTSIR-S1 air defence missile and gun system is a short range, last stand protection element against airborne threats. Which features should be inherent to such a weapon system? Primarily – the versatility of effect on all types of targets able to reach the last defensive line of the protected object.

The major design objective of the system is to counter high-precision weapons, above all cruise missile raids and weapons launched from manned aircraft. PANTSIR-S1 ADMGS successfully copes with this task due to missile and gun armament with a solid engagement area of 20 km in range and 15 km altitude, radar-optical target detection and weapon guidance systems. The weapon

system carries a considerable ammunition load of 12 surface-to-air missiles and 1400 pcs of 30 mm gun rounds, installed on a single truck chassis with a load capacity of around 20 tons. The weapon system allows engagement of targets on the move, providing air defence of both stationary objects as well as mobile units.

Over the last twenty years air threats have changed considerably, extensive experience of the weapon system's combat employment has been gained, the trends of further evolution of the air attack assets has been determined, and the real threat imposed by mini-drones, which currently not only perform reconnaissance but also assault missions, has been realised. Besides, the cruise missiles of the nearest

future will be hypersonic. Undoubtedly, such situation accelerates the development and manufacture of these missiles, especially due to the termination of the intermediate-range and shorter-range missile treaty.

Based on analysis of the above aspects, the KBP, a subsidiary of the High Precision Weapons Holding, has decided to develop a new generation PANTSIR-S1M short-range air defence missile and gun system. The engineering solutions implemented meet all the current and future requirements imposed by countering modern air threats and outperform the existing counterparts. Compared to the serially produced PANTSIR-S1 system the new PANTSIR-S1M employs high-



Images: KBP

PANTSIR-S1M for the Russian Army

velocity surface-to-air missiles (SAM) with an engagement range of up to 30 km at altitudes of up to 18 km, with curtain-type kinetic action warheads thrusting a cloud of high-density fragments in front of the target following the uplink command. This provides effective destruction of the targets due to kinetic hypersonic velocity imparted to the SAM after lift-off, low deceleration at the trajectory and added velocity of oncoming targets in combination with the alignment of the target and penetrators coverage area at ultra-high striking velocities.

Improvements

The improvements implemented in the new PANTSIR-S1M weapon system do not encompass the introduction of the new SAM type only. In order to enhance the efficiency of "standard" SAM employment, the control system has also been upgraded. The number of targets that can be fine-tracked by the radar is increased to four.

- The optronic system (OES) provides automatic and semi-automatic determination of the missile and target coordinates in the optical band, surveillance of the air space and target search by the operator, measuring of the range to the target. The OES comprises thermal imaging and TV channels, laser rangefinder, TV autotracker and optronic sensor for the localization of the SAM. Thus, the OES provides operation under the condition of reduced transparency of the atmosphere. The system performance range surpasses the range of the meteorological visibility by 5–10 times, which enables target detection and determination of target front and side projections coordinates with the specified accuracy.

The integrated multimode and multispectral radar-optical guidance system operating in dm-, mm- and IR-wavebands provides for high immunity of the PANTSIR-S1M system to jamming and, thus, for sharp rise of combat performance.

Wheeled, Tracked and Stationary

The mobile version of the PANTSIR-S1M system comprises the combat vehicle (up to 6 CVs in a battery) with two types of surface-to-air missiles, 30-mm rounds, transporting-loading vehicle (one vehicle per 2 CVs), maintenance assets and training aids.

The modular concept of the PANTSIR-S1M system design enables its mounting on wheeled and tracked chassis, as well as employment as a stationary version.

The innovative approach to the PANTSIR-S1M system design implementing the modular configuration concept makes it possible to employ the system for protection of oil rigs, vital administrative assets, military-tactical and other pin-point objects, as well as to install it on railway platforms. This results in low-cost integration of the weapon system with an existing system of maintenance, training and logistics already in service with a particular customer. The said concept also enables system customisation for the specific geographical conditions of customer-required applications.



High-velocity surface-to-air missile

The combat vehicle carrying the new PANTSIR-S1M system comprises the following recently-designed sub-systems:

- The search radar with two phased antenna arrays (PAAs), two transceiver systems, 2D electronic scanning in elevation and azimuth providing the following: the opportunity to detect ballistic targets, in particular due to the employment of the sector-search mode; increase of the detection range up to 80 km and increase of the number of detected targets to up to 40; increased reliability due to redundancy of the basic components of the PAA with the transceivers.
- The multifunctional tracking radar (TTR) with the increased surface of the PAA and increased power of the transmitter providing: increase of the detection and acquisition range of a target with RCS=1m² by 1.5 times; increase of the transceiver band by two-fold; decrease of the target tracking errors; simultaneous fine tracking of four targets.



Combat vehicle on tracked chassis

A400M Turns a Corner

Georg Mader

In the last 18 months, Airbus reached the significant milestone of 100 operational A400M aircraft delivered. Clearly, the aircraft is well on its way to overcoming several long lasting development hurdles.

The European “big players” recently had reason to celebrate reaching 100 A400M deliveries with the 10th out of 27 A400M aircraft supplied to the Spanish Air Force. The aircraft MSN111 performed its ferry flight on 24 May from Seville to Zaragoza, where the Spanish A400M fleet is based. In the same week, the A400M global fleet also achieved the 100,000 flight-hours landmark performing missions worldwide for all eight customer nations. This represents a significant boost in activity, with 40,000 hours added since late 2019.

Photos: Georg Mader



Malaysia has bought four A400M aircraft.

Protracted and Nasty Issues

The A400M programme was formally launched in May 2003, with partner nations Belgium, France, Germany, Luxembourg, Spain, Turkey and the UK committing to a combined total of 170 aircraft, with four for export customer Malaysia. Since its maiden flight on 11 December 2009, the loss of a prototype and several long-lasting issues seem to have been forgotten. Obviously, Airbus overcame the production faults affecting 14 propeller gear boxes (PGBs) produced by Italian supplier Avio Aero and a necessary interim PGB fix to resolve the problem (those PGB-retrofitted units reportedly have had no problems since), or input pinion plug cracking which released small metallic particles into the oil system. Some issues still remain, including the low- and high-pressure turbine discs of the Europrop TP400-D6 engines, once underestimated as made by – as Airbus’ Tom Enders once said himself – “an inexperienced consortium”, or the subsequent US\$1Bn charge over delivery issues and export prospects in 2016. A so-called



The Malaysian AF has also procured a Cargo Hold Part Task Trainer (CPTT) simulator from Rheinmetall.



Tests were recently completed in Spain to expand the aircraft’s capability for up to 25,000 ft for automatic parachute opening and up to 38,000 ft for free fall.

Author

Georg Mader is a defence correspondent and freelance aerospace journalist based in Vienna, Austria, and a regular contributor to ESD.

“re-baselining-contract” signed with the European launch nations in 2019 reduced the final assembly of the A400M to its current rate of eight to nine per year, thereby safeguarding manufacturing until 2030. In this context, it was agreed to extend the entire delivery by six years. Instead of the previous target of 2020, all 174 on the books are now due to be delivered by 2026. Nevertheless, the engine still seems to resemble a kind of burden for the operators, since Airbus is working with the consortium and the EU-regulators to re-certificate a new standard for the power plant. This is expected to happen this July – also enabling Airbus to establish new, “less conservative” maintenance schedules. Nevertheless, company officials do not deny they are not where they want to be on supportability, fleet availability and maturity. Airbus therefore calls for a “maturity drive”, which will run until 2023.

Unique Props

Part of the “burden” is – or was - design-inherent. Because on the largest European heavy-lifter (with its +30-tonne payload), the pair of propellers on each wing turn in opposite directions, with the tips of the propellers advancing from above towards the midpoint between the two engines. This is in contrast to the overwhelming majority of multi-engine propeller driven aircraft where all propellers turn in the same direction. The counter-rotation is achieved by the use of the gearbox fitted to two of the engines and with this, only the propeller turns in the opposite direction. All four engines remain identical and run in the same direction. The reason behind this - given by the manufacturer – was, that this eliminates the need to have two different engines on stock for one aircraft, simplifying maintenance and supply costs.

Further “Milestones” Reached

Recently, the A400M successfully conducted a major helicopter air-to-air refuelling certification flight test campaign in coordination with the DGA (French Directorate General of Armaments), completing the majority of its certification objectives, including the first simultaneous refuelling of two AH H225M CARACAL CSAR-helicopters. It was mainly the French who pioneered a 36.5 m hose, which eliminated the serious turbulence issue of the previous 24 m hose in combination with spoilers activated to hold the



Bandsmen from the Royal Air Force Pipes and Drums celebrate the display of an A400M at the RIAT 2019 airshow.

slow refuelling-speed. Also, recent tests were completed in Spain in collaboration with the UK's Royal Air Force parachute test team, to expand up to 25,000 ft for automatic parachute opening and up to 38,000 ft for free fall. The A400M is already able to drop up to 116 paratroopers, via simultaneous dispatch from the side doors with automatic parachute opening, from the ramp with automatic opening or in freefall, day and night. Also to note is performing automatic low-level flight in instrument meteorological conditions.

In German Service

While the ATLAS – as it is also called - has made great strides so far this decade in both development and operational terms, it has proven its value to nations during their pandemic response efforts. Utilisation rates for this large transport plane have soared everywhere since the start of the COVID-19 crisis, with flight hours in 2020 up 40 per cent on the previous year. On 5 May, the German A400M 54+05 delivered parts of an oxygen-generation device to India, flying



An A400M at the RIAT 2019 airshow



A Luftwaffe A400M refuelling two TORNADO multi-role combat aircraft during the ILA 2018 airshow

from Wunstorf to New Delhi. In the qualified MEDEVAC-role, the type also supported the re-location of COVID-infected Germans from Afghanistan. Related to the overall introduction and service in(to) the German Luftwaffe (GAF), since the last armament-report to the Parliament (Bundestag) from spring 2020, additional A400M aircraft delivered and accepted have brought the inventory to 35 (or meanwhile 36) out of the planned 53. The latest aircraft is a so-called “tactical version”, meaning it is equipped with a self-defence/countermeasures system based on DIRCM. Therefore it remains with Airbus in Spain, with the official handover connected to the DIRCM-fit, which should become operational on German A400M aircraft by 2024. Only 37 of the fleet will be “tactically” modified this way in the end. With current planning for 2021, two further airframes are scheduled to be delivered. The next contracted ability-standard is NSOC 2.0, as accepted by the programme nations. It is described as an important milestone towards final standard SOC 3.0 (FOC) scheduled for acceptance in 2023. At this point, it needs to be mentioned that once new clearances are made by the company, national flight trials and approval processes can take a further 12-18 months to complete.

Other Operators...

With two operators, the ATLAS is bound to take over more share of the market, since the Spanish Air Force retired its Lockheed Martin C/KC-130H transports last December and the British RAF will cease operations with its remaining 14 J-

model HERCULES – having accumulated only between 9,000 and 12,000 hours - much earlier than anticipated. This also means commitment and belief in the level of maturity the A400M has reached and interest in boosting the operational capabilities of its ATLAS fleet, as detailed in late March in the UK MoD’s “Defence in a Competitive Age” planning document for the period 2021-2025. This means including operations from unpaved runways or potential new applications for a transport, such as in supporting maritime patrol activities. The RAF already uses this aircraft type for such work while defending the Falkland Islands. It has so far received 20 of its contracted 22 ATLAS aircraft, with the remainder to follow in July 2022 and June 2023. London’s original commitment to the programme was for 25 units, but this was cut by three ahead of the programme’s launch order. France meanwhile is using the aircraft regularly in its military’s peacekeeping activities

in West Africa. Nine Turkish Air Force A400Ms based in Kayseri have evacuated Turkish, Azeri, Albanian and Georgian citizens from Wuhan, China. They have also however, delivered armaments to Misrata for the Turkish-backed Tripoli-based Libyan Government of National Accord. The third aircraft (MSN023) crashed during the first factory acceptance flight from Seville in 2015 and will be replaced with the tenth in 2022. Meanwhile in 2020, the Malaysian Air Force has received a Cargo Hold Part Task Trainer (CPTT) simulator from Rheinmetall. It has been reproduced to exactly the same original scale with all operating elements to train staff in the cargo bay. The TUDM operates four A400M.

Future Prospects

There is flexibility to increase production to 11 or 12 aircraft per year – or even more – should demand dictate. At Airbus, there is optimism about future additional sales of the ATLAS – both to existing operators and new international customers. Some even predict the A400M will enjoy major export success, while several nations around the globe – likely in Africa, the Asia-Pacific region and the Middle East - are merely observers. Indonesia, which had earlier talked about five aircraft, instead expressed interest in early 2018 in taking just two to support domestic logistics and humanitarian operations. Rather unexpectedly, there are indications that Airbus, with the A400M is – more or less closely - involved in the European 6th Generation Future Combat Air System (FCAS). Within that system-of-systems “combat cloud”, the ATLAS could air-deploy remote carrier vehicles or even wingman-likeUCAVs. According to company statements, flight trials have already taken place with one of the nations. ■



A Luftwaffe A400M at the RIAT 2018 airshow

Joint Power for Europe's Next-Generation Fighter

New challenges call for new responses. When it comes to the protection of the German and European airspace, a system made up of manned and unmanned flight vehicles – dubbed the Future Combat Air System (FCAS) – is the solution. And the Next-Generation Fighter (NGF) will be an essential part of this. The NGF is expected to enter service by 2040 – powered by an engine that goes far beyond today's capabilities.

At the end of April, MTU Aero Engines, Safran Aircraft Engines, and ITP Aero came to an overall cooperation agreement to provide a jointly developed, produced and supported engine to power the NGF, which is a core element of FCAS.

The programme took a decisive step forward when MTU Aero Engines and Safran Aircraft Engines created a 50/50 joint company in April. The new entity, called EUMET GmbH (derived from European Military Engine Team), will be based in Munich. The joint venture will be the sole contract partner for the participating nations in the engine programme. ITP will be contracted as a main partner to EUMET. Through ITP's agreement to join the programme as a main partner, an equal workshare between France, Germany and Spain was made possible. EUMET will be the sole prime contractor among the nations for all engine activities related to the Next-Generation Fighter. "We have set a reliable and solid framework among the partners for pragmatic and focussed decisions over the entire life-cycle of the engine", commented Michael Schreyögg, Chief Program Officer of MTU and first Chairman of the EUMET Shareholders' meeting. "We will now focus on the major next steps: Securing the contract for the demonstrator phase during the next few months and ramping up development activities in line with our highly ambitious 2040 timeline."

FCAS is a highly strategic programme that will enable Europe to maintain fundamental competencies in military engines, while also strengthening national and European defence capabilities. Through EUMET, the



Image: Airbus

Answering tomorrow's challenges: When the new European fighter jet takes to the skies in 2040, it will need a futureproof, high-performance engine from day one. Germany's leading engine manufacturer, MTU Aero Engines, is ready to meet that challenge now.

partners will be developing the technology and demonstrators for a best-in-class engine that will meet the evolving needs of European armed forces. Within EUMET, Safran Aircraft Engines will be responsible for the engine's overall design and integration, while MTU Aero Engines will take the lead regarding engine service activities. ITP Aero will be fully integrated in the design phase of the engine and develop the low-pressure turbine and nozzle, amongst other items. EUMET will oversee the development, production and support of the engine to power the Next-Generation Fighter (NGF).

According to the timetable defined by the national authorities, the next research and technology phase (R&T 1B/2) should pass the national approval processes by the middle of this year in order to move the FCAS programme to the next level.

"Establishing a joint company for this next European fighter engine is a further milestone in the close relationship between our companies, one that has already spanned six decades," adds Schreyögg. "This opens the next chapter in European aerospace cooperation and mirrors our equitable partnership."

There is no doubt that MTU is the German partner of choice in this endeavour. The company has the capability to provide any component needed in any phase of the life cycle of an engine – be it development, production or in-service support. This holds true in terms of the technological requirements for the next generation of engines as well as of the organisational prerequisites for an in-service support concept capable of meeting the requirements that might arise 20 years from now.

Germany's leading engine manufacturer is one of the world's leading development partners and has been actively involved in numerous military engine programmes for decades. The company is an expert in newly developed propulsion systems, such as the T408 for the CH-53K heavy lift helicopter, and has been for long-serving engine types, such as, for instance, the RB199 powering the TORNADO and the EJ200 powering the Eurofighter TYPHOON. With this background and its know-how, MTU possesses unparalleled expertise to support the development, improvement and success of advanced engine components for military aviation.

MTU Aero Engines is the long-term lead industrial partner for almost all engines flown by the German Armed Forces. The company's strong suit is developing new technologies and it can draw on decades of experience along the entire military engine lifecycle – qualities that will help it preserve the European aviation industry's technological capabilities in the military and commercial sectors well into the future.



Images: MTU

“We have full confidence in the F-35 programme”



Photo: DALO

As both the Commander of the Danish Ministry of Defence Acquisition and Logistics Organisation (DALO) and Danish National Armaments Director, Lieutenant General Kim Jesper Jörgensen entered office in February of this year. In this interview, he considers current tasks and programmes, as well as the prospects arising from the "Framework Agreement on Arctic Capabilities" concluded in February.

ESD: As far as the role, organisation and duties of DALO are concerned, is your organisation comparable to other defence procurement authorities like the French DGA, the Swedish FMV or the German BAANBw? Apart from that, are there other organisations involved in defence procurement in Denmark?

Jörgensen: Well, first of all, when it comes to organisational structures, then I would rather not make a specific comparison with other organisations. To be quite honest, I have only been in this position for a few months, so I will not make an assessment if we are most like this or that organisation. But what I can tell is that we have the complete procurement responsibility when it comes to equipment and IT. And also the task of actually running the systems. I know at least one organisation that, at least at a first glance, seems to be quite similar to us- and that is the Dutch Defence Materiel Organisation (DMO). We have all the tasks connected with the acquisition of both equipment and IT for all services and also other agencies within the MoD, for instance the Federal Emergency Management Agency. I think that is as far as I can go when it comes to defining the organisation and when it comes to the organisation's role as part of the acquisition process. And I would say that acquisition as such - that is the role of my organisation. But we have a very close relationship with our customers, as I would call them, the service headquarters, the headquarters of the Emergency Management Agency, etc. The same applies when it comes to industrial cooperation and cooperation with other government agencies. But the

procurement function as such has been centralised in this organisation.

ESD: Over the past few years, a number of organisational and procedural changes for or in the Ministry of Defence have been implemented. Do any of these might have an influence on the procurement process? Can you briefly describe the current process and the entry points for companies wanting to do business with the Danish armed forces?

Jörgensen: First of all, when it comes to the organisational changes, the one thing I would like to point out is that besides the concentration of all the acquisition activities in this one organisation, the assignment of the National Armaments Director, which could be described as a departmen-

tal function, has also been delegated to this organisation. So we are in charge of both the acquisition part and that of the National Armaments Director. And when it comes to the point of entry for companies, Danish or foreign companies wanting to enter into a business relationship with the Danish Defence, or wanting to learn about our requirements, should all contact my front door, which is what we call the Industrial Cooperation Division or the Industrial Cooperation Office.

ESD: The procurement of the F-35 fighter is the most voluminous military acquisition in Danish history. Denmark received the first F-35 on 07 April 2021. Based on the GAO Report 21-226 which highlighted that the US DoD needs to update modernisation

Photo: Lockheed Martin



The roll-out and delivery ceremony of Denmark's first F-35 in Texas



Photo: GDELS

At a ceremony in March 2019 attended by Denmark's Minister of Defence, Chief of Defence, DALO Chief and Chief of the Army, the Danish Army received the first of a new generation of PIRANHA wheeled armored vehicles manufactured by GDELS.

schedules and improve data on software development, there were some critical comments in this context. Do you see this as a major challenge for the programme and as a possible serious cost overrun that might affect other programmes?

Jørgensen: As you might know, I participated in the roll-out ceremony and the delivery ceremony of the first F-35 in

Texas. Let me be very clear: We have full confidence in the F-35 programme. And we have full confidence in the leadership demonstrated by the Joint Programme Office (JPO) in managing the programme. Obviously, a programme of this magnitude will encounter a number of challenges, both in the development phase and during the production and sustainment phase, and

that is only natural. We have made a similar experience with the F-16 programme. Today, we have more than 40 years of experience with that programme, and it has been a comparable experience: there have been challenges, which have had to be responded to in a very professional way. And that is why we are confident that with such an approach the challenges in the F-35 programme will be mastered, too, including the cost issues when it comes to the sustainment part of the programme. We have confidence that appropriate solutions will be found.

ESD: In February, the Danish Government tabled the framework agreement in support of strengthening the Danish defence capabilities in the Arctic and the North Atlantic. What capabilities exactly are to be improved? What is the expected financial volume of the programme and what are the implications for DALO's work?

Jørgensen: Well, first of all, when it comes to the improvement of capability in the Arctic region since then, the focus is on surveillance, or you may call it domain awareness, namely surveillance and the associated command and control capability. So our first priority is getting a better overview of ac-



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Such a weapon mix provides a highly effective layered protection shield against a wide spectrum of air threats.

Image: GA-ASI



Photo illustration of a Danish MQ-9B SeaGuardian patrolling Greenland's territorial waters

tivities in the area, both in the Greenland area and the surrounding area. And also, when it comes to the Faroe Islands, north of Scotland, both islands are within the area of operations of the Arctic Command, which I had the pleasure of commanding until I assumed the present position. Due to the vastness of the area, surveillance and command and control are essential. So therefore, naturally, that is the focus of this capability improvement programme. When it comes to specific capabilities, then the political decision draws the outline of the capabilities that now are my responsibility to provide. The scope of capabilities includes satellite surveillance for maritime domain awareness, drones and UAVs for maritime surveillance and also ground surveillance, and different data links and communication systems linking the sensors, the headquarters and operational units. Also, there is the re-establishment of an air surveillance radar on the Faroe Islands. There was a radar station on the Faroe Islands during the Cold War. It was disbanded after the Cold War. Now the decision is to re-establish a radar station on the Faroe Islands in order to improve our air domain awareness. Included in the outline package is also a number of coastal radars. In Greenland, coastal radars focus again on maritime surveillance. Included in the package are also funds for increased exercise activity, for instance, units exercising disaster management operations in Greenland. Also as part of the package, there is funding for establishing a military basic training facility in Greenland. In Denmark as such, we have national service. There is no national service for young people in Greenland, but the intention is to establish a basic military training facility, so the young people in Greenland can volunteer in order to get basic military

training and thereby, so to speak, get the entry ticket to participate in the defence of Greenland. I think that has been a rough outline of the capabilities included in the package.

ESD: Can you give us an idea about the projected time schedule for the entire effort?

Jørgensen: The funding as such will be available from 2023, so it is a question of planning the procurement efforts based on funds being available accordingly. Therefore, we are looking at least at the mid-twenties when it comes to several capabilities. That is all I can say right now simply because we are not that advanced in the planning of details.

ESD: Which of your current programmes are carried out in partnership with other national or multinational procurement organisations?

Jørgensen: Well, I can give you a number of examples when it comes to procurement executed in multinational context. One of them is our new combat uniform system, the camouflage uniforms used by soldiers. And there we are in the middle of a procurement process together with the other Nordic countries in the scope of the Nordic Defence Cooperation (NORDEFECO). I cannot disclose more details because we are in the middle of the procurement process here. That is one example of a procurement programme in a multinational context. Another example is a recent decision or contract to acquire anti-tank missiles, the SPIKE anti-tank missile system from Eurospike procured through the NATO Support and Procurement Agency (NSPA). These are the two latest examples that I can mention.

ESD: To what extent is the Danish defence industrial base capable of responding to the material requirements of the Danish armed forces? Are there areas where you have to rely on foreign contractors?

Jørgensen: Well, first of all, due to the limited size of our country and our population, there is a natural limit to to what extent our defence industry can fulfill our requirements, depending on which sector you are talking about. I think the sector where we are the most capable of providing for ourselves is the maritime sector, the shipbuilding sector. For various geographical and historical reasons, we have a well-developed maritime sector able to design and build ships within country. Of course, we need many subcontractors from abroad but the maritime sector, shipbuilding, is the one where we are most capable of supporting ourselves. When it comes to other sectors, the Danish defence industry is primarily employed as subcontractors to foreign main contractors. In my opinion and as far as I can see it, the Danish defence industry is capable of supporting or providing parts to a wide array of defence capabilities. But again, as I started out saying, when it comes to delivering complete systems and it is primarily the small scale programmes or the maritime sector.

ESD: Is there anything else you would like to comment on?

Jørgensen: Perhaps I should have started saying this first: As I told you, I assumed command here after having been the operational commander of the Joint Arctic Command, meaning that my background is operational; my background is not procurement. Instead, my background is operations and planning. And this means that I bring with me a perspective of the needs of the operational soldier, of the operational units. Therefore, it is very important for me that we have a close dialogue with the customers, meaning the operational soldiers and all the other customers we serve like the Emergency Management Agency, etc., so that we provide the solutions and the support needed by the operational units. And when you have operated in the Arctic, in a very limited infrastructure, you really get a first-hand experience of the importance of having the right gear and the right equipment and being able to support it in a very effective way. That kind of impression and experience is something I remember each and every day. And I am doing my utmost to make sure that we deliver the right service to the frontline personnel.

The interview was conducted by Jürgen Hensel.

Killer Code: Cyber-Supported SEAD

Thomas Withington

**Cyberattack is a versatile option for air defence suppression.
It is being taken seriously in NATO and allied nations.**

The UK's National Cyber Force (NCF) is a joint Ministry of Defence (MoD) and Government Communications Headquarters (GCHQ) organisation. GCHQ is the UK government's Signals Intelligence (SIGINT) collection agency. The NCF is responsible for offensive cyber warfare operations. Established in 2020, it operates alongside the National Cyber Security Centre (NCSC). The latter protects the UK government and its departments, alongside critical national infrastructure, from cyber warfare.

Announcing its creation in November 2020, GCHQ's press release said the NCF would perform "cyber operations to disrupt hostile state activities, terrorists and criminals threatening the UK's national security." These 'operations' include "countering terror plots to supporting military operations." One of mooted latter missions was "keeping UK military aircraft safe from targeting by weapons systems." This was reiterated in the UK government's Global Britain in a Competitive Age paper published in April. The paper outlined the British government's post-Brexit strategic and foreign policy commitments.

Global Britain may have articulated the words, but the UK MoD's Command Paper articulated the actions. Published shortly after the former, it details the capabilities the country will acquire and sustain in the coming years. The paper reveals that the UK has developed offensive cyber capabilities. These will be made wielded by the NCF. They will be made available to NATO (North Atlantic Treaty Organisation) as and when required. The Command Paper says the NCF will provide "capabilities that will be used to deceive, degrade, deny, disrupt, or destroy targets in and through cyberspace in pursuit of our national security objectives."

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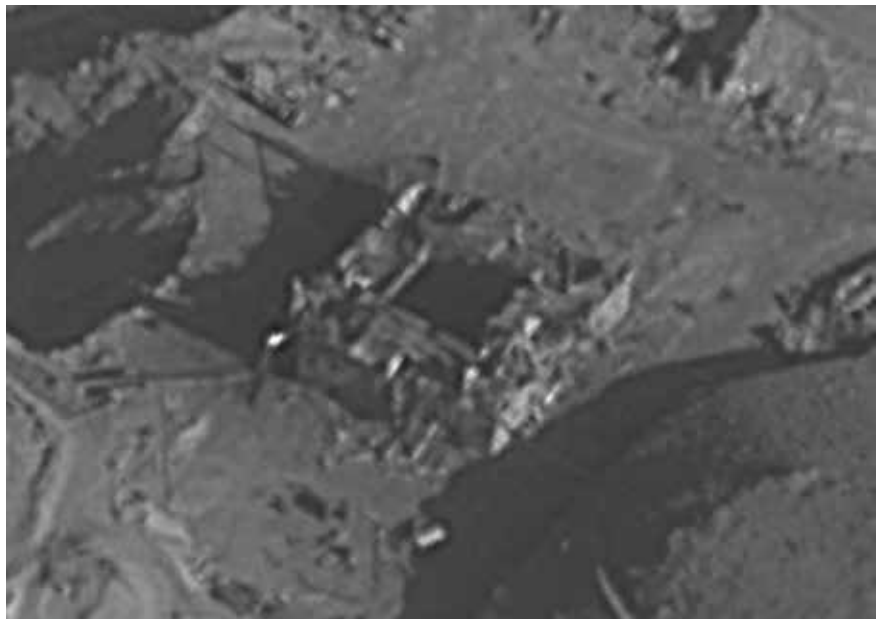


Photo: IDF

The remains of Syria's nuclear reactor at Deir ez-Zor. A cyberattack was believed to have assisted the safe ingress and egress of IAF aircraft to and from this target.

The commitment to keeping British military aircraft "safe from targeting by weapons systems" is interesting. It is an outgrowth of the UK's airpower posture detailed in the MoD's 2018 Combat Air Strategy. This merged industrial and military trajectories to ensure the country possesses cutting edge airpower. The strategy gave clues on the place of cyber warfare in this wider posture: "Cyber domains will also become increasingly important as we seek to maintain information advantage."

Neither the Combat Air Strategy, the Command Paper nor the Global Britain explains how the NCF will help safeguard UK military aircraft. Nonetheless, it seems likely that the NCF could perform cyberattacks against hostile air defences threatening British aircraft. What might this mean in principle?

Cyberattack

In theory, the NCF could attack hostile air defence systems like Surface-to-Air Missile (SAM) batteries. It could also engage

hostile radars. This is alongside battle management, command and control systems and communications integral to air defence. Any component of an Integrated Air Defence System (IADS) or deployed Ground-Based Air Defences (GBAD) accompanying the manoeuvre force relying on computers would be at risk.

Cyberattacks against hostile air defence could take many forms. Primarily they fall into two categories, disruptive and destructive. Disruptive cyberattacks could focus on denying certain computer functions or networks to an adversary. Destructive cyberattacks take things further. These aim to destroy hostile computers or computer networks. Both disruptive and destructive cyberattacks are performed with malicious code. This could be inserted into an IADS/GBAD through communications networks linking their constituent elements. These networks will use standard military radios, satellite communications or civilian/dual-use conventional telecommunications. Code could also be delivered via electronic attack. A standard RF (radio frequency)

Photo: USAF



The US Air Force's EC-130H electronic attack aircraft are believed to have the wherewithal to unleash cyberattacks on hostile air defences.

jamming attack against a hostile radar or IADS/GBAD communications system could be 'syringe' through which the code is 'injected' into a specific weapons system, sensor or other targets in the IADS/GBAD network. Official US documents say the US Air Force's Lockheed Martin EC-130H Compass Call communications intelligence/jamming aircraft has used its electronic attack payloads to deliver cyberattacks into hostile IADS. Hacking IADS/GBAD computer systems may allow data theft. This data could be converted into useful intelligence. This may betray valuable information on the working of the IADS/GBAD and accompanying weapons. It may also indicate comparatively weakly defended segments of airspace. Such areas might be exploited for ingress or egress routes to and from targets.

Using cyber warfare to support SEAD (Suppression of Enemy Air Defence) missions is not new. Dr. James A. Lewis, a leading cyber security expert, observed in his 2015 paper entitled "The Role of Offensive Cyber Operations in NATO's Collective Defence" that "as cyber and EW merge into a single activity, air operations will require cyber support." This can translate into attacks "against command and control systems ... and against the software that runs advanced weapons such as surface-to-air missiles." Cyber and electronic warfare have much in common. It is no accident that NATO increasingly groups these two missions together under the CEMA (Cyber and Electromagnetic Activities) umbrella. A 2019 US Congressional Research Service

publication entitled *Convergence of Cyberspace Operations and Electronic Warfare* said that both constitute "efforts to dominate aspects of the electromagnetic spectrum that transmit packets of information."

Using cyber warfare as a SEAD component has several attractions. It can help keep some aircraft out of harm's way. Planners may decide the certain IADS/GBAD targets are too dangerous to hit kinetically. Consider a Sector Operations Centre (SOC) controlling a swathe of hostile airspace. The SOC maybe deep in enemy territory. Aircraft might need to travel

hundreds of miles through heavily defended airspace to reach this target. Stand-off air-to-surface or surface-to-surface weapons may face similar threats. Attacking the computers controlling the SOC's may have a similar impact to a kinetic attack sans the cost in blood and treasure. The cyberattack might have little risk of causing collateral damage reducing the danger to civilians. Although the SOC's computer networks will be damaged, if not destroyed, the SOC may still be usable after the conflict. This is particularly important if the military action is intended to be limited, or as a warning.

SUTER

Cyber warfare is increasingly part of the SEAD toolkit. Details are scant, but it is known that cyber effects have been used to attack IADS/GBAD over the past two decades: On 6th September 2007, the Israeli Air Force (IAF) was believed to have used cyber weapons during an IAF attack on a nuclear reactor in Deir ez-Zor governate, eastern Syria. The attack took place on a Thursday evening. Intelligence sources have shared with the author that computers controlling the Syrian IADS were hacked shortly before. This involved blocking the feeds from radars funnelling data into the IADS to produce the national Recognised Air Picture (RAP). Instead, a fake RAP was produced. This showed the usual Thursday pattern of air traffic over and around Syria for when the strike was to take place. Syrian Air Defence Force cadres staffing the IADS would have

Photo: USAF



Standard SEAD capabilities include kinetic effects delivered by weapons like the Raytheon/Northrop Grumman AGM-88 High Speed Anti-Radiation Missile.

been none the wiser that their systems were hacked as the national RAP would have looked unremarkable.

The sources continued that the malicious code was not transmitted into the IADS via electronic attack. Operatives working covertly in Syrian are thought to have physically loaded the malicious code into the computers. This may have been done to overcome efforts the Syrians had taken to 'air gap' their IADS computers. Air gaps exploit the physical separation of computers from the internet to prevent their infection with malicious code via this route. Other physical security measures can include the omission of Universal Serial Bus (USB) sockets or other apertures through which malicious code could be inserted. In practice though all air gapping can do is reduce the risk of code finding its way into computers rather than eliminating it.

Fast forward to 20 June 2019, when US Cyber Command (USCYBCOM) attacked Iran's IADS. This occurred after Islamic Republic of Iran Air Defence Force SAMs downed a US Navy Northrop Grumman RQ-4A GLOBAL HAWK uninhabited aerial vehicle. Tehran claimed that the RQ-4B had violated Iranian airspace near the Strait of Hormuz.

USCYBCOM reportedly targeted fire control systems used by IRIADF SAM batteries. The exact scope of the attacks is in the realm of conjecture. That said, it may have prevented SAMs being launched, prevented batteries sharing their data with other parts of the IADS, or both. This was the first offensive action by USCYBCOM following its activation as a full combatant command in May 2018.

The attack may have employed Northrop Grumman's Unified Platform. This is what its manufacturer calls "an integrated full-spectrum cyber warfighting capability." USCYBCOM employs the Unified Platform for offensive and defensive cyber operations. Alternatively, the US might have employed BAE Systems' SUTER cyberattack apparatus. Like the Unified Protector, precise details on the workings of SUTER are sparse.

It is thought that SUTER exploits radar or communications antennas as its point of entry. Once inside the radar or radio it may remain there restricting its nefarious activities to that system. Alternatively, it may access the networks linking together an IADS/GBAD. It will get to work disrupting the computers controlling the IADS/GBAD or accompanying sensors and weapons.

Information in the public domain says that three variants of SUTER have been developed. Each adds progressively more capability: SUTER-1 lets attackers to extract the RAP seen by hostile air defenders. SUTER-2 lets attackers gain control of the IADS/GBAD, accompanying weapons systems and sensors. Finally, SUTER-3 can disrupt communications datalinks controlling ballistic missiles or SAM batteries. Reports say that SUTER has been used by US forces in the Afghan and Iraqi theatres since 2006. The paucity of a serious air defence threat in both countries from 2006 indicates that SUTER may have effectiveness beyond SEAD supporting other tactical or operational missions.

SUTER is thought to be deployable from an aircraft. This would make sense. If code is to be inserted via a radar or radio antenna then the platform performing the attack will need to be in a Line-of-Sight (LOS) range. This does not necessarily place that platform in danger: The RQ-4B has a cruising altitude of 60,000 18,000 metres. This would give on-board communications systems transmitting SUTER a LOS range of over 300 nautical miles (557 kilometres). In practice, SUTER would probably be trans-



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Photo: USAF



Cyber effects will be used extensively in future SEAD efforts at tactical, operational and strategic levels.

mitted into a hostile IADS/GBAD from a closer range, given the transmission power that such a range would require. In fact, transmission power levels are probably kept to a minimum. This would help to avoid alerting the targeted radar or radio it is being attacked. Nonetheless, an attacking aircraft may remain at a safe stand-off range performing the attack. The EC-130H discussed above is one platform thought to deploy SUTER. The RQ-4B maybe another although it seems unlikely that the RQ-4B shot down over Iran in 2019 was deploying SUTER given the IRIADF's initial success.

Operational / Tactical

There appears to be a division of labour for SUTER and the Unified Platform. As it can reportedly inject a cyber-attack directly into hostile IADS/GBAD and accompanying weapons and sensors, SUTER may be used at the tactical/operational level. It could be the weapon of choice when a cyberattack must be responsive and render only a part of an IADS/GBAD temporarily unserviceable. It appears that the IAF may have employed its SUTER-style software for exactly this purpose during the Syrian attacks.

Photo: US DoD



The twisted wreckage of an Iraqi SA-2 (NATO reporting name GUIDELINE) high-altitude/long-range SAM system. Cyber effects may prove just as destructive to such weapons in future battles.

Conversely, Unified Platform may have an operational/strategic bent. It might be used to close down the entirety of a hostile IADS/GBAD for a much longer duration. It would not be surprising if the Unified Platform was used for the opening stages of an air campaign where SEAD focuses on a major roll back of hostile air defences. The different yet overlapping focuses of SUTER-style software and the Unified Protector shows that these two capabilities can complement each other. This provides cyber SEAD tools commanders can use as and when required.

From a NATO perspective, several issues must be tackled if cyber warfare is to play a meaningful role in SEAD. Representatives from the alliance's Joint Airpower Competence Centre (JAPCC) told the author that responsibility for performing such tasks must be addressed: "The difficulty NATO faces is the multinational aspect." Cyber warfare capabilities are owned by partner nations and are not NATO-wide capability per se. This creates opportunities for the alliance to codify and formalise cyber warfare SEAD doctrines. This could take the form of common tactics, techniques and procedures, the JAPCC representatives continue.

Key to this is ensuring all air personnel are 'cyber minded': "Cyber is not well understood by all personnel. We need to make sure that our people understand the concept." Electronic warfare is familiar to air forces and well understood. An understanding of cyber and electronic warfare synergies, increasingly seen through the CEMA prism is paramount. This will unlock cyber's SEAD potential. Air campaign planners will need to understand cyber effects and that these are likely to be localised and time limited: Specific nodes in an IADS maybe targeted by a cyberattack, but the enemy may see the attack and take remedial action. An anti-radar missile attack against a radar may take that system out of the fight either permanently or for a prolonged period. A cyberattack might be quicker to recover from. Therefore, cyber effects and their characteristics must be considered not only in battle but during the planning process.

Cyberattack is part and parcel of contemporary SEAD capabilities and its importance is certain to increase. Electronic and kinetic warfare have hitherto been the two capabilities available to commanders when prosecuting SEAD. Cyber offers a host of additional capabilities. The UK has shown it is prepared to exploit these capabilities to the full, as have the US and Israel. Other NATO and allied nations will do the same. ■



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Magnum Force in the Anti-Radar Game

Doug Richardson

An anti-radiation missile (ARM) is a missile designed to detect and home in on an enemy radio emission source. Typically, these are designed for use against an enemy radar, although jammers and even radios used for communications can also be targeted in this manner.

When grey-haired missile engineers meet for drinks in the UK town of Stevenage, the home base of MBDA UK, one of the stories that they reminisce over is likely to be what a fictional detective such as Sherlock Holmes or Philip Marlow might have described as "The Tale of the Terrified Typist". Like all legends, it has probably been embellished with each retelling, but the original version – as told to this writer soon after the event that gave rise to it – was as follows:

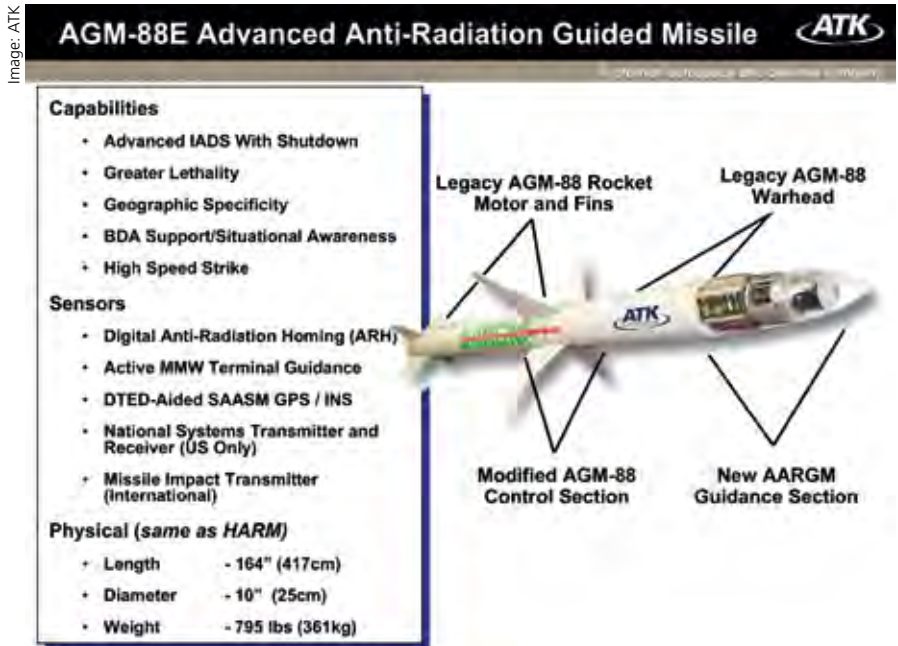
Early in 1991, the company (which was then BAe Dynamics) had an important package that had to be delivered to the UK Royal Air Force (RAF) transport base at Brize Norton in Wiltshire, from which a waiting aircraft would rush it to the Gulf, where the war to liberate Kuwait was about to begin. The package in question was so highly-classified that it had to be hand-delivered, a task that was entrusted to one of the company's secretaries.

Lady and package were bundled into a waiting police car, which transported them at high speed to the county boundary, where another police car from the next county's police force was waiting to take over the task. This process was repeated from county to county until lady and package arrived at the waiting aircraft after a journey of around 160 km that had taken only 70 minutes. The police drivers probably enjoyed their chance to drive 'flat out', and the secretary's nervous system is reported to have made a full recovery.

Once safely at its destination, the mysterious package – described to the writer simply as 'hardware' – was a key element in preparing the UK's Royal Air Force to take BAE's then-new ALARM (Air-launched Anti-Radar Missile) to war. We can spec-

Author

Following an earlier career in engineering, **Doug Richardson** is a defence journalist specialising in topics such as aircraft, missiles, and military electronics.



The AGM-88E version of HARM combines existing hardware with a modified control section and an all-new seeker.

ulate that it might have been needed to programme the missile's seeker with freshly-prepared threat-emitter details that matched Iraq's heterogeneous mixture of old and new air-defence hardware purchased from east and west.

In practice, the most widely used anti-radiation missile (ARM) during the 1991 Gulf War against Iraq was the AGM-88 High Speed Anti-Radiation Missile (HARM). Developed by Texas Instruments as a replacement for the earlier AGM-45 SHRIKE and AGM-78 Standard ARM, the AGM-88 started life as a USN programme, so was carried by the A-6E, A-7, F/A-18A/B, and EA-6B. The USAF adopted HARM, initially fielding it on F-4G WILD WEASEL aircraft, then later on specialised F-16s that had been equipped with the HARM TARGETING SYSTEM (HTS), a pod-mounted system used to detect and target hostile radar systems instead of relying on the missile's built-in capability.

Harm weighs 361 kg and carries a 66 kg warhead. It has a maximum speed of Mach 2.9, and a maximum range of 80 km when

launched from medium altitude or 25 km from low altitude. Production missiles are manufactured by Raytheon, which had purchased the defence business of Texas Instruments. Initial operating capability was achieved in 1983, and the first combat launches were made against Libyan targets in 1986.

The AARGM Missile

In 2005, the US DoD and the Italian Ministry of Defence signed a Memorandum of Agreement on the joint development of the AGM-88E ADVANCED ANTIRADIATION GUIDED MISSILE (AARGM). This would fit the missile with a new seeker with a wider field-of-view and increased frequency range, an additional active W-band millimetre-wave seeker able to cope with non-emitting targets, including those that had shut down, a GPS subsystem that would allow engagement and avoidance zones to be specified, and an Integrated Broadcast Service Receiver (IBS-R) unit able to transmit real-time images of the target.

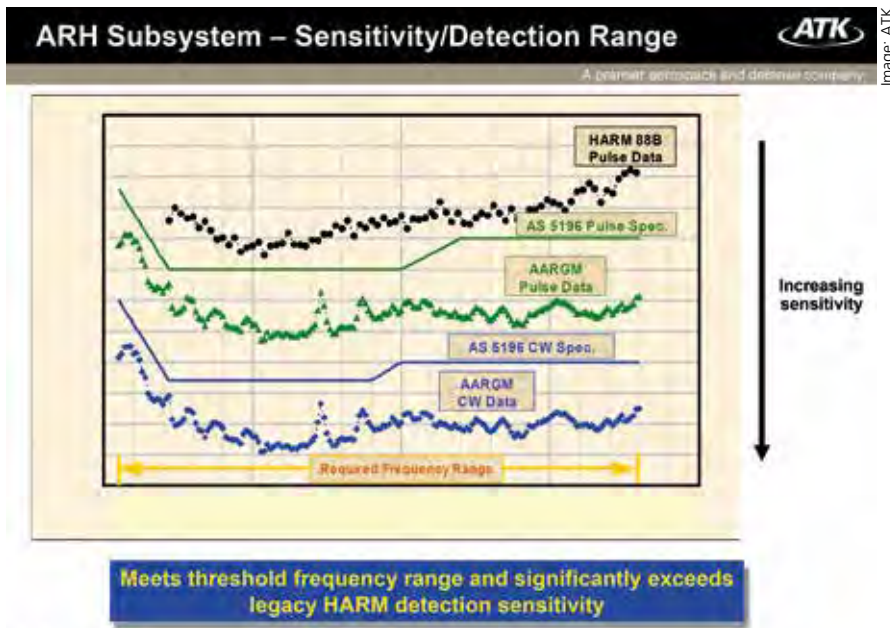


Image: ATK

had a single motor that had separate solid propellant boost and sustain charges, both ignited at the same time and both discharging combustion products through the same chamber and nozzle. The sustain thrust was [used] to maintain speed for the climb to operating altitude."

ALARM was used operationally by the UK in the 1991 and 2003 Gulf Wars, and in the NATO campaign against the former Yugoslavia. During the latter campaign, it is reported to have destroyed an important Serbian air-defence radar with a single shot – a target that had survived close to 100 HARM attacks.

Although the original ALARM seeker may have been compromised when an apparently near-intact missile was recovered by the Yugoslavian authorities in 1999, an improved seeker was subsequently fielded as part of a mid-life update intended to address the increasing sophistication of threat radars and anti-ARM countermeasures.

ALARM was withdrawn from Royal Air Force service at the end of 2013, leaving the UK without an operational ARM. Although some unofficial reports have suggested that the hardware is still in storage, the weapon has never been integrated on the EUROFIGHTER TYPHOON. The missile is still operational with the Royal Saudi Air Force, which has used it against Houthi targets during the current conflict in Yemen. When the METEOR BVR missile was still in development, MBDA studied a possible ARM version that would have combined the high speed of the air-to-air weapon with a combination of passive anti-radar homing

This diagram compares the frequency coverage and sensitivity of the AARGM seeker with those of the earlier AGM-88B.

Initial Operational Test and Evaluation (IOT&E) of the AARGM took place in the spring of 2012, and was followed by the authorisation of Full-Rate Production (FRP) later that year, a task handled by Orbital ATK. AARGM entered service with the US Navy and Marine Corps, and was adopted by Italy and Germany, but Raytheon developed a second improved variant known as the AGM-88F HCSM (HARM CONTROL SECTION MODIFICATION) which was adopted by the USAF.

The latest HARM variant is Orbital ATK's AGM-88G AARGM-ER. This teams the guidance system and warhead of the AGM-88E with a new airframe that lacks the mid-body cruciform wings used by earlier versions, but has a more powerful propulsion system of increased diameter that provides greater speed and range. AARGM-ER started life in 1998 as a USN programme, but soon attracted USAF interest.

Like most ARMs, HARM only poses a direct threat to hostile radars when it is in flight. In order to allow the ingress of a strike force, a series of launches must be made in order to keep threat radars silent. This tactic results in a high expenditure of missiles. During the 1991 Gulf War, the US fired more than 2,000 HARM rounds, and would fire a further 480 during the 2003 Gulf War.

The ALARM Missile

When developing its ALARM missile, the UK opted for a relatively small weapon weighing only 268 kg that could be carried to supplement rather than partially replace

an aircraft's ordnance load. In addition to allowing a traditional direct-fire mode, the BAe (now MBDA) design team also provided a novel loiter mode in which the missile would climb to an altitude of around 40,00ft, then deploy a tail-mounted parachute. If it detected a newly-activated threat radar, the missile would release the parachute, then fly a diving attack.

Many sources claim that the missile reignites its rocket motor and executes a powered dive. Although widely reported, this is not correct, MBDA tells ES&D. "ALARM



Photo: ATK

Features of the AARGM-ER include long fuselage strakes, and the increased diameter needed to house a more powerful rocket motor. The fuselage incorporates a coating intended to protect the interior from the heating effects created by the missile's speed.

Photo: RAF



Seen here on a TORNADO of the UK Royal Air Force, the MBDA ALARM missile was phased out in 2013. It now serves only on the TORNADO aircraft operated by the Royal Saudi Air Force.

and a millimetric-wave seeker. However, the company decided to focus its efforts on the air-to-air configuration, and seems to have shelved the idea of an ARM variant. In 2012, India's DRDO began development of the RUDRAM-1 ARM, and the first flight test took place on 9 October 2020. Conducted off the Odisha coast, this test used a Sukhoi Su-30 as the launch aircraft, but the missile was designed to be compatible with the MIRAGE-2000, LCA TEJAS, LCA Mk 2, and JAGUAR. RUDRAM-1 is reported to be 5.5 m long, 140 kg in weight, and to have a range of 100-250 km.

Taiwan's TC-2A is an ARM variant of the Chung Shan Institute of Science and Technology's T'EN CHIEN-2A BVRAAM missile. Flight tests started in the mid-1990s, and the weapon arms the locally-developed CHING KUO fighter. Maximum range is reported to be 100 km. Brazil began development of an ARM in 1997. Highly classified at first, the programme was handled by Brazil's DCTA (Aerospace Technology and Science Department) and Mectron (now SIATT). Brazil's Institute for Advanced Studies developed the missile's fibre optic gyroscope

(FOG) module, while Opto Eletronica tackled the proximity fuse. Attempts to procure hardware needed to create the passive seeker were blocked by the USA in 1999, so DCTA embarked on the development of an all-indigenous seeker.

In 2008, the Brazilian Air Force publicly displayed the resulting MAR-1 during an open day, and the Brazilian government approved the sale of 100 MAR-1 missiles to Pakistan. By 2013, Mectron was reported to have delivered training rounds, equipment for mission planning, logistics and support, and to have integrated the MAR-1 with Pakistani MIRAGE III/V fighters. SIAT no longer lists the MAR-1 as an active programme, so deliveries to the Brazilian and Pakistani air forces have presumably been completed.

Russian Weapons

Russia offers three basic types of ARM for export, each available in several variants. The Kh-25MP and Kh-25MPU are the current versions of the Kh-27 (AS-12 KEGLER). Weighing 310 kg and 320 kg respectively at launch, they have a maximum range of 40 km, and carry a 90.6 kg blast/fragmentation warhead. Two patterns of seeker can be used, depending on the target to be engaged.

The -25MP and -25MPU were followed into service by the Kh-58 series (AS-11'Kilter') third-generation ARMs. The Kh-58E is the basic export model, a 650 kg weapon with a range of 120 km for a high-altitude launch or 36 km at low altitude. It can be fitted with any one of five alternative seekers according to the type of radar to be targeted. Fielded in the early 1990s, the Kh-58U introduced modified tail fins and an improved rocket motor that doubled its range.

The Kh-58UShKE incorporates folding aerodynamic surfaces that make it compatible with internal carriage in an aircraft weapons bay fitted with UVKU-50 type launchers. Its guidance system teams a passive broadband seeker and a strapdown inertial navigation system. The Russians classify the seeker as operating in the "combined A/A/B/B/C frequency band". These band designations do not match those used in the West, so seem to be a scheme used only in Russia. However, another statement by Rosoboronexport gives the seeker's operating range as being against pulse emission mode emitters in the 1.2-11 GHz frequency range.

The Kh-31P is a 600 kg-class ramjet-powered weapon with a missile cruising speed of 1,000 m/sec, a maximum range of 110 km, and an 87 kg warhead. It uses three optional seeker heads designated L-111, L-112,

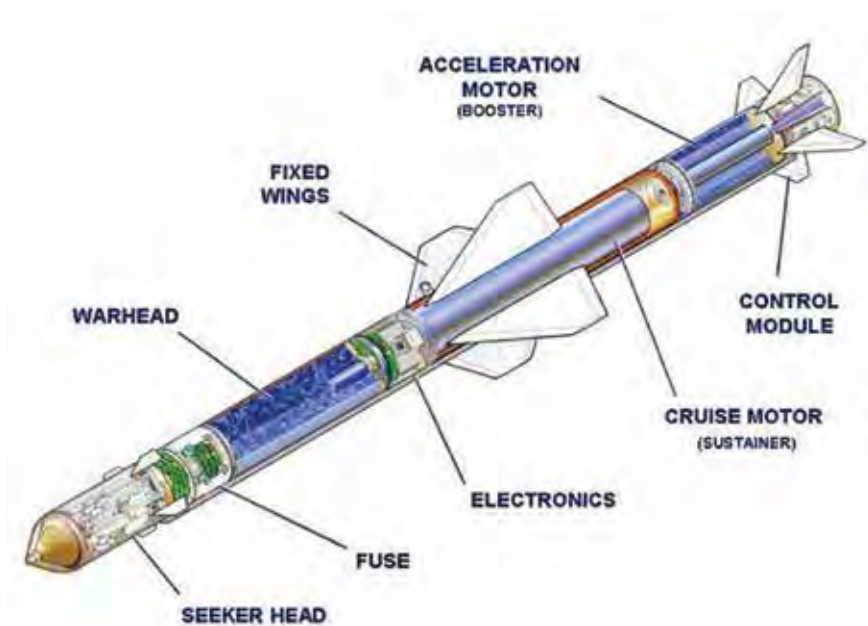


Image: Brazilian AF

Internal configuration of Brazil's MAR-1 missile. The US Government refused to supply a seeker for the weapon, a decision that triggered the development of a local equivalent.

and L-113. According to Rosoboronexport, these operate in the frequency bands used by the continuous-wave and pulsed radars of surface-to-air missile and anti-aircraft artillery systems.

Development of the Kh-31PK was completed in the late 1990s, but the project remained classified until 2006. This version retains the existing powerplant and control system, but used a improved version of the seekers, a proximity fuse is designed to be effective against antennas mounted 4-15 m above the ground, and a warhead of increased lethality. An improved seeker-cooling subsystem allows the missile to be carried on missions lasting up to four hours or more.

Production of the Kh-31PD started in 2012. It weighs 715 kg, has a range of up to 250 km and carries a 110 kg warhead. Its guidance system consists of what Rosoboronexport describes as a "wide waveband range passive radio homing head" plus an inertial system. Prior to launch it can be locked onto targets up to 15 degrees from the aircraft's heading, and after launch can turn up to 30 degrees from its initial flight path.

Chinese Developments

China's Hongdu Aviation Industry Corporation manufactures the Russian Kh-31P under the local designation YJ-91. The CATIC LD-10 is a more recent Chinese ARM programme, and is based on the PL-12 medium-range air-to-air missile. The active-radar seeker of the latter has been replaced by a passive-homing unit. Pakistan ordered the missile in 2011, and received an initial batch in 2016.

The CM-102 supersonic ARM was shown for the first time at Airshow China 2014. Developed by CASIC and based on the PL-16A long-range air-to-air missile, it has maximum range of 100 km and carries an 80 kg warhead. The seeker covers the full range of frequencies from 2-18GHz. The CM-103 is even larger, and is reported to be able to deliver a 388 kg warhead over ranges of up to 100 km.

Having reached the final paragraphs of this article, the reader may still be trying to understand the relevance of its title. They may already be aware of the NATO radio calls "FOX TWO" and "FOX THREE" used to announce the launch of infrared-guided and AMRAAM-class missile. The equivalent for a HARM launch is "MAGNUM", a word which if heard in a radio transmission can sometimes be enough to cause enemy radars to cease emitting. In today's anti-radar game, the threat of an ARM launch can prove as combat-effective as having a missile en route. ■



Photo: DRDO

At the time of this separation test, India's RUDRAM-1 missile was known as the New Generation Anti-Radiation Missile (NGARM).



Photo: Rosoboronexport

Folding aerodynamic surfaces allow Russia's Kh-58UShKE to be stored in the internal weapons bay of fighters such as the Su-57.



Photo: KnAAPO

A Russian Su-30MK launches a Kh-31P missile. After booster burnout, the missile will transition to ramjet-powered flight.

Attritable Aircraft

Sidney E. Dean

Armed forces on both sides of the Atlantic – and beyond – plan to add attritable aircraft to their fleets. “Attritable” is a reference to attrition warfare, and should not be equated with “disposable.” Rather, armed forces are seeking to acquire sophisticated unmanned aircraft which can be deployed numerous times, and preferably never be shot down.

By increasing the number of combat aircraft in the fleet, it becomes possible to sustain losses while maintaining combat power. The loss of attritable aircraft is acceptable if it contributes sufficiently to a tactical or strategic objective. The primary consideration determining the acceptability of the loss is whether the operator or the adversary gains the greater advantage through the exchange. For example, the loss of a highly sophisticated Unmanned Aerial System (UAS) might be considered an acceptable price if the mission eliminates an enemy air-defence node, thereby enabling follow-on forces to inflict significant damage to the enemy.

To be considered “attritable”, however, the planes must be produced at considerably lower cost than manned aircraft, and in sufficient numbers to ensure a continued operational capability after the loss of several units. A September 2020 paper by the Mitchell Institute (US Air Force Association) predicted costs between US\$2M and US\$20M per aircraft, depending on sophistication and capabilities. The same study estimated that manufacturing an individual UAS might take weeks, rather than the 18 months required for a manned combat aircraft, making it easy to scale up production on short notice.

While attritable aircraft are by definition unmanned, the term is not synonymous with UAS. Some highly sophisticated unmanned aircraft – including large, high-performance combat aircraft such as BAE’s TARANIS concept – will be too expensive and too capable to be classified as attritable; with exception of the human crew, the loss of such expensive high-performance planes would be every bit as damaging as the loss of a manned aircraft. On the other hand, the majority of currently operational UASs – while expendable – lack the sophistication and operational capability demanded of the aircraft being designed for the “attritable” category.

Credit: AFRL



Artist's concept of a SKYBORG low-cost UCAV

Photo: U.S. Air Force



The SKYBORG autonomous core system launched aboard a KRATOS UTAP-22 tactical unmanned vehicle at Tyndall AFB, Florida in April 2021

Capabilities and Operational Concept

Highly advanced artificial intelligence (AI) is a prerequisite for fielding attritable aircraft. Command and control will include a combination of autonomous operations and remote control, either from a ground station or from a manned aircraft (Manned-unManned Teaming or MuMT). Experiments conducted by

USAF’s Air Force research Laboratory (AFRL) concluded that a single human can safely control up to seven UAS if these are equipped with adequate AI. The capabilities profile of the objective aircraft will be similar to that of manned aircraft, which classifies them as Unmanned Combat Air Vehicles or UCAVs. In order to keep up with manned combat aircraft, they will be equipped with jet engines. Most designs feature low

observable/signature reduction attributes to enhance tactical advantage and survivability. The mission profile will be geared toward sophisticated applications including ISR (Intelligence, Surveillance and Reconnaissance), strike, and electronic warfare (EW). They will most likely be flown in direct support of manned aircraft, acting as force multipliers. The primary impetus for developing attritable aircraft is in fact the likelihood that sophisticated opponents will have powerful Integrated Air Defence Systems (IADS) consisting of multiple layers of sensors, ground based interceptors and interceptor aircraft. Attritable aircraft will increase the number of offensive platforms, enhancing offensive capability while simultaneously taxing the enemy's IADS. These aircraft might conduct particularly high-risk segments of a mission, such as suppressing or destroying enemy air defences, temporarily blinding them via EW, or drawing enemy air-defence fire to reveal the location of opposing force launchers. In a similar vein, UAS can detect enemy aircraft or lure them into kill zones. Several nations have dubbed their fixed-wing combat MuMT projects as "LOYAL WINGMAN" programmes.

USAF SKYBORG

The United States Air Force (USAF) LOYAL WINGMAN programme has been redesignated as SKYBORG. USAF awarded prototype development contracts to several firms in 2020. Payload options will include air-to-ground weapons, electronic warfare suites, communications relays, and a variety of sensors. These UCAVs will also be able to carry and deploy smaller UASs as reconnaissance assets or as loitering munitions. USAF plans to fly the first prototype in 2023. Like other LOYAL WINGMAN concepts, SKYBORG is primarily intended to fly joint missions together with manned aircraft, including the F-22, F-35, or future manned combat aircraft models. The crew of the manned plane would most likely maintain operational control over the UAS, especially as the flight approaches its objective. This control would take the form of issuing commands and directives (including weapons release), with the UAS' AI independently executing the commands and retaining control over flight manoeuvres. Missions could include Suppression of Enemy Air Defence (SEAD) or destruction of other enemy targets. Other applications could include electronic warfare, triggering enemy air defences which would then be targeted by the manned aircraft,



Photo: AFRL

The XQ-58A VALKYRIE demonstrates the separation of the ALTIUS-600 small UAS in a test at the US Army Yuma Proving Ground test range in March 2021. This test was the first time the weapon's bay doors have been opened in flight.



Credit: AFRL

A VALKYRIE prototype utilising Rocket-Assisted Take-Off (RATO) to operate from short or improvised runways.



Photo: BAE Systems

Artist's rendering of BAE Systems' SKYBORG solution

Photo: GA-ASI



General Atomics Aeronautical Systems, Inc. (GA-ASI) conducted captive carry SPARROWHAWK Small Unmanned Aircraft Systems (sUAS) flight demonstrations in September 2020. The SPARROWHAWK aircraft is designed as an airborne launch and recovery demonstrator aircraft tailored to fit GA-ASI platforms, and is focused on Advanced Battle Management System’s technologies. It or similar small UAVs could be carried as payload aboard attritable aircraft.

Photo: U.S. Air Force



A US Air Force F-22 RAPTOR and F-35A LIGHTNING II fly in formation with the XQ-58A VALKYRIE low-cost unmanned aerial vehicle over the US Army Yuma Proving Ground testing range during a series of tests in December 2020. This integrated test follows a series of gateway ONE ground tests that began during the inaugural Department of the Air Force on-ramp last year in December.

or detecting ground targets for manned aircraft. In the latter role, sending the unmanned wingman into the enemy air defence zone would permit manned aircraft to remain at a safer distance, and fire stand-off weapons at the detected targets.

According to Douglas Meador, deputy programme manager of the AFRL’s Low-Cost Attributable Aircraft Technology programme, the term “LOYAL WINGMAN” can be misleading. “It gives the impression these aircraft are going to be flying close together [but] in many concepts ...

these aircraft won’t be in visual range of each other,” Meador told Air Force Magazine in September 2020.

Operational concepts and requirements are still being refined. The Air Force Warfighting Integration Capability study group (AFWIC) has considered the feasibility of establishing five to ten squadrons of low cost attritable aircraft, according to Colonel Frederick Haley, deputy director of AFWIC’s futures and concepts division. An alternative under consideration would be integrating the UAS into F-35 squadrons, with two unmanned aircraft per manned plane, Haley told Air Force Magazine.

BAE Systems

BAE Systems was awarded a US\$400M contract in October 2020, somewhat later than other firms, to develop a UCAV prototype. Drawing on two decades of autonomous system development, BAE announced that it would equip its prototype with in-house mission management and control systems, sensors and payloads.

Boeing

Boeing has already contracted with the Royal Australian Air Force (RAAF) to develop that service’s LOYAL WINGMAN system, also known as the Airpower Teaming System or ATS. While the aircraft resembles the MQ-25 autonomous UAS which Boeing is developing as a carrier-based tanker for the US Navy, the firm describes the RAAF LOYAL WINGMAN as a “clean-sheet” design. The ATS is currently undergoing flight tests in Australia. Current RAAF planning calls for deploying the ATS for ISR and target acquisition.

Boeing has announced that it will base its SKYBORG prototype on the 11.7-metre long ATS. Performance characteristics include a 2,000 nm range and “fighter-like” manoeuvrability. A core feature is the 2.6-metre long modular nosecone, which can be adapted to various sensor payloads. The nosecone can be exchanged quickly, permitting preconfigured payloads to be kept ready at operational airfields. Unofficial estimates of the unit cost place the ATS in the competitive US\$2M to US\$3M range.

General Atomics

General Atomics – Aeronautical Systems Inc. (GA-ASI) is using two of its remotely piloted AVENGER UAS as testbeds for

SKYBORG technology and concepts. The AVENGERs are being provided with upgraded datalinks and the core SKYBORG System Design Agent (SDA) software which will enable manned aircraft rather than a ground station to control the UAS. The jet-powered AVENGER has a 20-hour flight endurance and a 15,000-metre service ceiling. GA-ASI states that it can be configured to carry air-to-ground weapons as well as small UAS (sUAS) as payload. These sUAS could be released at standoff range to conduct ISR and targeting for the larger unmanned aircraft. The experimental flights will take place through 2022.

Kratos

Kratos is basing its submission on the XQ-58A VALKYRIE UAS, which USAF has been testing since before the inception of the SKYBORG programme. The 9.3-metre long VALKYRIE's performance features include a cruise speed of .72 Mach, a 3,000 nm range, and a 20,000-metre surface ceiling. The internal payload bay



Photo: Airbus

As a core element of FCAS, the Next Generation Weapon System (NGWS) will rely on manned/unmanned teaming of fighter aircraft and so-called Remote Carriers.

can carry a 270 kg payload; the same payload can be carried externally under the wings. On 26 March, a XQ-58A released a multi-purpose 3.5 kg ALTIUS 600 sUAS, demonstrating the capacity

to operationally deploy individual or multiple (swarming) drones from the UCAV. The VALKYRIE has also been deployed as a tactical communications link together with mixed flights consisting of F-22s and F-35s; during these tests the UAS permitted the two manned aircraft types, whose data systems are not directly compatible, to communicate.

Like several other UCAS models, the VALKYRIE is highly modular. According to Kratos, most major elements of the plane, including the nose, the wings and the wings' leading edges can be exchanged to meet individual mission requirements. In 2019, Kratos estimated unit costs of US\$2M per VALKYRIE UAS, or roughly twice as much as a cruise missile. This estimate was based on a procurement contract for 100 units. The price per plane does not reflect the cost of sensors or other payloads.



Photo: Airbus

Artist's Concept of the Future Combat Aircraft System encompassing manned aircraft and unmanned Remote Carriers controlled via satellite link



Photo: Airbus

Remote Carrier UAVs of the Future Combat Aircraft System

SKYBORG AI

While the UAS fuselage and payload packages will be critical to mission performance, the true key to success lies with the SKYBORG AI system being developed by the AFRL. The software suite which will enable autonomous flight as well as flawless response to external input is formally designated as the SKYBORG Autonomy Core System or ACS. The first ACS flight test was performed on 5 May 2021. For this test, the software was loaded aboard a Kratos UTAP-22 MAKO, a 6-metre long UCAV previously developed for LOYAL WINGMAN applications. The test flight lasted 130 minutes and was deemed a success. The accompanying USAF press release stated that "the ACS demon-

Credit: Airbus



Networked flight including manned EUROFIGHTER and NGF fighters and unmanned Remote Carriers

Photo: UK MoD



Artist's concept of an RAF MOSQUITO LOYAL WINGMAN

Credit: UK MoD



Artist's concept of manned-unmanned combat aircraft teaming

Credit: Boeing



Boeing developed the Royal Australian Air Force's LOYAL WINGMAN prototype.

strated basic aviation capabilities and responded to navigational commands, while reacting to geo-fences, adhering to aircraft flight envelopes, and demonstrating coordinated manoeuvring."

The 5 May flight was designated as Milestone 1 of the Autonomous Attributable Aircraft Experimentation (AAAx) programme. "We're extremely excited for the successful flight of an early version of the 'brain' of the SKYBORG system. It is the first step in a marathon of progressive growth for SKYBORG technology," said SKYBORG Programme Executive Officer (PEO) Brigadier General Dale White. Milestone 1 was the first in a series of ACS experiments planned over the next several months. The AFRL plans to demonstrate direct manned and unmanned teaming between aircraft and multiple ACS-controlled unmanned aircraft during these tests.

European Programmes

Comparable programmes are being pursued in Europe.

RAF LOYAL WINGMAN

The British Royal Air Force (RAF) LOYAL WINGMAN programme is also known as Project MOSQUITO. This project devolved out of the RAF's overarching Lightweight Affordable Novel Combat Aircraft (LANCA) concept initiated in 2015. LANCA sought to enhance combat mass and force resilience by developing UCAVs capable of MuMT or autonomous/unmanned swarm operations.

A phase 2 Project MOSQUITO contract was awarded in April to an international group including Spirit AeroSystems Belfast (airframe and lead contractor), Northrop Grumman UK (AI, networking, human-machine interface), and Intrepid Minds (avionics and power). The attritable MOSQUITO UCAV will be deployed alongside the RAF's F-35, TYPHOON and next-generation TEMPEST manned fighters to enhance protection, survivability and information advantage to aircrews. According to the British MoD, the lightweight, composite-hull UCAV's internal payload bay will accommodate air-to-ground and air-to-air weapons; the UCAV will be able to engage aerial targets including enemy combat aircraft and air-to-air missiles. Full-scale prototype flight is planned for 2023.

FCAS

The Franco-German Future Combat Air System (FCAS) being developed by Air-

bus and Dassault will include the manned Next Generation Fighter (NGF) as well as UCAVs designated as Remote Carriers (RC). NGF and UCAVs will be fully networked, and will jointly constitute the Next Generation Weapon System (NGWS). The RC will be produced in various size classes, from expendable air vehicles weighing only a few hundred kilos, to more sophisticated LOYAL WINGMAN aircraft weighing several tons. Modular payloads will support missions ranging from ISR and target acquisition to EW strike, kinetic strike, and air-to-air combat. Operational models include swarm attacks by RC aircraft, including flights involving various types of RC.

Unlike USAF's SKYBORG programme, which is developing UCAVs to join the existing air fleet, FCAS is being developed from the start as a unified system encompassing manned and unmanned elements. While this should facilitate the seamless integration of NGF and RCs, it also means that the full system will be fielded later than the US or British attritable UCAVs. According to Airbus, the cur-



Photo: Boeing

Artists' concept of the Boeing ATX operating with a manned fighter

rent planning calls for introducing MuMT between upgraded existing fighters such as the Eurofighter LTE and first-genera-

tion RCs in the early 2030s. The full FCAS vision – with the NGWS as its core – is expected to be operational by 2040. ■

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Finally, a MiG-21 Replacement

An Update on the Croatian Air Force

Alan Warnes

On 28 May, Croatia's Prime Minister Andrej Plenković announced his government had selected to purchase 12 French Dassault RAFALE fighters in a deal worth €999M. The decision brings an end to a long-running saga that has seen the GRIPEN and ex-Israel Air Force F-16 purchases both selected since 2015 then subsequently cancelled.

Croatia is one of Europe's top tourist destinations, and for many the clear waters and idyllic coastline portray a peaceful tranquil country. Thirty years ago, it was not like that. A civil war in the wake of the Yugoslavia breakup saw thousands killed and who can ever forget the images of Dubrovnik being battered by Serbian mortars. Now the country is thriving particularly along the Dalmatian coastline. For its air force, the past has taken longer to shrug off, with the elderly Cold War MiG-21s still trying to protect NATO's integrated air defence system. Undeniably, the stigma of still operating these fighters to support NATO has cast a shadow of doubt over the CAF's capabilities, but they are all set to change. In selecting the RAFALE F3R – the latest standard of the Dassault fighter – the CAF will be catapulted into a brand new era. The Croatian Prime Minister went on to say, "We get a highly rated and capable fighter which means Croatia will have the most advanced fighter aircraft in Europe." Dassault issued a press release, saying, "As well as the 12 ex-French Air force aircraft, the contract will include fleet support and training." The company added, "Along with our partners we are delighted with the choice of Croatia as a first-time user of a Dassault aircraft and the fifth Rafale export customer. "This latest success in a competition between European and U.S. aircraft confirms the technological and

Photo: Alan Warnes



The CAF is set to operate 12 ex French Air Force RAFALEs within the next two years or so.

operational superiority of the RAFALE, latest-generation, combat proven, multirole fighter. It also reinforces the RAFALE's position in European air forces, making an active contribution to European defence sovereignty."

The RAFALE beat off competition from the Lockheed Martin F-16 Block 70/72, Saab JAS 39 GRIPEN, second-hand former Italian Eurofighter TYPHOONS, and second-hand Norwegian or Hellenic F-16s. Jumping from the Soviet-era MiG-21bis to an advanced fourth-generation jet will undeniably bring big hurdles. The CAF is jumping a generation, so will need to rapidly modernise everything that they are currently using, to operate the ex-French Air Force RAFALEs that will subsequently be upgraded to F3R standard.

All the old operational procedures and tactics will be swept out of the window when the RAFALE F3R arrives. With its extremely capable RBE2 active electronically scanned array (AESA) radar, very

impressive Spectre electronic warfare system and the latest beyond-visual-range air-to-air missiles (BVRAAM), the jet will be a master-class in multirole operations that brings a highly-capable sensor-fusion capability. One of the biggest challenges the CAF will face is to bring in new French infrastructure that such a modern fighter needs, and there will of course be a need to acquire a new lead in fighter trainer even if the French will initially train all the new pilots.

MiG-21s until 2024?

Right now, the CAF is flying four modernised single-seat MiG-21bisDs and a similar number of dual seat MiG-21UMD two-seat trainers with the 191 Eskadrila Lovačkih Aviona (ELA - 191st Fighter Aircraft Squadron). The unit based at Pleso Air Base is situated just outside the capital Zagreb and has 12 MiG-21s on strength, but the other four MiG-21bisDs are currently stored.

Author

Alan Warnes is a journalist specialising in military aviation. For 12 years, he was the Editor of AirForces Monthly. He has also written several books, including two on the Pakistan Air Force (in 2008 and 2017), and most recently on 100 years of Aero Vodochody.

Of the 12 jets, the three surviving original MiG-21bis were acquired in 1993 from Kyrgyzstan, followed in 2003 by the four dual-seaters in 2003 and then five more MiG-21bis from Ukraine in 2013. In a deal signed during 2013, they were all modified by Ukraine's Odesa OAZ repair plant. Some issues stemming from problems integrating the new NATO/ICAO-compatible equipment meant that deliveries of the 12 old jets were delayed but all the aircraft had arrived by July 2015. A massive scandal erupted when it was discovered four of the five ex-Ukraine aircraft had arrived with forged documents. They were portrayed as ex-Algerian aircraft but actually came from the Bulgarian Air Force and were officially withdrawn from service and scrapped. The revelation led to the four aircraft being withdrawn from use and being placed into storage in 2017.

Training

Flying training is centralised at Zadar-Zemunik known as the 93rd Zrakoplovna Baza (Air Force Base) on Croatia's north-west coast. Screening is carried out on five Czech-built ZLIN 242Ls acquired in 2007/08, to measure the student's poten-



Photo: NATO Warnes

With the arrival of 12 RAFALES, the elderly MiG-21s will be retired.

tial to fly. As a student aviator, they will go through 50 hours of basic flying training, which is the responsibility of the 392nd Aircraft Squadron formerly known as Eskadriła Aviona (Fixed Wing squadron), flying the PILATUS PC-9s and ZLIN 242s. Today, there are 14 PC-9Ms still serving, but one of the five ZLINs was lost in a tragic accident that claimed the lives of both the instructor and the student on 7 May 2020. For helicopter training, there are eight Bell 206B JET RANGERS serving 393 Squadron.

The two-year training programme comprises around 200 flying hours that starts with basic training and goes through formation flying, night flying, instrumented rating and advanced training. The latter will include mountain ops in the nearby Mount Velebit where there is often some tricky flying to be had, operating with external loads and NVG (night vision google) training. Three of the Bell 206s are equipped with NVG-compatible instrument lighting. After graduation, the pilot has three options – the Mi-

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For helicopter training, Croatia operates eight Bell 206B JET RANGERS.

8MTV-1 at Split-Divulje, Mi-171 at Lucko or stay with the squadron and fly the OH-58D KIOWA WARRIOR.

A deal for 16 surplus US Army OH-58Ds was signed in November 2014, but a lack of funding for their overhaul and upgrade delayed the deal. Croatian Parliament finally formally gave the go-ahead for the procurement on 24 February 2016 and were supplied free-of-charge as Excess Defense Articles, with Croatia paying only for some additional modifications to the helicopters. All 16 were selected from examples acquired by the US Army under the Wartime Aircraft Replacement (WRA) programme. They are older model OH-58A airframes which were upgraded to OH-58D standard and redelivered back to the US Army after conversion between 2012 and 2015. Since then, they had each only logged between 100-600 flying hours before being offered to Croatia. All were delivered to the at Zadar-Zemunik in 2016. One was lost with both crew on 27 January 2020.

The helicopters are used for light attack, using HYDRA-70 rockets and the HELLFIRE. While they regularly fire the rockets, the prohibitive costs of the later, at around \$100,000 means the firing of the HELLFIRE is only simulated. The squadron reached initial operational capability in December 2017, and the unit's instructors started training pilots in 2018, with the first course graduating the following year.



The CAF has a big fire-fighting flight that includes a two-seat AT 802A FIREBOSS.

HIPs

Two units currently fly the sturdy Russian HIP. The 194th Multipurpose Helicopter Squadron at Zagreb-Lucko operates ten newer Mi-171Sh and around some of the 12 older Mi-8MTV-1 still operational, although there is a detachment at Zagreb-Lucko. The 395th Transport Helicopter Sqdn at Split-Divulje close to Split International Airport, fly the Mi-17-1VA, Mi-8MTV-1 and Mi-8PS11. As well as being used for tactical operations, the surviving Mi-8MTV-1 HIPs also fulfil a fire-fighting role, when they are fitted with Soko Flory fire-fighting buckets. There are currently four UH-60M BLACK HAWKS on order, which will be flown by the Croatian Special Forces.

Fire-Fighting Assets

During the dry hot summers, Croatia can be badly affected by wild fires and unlike the USA, Croatia believes in putting out the fires as quickly as possible. The last thing the government wants is images of fires wreaking havoc in a country that relies heavily on its tourists. As a result, it operates a fleet of fire-fighting fixed wing aircraft.

Pilots flying with the 855th Fire Fighting Squadron at Zadar-Zemunik are unlikely ever to leave fire-fighting, as the former squadron CO, Major Davor Turković, told the author, "there is no turning back".

If they can cope with that then they could end up flying one of the four Air Tractor AT 802A FireBosses and two amphibious AT 802F mounted-on floats. When the aircraft were acquired in late November 2007/ July 2008, a two-seat Fire Boss was not available, but when they were four years later, the CAF ordered one to shorten the length of time new pilots require to become operational. Alternatively, there are six bigger Bombardier 415s that can drop a bigger load for bigger fires. The fleet of smaller water-bombers allows the CAF to fight small fires and to get into locations like steep valleys, which the Bombardiers cannot access. Turkovic, a veteran of 15 seasons as a fire-fighter with thousands of water drops on the Bombardier 415 finished: "I want someone who will understand that fire-fighting is a lifestyle and not just a job. Someone who doesn't mind being away from the family during the summer, who cannot take holidays during the fire-fighting season and doesn't drink on the air base where they are on call all the time." That sums up the life of a fire-fighter, which with 12 aircraft is almost a quarter of the CAF's fleet, highlighting the importance of these aircraft.

What Next?

As the CAF moves to modernise its ageing air force with cutting edge RAFALES, questions will be asked as to whether they really needed such a sophisticated fighter, which costs between €60,000 - 80,000 per hour to operate. There will be a need for more simulation, to offload some of this expensive flying, which most European air forces now do. Along with the synthetics, there will also eventually be a need for a lead-in fighter trainer or at least the requirement to train on one. Whether that is a CAF asset or with a flying academy like the Italian Air Force/Leonardo International Flight Training School is unclear. The CAF has not operated a large transport aircraft since the Antonov An 32s were retired in 2013, and while they may not have a need right now there will come a time when they will. Airbus and Leonardo will undoubtedly be offering the C295 and C-27J, respectively. Longer term, there will also be a need to replace the Mi-8/17 HIPs which are becoming older and costlier to maintain due to the cost of Russian spare parts. All the HIPs are overhauled by ZTZ at Velika Gorica outside of Prague. The CAF is obviously taking its NATO responsibilities more seriously now, with the expected 2% GDP target now set to be reached. ■



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Airborne Radars

Keeping up-to-date, in the face of increasing demands for more accurate systems

Georg Mader

Larger airborne early warning and surveillance systems on multi-engine aircraft and helicopters have to meet increasing demands to locate ever smaller targets like periscopes or small UAVs. At the same time, some platforms are becoming increasingly more expensive to operate and are earmarked to be replaced, or at least life-extended through various modernisation programmes.

According to various market forecasts, the global military airborne radar market is expected to grow at a Compound Annual Growth Rate (CAGR) of 3.8 per cent to a value of US\$4.2Bn by 2029. The segment of airborne fire-control radars (on fighters) is expected to gain or cover ~50 per cent of that figure. Until the end of the decade, North America is predicted to dominate the sector with ~40 per cent, followed by the Asia-Pacific region (China, India, South Korea and Australia) and Europe, with shares of ~27 per cent and ~20 per cent respectively. In this segment, we meet all the “big players” like Lockheed Martin, Northrop Grumman, Raytheon and L3Harris Technologies (all US), Thales Group (France), IAI, ELTA and Elbit (all Israel), Leonardo SPA (Italy and UK), BAE Systems (UK), Hensoldt AG (Germany) or Saab AB (Sweden), but also Turkish Aselsan or – while mainly concentrated on its own forces - subsidiaries of Russia’s Rostec (like JSC Radar-MMS) or Chinese laboratories and manufacturers equipping KJ-500 and KJ-2000 under the roof of the state-run AVIC.

Photo: IIAF



An Italian IAI-built AEW&C G550

Photo: RAAF



The Boeing 737 WEDGETAIL

Wide Variety of Tasks

While rotating antennas on Airborne Early Warning & Control Aircraft (AEW&C) like the USAF- and NATO-operated E-3A AWACS (E3-D in UK) on vintage Boeing 707/320s have been around for decades.

Author

Georg Mader is a defence correspondent and freelance aerospace journalist based in Vienna, Austria, and a regular contributor to ESD.

These aircraft were recently accompanied – or even challenged - by emerging multi-mission surveillance systems mounted on much cheaper to operate business jet and commuter platforms. Like Saab’s GLOBAL EYE for the UAE Air Force and included in its Finnish HX-offer, its ERIEYE bar on various Embraer-145 twin-jets (as in Greece or Brazil) or fuselage-conformal systems preferred by IAI (as on the latest

Israeli ORON or G550-platforms for Italy). Altogether, their integrated sensor suite offers exceptional air defence and air battle-management capability, with accurate and reliable high-altitude long-range continuous 360° azimuthal surveillance of all airborne and maritime threats. The later AEW&C aircraft are equipped with the latest generation of Gallium Nitride (GaN) AESA-radar, integrated with other



Photo: Georg Mader

A NATO E-3A with Belgian escort

before launching. To the author, it has been confirmed by UAE AF officers that a 'healthy' separation distance and vigilant on-board fighter-control officers act as their 'last line of defence', that is, if their own fighters are operating in a Combat Air Patrol role at a realistically manageable distance for Quick Reaction Alert-readiness state. This would be the case for all US E-3s, Japanese 767-AWACS, or Australian E-737s, not least since their own escorts might not have sufficient range capability...

Developments, Replacement and Modernisation efforts

The oldest airborne radar system (and airframe) - which has pioneered this segment - is the original line-up of 18 Boeing E-3As (now reduced to 14), with the component directly supported by Belgium, Canada, the Czech Republic, Denmark, Germany, Greece, Hungary, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Turkey, and the US. They are built around a 9.1 m-diameter rotating radome that has a range of more than 400 km (which results in coverage of more than 500,000 km² of airspace) to look down, detect, identify, and track low-flying aircraft over land or water. Leonardo announced on 21 May, that it has been contracted by Boeing as the prime contractor for the NATO AEW&C programme-management agency to upgrade the first NATO E-3A test aircraft. The contract, which is to be completed by 2023, includes the installation of newly-developed hardware under a FLEP-programme and will be carried out at their Venice-Tessera plant in Italy. It was, however, not specified when the upgrade is planned to be rolled out to the remaining 13 NATO aircraft. NATO plans to spend US\$1Bn for a final life-extension of the aircraft, which would keep it flying until

Photo: Georg Mader

**Rollout of the Saab GLOBALEYE in the United Arab Emirates**

advanced ISR-sensor-systems. Furthermore, the mission sets are long-range air-and maritime-surveillance able to deliver situation awareness, electronic order of battle-management and generation, air defence C2, network-centric warfare operations or communications/relay node in information dissemination. For that, they also usually utilise IFF, SIGINT and sophisticated encrypted communication systems, to generate and disseminate an air and maritime situation picture.

siles, with (albeit claimed) ranges up to 400 km, such as the Chinese PL-21 or the Russian R-37M. This effort fits well with the fact that their Stealth fighters like the J-20 or Su-57 respectively, are designed to be low-observable in the frontal aspects in particular, in order to get close(r) to the enemy's high-prize assets

Prime Targets

Since – as is the case with tanker aircraft – being a critical, high-value force multiplier in any scenario, these normally highly expensive aircraft are also prime targets for opposing forces and need to maintain a certain distance from so-called hot air spaces. Subsequently and unsurprisingly, Russia, and also China are at the forefront – in line with their anti-access/area denial mantra – of developing and fielding ultra-long range air-to-air mis-



Photo: Saab

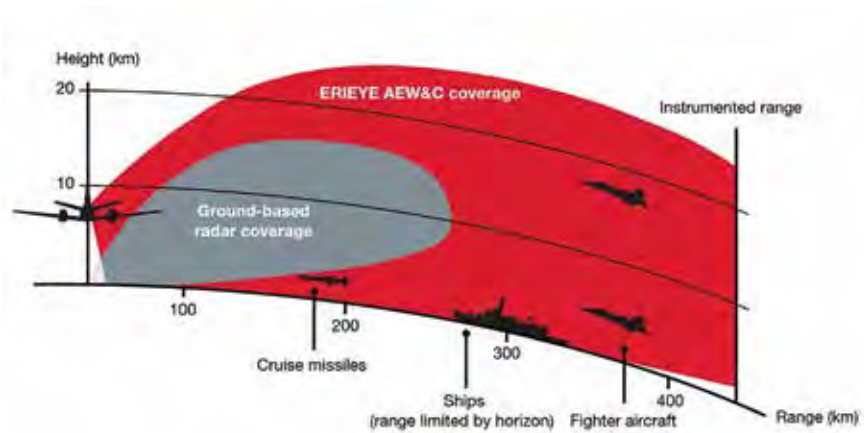
The Interior of the Saab GLOBALEYE

Graphic: Saab



Graphic rendition of Saab's GLOBALEYE

Graphic: Saab



A graphic illustrating the coverage of Saab's ERIEYE AEW&C aircraft

2035. Last June, a first indication of a distant replacement was mentioned, when a NATO official said that a replacement for the AWACS could include different combinations of systems in the air, on land, at sea, in space and in cyberspace. The aim is

for the solution to be ready by 2035, when the E-3 airframes need to be retired. Likely contenders would (again) be Boeing and Northrop Grumman and European Saab and/or Airbus – or any joint transatlantic solution.

Photo: Author



The KJ500s

An indication of where it might be stationed comes from the UK, where the RAF's E-3Ds, flown out of RAF Waddington by 8 Squadron, are due to be retired later this year and replaced by the E-7A WEDGETAIL with its fixed radar-bar from 2023 on. Boeing UK announced late last November that the first fuselage sections for the first two aircraft to be modified had been delivered to STS Aviation Services in Birmingham. The fleet of RAF Global Express-based Raytheon Sentinel R1 Airborne Stand-Off Radar (ASTOR) wide-area ground-surveillance aircraft have already been retired, and are likely to be replaced by either the unmanned General Atomics' PROTECTOR RG1 from about 2024, or partly by the Boeing E-737, also operated by the air forces of Australia, Turkey and South Korea. And in the US, Gen. Kenneth S. Wilsbach, head of the US Pacific Air Forces made the call this February for acquiring the E-7s to support, or later replace the USAF's ageing E-3A fleet.

In the meantime, it is worth noting the successful transfer of the UAE's AEW-component from two small Saab-340-based ERIEYE to (now five) top class Saab GLOBALEYE multi-mission surveillance platforms. Sweden's Saab has received the much-anticipated option now bearing fruit in the form of a follow-on order by the UAE (worth US\$1Bn) for two additional GLOBALEYE aircraft this January. It is an extension of a 2015 deal for three units, made up of Bombardier GLOBAL 6000 business-jets equipped with Saab's latest ERIEYE long-range radar and other surveillance sensors. The UAE's military received its first GLOBALEYE from the original deal in the spring of 2020, just as the COVID-19 crisis was just beginning to bite. In general, the GLOBAL 6000 VIP series are looking to continue to becoming popular platforms for intel-gathering and early radar-warning. A year ago, the German Government ditched plans to buy US Navy TRITON drones for SIGINT collection, choosing instead to install the requisite sensing equipment on similar manned jets. Also last year, Saab landed a secretive AEW&C deal worth SKr1.6Bn (US\$165M) for an undisclosed number of its turboprop Saab-2000 ERIEYE AEW&C aircraft. It could be a follow-on order for Pakistan.

Israel Aerospace Industry (IAI) is one of a select few companies which possesses all the necessary technology capabilities in-house which achieved a major breakthrough in AEW and Special Mission Aircraft, thanks to advanced sensor miniaturisation technology coupled with

Artificial Intelligence (AI) and machine learning software applications, allowing high-performance business jets to be used as Special Mission Aircraft. Last year, it received a US\$350M contract from what they named as "a major European country". Last December, the US State Department issued an approval for the FMS-sale of two G550 AEW/ISR to the Italian Government, with L3Harris at Greenville, Texas, acting as prime contractor and system installer. They are expected to resemble the SHAVITS operated by Israel. Australia has also ordered four L3Harris-modified versions, which will be known as the MC-55A PEREGRINE. ELTA's CAEW (Conformal Airborne Early Warning) aircraft are fitted with dual band AESA-radars, providing uncompromised 360° azimuthal coverage. IAI has also entered into cooperation agreements with Airbus and Embraer to develop and market additional AEW&C aircraft variants.

Furthermore, last December, the Indian MoD Defence Research and Development Organisation (DRDO) was allowed to convert six former Air India A320 family aircraft into advanced airborne-radar carriers



The Russian VKS A-50U

The Russian VKS A-50U

that are able to "peek deep inside China or Pakistan to alert the authorities". This alters plans from 2015 to acquire two brand new AWACS based on the much bigger Airbus A330 platform. The aircraft would be sent to France where the modifications would be carried out and the AWACS delivered to the IAF up to seven years from now. Currently, since 2009, the IAF operates three IL-76 based IAI PHALCON AWACS and two home-made Embraer

EMB-145-mounted NETRA airborne radars with limited ability. The NETRA – delivered after nearly two decades by DRDO in 2015 - has limitations in terms of vision and capability. Unlike the 360° capability of the PHALCON, the NETRA cannot see all around, as its radar has only 240° coverage. In contrast, its potential opponents in the Chinese PLAAF has nearly 20 airborne radars with 360° view, whereas Pakistan has eight such platforms.

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Photo: Georg Mader



The RAF's retired SENTINEL on a Bombardier G600

Photo: Georg Mader



A Hellenic Air Force EMBRAER 145 AEW&C

Photo: IAF



INDIA EMB-145 AEW&C

Photo: IAI



IAI's ORON conformal radar-platform

Radar-MMS from St. Petersburg is maybe the most prominent Russian designer, manufacturer and system integrator of avionics suites for airborne radar and monitoring equipment in AEW-, patrol- and special-mission aircraft. Since 2011, the Russian VKS has operated 16 Il-76/PS90-based BERIEV A-50U (NATO: MAIN-STAY) AEW&C aircraft, one – in the later version's distinctive dark-grey scheme - was just this May seen accompanying three Tu-22M3 BACKFIRE-C swing-wing bombers deployed to Khmeimim Air Base in Syria.

Helicopter AEW Systems

As a consequence of lessons learnt by the Royal Navy during the 1982 Falklands War when the lack of AEW coverage for the Task Force represented a major tactical handicap, essentially rendering its ships vulnerable to low-level Argentinian air-attack, the Westland AEW SEA KING AEW.2 and .5 and later the ASaC7 naval helicopter-based radar was developed and operated from both the INVINCIBLE class aircraft carriers and later the helicopter carrier HMS OCEAN. They carried the Thorn-EMI ARI 5980/3 SEARCHWATER and later SEARCHWATER 2000 radar, attached to the fuselage on a swivel arm and protected by an inflatable dome. The latter was capable of simultaneously tracking up to 400 targets, instead of 250 previously. The Spanish Armada fields the SH-3 SEA KING in the same role, operated from the JUAN CARLOS I. Meanwhile, since 2010, the Royal Navy has begun to replace these with the CROWSNEST system fitted to some of their MERLIN HM.2 fleet. It sailed on 1 May with the new carrier QUEEN ELIZABETH on a 26,000 mile deployment to the Indian and Pacific Oceans. The Italian Navy, from its aircraft carriers CAVOUR and GIUSEPPE GARIBALDI operates the EH-101AEW. The Russian-built KAMOV Ka-31 is deployed by the Indian Navy on the carrier INS VIKRAMADITYA and TALWAR class frigates and will be deployed on the new INS VIKRANT. The Russian Navy has two Ka-31R variants, at least one of which was deployed on their carrier ADMIRAL KUZNETSOV to the Mediterranean in 2016. It is fitted with the E-801M OKO (Eye) airborne electronic warfare radar that can track 20 targets simultaneously, detecting aircraft up to 150 km away and surface warships up to a range of 200 km. ■

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Taking Flight: Advances in Airborne Autonomy

Gerard Cowan

Autonomous Unmanned Aerial Vehicles (UAVs) are an increasingly crucial asset for militaries, undertaking essential missions even in the absence of communications. There has been a range of advances in recent years, as developers work to overcome a number of technical challenges.

UAVs may require autonomy for a number of reasons. In a recent paper for SIPRI, Justin Bronk, research fellow for airpower and technology at the Royal United Services Institute (RUSI), noted that if such systems are to make sense as an investment for state-on-state conflicts, they must be able to detect, classify, prioritise and engage targets according to pre-set mission tasks and rules of engagement, without real-time human control. The reason is clear: in a highly contested area, amid a high-intensity scenario, the data or satcom link could be jammed or disrupted.

The technological requirements of such capabilities have already been demonstrated at a range of levels. Indeed, it is unlikely that they would demand any level of advanced automation beyond those seen in other areas of aviation or other sectors, Bronk wrote. For example, the detection and subsequent destruction of enemy combat aircraft in a war 'is not something that requires subtle judgements in terms of international humanitarian law and estimates of proportionality or collateral damage', according to the paper.

JADO Battlespace

Advanced militaries are increasingly focused on a joint all-domain operations (JADO) or joint all-domain command and control (JADC2) battlespace, where

Photo: Northrop Grumman



Northrop Grumman's Battlefield Airborne Communications Node (BACN) gateway system is hosted on a high-altitude aircraft to provide persistent connectivity and operational support 24 hours a day, seven days a week as part of the BACN programme.

land, sea, air, space and cyber are more highly integrated than ever before. In this scenario, it will be essential that autonomous UAVs leverage enhanced interoperable networking capabilities, along with a common message standard that will enable the platforms to join Internet of Military Things (IoMT) operations.

This has been a focus for a number of providers; for example, Northrop Grumman is providing its gateway system capabilities on multiple legacy platforms, but is also preparing next-generation systems that will integrate communications and sensor systems more securely, according to Colin Phan, director of strategy at the company's Networked Information Solutions Division. Collaborative autonomy software will also be important in this environment, allowing for the effective management of autonomous fleets, where heterogeneous autonomous systems, legacy UAVs and manned systems will be required to operate together and interact in highly contested environments. Northrop Grumman's Distributed Autonomy/Re-

sponsive Control (DA/RC) system aims to drive such tactical interoperability across allied forces, according to Autonomous Systems Chief Strategist John Haun. The aim is to improve the ways in which humans and machines collaborate, Haun said, but "also allow machines to work better together, including systems from different service branches".

For developers of autonomous UAVs, it is vital to consider the current threat environment. Airspace that was once thought permissive is becoming increasingly contested, demanding survivable UAVs that provide a persistent, multirole capability.

Manufacturers are taking various approaches to delivering this capability. For example, Lockheed Martin Skunk Works – which has developed a range of UAVs and is currently working on a number of new projects, such as the Next Gen UAS and LongShot programmes – develops open architecture standards and works to enable integration and connectivity in a JADO or JADC2 environment.

Author

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This is viewed as a critical capability, notably for the US and its international allies to operate in the advanced threat environment. It is also important to consider interoperability with existing assets, with the Next Gen UAS functioning as an unmanned ISR system that enhances the capability of existing assets.

Technological Complexities

It is important to consider the practicalities of developing and operating such systems, not least on a cost level. One way to help ensure affordability is through utilising digital engineering, such as the deployment of "Digital Twins", according to Lockheed Martin. Such concepts aim to overcome a key challenge with such systems – balancing affordability with advanced capability. Digital engineering can replace siloed designs with a fully integrated digital backbone, in which the entire system is iteratively designed, with engineering, production, supply chain and other elements connected through a cohesive digital thread.



Photo: IAI

IAI's HERON family can fly in autonomous mode, though the aircraft are always monitored by human operators.

Operating UAVs autonomously is much more technologically complex than operating with a human in the aircraft, de-

manding additional safety features and machine redundancies. This is particularly challenging "as we are building artificial



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Photo: Aurora



Aurora's Modular Intercept Drone Avionics Set (MIDAS) is an AI-enabled autonomous solution with optical sensors and a customised payload designed to defeat multiple adversarial UAS.

intelligence and machine learning into an automated flying environment that is characteristically unforgiving", according to Mark Dillon, Director of Business Development at Aurora Flight Sciences, an autonomous aircraft systems specialist that is part of Boeing. The company is focused on autonomy and interoperability on a number of levels, including enhancing manned-unmanned teaming for the US Navy's MQ-25 programme, work that it is carrying out with Boeing. The MQ-25 is one example of the logistics potential

of autonomous UAVs, with the system set to operate from aircraft carriers to autonomously provide in-flight refuelling for aircraft.

Autonomy will be a key area of development across a wide variety of platforms looking forward, not just in terms of UAV missions, but also in counter-UAS applications. For example, Aurora participated in the US Department of Defense's technology demonstrator focused on Low Collateral Effects Interceptors (LCEI), through which the company

demonstrated the Modular Intercept Drone Avionics Set (MIDAS), an AI-enabled autonomous solution with optical sensors and a customised payload designed to defeat multiple adversarial UAS. The system is cued from ground radar and locks onto targets autonomously with its on-board sensor.

Challenges and Opportunities

Autonomous UAVs must prove their worth on a number of levels, the most basic of which is demonstrating their effectiveness when compared to manned systems. They must prove their ability to preserve manpower for operational functions, increase operational efficiency and reduce threats to human life. Additionally, the systems must complement manned systems effectively, among a range of other challenges, said Dan Bichman of the Malat division of Israel Aerospace Industries (IAI). IAI Malat produces the HERON family of military UAVs, which can fly in an autonomous mode, though is always monitored by a human operator.

There are likely to be a range of technological advances in the coming years aimed at supporting such objectives. For example, some industry experts expect to see developments in vertical take-off and landing (VTOL) capabilities for tactical missions at land and sea, along with wide-area surveillance using UAVs in these domains. Autonomous UAVs are also likely to increasingly supply logistics supply and support, Bichman said, adding that he expects to see the further development of "systems to analyse and distribute information in real-time across all levels".

There are a range of exploratory activities in the US Department of Defense and beyond related to the use of AI in airborne applications, including swarm operations, manned-unmanned teaming, and sensor data processing. Vern Boyle, Northrop Grumman's vice president for advanced processing solutions, also highlighted a number of interrelated disciplines, which will utilise similar technologies and will often need to be integrated with autonomous UAV solutions: these include cognitive electronic warfare (EW) and intelligence JADC2 applications.

"In the future, early adoption of artificial intelligence applications will most likely be in the areas of intelligence, surveillance, reconnaissance (ISR) data processing, in support of a variety of missions, including ISR in support of strike missions," Boyle added. ■



Photo: Lockheed Martin

Lockheed Martin Skunk Works is working on a number of new projects, including the Next Gen UAS, shown in this rendering.

A Different Option – Rediscovering Lightweight Combat Aircraft Solutions

David Saw

Air forces can be priced out of existence by the escalating cost of state-of-the-art combat aircraft which is why many air forces around the world are seeking for affordable combat aircraft solutions that can undertake a sizeable proportion of their mission requirements at an acceptable cost.

The modern first-line combat aircraft is a highly sophisticated and highly capable piece of equipment. Unsurprisingly, this comes at a significant procurement cost. These aircraft are expensive to acquire, expensive to operate and expensive to maintain. Then you have to factor in the cost of the weapons that a combat aircraft of this sophistication is going to employ. These systems are characterised by their advanced capabilities and application of high technology, and capability never comes cheap.

Over the years, there have been numerous efforts to fight cost escalation in combat aircraft and the results have been less than satisfactory. In generation after generation of combat aircraft, procurement cost has risen and it has proven virtually impossible to turn back this tide of increasing cost. One way of avoiding unpleasant discussions about cost increases has been to counter this problem by stating the qualitative advantages of the modern combat aircraft, meaning that qualitative superiority in a far more efficient metric than quantitative superiority. In short, the message is that quality beats numbers.

FCAS and TEMPEST

The quality versus numbers argument is certainly a valid one, but there comes a point where you reach a situation where you simply do not have enough airframes to conduct the number of missions that you need to perform. It would appear that we have now reached or are reaching this point, because the next generation of combat aircraft, often called sixth generation combat aircraft, in Europe such as the *Système de combat aérien du futur* (SCAF)/Future Combat Air System (FCAS) being worked on by France, Germany and Spain are being defined as a 'system of systems.' This means that you will have multiple air vehicles capable of conducting



Photo: FAB

From the 1960s onwards, the Northrop F-5 family of combat aircraft has defined the lightweight combat aircraft. This particular F-5EM of the Brazilian Air Force remains in service and will eventually be replaced by the GRIPEN.

multiple missions, with the objective that qualitative superiority decisively defeats numbers in air combat. Britain is heading up the other European sixth generation fighter programme, known as TEMPEST, with Italy and Sweden also participating. In addition, one should not forget the LOYAL WINGMAN programme being conducted by Boeing for the Royal Australian Air Force (RAAF), this is a UCAV designed to act as a force multiplier both independently and operating under the control of existing combat aircraft assets.

Combat aircraft technology marches ceaselessly onwards. SCAF/FCAS and TEMPEST are the European solutions to the sixth generation combat aircraft challenge. We can also expect sophisticated solutions from the US Air Force and the US Navy as they look to replace legacy combat aircraft and work towards successor technologies for a Joint Strike Fighter (JSF) replacement. Other

aerospace powers such as China and Russia will be developing their sixth generation combat aircraft solutions as well, all of which indicates that future threats will be more challenging and complicated than ever before.

While the possibilities offered by future combat aircraft technologies are very exciting, we already know that it is logical to assume that these future aircraft will cost significantly more than those of the current generation. We have already reached a point where many air forces around the world have had to concede that they can no longer afford to acquire and operate state-of-the-art combat aircraft. There was a time during the Cold War where the superpowers were prepared to offer high performance combat aircraft to their allies/surrogates in the developing world for very little if any cash upfront. Those days are long gone. Today, air forces in the develop-

ing world are seeking affordable combat aircraft solutions that can undertake a sizeable proportion of their mission requirements at an acceptable procurement and sustainment cost.

The Tyranny of Numbers

What is becoming clear is that the number of air forces that are capable of acquiring and operating a serious number of advanced combat aircraft is declining. The trends are already visible and Belgium provides an excellent example of how European air forces are shrinking in terms of numbers. At the end of the 1970s, Belgium, along with Denmark, the Netherlands and Norway moved to acquire a successor to their Lockheed F-104 STARFIGHTER fleets. The F-16 was selected as the winner of the requirement in 1978 and Belgium ordered a first batch of 96 F-16A and 20 F-16B aircraft. The first aircraft, an F-16B, was delivered to the Belgian Air Force (BAF) on 29 January 1979. Deliveries of the first batch of 116 aircraft to Belgium was completed in May 1985. Prior to that, in February 1983, a second batch order for 44 F-16A/B BLOCK 150CU was placed with the aircraft being delivered between 1987 and 1991.

As previously noted, the F-16A/B replaced the F-104 in Belgian service, with that fleet consisting of 101 F-104G and 12 TF-104G. The F-104 fleet retired in 1983 after a little over twenty years in Belgian service. BAF combat aircraft capabilities were much larger than the F-104 and its F-16 successor; they had also ordered 106 Dassault MIRAGE 5 fighters in three variants in 1968: fighter (5BA), reconnaissance (5BR) and operational conversion (5BD). There were plans to keep some of the MIRAGE 5 fleet

Photo: RAF



In 1972, the RAF placed an order for 175 HAWK T.1 advanced jet trainers. During the 1980s, numbers of these aircraft were upgraded to the T.1A configuration to act as a lightweight day fighter equipped with SIDEWINDER missiles and a gun pod.

in service into the 1990s, but with the end of the Cold War, the decision was taken to retire the MIRAGE.

With the end of the Cold War, Belgium like many other European nations sought to profit from the 'peace dividend' that was supposed to emerge from the reduced requirement for defence spending. This saw a single-service military structure adopted and the BAF became the Composante Air (Air Component). The F-16 fleet was reduced to 72 aircraft and 18 spare aircraft (84 F-16A and 6 F-16B). Subsequently, fleet numbers were reduced to 60 aircraft, then down to 54, with attrition reducing numbers further. In October 2018, Belgium announced the selection of its next generation combat aircraft and the replacement for the F-16, in the form of the Lockheed Martin F-35A Joint Strike Fighter (JSF) with 34 aircraft to be acquired.

At the end of the 1980s, Belgium was on course for a combat aircraft fleet of well over 200 aircraft, although it was envisaged that into the 1990s the fleet would

decline in numbers and would be based on a single type, the F-16A/B, with all aircraft going through the Mid-Life Update (MLU) programme to extend service life and increase operational capabilities. The end of the Cold War changed these assumptions. Indeed, there was a point where Belgium was said to be considering ending the combat capability of the Composante Air! The JSF acquisition decision allowed Belgium to retain an air combat capability, but this was accompanied by a dramatic reduction in numbers.

Back in the 1970s when Belgium, Denmark, the Netherlands and Norway got together to replace the STARFIGHTER in what was then described as the 'sale of the century,' major numbers of aircraft were to be acquired. As previously stated, Belgium ordered a first batch of 116 F-16A/B, followed by a second batch of 44 aircraft. Denmark ordered a first batch of 46 F-16A and 12 F-16B, followed by a second batch of 12 aircraft in 1984 and later a batch of seven ex-US aircraft as attrition replacements. The Netherlands' first batch consisted of 80 F-16A and 22 F-16B aircraft, with the second batch order being for 97 F-16A and 14 F-16 B aircraft. Norway ordered 60 F-16A and 12 F-16B aircraft, with an additional purchase of two F-16B aircraft direct from the US production line.

All together, these four European air forces would go on to acquire a total of 514 F-16A/B aircraft from the end of the 1970s until the early 1990s. These four air forces have now all signed up for the JSF; Belgium for 34 F-35A, Denmark for 27 F-35A, the Netherlands for 46 F-35A and Norway for 52 F-35A. This provides a perfect example of how acquiring next generation combat aircraft leads to significant reductions in aircraft numbers. Between them, the four air forces will be acquiring only 159 F-35A JSF aircraft, when once they had acquired 514 F-16A/B.

Photo: French Navy



An ALPHA JET of the French Navy in flight. The ALPHA JET was developed to meet the advanced jet trainers needs of both France and Germany. Apart from its training mission, attack versions of the aircraft were developed to meet the requirements of export customers.

Searching for Solutions

Air forces experiencing significant reductions in combat aircraft numbers as they look to acquire next generation combat aircraft is not a new phenomenon. In Europe, the rapid pace of technological change post-1945 saw a transition from piston-engined aircraft to jets. The problem was that generational change in jet-powered combat aircraft was so rapid in the 1950s and that it came together with significant cost increases. At this point, numbers were still an important consideration in force structures and it was becoming increasingly apparent that, at a certain point, air forces could be priced out of existence by the escalating cost of combat aircraft. The effort to counter this trend would see the development of a new category of affordable combat aircraft, often called lightweight fighters.

One can trace the roots of the lightweight fighter back to 1953 and a NATO competition for a lightweight combat aircraft, with a requirement issued in December 1953. It is rather extraordinary that even at this early stage, it was recognised that something had to be done about confronting cost escalation in combat aircraft. However, this requirement did not call for an 'austere' aircraft design. In fact, what they were looking for was a rather ambitious combat aircraft that just happened to be in a lightweight package. Another important consideration for these new lightweight fighter designs was that they would be able to accommodate capability growth over their service life. It was obvious that the pace of technological change in combat aircraft was so rapid that failing to allow for growth potential would doom a combat aircraft to rapid obsolescence.

If there was one combat aircraft design that would come to symbolise what the lightweight fighter concept was all about then that would be the Northrop F-5. What Northrop did was to develop a highly flexible family of designs under the N-156 designation to meet a number of different requirements that were emerging in the 1950s. Initially, their efforts were directed towards a US Navy light fighter requirement to equip escort carriers, but with the demise of the escort carrier that opportunity disappeared. Then came the breakthrough, the US Air Force had generated a requirement for a supersonic trainer to replace the existing T-33 and Northrop proposed the N-156T, they won the competition in June 1959 and that resulted in the T-38 TALON being adopted by the US Air Force, with over 1,000 aircraft manufactured before production ceased in 1972.



Photo: Leonardo

Italy has long been a highly successful manufacturer of advanced jet trainers, with the M-346 MASTER from Leonardo continuing that tradition, following on from types such as the MB-326 and MB-339. The M-346 is also available in a version optimised to meet attack mission requirements.

The N-156 design team certainly manage to engineer the T-38 as a solution for an extended service life, the aircraft entered service in the early 1960s and is still in service today. The T-38 will be replaced by the T-7A RED HAWK, manufactured by Boeing in partnership with Saab, this design was selected by the US Air Force in September 2018 and it is intended to acquire 351 T-7A aircraft. There are ambitions for the T-7A aircraft beyond the training role, where it is one of a number of different solutions being suggested for future lightweight fighter requirements.

While Northrop had won the T-38 contract, they still had ambitions for the N-156 as a fighter design and continued to fund development of that variant, matters were helped by a contract won in 1958 for three prototype N-156F fighter aircraft to be evaluated as a possible candidate for a combat aircraft that could be delivered to US client nations as military assistance. The N-156F was extremely successful in trials, but it was only when the US government generated the F-X requirement for a low-cost export combat aircraft that Northrop found their fighter programme. In 1962,



Photo: Aero Vodochody

Aero Vodochody in the Czech Republic continues to be a major provider of jet trainer and light attack aircraft solutions, with the L-39NG as their primary current offering. The aircraft has been acquired by Vietnam as an advanced jet trainer, while Senegal has selected the aircraft for light attack and counter-insurgency missions.

Photo: Embraer



Embraer developed the original TUCANO as both a training aircraft and counter-insurgency aircraft. The latest A-29 SUPER TUCANO variant continues to offer both combat and training capabilities. The US acquired 20 SUPER TUCANO aircraft to give the Afghan Air Force a light attack capability.

the N-156F was selected to meet the F-X requirement as the F-5A, over the next ten years Northrop would go on to build 624 F-5A aircraft, 200 F-5B trainers and 86 RF-5A reconnaissance aircraft. Canadair built 240 CF-5 aircraft under license, while Spain built 70 NF-5 aircraft under license.

The was still more to come from the N-156 family, as Northrop sought to win a new US programme for an export fighter known as the International Fighter Aircraft (IFA). Here the aim was to offer US allies an affordable combat aircraft that would be competitive with the Soviet MiG-21 and this led to the development of the F-5E TIGER II. Still a lightweight fighter, the F-5E was larger than the F-5A, had more powerful engine, a radar and improved avionics, plus more weapon possibilities. Deliveries of the F-5E commenced in 1973 and Northrop would go on to build 792 F-5E, 146 F-5F trainers and 12 RF-5E reconnaissance aircraft. Switzerland would acquire 98 F-5E aircraft, the majority assembled at Emmen in Switzerland, and 12 Northrop-produced F-5F (currently Switzerland has 20 F-5E and 5 F-5F aircraft in service). The Aerospace Industrial Development Corporation in Taiwan would build 242 F-5E and 66 F-5F aircraft under license, while Korean Air manufactured 48 F-5E and 20 F-5F aircraft under license for the Republic of Korea Air Force (ROKAF). There could have been a third generation of Northrop lightweight fighters. At one point, the US government was looking for an export fighter as they were concerned over weapons proliferation and unwilling to sell the F-16 except to NATO and other major allies. This created an opening for an

export fighter that Northrop were hoping to fill with their F-20 design. Unfortunately for Northrop, the Reagan administration was prepared to sanction widespread F-16 exports and that marked the end of the F-20.

Past and Present

Another path to obtaining a light combat aircraft capability is to use a training platform for operational tasks. As western countries entered the counter-insurgency era in the 1950s, it was found that training aircraft, even carrying a light bomb load, had a useful role to play in providing air

support to ground forces. As jet trainer came to the fore in the 1950s, they added a new factor to light attack possibilities. For example, the US Air Force had taken the Cessna T-37 into service as a trainer. By the 1960s, the aircraft had been upgraded and reworked into a dedicated light attack aircraft as the A-37B DRAGONFLY.

European industry was able to support a wide range of jet trainer designs many of which would go on to develop a more than respectable combat capability. France had the Fouga MAGISTER; 900 of these were built in the 1950s and the type was widely exported, with the aircraft being used in combat by Cambodia, Israel and Morocco amongst others. The successor to the MAGISTER was the Dassault/Dornier ALPHA JET, which was built to meet the advanced jet trainer needs of France and Germany. A combat variant was developed and this was adopted by Egypt and Nigeria to name but two.

Britain introduced the JET PROVOST in the mid-1950s and in the 1960s went on to introduce a dedicated attack variant in the form of the STRIKEMASTER, which saw operational service in the Middle East and South America. Also in Britain, W.E.W Petter, the British aircraft designer, responsible for aircraft such as the CANBERRA bomber, had come to the conclusion that lightweight combat aircraft were the way forward and had gone on to develop such a system in the form of the Folland GNAT aircraft. A trainer version of the GNAT was adopted by the RAF, but the aircraft was exported with considerable success as a fighter, with India as the largest customer. Hindustan Aeronautics (HAL) built the air-

Photo: Boeing



The T-7A RED HAWK built by Boeing in partnership with Saab was selected in 2018 as the successor to the Northrop T-38 TALON as the US Air Force advanced jet trainer, with 351 aircraft to be acquired. Boeing project an export market for a combat derivative of the T-7A.

craft under license and in the 1970s produced an improved version of the aircraft as the AJEET.

The Aermacchi (now Leonardo) MB-326 was a highly successful jet trainer that was widely exported and which spawned dedicated light attack variants, including a single-seat version. The aircraft was succeeded by the MB-339 at the end of the 1970s and this aircraft also saw combat use by both Argentina and Eritrea. The latest generation advanced jet trainer from Leonardo is the M-346 MASTER and here the aircraft is capable of offering weapon training capabilities, as well there being a dedicated attack variant.

In the Soviet era, the majority of advanced jet trainers utilised by the Warsaw Pact nations and their export customers were the product of Aero Vodochody in what was then Czechoslovakia. The first jet trainer to enter service was the L-29 DELPHIN in the 1960s; this was followed by the L-39 ALBATROS in the 1970s, with both aircraft produced in substantial numbers. With the fall of the Soviet bloc and the emergence of an independent Czech Republic, Aero Vodochody further developed the L-39 initially into the L-59, which was acquired by Egypt and Tunisia, and then into the L-159 Advanced Light Combat Aircraft (ALCA) that was acquired by the Czech Air Force.

Currently, Aero Vodochody is offering the L-39NG as an advanced jet trainer. This is based on the original L-39 and features advanced avionics and a modern high performance engine. The aircraft performs all classic training missions and is also equipped for combat operations. One of the first customers for the L-39NG was the Senegal Air Force, who will use the aircraft for light attack and counter-insurgency missions once the contract details are resolved. Other customers include Vietnam who has purchased 12 L-39NG.

In the 1960s, the RAF generated an operational requirement for a successor to the Folland GNAT as an advanced jet trainer; the HAWK aircraft was selected to meet the requirement and in 1972 the RAF placed an order for 175 HAWK T.1 aircraft. In the 1980s, the RAF converted a large number of aircraft to the T.1A configuration to provide a lightweight day fighter capability with a couple of AIM-9L SIDEWINDER missiles and a 30mm cannon pod. Initial export aircraft were the 50 series followed by the 60 series, the latter aircraft providing the basis for the US Navy GOSHAWK trainer. Then came the HAWK 100, offering more performance in training and combat missions, and there was also the HAWK 200



Photo: KAI

The Korea Aerospace Industries (KAI) FA-50 combat aircraft is one of a family of trainer and combat aircraft developed to meet Republic of Korea Air Force (ROKAF) requirements. Countries such as Korea are becoming increasingly competitive with European manufacturers in areas previously dominated by Europe.

single-seat fighter derivative. The HAWK has been further developed with the RAF acquiring new aircraft and more export contracts obtained, most notably from India.

A light attack aircraft need not be jet-powered. Turboprop trainers such as those from Embraer and Pilatus are perfectly capable of conducting weapon training and light attack missions. Indeed, the original Embraer EMB 312 TUCANO was designed with a counter-insurgency mission capability from the start. The latest TUCANO variant, the A-29 SUPER TUCANO has been sold in Africa, Asia and the Middle East, and was selected by the US Air Force to meet the Light Air Support (LAS) requirement to provide the Afghan Air Force with 20 light attack aircraft.

Futures

The next generation of combat aircraft will be more sophisticated than ever before, more expensive than ever before and air forces will be able to afford fewer of them than ever before! Not every mission requires a highly sophisticated solution and this creates an opening for more cost effective alternatives. Then, outside of the major air forces, there are those whose ambitions for airspace surveillance, light attack and counter-insurgency capabilities will also have to be met by more affordable alternatives.

Some might suggest that ground attack missions could be met by attack helicopters – a fair point but these days, an advanced

attack helicopter is a very expensive proposition to acquire and operate. Another future possibility might be a UCAV-based solution, although complications over effective target identification, designation and engagement would cause concern.

There still seems to be a light combat role for jet trainers and turboprop trainers. From the operator perspective, there are also plenty of choices in terms of suitable aircraft to be acquired. In the context of advanced jet trainers, this was a market sector that Europe dominated. For many years, now matters are not so clear. Competing designs exist from Russia and China, while new competitors such as Korea are successfully entering the scene.

Lastly, we come to the question of whether there is a market for true light combat aircraft, what one might describe as an F-5E/F for the current era. This is a difficult question. Light combat aircraft such as the Sino-Pakistani JF-17 or the Indian TEJAS are potentially being built in numbers, but will they define an era as the F-5 did? Will we see aircraft such as the Korean KF-21, which Indonesia has invested in, and a future Turkish TF-X fighter, becoming export successes? It might be that these appear far more sophisticated in conception heading for F-16 replacement territory rather than F-5 capabilities, thus limiting their chances of a mass market. Certainly, there still appears to be a space for a true multi-mission light combat aircraft. What that aircraft might actually be is yet to be determined though. ■

JTAC: Roles and Equipment

André Forkert

Joint Terminal Attack Controllers (JTAC) are troops who direct combat aircraft, helicopters or unmanned aerial vehicles engaged in close air support. Previously known as Forward Air Controllers (FAC), their role today is often part of the Joint Fire Support Team (JFST) as they also make use of indirect fire weapons (artillery and mortars) and ship-borne fire.

FACs, JTACs, JFSTs or even Special Operating Forces JTACs (SOJTAC) – they all have the same mission and very similar equipment. Their mission is to provide the fighting force with support fire. A distinction is made between vehicle-mounted - e.g. on the KMW FENNEK - remote (dismounted operation and recourse to vehicle support), and fully dismounted JTACs, as the latter must use much more compact and lighter equipment. The JTACs/JFSTs are equipped with a wide-range of communication, observation and reconnaissance tools for carrying out their diverse tasks.

Germany: Project JFST Dismounted

The German Army is currently carrying out a JFST dismounted (JFSTabges) project. The JFST dismounted equipment sets to be procured comprise one air/ground and one ground/ground team each, which are equipped identically. Their capabilities are thus exactly the same as those of the FENNEK-based teams.

The technical system concept 'JFSTabges' is divided into different sub-components of target reconnaissance, navigation, IT equipment dismounted operation, communication and endurance capability. The resulting system components are interconnected by a central interface system and energy supply management. In the team, target reconnaissance consists of the primary optical and secondary optical reconnaissance means (daylight, residual light and thermal imager), the gyro and goniometer unit, the laser target designator, the IR target marker and two AN/PSN-13 Defence Advanced GPS

Author

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Photo: Safran



The electro-optical reconnaissance equipment MOSKITO Ti+ combined with the gyro and goniometer unit STERNA for very precise target information

Photo: Leonardo



The Slovenian Armed Forces have procured the Type-163 laser target designator from Leonardo.

Receivers (DAGR) for external self-positioning (Global Navigation Satellite System; GNSS). The modular and scalable equipment can be individually assembled depending on the mission. The necessary energy is provided through two SFC JENNY fuel cells and solar panels.

The complete equipment must not only result in a system, but must be transportable over a long period of time and long distances by two to six soldiers in infantry operations. The first systems are scheduled for field tests in 2021 and will be used for the first time in the NATO Very High Readiness Joint Task Force (VJTF) in 2023. Initially, 83 systems are planned, but 109 will be needed to be fully equipped.

Observation and Reconnaissance Equipment

A JTAC must be able to reconnoitre and identify its targets, sometimes over very long distances and capable of determining the position very precisely for the guided weapons to be employed. Long-range sensors are therefore necessary for this purpose.

The primary electro-optical reconnaissance equipment includes day and night channels, thermal imaging scopes and often secondary reconnaissance equip-

ment such as a purely optical glass channel as back-up. To produce the high level of accuracy required, they are fixed on a gyro and goniometer unit - such as the STERNA from Safran Vectronix. Suitable reconnaissance sensors include systems such as JIM LR, MOSKITO TI+, VECTOR (all from Safran), NYXUS BIRD from Jenoptik or the Long View CR/SW from Elbit Systems.

As with observation equipment, there is a wide range of Laser Target Designators (LTD) available on the market. For example, the Type 163 LTD from Leonardo, RATTLER G/H from Elbit Systems, L3Harris SCARAB, DHY308 LW from CILAS, HAMMER from BAE Systems, AN/PEQ-1C from Northrop Grumman, LF28A or TYR from Thales.

Thus, the RATTLER G (1.55 kg) and RATTLER H (1.3 kg) are the lightest systems, but they also offer relatively little energy. The type 163 LTD from Leonardo can be considered something like NATO's standard LTD. So far, 750+ have been delivered to 23+ NATO countries. It has a size of only 2 litres and a weight of less than 2.5 kg. In terms of power, it offers up to 80 mJ and up to 10+ km range. Since 2020, a DMC (Digital Magnetic Compass) was integrated to display laser to target line and compass heading. SCARAB, with 80-120 mJ offers the most energy.



Photo: Leonardo



The type 163 LTD from Leonardo is the standard in NATO. Slovenia was the 23rd user, and NATO members can procure through the NSPA framework contract.



Photos: B.E. Meyers

The IZLID ULTRA is a small, lightweight, handheld device that can be used as a laser illuminator, pointer or designator. It is the standard for US JTACs.



Photo: DARPA

PCAS makes the targeting process faster, easier and safer. From December 2012 to March 2013, DARPA conducted field tests of the PCAS ground software in Afghanistan.

Photo: Elbit System UK



British JTACs and JFSTs are to receive new target location and observation systems for infantry operations as part of the Dismounted Joint Fires Integrator programme. Elbit Systems UK has been contracted to supply the systems.

It is important to understand that more energy ensures greater detectability of the laser spot at greater distances. At the same time, it means more distance to the target and thus more tactical flexibility, accuracy for weapon use and operator safety. Attenuation due to atmospheric disturbances (fog, rain, snow) can also be compensated by high energy lasers.

Another factor is laser divergence, i.e. the diameter of the laser spot on the target, which should ideally be 1 metre at a target distance of 5 km. The reconnaissance equipment or LTD is supplemented by a so-called SeeSpot Device. This enables a laser spot of an LTD to be seen and displayed with the correct laser repetition frequency (Pulse Repetition Frequency), the so-called "laser code", even in normal daylight and in very bright sunlight. There are commercially available systems with various magnifications and as attachments for other optics. The LTD TAR from Thales and DHY306 LW from CILAS already have SeeSpot permanently

integrated. The type 163 can also integrate SeeSpot data, so the user has all relevant data in one system. In addition, the Type 163 LTD is optimised for use with the guided VULCANO artillery ammunition with SAL Seeker.

Laser target illuminators and pointers such as the IZLID ULTRA from B.E. Meyers are significantly smaller. It has a wavelength of 860 nanometres (nm) and thus operates in the near infrared range (NIR). The ULTRA is the successor of the IZLID 1000P, but is more compact (22.8x4.3x4.6 cm) and lighter (332 g with two 3V CR123A batteries). The output power is 1 W. This allows targets to be marked at distances of up to 43 km. For area-wide illumination, the laser then reaches up to 7 km (12 mrad). Different versions are offered, as a hand-held solution and adaptable on a Picatinny rail. In addition, there are versions with other wavelengths such as 1,064 nm or 1,550 nm (Ultra Short Wave Infrared; SWIR).

The UK's JTACs recently received a new target location and observation system for dismounted operations. At the heart of the system is Elbit Systems' HattoriX, which was first unveiled publicly in late 2018. It is in use by the Israeli Defence Forces and, according to reports from the company, has recently undergone successful testing by a number of armed forces in Europe and by NATO member countries. The system's unique selling point is its ability to passively and rapidly detect Category 1 target data (target location error <6 m). HattoriX can be combined with any electro-optical system to form a target location and observation device and consists of a goniometer, a mission computer,

Photo: Rockwell Collins



The DAGR is a mobile-held military GPS device that has appropriate encryption/coding and generates military coordinates.

Photo: L3Harris



PRC-117G offers access to DAMA-Satcom and SATURN, includes Suite BININE and Sierra II cryptography with which voice and data can be transmitted up to TOP SECRET. In the narrow band, it transmits with a power of 10 W, in SATCOM with 20 W and in the high band with an average of 5 W and a maximum of 20 W.



Photo: R&S

SOVERON, the tactical radio communication system from Rohde & Schwarz, consists of SOVERON D (formerly SVFuA), the SOVERON VR vehicle radio (centre) and the SOVERON HR handheld radio (right).

a touch-screen display unit and a light-weight tripod. It is a passive/active target acquisition system to enable forward artillery/infantry observers and soldiers with similar tactical missions to provide direct fire support in a few steps and within a very short time and to transmit all target information to effectors. Passive targeting is achieved by data fusion of terrain data from a Geographical Information System (GIS) database with preloaded target data, the system's visual feed and C2 information. For this purpose, the system combines photogrammetry algorithms and an augmented reality (AR) overlay. This allows Category 1 data to be generated without the use of active emitters (e.g. laser rangefinders) that can be detected by enemy reconnaissance systems, and seamlessly transferred to any command and control information system as well as the weapon's engagement system.

These systems are complemented by the DAGR (Defence Advanced GPS Receiver) equipment, a mobile-held military GPS device that has appropriate encryption/coding and generates military coordinates. The DAGR was launched in 2004 and is manufactured by Rockwell Collins. According to the manufacturer, it operates on the L1 and L2 frequency bands, can be ready for operation within 100 seconds (from a cold start) and is specially protected against jamming (Selective Availability Anti-Spoofing Module (SAASM); 41 dB). It weighs 430 g and the four batteries allow for 14 hours of operation.

Communication

In addition to reconnaissance, communication is particularly important. Since support weapons (aircraft, artillery, ships) are often provided multi-nationally, the



Photo: Elbit Systems

The RATTLER GIH from Elbit Systems

JTAC must also be able to communicate with them all. Purely national solutions are therefore out of the question. Since close air support is mainly provided by US forces, the L3Harris radios are also the standard within NATO, primarily the AN/PRC-117F/G. More functionalities are offered by the L3Harris AN/PRC-158, as well as the AN/PRC-163. Already, the single channel radio L3Harris PRC-117G (Falcon III) offers NATO SATURN as a powerful and introduced (STANAG) Ground-Air-Ground waveform. In the frequency range from 30MHz to 2GHz, various transmission methods are also possible, such as the MANET waveform ANW2C.

The PRC-158 (FALCON IV) complements the 117G. Here, two radio channels, extended up to 2.5 GHz, can be found in almost the same volume. The unit is only 300 g heavier than the PRC-117G at 3.7 kg (5.4 kg including battery). But Rohde & Schwarz with the SOVERON family, Elbit Systems with E-LynX or Thales also offer corresponding radios.

In order to become even faster, safer and better, the Persistent Close Air Support (PCAS) project is being developed by the Defense Advanced Research Projects Agency (DARPA) in the US. It offers real-time information exchange, faster response and precise targeting. Instead of voice transmission, digital target information is sent. This saves an enormous amount of time and leads to fewer errors

and greater accuracy. It also reduces the pilot's workload. According to Raytheon, a PCAS-enabled soldier can request air support for multiple targets from manned or unmanned platforms in less than six minutes. Voice requests, on the other hand, can take up to 30 minutes to plan and coordinate.

The PCAS network shares all information digitally between JTACs, pilots and other connected soldiers, via tablets running the Tactical Assault Kit software. The PCAS algorithms in the aircraft help locate targets, map attack routes and deploy the right weapon at the right time for a given target. ■

Defence Against the Threat of Short and Medium-Range Ballistic Missiles

Tim Guest

The 2020 ballistic missile attack on the al-Asad and Erbil air bases in Iraq highlighted the threat such weapons pose to western forces and the need for effective defence against them. This article looks at the kinds of threat western allies face from short and medium-range ballistic missiles (SRBM/MRBMs) in current and potential theatres of operation, along with aspects of, and latest developments to, NATO's latest ballistic missile defence (BMD) strategy.

Five days after the killing of Islamic Revolutionary Guards Corp (IRGC) leader, Qassem Soleimani, on 3 January 2020, the IRGC, in reprisal, launched between 16 and 22 SRBMs at the US air bases at al-Asad and Erbil in Iraq. Though some failed during flight, those missiles that did reach their targets delivered conventional payloads containing at least 1,100 lbs of HE with considerable precision. From first launch to final impact, the whole attack lasted 80 minutes.

Photo: US Army



A SABRE short-range ballistic missile launches in June 2017 at the White Sands Missile Range, N.M., for a test of the PATRIOT Advanced Capability-3 Missile Segment Enhancement, an advanced missile defence system.

The Threat in Actuality

The missiles were launched and landed in three waves in the early hours of 8 January 2020; US satellites detected heat and light signatures from the launched missiles and provided the intelligence for final defensive actions at the bases, while earlier intel about the satellite imagery being used by Iran to determine their targeting provided just enough time for the evacuation of troops and materiel. Neither base had defensive anti-ballistic-missile (ABM) capabilities that could deal with this threat nor the majority of troops on the ground, with only minutes to respond to intel of the impending barrage, dispersed to the 'relative' safety of the desert. Rear guards, however, remained to protect both bases in case of ground assault, and were protected from the direct impact effects of the missiles by bunkers and shelters. Many did, nevertheless, suffer traumatic brain injury from the concussive effects of the blasts and

the bases themselves sustained considerable damage. The attacks were designed to kill the personnel and destroy the materiel seen by the Iranians in the last satellite imagery they relied on prior to missile launch. The intelligent and just-in-time use of intel by US commanders, however, thwarted those intentions and saved both lives and equipment. Since then, PATRIOT missile batteries have been deployed to protect US forces at the bases.

The SRBMs allegedly used in the attacks, launched from at least two sites, were the FATEH-313 and the QIAM-2 SRBMs; the FATEH-313 is a solid-fuel missile with a range of some 500 km and improved accuracy over previous systems – satellite imagery determined it displayed a 12 m circular error probable/CEP. According to the Center for Strategic and International Studies (CSIS), the FATEH-313 gives Irani-

ans an expanded target set with which Tehran can threaten more regional neighbours, as well as military bases of western forces. Same time, these mobile missile systems can 'shoot and scoot' inside Iran, making it difficult for the launchers to be targeted before the missiles are fired. And it is not only land forces that are threatened by Iranian ballistic missiles, but also naval fleets. The CSIS reported that in September 2020, the IRGC's Aerospace Division displayed a new anti-ship BM (ASBM), the ZOLFAGHAR BASIR missile, with an enlarged booster and a range of some 700 km.

In the European theatre, another threat was reported in ESD's sister journal, Maritime Security & Defence, in February – the ISKANDER-M (SS-26 STONE) tactical ballistic missile, operational with Russia's Baltic Fleet. As well as ship-borne

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ISKANDERs the fleet has a ground-based ISKANDER unit, (a land-based system was deployed in Syria), with the 152nd Guards Missile Brigade. Capable of engaging targets at 500 km, the ISKANDER-M travels at a hypersonic speed of 2,100–2,600 m/s (Mach 6–7), can achieve a CEP of 5-7 m using an optical homing head, (or between 30-70m without), and is intended as a theatre weapon using conventional or thermonuclear warheads. The maximum yield of the nuclear warhead is 50 kilotons of TNT.

Further Threat Considerations

So, while the potential for an SRBM attack to paralyse an airbase is a seriously troubling and real scenario for defensive military planners, (a recent RAND Corporation study estimated a BM attack with 50 missiles would put a base out of action for larger fixed-wing aircraft for at least a week), the threat in the maritime space is also most real. A fleet formation, e.g. a battle group, the US 5th Fleet in the Persian Gulf, or the UK's Carrier Strike Group which set out 23 May on its maiden voyage, also faces the nightmare scenario of potential decimation, were a single ASBM of short or medium range, with accurate CEP, to be armed with a tactical nuclear warhead and be successful in reaching its target without being destroyed en route. However, whilst today's ballistic missiles can achieve hypersonic speeds, they do follow predictable parabolic flight paths, which ship-borne defensive systems can track 'relatively' easily.



Photo: US DoD

Remains of an Iranian Qjam ballistic missiles and guidance components like those launched against al-Asad and Erbil air bases are part of the Iranian Materiel Display (IMD) at Joint Base Anacostia-Bolling in Washington, DC. The DoD established the IMD to present evidence Iran is arming dangerous groups with advanced weapons, spreading instability and conflict in the region. The IMD contains materiel associated with Iranian proliferation into Yemen, Afghanistan and Bahrain.

For readers not immersed in all things ballistic missile, let us further clarify the SRBM and MRBM threat. Powered initially by a rocket stage or stages, BMs then follow an unpowered parabolic trajectory to their target. SRBMs have a maximum range of 1,000 km and are also known as tactical ballistic missiles; MRBMs reach ranges between 1,000 and 3,000 km and are also known as theatre ballistic missiles. Both typically carry conventional, HE payloads. [NB: Intermediate-range and long-range bal-

listic missiles are expected to typically carry nuclear warheads].

Let us now take brief look at aspects of the allied defensive approach and measures underway to address the threat.

NATO's Defensive Approach and Developments

NATO sees the continuing proliferation of ballistic missiles amongst potential western adversaries as a major threat, increasing the likelihood of future ballistic-missile attacks on allied soil, and/or forces stationed overseas, if a conflict scenario arises. The Alliance's BMD strategy, first explored in 2002, forms part of its key tenet of collective defence and, as far back as 2010 in Lisbon, NATO members agreed to construct a purely defensive territorial BMD capability in several member states and around the Mediterranean, addressing all BM threats including systems to counter SRBMs and MRBMs. In July 2016, the Initial Operational Capability of NATO's BMD was announced as a capability to defend Alliance populations, territory and forces across southern NATO Europe against a potential ballistic missile attack, and described as stronger than anything preceding it. This collective defensive capability incorporates assets and materiel commonly funded by all allies, though some voluntary contributions have been added by certain individual members. In addition, several Allies have already



Photo: US DoD

A Standard Missile 3 Block IIA launches from the AEGIS ASHORE Missile Defence Test Complex at the Pacific Missile Range Facility in Kauai, Hawaii, December 2018.

Photo: US DoD



AEGIS ASHORE is designed to provide mid-course defence against medium and intermediate-range ballistic missiles.

Photo: US DoD



A Terminal High Altitude Area Defence (THAAD) interceptor missile launches during a flight test at the Ronald Reagan Ballistic Missile Defence Test Site in the Marshall Islands in 2019. A THAAD system was temporarily deployed at the AEGIS ASHORE site at Deveselu Air Base in Romania in 2019 when the NATO BMD system was taken offline for system updates.

Photo: US DoD



Soldiers train with a Terminal High Altitude Area Defence system for short- and medium-range missile defence at Andersen Air Force Base, Guam. A THAAD system was deployed briefly at the AEGIS ASHORE site at Deveselu Air Base in Romania in 2019 to enable the updates to the AEGIS system.

offered their contributions or are undergoing development or acquisition of further BMD assets, such as upgraded ships with BMD-capable radars, ground-based air and missile defence systems, or advanced detection and alert capabilities. For its part, through its European Phased Adaptive Approach (EPAA), the US contributes to NATO BMD with deployments of materiel in various member states. In Turkey, for example, a US BMD radar is hosted at Kürecik. In Romania, a US AEGIS ASHORE site is in place at Deveselu Air Base. Indeed, on 12 May, NATO's Deputy Secretary General Mircea Geogană marked the 10th anniversary of the agreement between Romania and the US to establish NATO's land-based BMD system at Deveselu in southern Romania by addressing senior officials at the Romanian Senate, thanking them for hosting AEGIS ASHORE in the town of Deveselu, to provide 24/7 defence against BMs from outside the Euro-Atlantic area. Built and operated by the US on behalf of NATO, the missile defence base forms part of the larger European NATO missile shield, as touched on above, in line with the NATO Lisbon Summit in 2010. Mr Geogană stressed that NATO's work on missile defence continues, 'as missiles remain a weapon of choice for potential adversaries'. He stressed that missile defence is 'purely defensive'.

In Germany, the BMD command centre, under EPAA, is located at Ramstein Air Base. In addition, it was recently reported that Germany's Ministry of Defence had dropped plans for a next-generation air defence system, the Taktisches Luftverteidigungssystem (TLVS), which had been intended for use against latest ballistic and other missile and airborne threats. Instead, Germany will upgrade its PATRIOT systems starting in 2023, aiming to keep them in-service beyond 2030, though it will invest in other AD tech.

Also under EPAA, Poland will also be operational with another Aegis Ashore site at the Redzikowo Military Base in 2022, following construction delays, and Spain is hosting four multi-mission, BMD-capable AEGIS ships at the Rota naval base.

While all these installations are predominantly the voluntary national contributions, though integral parts of the NATO BMD capability, several allies currently offer further ground-based air and missile defence systems. These systems include: 1) Raytheon's PATRIOT missile defence system, as deployed in Germany, which comprises radars, command-and-



Photo: NATO

The AEGIS ASHORE at Deveselu in Romania provides 24/7 defence against BMs – MRBMs and longer range systems - from outside the Euro-Atlantic area.

Romania Highlights Strengthening Alliance BMD

Romania actually plays an important part in NATO's BMD strategy beyond just AEGIS ASHORE. The country is on track to receive new, modernised PATRIOT systems in 2022 to become the first country to field the newest version of the system. Raytheon received the go-ahead in early 2021 after the US Army held a critical design review of significant updates to the air and missile defence system. Romania already has one PATRIOT fire unit in place, delivered last September, in response to its concerns, as a NATO member, about security in the Black Sea region. It is among 17 PATRIOT partner nations whose operational scenarios and data inform updates. The company uses that feedback to ensure the system's continued reliability, maintainability and capability to outpace the full spectrum of threats, from tactical ballistic missiles and cruise missiles to unmanned aerial vehicles and advanced aircraft. In addition to receiving the latest system, Romania will also take advantage of the configuration's flexible architecture to upgrade its current unit in alignment with the new ones. When Raytheon sets up the modernised fire units in Romania in 2022, it will do so alongside both the US Army and the Romanian military. That collaboration includes new equipment training where the system's Romanian operators and maintainers will get hands-on instruction for the new and enhanced configuration with overarching goal for the Romanian military to become self-sufficient.

Photo: NATO



SAMPITS, Eurosam's theatre-level AD system, which is one of only a handful of European-produced systems that can counter ballistic missiles. Fielded by Italy and France, SAMPITS defends against SRBMs with ranges up to 600 km.



Romania is on track to receive new, modernised PATRIOT systems in 2022 to become the first country to field the newest version of the Raytheon Missiles & Defense system.

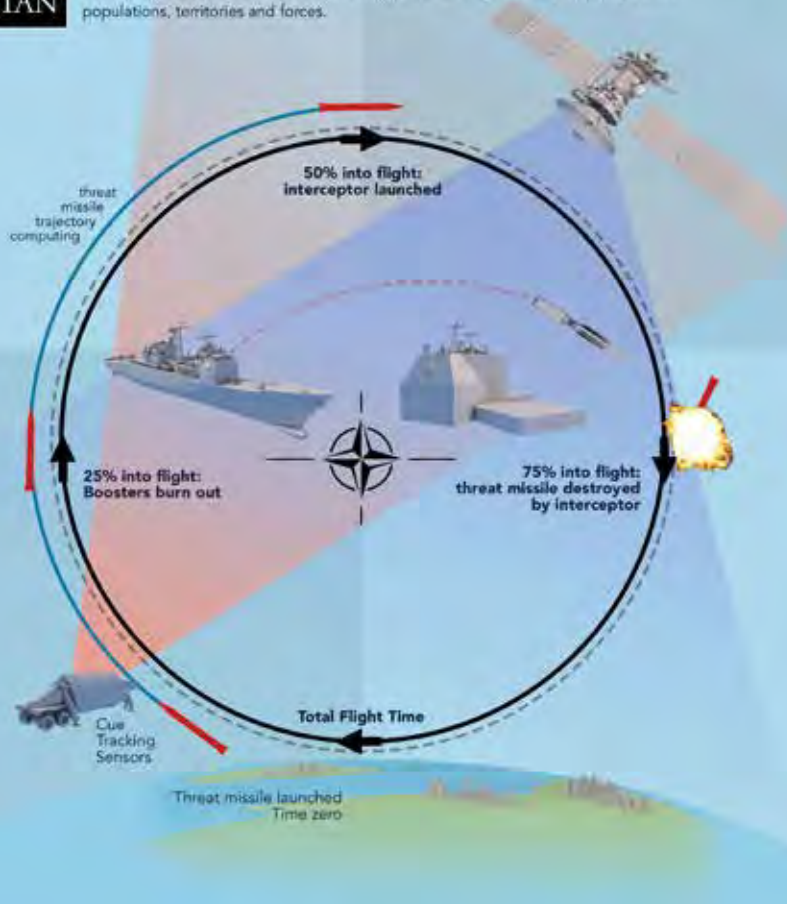
In Good Hands

This article has only skimmed what is a most complex subject, has only mentioned a handful of actual systems, has only touched upon the defensive-strategy thinking that will, hopefully, keep the



BALLISTIC MISSILE INTERCEPT

If a hostile ballistic missile was launched against a NATO nation, there would be only minutes to react. NATO's ballistic missile defence system uses networked sensors and interceptors that provide a layered defence. It calculates the missile's trajectory, evaluates the threat and determines the best option for interception. It also provides warnings on the predicted impact areas to alert national authorities. Once the threat is pinpointed, the best suited interceptor launches from sea or from land to neutralize the attacking missile, protecting NATO populations, territories and forces.



Source: NATO

Graphic illustrating a BM intercept

world safe from any aggressors electing to use SR and MRBMs in a future conflict. Let us end on a reassuring note, understanding that BMD thinking and strategy in NATO is in good hands and see who those hands belong to. NATO's Defence Policy and Planning Committee on Missile Defence (DPPC MD) is the senior committee under the North Atlantic Council that oversees and coordinates all efforts at the political-military level to develop and advise on NATO's BMD capability. There is also the Conference of National Armaments Directors (CNAD), which is the senior committee responsible for steering the BMD programme, so that all necessary technical functionalities for BMD planners and operators are developed. As for responsibilities for overall policy aspects of NATO Integrated Air and Missile Defence (IAMD), this falls to the Air and Missile Defence Committee (AMDC) as senior entity. Several other NATO senior committees address NATO BMD in the context of broader topics, such as civil emergency planning or crisis management, and when it comes to the men in the field prosecuting BMD in the flesh, it is NATO's military authorities who are responsible for developing a military doctrinal framework for BMD together with related operational planning, training and execution. ■



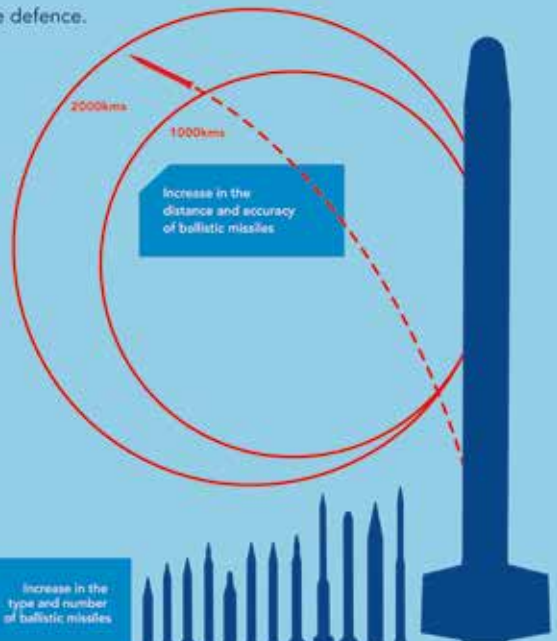
The Proliferation of Ballistic Missiles: An Increasing Threat to the Alliance

The proliferation of ballistic missile capabilities does not necessarily mean there is an immediate intent to attack NATO, but the Alliance has a responsibility to take this into account as part of its mission to protect its populations, territories and forces. NATO BMD is intended to defend against potential threats emanating from outside the Euro-Atlantic area.

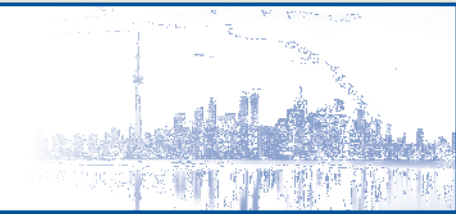
Protecting NATO European Allies, a core task of NATO's collective defence.

27 COUNTRIES **560** MILLION PEOPLE

Substantial number of countries with BM capabilities



Source: NATO



Viewpoint from Toronto



Photo: Debalina Ghoshal

Russia-US New START Treaty Extended: Arms Control Still a Reality

Debalina Ghoshal

The New START 2010 between Russia and the United States came into force in 2011, with the objective to take measures on further reduction and limitation of strategic offensive arms. According to the Treaty, both sides should reduce their deployed nuclear weapons to 700 delivery vehicles and 1550 warheads. In addition, both sides would reduce launchers to 800 deployed and non deployed launchers and deployed and non deployed strategic bombers. This year, the two erstwhile Cold War superpowers entered into negotiations on this crucial treaty. Both agreed to extend the treaty officially for five years. This comes as a great respite especially after the collapse of the Intermediate Nuclear Forces (INF) Treaty.

The Russians have always been concerned about the United States planning to equip nuclear capable submarines and aircraft with conventional weapons under the Conventional Prompt Global Strike (CPGS) plan that aims to develop a family of conventional weapon systems. In fact, Russian Defence Ministry Spokesperson Alexander Yemelyanov has raised concerns in October 2017 that the CPGS would “ruin the current balance of power and ensure the US global strategic dominance.” In addition, the United States is also working on hypersonic systems that are of further concern to the Russian Federation.

Despite the New START treaty in force, the United States conducted two tests of the MINUTEMAN III Intercontinental Ballistic Missile (ICBM) and ICBMs which may have a role in as part of the CPGS strategy. The Navy is also gearing up for developing weapons that could suit the CPGS strategy.

Talks on New START was definitely on Russia’s cards as not just considering the CPGS strategy, but Moscow has also been apprehensive of US missile defence systems. Russia has time and again questioned the need for missile defence in Europe especially as they feel the Iranian nuclear threat has subsided. According to Russia’s Permanent Representative to the North Atlantic Alliance Alexander Grushko, the US missile defence system including the sea-based missile defence system would only result in a more “complex strategic stability arithmetic.”

In February 2018, the United States announced a more aggressive

stance towards Russia warning Russia of facing “unacceptably dire costs”, even if Russia threatened a limited nuclear attack on Europe. Russia has already chalked a strategy to ‘escalate to de-escalate’ in which Russia could use small yield nuclear weapons in a limited and conventional conflict in Europe. Russia is reported to have deployed tactical nuclear-capable ballistic missiles in Kaliningrad - a Russian exclave on the Baltic bordering Lithuania and Poland. The issue of tactical nuclear weapons are a concern for the United States, and this was expressed this year too. In addition, the United States also raised concerns about Russian SARMAT ICBMs and the AVANGARD Hypersonic Glide Vehicle (HGV). HGVs enable a ballistic missile to evade enemy missile defence and the AVANGARD’s greater manoeuvrability makes it difficult to intercept it. The SARMAT is reported to be capable of carrying the AVANGARD HGV.

At present, amid the adversarial relation, both the United States and Russia find it conducive to extend this crucial nuclear arms control treaty as a sign of willingness to be transparent about long-range nuclear forces and to enhance their cognizance of each other’s nuclear forces. While the New START Treaty does not prevent the two erstwhile superpowers from modernising their nuclear forces, the Treaty however, provides room for discussions on the modernisation of nuclear forces and its impact on nuclear deterrence and strategic stability.

Both Russia and the United States would have a common concerning factor - and that is China. China’s long range nuclear delivery systems with capability to evade the missile defence of opponent and their dual capable missile systems were a thorn in the progress of the INF Treaty.

It is only sensible that at this moment the United States and Russia abide by the New START considering that any breach of this treaty would only complicate strategic stability and can lead to an uncontrollable global arms race that would be beyond the capabilities of either Russia or the United States to control.

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Power Electronics for the Power-Full Battlefield

Tim Guest

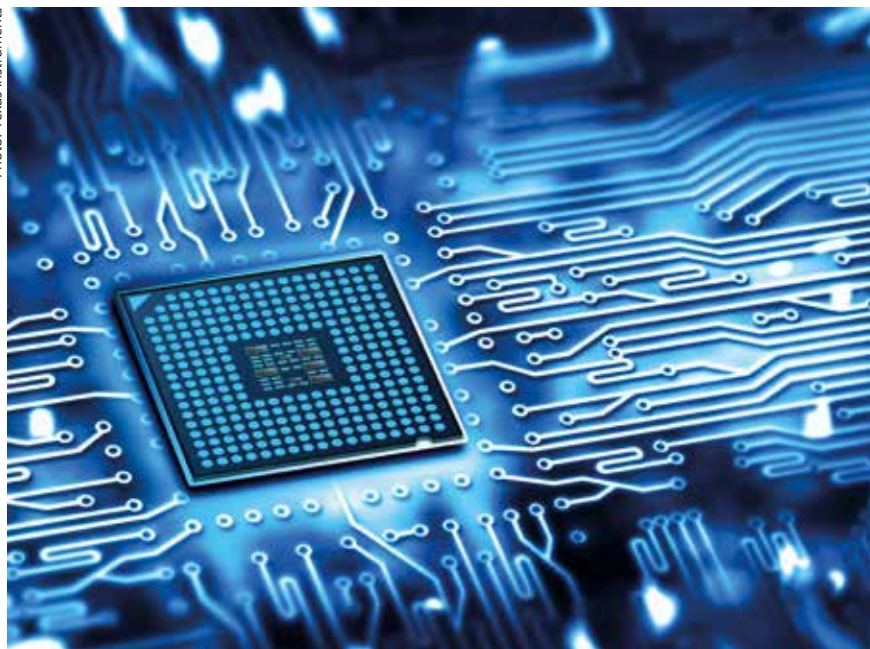
Modern warfare relies on electrical power like never before to drive, run, or operate a plethora of equipment across airborne, naval and land domains. This article looks at how the need, by military systems – many of which are becoming increasingly smaller every day – for readily-available power and its ‘measured’ delivery to various sensors, weapon systems and ancillary equipment, relies on power electronics of various kinds and why this market is only set to grow massively.

Military systems, both small and large, require electrical power to be delivered to them, often in very specific ways and amounts, if they are to perform optimally. Power electronics, such as voltage regulator systems, transformers, conversion systems, help ensure power, from source to application, meets the right parameters for the job at hand.

Overview

Power electronic systems are found in almost all electronic equipment delivering power conversion of AC to DC, DC to AC, AC to AC, DC to DC, power conditioning to remove distortion or harmonics, voltage dips and over-voltages. And they are also used for high-speed and/or frequent control of electrical parameters such as currents, voltage impedance, and phase angle. In most mobile devices, ruggedized tablets, for example, increasingly adopted by military users, DC-DC converters are used to maintain voltages at a steady, fixed level, no matter what the device’s battery voltage level is; such converters are also used for electronic isolation and power factor correction. Another type of DC-DC converter is the power optimiser, developed to maximise the power supplies that can be harvested from renewable energy sources, such as solar photovoltaic cells and wind energy, both widely used as power sources in military smart energy and water applications. Another power electronic solution is the rectifier, or AC-

Photo: Texas Instruments



Power electronic systems are found in almost all electronic equipment. Pictured: a TI embedded processor, a type of microprocessor designed into a system to control electrical and mechanical functions.

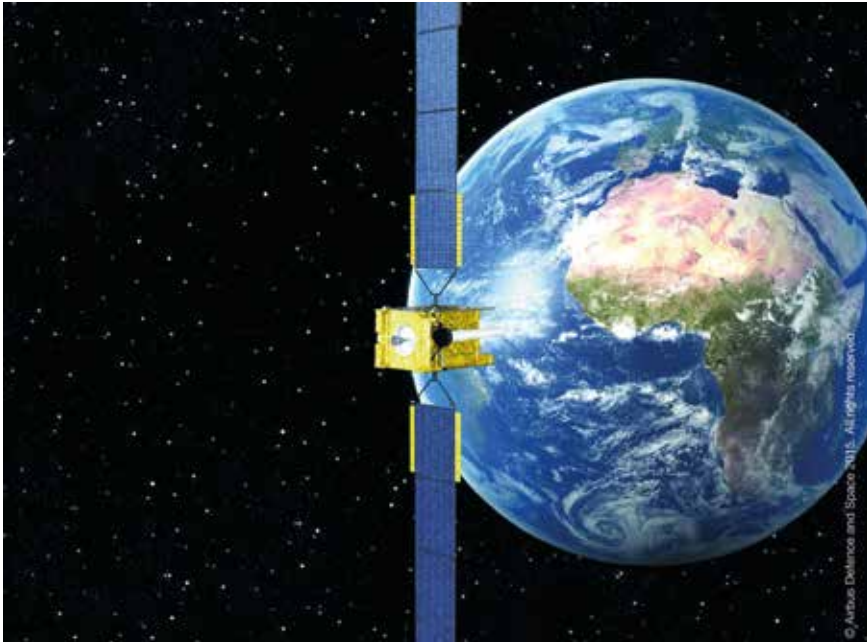
Photo: Rafael



In ruggedised tablets, DC-DC converters are used to maintain voltages at a steady, fixed level. Pictured is the SPIKE operator screen.

Author

Tim Guest is a freelance journalist, UK Correspondent for ESD and former officer in the UK Royal Artillery.



Graphic: Airbus Defence and Space

Military satellite systems demand ever smaller and lighter onboard systems with similar SWaP requirements from power electronics employed. Pictured is the SKYNET satellite.

DC converter, a solution employed every time an electronic device, such as a computer, a field medical monitor, or a video monitor screen, is connected to a mains or generator-based electricity supply. Rectifiers might only convert AC to DC, though they can also change voltage levels to the equipment. In addition, voltage regulator systems, mains power transformers and frequency converters are just some of the other power electronics widely used in a range of tri-service and space-based scenarios, from naval on-board electronics and propulsion, to aircraft starting, support and maintenance equipment, tank and armoured vehicle simulation and training suites, satellite design, drone systems and more.

In modern electronics, such power conversions as mentioned are performed with ever smaller semiconductor switching devices, including diodes, thyristors and power transistors, including the power 'metal oxide semi-conductor field effect transistor', or MOSFET, and the Insulated-Gate Bi-polar Transistor, or IGBT. Gallium arsenide (GaAs) and laterally diffused MOS (LDMOS) have been used in electronic systems and devices for many years and silicon-based LDMOS FETs as well as GaAsFETs are now widely used in RF and millimetre wave communications solutions. But the need for small 'size, weight and power' consumption (SWaP) devices in military systems is, today, one of the key reasons that advances in semiconductor technology and component integration is so important in helping equipment manufacturers achieve the smaller end-product sizes users demand.

Trends

With defence systems typically requiring very reliable electrical power in the form of three-phase/single-phase AC, or 50 Hz/400 Hz, or regulated 5, 12, 24, 28, or 48-Volt DC, no matter what shape the electrical power takes the conditioning and control of electrical power supplied to increasingly smaller and highly sensitive electronics components inside latest military systems and equipment, is being guided by certain trends. Such trends include the need for more acute cooling and thermal management, open architecture adherence, striving for greater power-density and SWaP, as well as a much greater use of commercially off-the-shelf systems. The quest for miniaturisation in many defence systems is one of the reasons driving the trend in SWaP; as user systems demand evermore



Photo: EXPAL

Rectifiers, or AC-DC converters are used every time an electronic device, such as a computer or video monitor screen, such as in a military training suite, is connected to a mains or generator-based electricity supply. Pictured is the SIMOX training instruction suite.

power density from the smallest possible batteries, components, or power storage devices, this size and weight reduction in, for instance, the electrification of vehicles and aircraft, and in satellite design, is critical. And with a growing number of vehicular defence applications involving electrical powertrains and greater electrification of all onboard systems, including advanced, specialised sensors, many requiring their own dedicated and reliable sources of high-quality electric power, exacting use of power electronics is critical. Such systems as azimuth and elevation servo drive units, outrigger drives, various power and servo amplifiers, communication systems, radar, consoles and displays all require their own main and stand-by power sources, in turn needing effective power electronic solutions helping to manage the electrical conversion and delivery, from source to application, across the platform.

Market

If there's any doubt about the importance and widespread nature of power electronics solutions and use, a recent report on the market in both the defence and commercial arenas, by Fortune Business Insights, is worth a brief mention. It looks at the very latest trends and developments in this critical area of electronics, addressing and separating out its analysis of power electronics solutions by type, material, voltage, end-user and ending with a regional forecast and market projections from 2021 out to 2028. The report underscores the importance of power electronics in the support of power management solutions that will both improve energy conservation while reducing energy losses from systems such as aircraft engines, satellites, military vehicles and weapon

Photo: Militem



A growing number of vehicular and autonomous vehicle defence applications involve greater electrification of all onboard systems and specialised sensors, demand exacting use of power electronics components. Pictured: THemis autonomous vehicle.

Image: STMicroelectronics



STMicroelectronics has just launched an integrated MasterGaN 4 device for high efficiency power conversion. Its GaN HEMTs (High Electron Mobility Transistors) represent a major step forward in power electronics.

systems. It explains that a rising demand for automated weapons and electric vehicles for military applications alongside the growing aerospace and defence industries in the economies of China and India will drive growth opportunities for the power electronics sector in the coming years.

The report says that progress in technologies enabling the development of ever-more advanced semiconductors, nanotechnology and the Internet of Things are expected to propel the power electronics sector in the forecast period. That said, silicon is, according to the report, likely to remain the most widely employed material used in power electronics for some time due largely to its availability, compatibility with a variety of substrate materials used in power electronic production, as well as low production costs themselves. It also describes a rising need for high power density IGBT modules, (as mentioned earlier), in aircraft applications due to lightweight and advanced feature design criteria demands, including moves to arrive at all-electric systems. Indeed, IGBT module demand is set to increase rapidly in order to improve electronic device performance

and reduce the overall weight of aircraft and advanced weapon systems, as well as spacecraft of all descriptions.

As for some of the key players in the power electronics space, the report

Photo: Airbus Defence and Space



The power electronics market in the AP Region is bolstered by massive demand from China's military, its space programme as well as huge uptake across commercial transportation and public safety and security sectors for increasingly sophisticated electronics solutions. Pictured: THR8 handset, Shenzhen Metro.

makes mention of companies across the globe, including: TT Electronics in the UK, STMicroelectronics in Switzerland, Infineon Technologies in Germany, NXP Semiconductors in the Netherlands, Renesas Electronics and Mitsubishi Electric Corporations in Japan, as well as a range of US players such as Microsemi, Texas Instruments, On Semiconductor, Collins Aerospace and others.

Regional splits for global analysis in the report are: Europe, North America, Asia-Pacific and the rest of the world, with North America set to lead the way in the coming years driven mostly by its quest for advanced weapon systems and its space programme. Taking second place, however, is the AP Region with China's military industrial complex and its race to achieve global military superiority with advanced weapons cited as driving main demand, bolstered also by its space programme and the space programmes of regional neighbours, India and Japan.

Outlook

As the above report illustrates, power-hungry military systems and sensors that require reliable and high-quality power, managed and precisely delivered for everything from handheld drones, communications, satellites, vehicle-borne and soldier-worn sensors, naval propulsion, hybrid-electric drives, aircraft engines and more, will ensure the health of the power electronics sector for years to come and drive its R&D to find new ways of doing the same things, though in smaller, lighter, more efficient packages. ■

European Market Opportunities for the F-35 LIGHTNING II

Finland, Switzerland and Spain are the new objectives in Europe

Esteban Villarejo

The programme is consolidated in seven countries although there are doubts about the impact of the new TEMPEST programme upon the original British acquisition of 138 aircraft.

Three countries represent the new 'battlefield' for Lockheed Martin to spread the sound of the F-35 LIGHTNING II over European skies: Finland (Air Force), Switzerland (Air Force) and Spain (Navy). Although the possibilities of playing 'tic-tac-toe' are difficult, Lockheed Martin believes it can seal a contract with one, thereby joining the seven current European nations which already have a commitment to the fifth generation stealth fighter jet namely the UK, the Netherlands, Norway, Italy and Denmark (European programme partners) and Belgium and Poland (foreign military sales costumers in Europe).

On the other hand, serious doubts have appeared in the United Kingdom and Italy that could lead to a decrease in the expected orders. These doubts are related to the post-pandemic situation and the cost per flight hour (\$35,000) but are also influenced by the UK's new jet fighter programme – TEMPEST – which could make London considerably reduce its initial request of 138 F-35B for the Royal Air Force and Royal Navy.

New Opportunities in Finland, Switzerland and Spain

In January 2020, the Finnish Air Force began the flight test evaluation of the F-35 LIGHTNING II as part of its programme to replace the 55 Boeing F-18 HORNET whose service life ends by 2030. A final decision is expected this year with a contract valued at €10Bn. This represents a major opportunity for Lockheed Martin.

In October 2020, the State Department approved a possible Foreign Military Sale to Finland of 64 F-35A (CTOL, conventional takeoff and landing) with air-to-air missiles and air-to-ground precision guided munitions and related equipment at an estimated cost of US\$12.5Bn. Finally, the US Government and Lockheed Martin



Photo: Kaszynski, Lockheed Martin

Norway's first F-35 during a test flight in October 2015

submitted a best and final offer (BAFO) on 29 April 2021 to the Finnish Government. The F-35 offering is a total package that includes F-35A aircraft and a sustainment solution tailored to meet Finnish security of supply requirements and to support all operational needs if forced to operate in a closed border scenario. The BAFO also includes many first-of-a-kind opportunities for Finnish industry to work directly on F-35 production and sustainment. "The F-35 will provide Finnish industries with high technology job opportunities that no other competitor can offer," said Bridget Lauderdale, F-35 Programme vice president and general manager.

Contenders to replace the F-18 fleet include the Lockheed Martin F-35, Boeing F/A-18 SUPER HORNET, EUROFIGHTER TYPHOON, Dassault RAFALE and Saab GRIPEN.

Switzerland

As for Switzerland, in September 2020, Lockheed Martin proposed a possible foreign military sale of 40 F-35A LIGHTNING

II aircraft and related equipment for an estimated cost of \$6.58Bn.

This offer would aim to replace the ageing fleet of F/A-18 HORNET and F5 TIGER. The selection, to be taken by the Swiss Federal Council is awaited in 2021.

The operational cost is the greatest handicap of Lockheed Martin within this contest where the EUROFIGHTER consortium, led by a German campaign, seems to be the greatest competitor. Lockheed underlines the cost per flight hour will go down from \$35,000 to \$25,000 by 2025, two years before Swiss deliveries would start.

Spain

In Spain, the Ejército del Aire will progressively replace 85 F-18 HORNET jets between 2025-2035. The only industrial solution for the Spanish Government seems to be the EUROFIGHTER. But there is an option for Lockheed Martin to penetrate this Airbus market: the necessity of the Spanish Navy to replace its 12 HARRIER AV-8B aircraft before 2030. Of course, this means the short take-off and vertical-landing F-35B,

Photo: MoD Netherlands



On 31 October 2019, hundreds of guests gathered at Leeuwarden Air Force Base to welcome the first operational F-35 for use in the Netherlands.

though no official offer has been submitted by Lockheed Martin despite the fact that there are some ongoing conversations at the Spanish Navy level to try not to lose this capability after 2030.

Belgium and Poland: Two Last European Customers

In October 2018, Belgium chose the F-35 LIGHTNING II to replace its fleet of F-16s. This represented a huge setback for the European Union's defence policy and the European options of the EUROFIGHTER and the French RAFALE. The prize was the official reason provided by the Bel-

gian Government to choose the US option as the deal with Lockheed Martin was 34 F-35A for US\$4.55Bn. The initial offer submitted in January 2018 was \$6.53Bn.

Deliveries are scheduled for 2023, although the first Belgian F-35A will reach the Florennes Air Base, home of the 2nd Tactical Wing, in late 2024 after the training programme at Luke AFB (Arizona). The Belgian Air Component will also operate F-35s from Kleine-Brogel Air Base. On the operational side, the agreements that Belgium will reach with neighbouring Netherlands for Quick Reaction Alert missions will be a key issue.

Poland concluded its fighter acquisition programme with the signing of a Letter of Offer and Acceptance between the US and Polish Governments on 31 January 2020 for 32 F-35A variant jets with initial deliveries beginning in 2024 and in-country deliveries in 2026. The cost of the deal was US\$4.6Bn (it was also reduced from the initial US\$6.5Bn). The objective of the programme was to replace its outdated Soviet-era Sukhoi Su-22 and Mikoyan MiG-29 aircraft. This contract came after tension with F-35 development partner, Turkey, over Ankara's plans to buy the Russian S-400 missile defence system. And of course, it was also done after the decision by former President Trump to strengthen security and defence ties with Warsaw.

Recently, the Polish MoD announced that the F-35 will operate from Lask Air Base in central Poland.

The European F-35 Industrial Partners

The United Kingdom is currently at a crossroads, which could present a problem for the F-35 Joint Strike Fighter programme in Europe. The COVID-19 pandemic has obviously created other economic scenarios; besides, London has another long-term programme with the jet fighter TEMPEST. This is also a priority for the 'new UK' post Brexit. Then there is the question of whether London will buy the 138 F-35B aircraft as initially planned, or the 48 jet fighters already ordered? These doubts are reasonable, despite that fact that "UK is the programme's only Level 1 partner and has garnered tremendous economic benefits from the F-35. British industry will build 15 per cent of each of the more than 3,000 planned F-35s, generating significant export revenue and GDP growth", as Lockheed Martin likes to explain.

However, the new defence spending plan released in March by the UK MoD is not strong enough to underline its commitment to the '138 aircraft plan' of F-35B (short-takeoff-and-vertical-landing combat jet) to equip the Royal Navy and Royal Air Force (Marham Air Base). The document reveals a plan to "grow the Force, increasing the fleet size beyond the 48 aircraft that we have already ordered". But it does not specifically compromise the original plan for 138 aircraft.

London has already allocated £2Bn in development funding for TEMPEST over the next four years. Therefore, there are serious possibilities that the UK will finally adopt a medium-term formula for the acquisition of around 65-75 aircraft. But this is still just speculation.

Photo: US Air Force



US Air Forces in Europe Commander Gen. Jeff Harrigan presented a letter to Inspector of the Polish Air Force Maj. Gen. Jacek Pszczoła, welcoming Poland to the European F-35 User's Group, in Dęblin, Poland, on 31 January 2019. Poland is the ninth member of the European F-35 User's Group, and the first country in Eastern Europe to transition to the F-35.

Important milestones of the British programme include the fact that in 2012, the UK's first F-35B was delivered from Lockheed Martin's Fort Worth (Texas) facilities and in 2020, the Royal Navy declared Maritime Initial Operational Capability.

Italy

Italy has reached two milestones this year. In May, the Italian Air Force deployed four F-35A LIGHTNING II jets to Amari Air Base (Estonia) as part of NATO's Baltic Air Policing operation. It is the first time this kind of 5th generation jet fighter has been deployed to the Baltic mission.

The second main piece of news was the reception and flight clearance recommendation for operation of the first F-35B on the aircraft carrier CAVOUR. The process will be complete with the acquisition of the Final Operational Capability with the delivery of the last F-35B.

The planned programme for the Italian Armed Forces consists of 60 F-35A and 30 F-35B jets. However, the impact of the global pandemic triggered a huge political debate about the necessity of calling for a halt in F-35 purchases. In the end, Italy has continued with its purchasing, without interruption. Last year, Italy received 15 F-35 deliveries (12 F-35A and 3 F-35B variants). The Italian Air Force operate the F-35A from Ghedi Air Base and Amendola Air Base.

The Netherlands

The Netherlands was the second international partner to receive the F-35, and continues to serve as a key contributor to the production and sustainment of the F-35 LIGHTNING II fighter. The Royal Netherlands Air Force (RNLAf) operates the F-35A from Leeuwarden Air Base where the first operational aircraft arrived in 2019. In the future, Volkel Air Base will also be home to their F-35s. The Dutch programme foresees 46 aircraft after an extension of nine units in 2019.

Norway

The Norwegian Government selected the F-35 as the replacement for the F-16 fleet in 2008. The Royal Norwegian Air Force operates the F-35A variant aircraft that includes a drag chute to assist with landing in icy conditions and to help reduce landing distance on short airfields. Norway's programme foresees 52 F-35 aircraft. Norway's F-35 fleet operates out of Ørland Air Base. In addition, a Quick Reaction Alert base is being created at Evenes Air Base. The Norwegian Government selected the F-35 as the replacement for the F-16 fleet in 2008. Their first international deployment was concluded with the F-35 during NATO Air Policing missions in Iceland. Last year, Norway received 21 deliveries and expects to add another seven this year.

Denmark

On 7 April 2021, the Danish Defence Command (Forsvaretsdk) took delivery of its first F-35 LIGHTNING II. The fighter jet will remain at US Luke Air Force Base (Arizona) for the training of pilots and maintenance crew. The Royal Danish Air Force expects its first F-35A to arrive in Denmark in 2023, which will be followed by flight operations the same year. It will be based at Royal Danish Air Force's Fighter Wing Skrydstrup. F-35A fighter deliveries will run until 2026 after Denmark selected the F-35 for their new fighter programme; it is fully committed to procure 27 F-35A aircraft. ■

Masthead

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“We have the complete portfolio.”

Photo: Embraer Defense & Security



Embraer Defense & Security is the leading aerospace and defence industry in Latin America. In addition to the A-29 SUPER TUCANO light attack and advanced trainer and the multi-mission KC-390 military airlift, it provides a full line of integrated solutions and applications such as Command and Control Center (C4I), radars, ISR (Intelligence, Surveillance & Reconnaissance) and space. ESD had the opportunity to talk to Jackson Schneider, President & CEO, Embraer Defense & Security.

ESD: How do you see the market for Embraer’s defence products?

Schneider: We have a complete portfolio that goes beyond the aircraft, including solutions for air, land, sea, space and cyber. We’ll continue with a wider defence and security focus, our main business, but we are also open to diversification opportunities, evaluating potential partnerships and new businesses in high technology segments related to our business, such as cyber security, air traffic control and satellites. In terms of new developments, we have signed two memorandums of understanding (MoU) with the Brazilian Air Force (FAB). The first was established for a study of a potential development of a short take-off utility transport (STOUT). The second is a cooperation for the study and evaluation of the necessary capabilities for the conceptual design and development of advanced unmanned combat aerial vehicle (UCAV).

ESD: The C-390 has been successful in approaching the European market, with specific interest and orders already achieved: which are your next key goals in the region, and what does the C-390 offer that other contenders cannot?

Schneider: The C-390 MILLENIUM, or KC-390 MILLENIUM when the customer opts for its tanker additional capability, was designed to establish new standards in its category, offering outstanding mobility, quick reconfiguration, high availability, greater flexibility, and easier maintenance in a unique platform. Since it entered operation with the Brazilian Air Force (FAB), the KC-390 MILLENIUM has been proving its excellent performance, reliability and capacity as a new generation multi-mission aircraft. We have delivered four multi-mission KC-390 MILLENIUM to FAB

and deliveries for Portugal and Hungary are scheduled to begin in 2023. Regarding new contracts, we cannot comment about new sales prospects, but we are very confident and optimistic. However, I can tell that since we received orders from Portugal and Hungary, two NATO nations, there was a growing interest around the C-390 MILLENIUM in the international market and there are several potential customers requesting information about to aircraft.

ESD: Increase in low(er) cost platforms for Light Attack, Air Support and Training has been growing throughout Europe and NATO. The market is highly competitive, so what successes has the SUPER TUCANO achieved, and why? In terms of using a lightweight aircraft to deliver longer-range, heavier ordnance, what does the SUPER TUCANO now offer, and what of the future?

Schneider: The A-29 SUPER TUCANO is the worldwide benchmark for close air support and light-attack. It is an extremely rugged, combat proven platform and a reference for basic and advanced training. The aircraft was selected by more than 15 air forces around the globe, including the United States Air Force (USAF), and over 250 A-29 SUPER TUCANOs were delivered, accumulating more than 430,000 flight-hours, of which over 60,000 flight-hours were spent in combat. The A-29 was designed to operate from austere and unprepared surfaces. This design strength not only creates significant operational flexibility, it also enhances the overall survivability of the aircraft especially compared to the vulnerabilities of aircraft that need to operate from established airfields. In October 2020, the Philippine Air Force (PAF) became the newest A-29 SUPER TUCANO operator, when all six aircraft ordered were

Photo: Embraer Defense & Security



The A-29 SUPER TUCANO



Photo: Embraer Defense & Security

Embraer's subsidiary Atech will integrate sensors and weaponry into the combat system of Brazil's new TAMANDARÉ class ships.

delivered. During the first quarter of 2021, the first two A-29 SUPER TUCANO for the Combat Aviation Advisor (CAA) mission for the Air Force Special Operations Command (AFSOC) programme were delivered to Sierra Nevada Corporation (SNC). Embraer also delivered the seventh aircraft of the Nigeria Programme for the Nigerian Air Force (NAF) and supported SNC and the United States Government during the flight test campaign, as part of the Military Flight Release Phase II of the Nigeria Programme. The full fleet of A-29 SUPER TUCANO aircraft for the NAF are currently in production by SNC and Embraer at the Jacksonville facility with delivery to the NAF expected on schedule in 2021. Regarding new contracts, there are several cases in different stages, but we cannot comment.

ESD: In past few years, Embraer Defence has diversified its portfolio of products. How this is going?

Schneider: In its path for diversification, Embraer acquired some companies in recent years, such as Atech, whose main expertise lies in the development of innovative solutions with applications in the areas of air traffic control, command and control systems, instrumentation & control systems, embedded systems and simulators. Atech is part of Águas Azuis Consortium, formed by thyssenkrupp Marine Systems and Embraer Defense & Security, selected by the Brazilian Navy for the construction of four surface vessels in the TAMANDARÉ Class. Also, in our strategy to grow in related fields, Embraer Defense & Security believes that there is a growing demand for cyber security solutions in the global

defence market. Therefore, the company announced a contract for a capital investment in Tempest Security Intelligence. The largest cybersecurity company in Brazil, Tempest positions itself as a provider of complete solutions for business protection in the digital world. By investing in Tempest, Embraer seeks to enhance the company's prospects for growth and expansion in both Brazil and abroad.

ESD: You mentioned the TAMANDARÉ class programme. Can you explain more about this programme?

Schneider: Emgepron, an independent state company, linked to the Ministry of Defense through the Brazilian Navy Command, and Águas Azuis signed last year the contract to build four state-of-the-art TAMANDARÉ class ships, with deliveries scheduled between 2025 and 2028. The construction will take place 100% in Brazil and is expected to have local content rates above 30% for the first vessel and 40% for the others. thyssenkrupp will supply the naval technology of its proven MEKO class vessels that are already in operation in 15 countries. Embraer will integrate sensors and weaponry into the combat system, bringing also to the programme its more than 50 years' experience in systems technology solutions and in-service support. In addition to construction, the contract includes a sustained transfer of technology in naval engineering for building military ships and combat and platform management systems, as well as integrated logistical support and lifecycle management. It provides for a solid national partnership model with proven ability to transfer technology and qualify local labour, which guarantees the development of future strategic defence projects in Brazil. The naval alliance between thyssenkrupp Marine Systems and Embraer Defense & Security can also enable creating a base for exporting naval defence products from Brazil.

The interview was conducted by Stephen Barnard.

Photo: Embraer Defense & Security



The C-390 MILLENNIUM

A New Type of Defence Company



Photos: Ukroboronprom

Yuriy Husyev, General Director of Ukroboronprom, during a working visit to Turkey

This year, the state-owned defence corporation Ukroboronprom is to undergo reform. It is to be divided into two holding companies named "Defence Systems of Ukraine" and "Aerospace Systems of Ukraine". The first holding will unite all the companies producing weapons and military equipment for the Ukrainian Army, while the second holding will combine space and aerospace. The goal is a profound reform of a key Ukrainian industry in the face of Russian aggression. ESD had the opportunity to talk to Yuriy Husyev, General Director of Ukroboronprom.

ESD: At the end of 2020, Ukroboronprom celebrated its 10th anniversary. What laid the groundwork for founding the organisation and who issued the decree?

Husyev: Indeed, Ukroboronprom was established in late 2010 as a result of administrative reforms in accordance with the Orders of the then President of Ukraine and relevant resolutions by Ukraine's Cabinet of Ministers. At the time of the establishment of the State Concern "Ukroboronprom", the situation in the defence industry was as follows: the dispersion of enterprises between a number of governmental bodies, insufficient efficiency of state property management, and non-efficient budget allocation. I believe this has become the main argument to shift towards market management methods in the defence industry.

Therefore, the vast majority of defence enterprises were placed under the management of the state economic association known as State Concern "Ukroboronprom". Thus, the enterprises for defence products design, manufacture and trade, both for domestic and foreign markets, came under Ukroboronprom. At that time, it was envisaged that Ukroboronprom would see to it that the demands of Ukraine's Armed Forces regarding the latest models of armaments, upgrades, repair, and disposal were duly met. Secondly, it was to strengthen Ukraine's international prestige by expanding markets for competitive defence industry products. Thirdly, it was to enhance the role of the domestic defence-industrial complex in the social and economic development of the country. Indeed, this kind of vision is completely correct. It is another matter that

for about 10 years, Ukroboronprom has been carrying on differently — meaning, not everything has been done.

There are many reasons for this, both internal (employment issues), and external (political). In 2014, the war began in Ukraine. The needs of our army have changed, as well as the technology of warfare in the world as a whole has changed. Ukraine was faced with new challenges. In order to be able to respond, we now need to reform Ukroboronprom. I want to emphasise that as an international partner, Ukroboronprom will not cease to exist; it will not be liquidated, but will be transformed. This is extremely important. This transformation will become a historic event for Ukraine, because the old standards will be replaced by a com-

pletely new type of defence company, meeting OECD corporate governance standards. Ukraine's new defence complex will become a powerful player and a reliable partner on the international market of armaments and military hardware.

ESD: How many companies are now part of Ukroboronprom and what do they have to offer the international market? Can you provide turnover and income rates?

Husyev: As a State Concern, Ukroboronprom includes over 100 enterprises today, some of which are on the temporarily occupied territories, which Ukraine is definitely going to return.

The development of modern models of rocket and space technology, military transport aircraft, shipbuilding, high-



The fuselage of the new AH-178 for the Ukrainian Army

precision weapons, armoured and engineering equipment, reconnaissance and radio suppression, radar weapons for various purposes offer the greatest potential in Ukraine. The level of development of countries involved in aircraft building places Ukraine among the most developed countries. Only five or six high-tech countries possess an industry at this level. Some models of Antonov-type aircraft are several steps ahead of similar foreign models.

Ukraine has extensive experience in building equipment such as helicopters and aircraft carriers, in addition to civilian vessels for various purposes. Ukraine's production and technological capabilities allow for the manufacture of vessels of various classes and purpose, with a deadweight of up to 150-180,000 tonnes. In the future, Ukraine will be capable of producing its own Naval and Merchant Navy ships.

Ukraine is one of the world's leaders in gas turbine construction. We design and manufacture gas turbines for sea vessels, for electricity and gas pipelines.

Ukraine's armoured engineering has a single closed cycle production of modern models of tanks and armoured personnel carriers. Structurally, this branch of production is self-supporting and able to provide a cycle from development to serial production of final products. The BM OPLOT tank is the latest development, created with the use of advanced technologies and design solutions.

Ukraine is among ten countries able to develop and manufacture modern missile weapons and the whole production line of high-precision weapons.

As for financial performance, I can only say that the State Concern demonstrated earnings growth in recent years. For example, the net profit for 2020 grew more than twice - to be precise, by +108.36 per cent, compared to that in 2019.

ESD: What is the average annual budget invested in research and technology by Ukraine's defence industry? How much of the total number of workers in industry are involved in research and do these figures reflect any trend?

Hushev: It is common among all countries that defence is one of the most high-tech industries. Among the concerned entities, we have both manufacturing enterprises and over two dozen specialised design bureaus, research institutes, research and design centres. These are all research institutions whose main activity is conducting research and creating new defence technologies.



Yuriy Hushev giving a presentation of Ukroboronprom's products at Aero India 2021

Today, on the order of Ukraine's Defence Ministry, Ukroboronprom's scientific institutions conduct dozens of state design works to create the latest models of weapons and military hardware, specifically, in the field of high-precision missiles, innovative radar stations, and new models of armoured vehicles. In total, for these purposes in 2021, the Defence Ministry allocated to our enterprises about 5 per cent of the state defence order (over UAH 1Bn or about US\$35Mn).

At the same time, all our enterprises also carry out internal research and development. After all, ammunition production never stands still, and a lot of things change quickly. Workbenches, machine tools and other equipment are being improved. And in order to change some of the smallest details in a serial model of armament or to implement a small detail in new equipment to reduce the cost of production, the company must conduct research at all the relevant stages, tests and financial costs.

Usually, experience shows that Ukrainian manufacturing defence companies try to invest about 10 per cent of their profits in government design work. In turn, scientific institutions of the defence industry complex allocate at least 70 per cent for these purposes. That is, with the growth of production of the Ukrainian defence industry, the volume of investments in research, innovation and technology will grow proportionally.

At the same time, we have already started reforming Ukroboronprom and plan to become a driver of scientific, technical and innovative development of the defence industry. This year, we will recommence with the operation of the Council for Scientific and Technical Development and Innovations of Ukroboronprom, which includes the most recognised experts in Ukraine's defence industry, science and innovation community. The work of this Council will contribute to the large-scale reshaping of the way new types of weapons and military hardware are created.

ESD: How many clients outside Ukraine does Ukroboronprom maintain business relations with? Can you provide examples of current programmes?

Hushev: In 2020, companies of the State Concern exported weapons, military hardware and services to almost 50 countries. In total, over 70 countries are partners of Ukroboronprom in the global arms market. Today, we are active in negotiations in order to expand cooperation in the field of guided missile weapons and anti-tank missile systems. For the first time, Ukroboronprom's enterprises signed large-scale contracts for the supply of missiles and high-precision weapons to a number of countries in the Middle East and North Africa, won a tender and launched contracts for the supply of anti-tank missile kits to one Asian-Pacific country. Latin American countries, who have significantly increased the ac-



Yuriy Husyev visiting the Aero India 2021 trade-show

tivities of their domestic enterprises, are also included among those important programmes. Indeed, we have increased our own presence in the Peruvian market after we signed a contract for the construction of the An-178 aircraft. We are participating in a number of major tenders to supply Ukrainian military goods, as well as provide relevant services. We are also working to strengthen our position in the aviation markets of Latin America and Asia.

A large contract for the construction of a light armoured vehicle repair plant is underway in one of the countries of the Asia-Pacific region.

We are continuing with our cooperation with Turkey, supplying aircraft engines and providing technical support of the integration of engines into UAV systems. Today, the top five products of the State Concern are as follows:

1. Ship gas turbine engines and units, equipment for Navy hardware;
2. Manufacture and repair of aircraft engines;
3. Anti-tank missile systems and missiles for them;
4. The GURT system;
5. Repair and modernisation of aircraft.

ESD: To what extent is the Ukrainian defence industry able to meet the needs of the Ukrainian Armed Forces? Are there areas where you have to rely on foreign suppliers?

Husyev: For the team of Ukroboronprom and for me as the head of the State Concern, meeting the needs in armaments and military equipment of Ukraine's

Armed Forces and other law enforcement agencies is a priority. This is our mission. Thus, last year, Ukroboronprom's enterprises fulfilled 100 per cent of contracts under the state defence order. No disruptions, no delays. On the contrary, every fifth contract was executed ahead of schedule.

If we talk about numbers — 46 of our companies that have fulfilled 55 contracts under the 2020 state defence order are ahead of schedule. Given the external threats and the situation near the state borders, the Concern has analysed its capabilities and we are ready to produce twice as much weaponry and military hardware to be ordered by our country, if necessary. Some of the needs of our Army are met by private manufacturers and our foreign partners; I mean the countries with whom we have friendly relations apart from the contractual links. And we are grateful to them for the opportunity to receive modern weapons that meet NATO standards.

France, UK, Germany, Denmark, Israel, Turkey, the Czech Republic, Poland, Latvia, Lithuania, Cyprus, Canada and the United States made up the arms suppliers for Ukraine's security forces in 2014 - 2020.

ESD: In your opinion, what technological industries are most likely to demonstrate the biggest growth of potential to lay the groundwork for Ukraine's defence industry and why?

Husyev: Today, most of Ukraine's partner countries are changing their options towards military-technical cooperation. Specifically, from the direct purchase of weapons to the use of offset schemes,

the purchase of technologies, creation of joint projects or deployment of domestic weapons production.

There are changes underway in the structure of arms supplies in the world: there is a steady increase in demand for combat aircraft, naval equipment, air defence and unmanned systems. Speaking globally, today we are witnessing and participating in very rapid changes - fundamental changes in the paradigm and technology of warfare itself. The age of fighter jets is gone. The future lies with wars between drones and unmanned systems. I am sure that in the coming decades we will see a growth in production of robotic systems that will independently determine the target, track it and strike it. They will analyse the data themselves and assess the consequences of their strikes.

Our global challenge today is how to educate a new generation of engineers and designers to work with weapons of the future. And I think it's right to bet on that.

Ukroboronprom has already begun cooperating with the leading higher education institutions of Ukraine. We are investing in a new generation - a new generation of professionals who will work in the country's defence industry tomorrow. The next step is to launch educational training programmes together with leading international educational institutions.

ESD: Can Ukraine's defence industry now offer European quality at lower prices than Western ones?

Husyev: The State Concern's enterprises have developed many innovations that have significant potential in the international market for armaments and military equipment. For example, the VILKHA multiple launch rocket system and missiles for them, the NEPTUNE coastal missile defence system, An-178/188 aircraft, a line of new combat modules, armoured combat vehicles of the new generation based on the modular concept, anti-tank missile systems, strike and reconnaissance drones, aircraft engines, gas turbine units for marine equipment and many others.

Besides, one of the main products of Ukraine's defence industry is providing services for repair and modernisation of weapons and military hardware. Ukraine is one of the few countries able to repair and modernise almost any piece of hardware produced in the Soviet Union. It is a unique and popular product, which is in steady demand.

The interview was conducted by Jürgen Hensel.

Update: The Integrated Battle Command System

Henry Richardson

The US Army's Integrated Air and Missile Defense Battle Command System (IBCS) network is its keystone technology for the future of the Army Integrated Air and Missile Defense (AIAMD) network.

IBCS connects a multitude of sensors, command and control systems and effectors within a battlespace to allow a fusion of sensor information to queue any weapon system, allowing the best effector to engage a threat even where its own local sensors are not best positioned to direct it.

In essence, IBCS moves the Army's command and control of air and missile defence assets from a system-centric approach with isolated operational and communication processes to an integrated network centric approach where individual systems are instead part of an integrated air defence ecosystem. By mandating compliance with the architectures for all future sensor, command and control (C2) and effector procurements and upgrades, the Army would possess a 'plug and play' network where any sensor can queue any effector with interface to any C2 node for control and monitoring.

Milestone C review was scheduled for November 2020 but it was not until January 2021 that official announcement of the decision to progress the acquisition was made, which saw the Northrop Grumman-designed IBCS system move into the production and operational testing phase which, if successful, will see an initial operational test and evaluation (IOT&E) programme commence in Q3 2021.

Since the programme was launched in 2009 the Army has spent approximately US\$2.5Bn on IBCS and has experienced a number of significant delays and problems, but recent Limited User Test (LUT) in late 2020 saw a successful demonstration of the networking of two AN/MPQ-65



Photo: DVIDSHUB

The IBCS Engagement Operations Centre at White Sands Missile Range during limited user test (LUT) in 2019

PATRIOT radars, two AN/MPQ-64 SENTINEL radars, a number of M903 PATRIOT Launching Stations (LS), two battery Engagement Operations Centres (EOC) and two battalion EOCs. The disparate systems, which were spread over a 70 km area, were linked using Integrated Fire Control Network relays (IFCN).

IFCNs are the primary organic communications infrastructure for the broader

AIAMD network and provide a trailer mounted mobile communications node which extends connectivity to remote launcher and sensor platforms. The IFCN systems themselves have a troubled history with particular issues around reliability and uncommanded disconnections. However, the Army is confident these have been resolved and the current system is performing as required.



Photo: Raytheon

The Raytheon AN/MPQ-64 SENTINEL radar

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The LUT saw the network of systems presented with two simultaneous targets, an MQM-178 FIREJET aerial target and a BLACK DAGGER tactical ballistic missile. The latter is a low cost target missile that utilises existing Army components reaching the end of their useful life rather than have them sent for demilitarisation.

The MQM-178 was successfully intercepted by a MIM-104E PAC-2 missile, with the BLACK DAGGER to be intercepted by a salvo of two missiles, the standard engagement profile for a ballistic missile target, consisting of a MIM-104F PAC-3 Cost Reduction Initiative (CRI) missile and a MIM-104F PAC-3 Missile Segment Enhanced (MSE) missile. Though the PAC-3 CRI succeeded in intercepting and defeating the target, the PAC-3 MSE missile failed to fire.

The Army also tested the resilience of the network, using ground-based jammers to incapacitate an IFCN relay node during the test, however as intended the network continued to pass data in spite of the electronic attack.

Earlier tests had proven the system's capability against multiple low level manoeuvring threats, with two cruise missile targets flying in formation through cluttered mountainous terrain successfully engaged and defeated by PAC-3 missiles. With progress in the US proving promising, exports are already lining up for the system. In 2018, Poland selected IBCS in a US\$713M contract as the C2 architecture for its own national air defence network, called the WISLA programme. For the Wisla requirement, Northrop Grumman will supply and unspecified number of EOC, IFCN and associated software to provide the C2 capability for the network. Poland is also procuring the PATRIOT system for their effector requirements, which was selected in a US\$4.75Bn contract signed in 2018 for the supply of two PATRIOT batteries. Follow on orders are expected for further launchers, enhanced sensors and a new low-cost interceptor missile for low-end threats such as small unmanned aerial systems (UAS).

Emerging Challenges

The concept of a 'next generation' completely integrated air and missile defence network, which the Army now calls Advanced Integrated Air and Missile Defense (AIAMD) was born almost 20 years ago, when the air defence picture was a decidedly simpler environment. Manoeuvring fast jets and helicopters at medium to low altitude alongside typically



Photo: Lockheed Martin

The Lockheed Martin Missiles & Fire Control PATRIOT PAC-3 MSE missile during live fire testing. The PAC-3 MSE is optimised for ballistic missile defence but retains capability against a range of targets from small UAS through manoeuvring fast jets.

non-manoevring strategic bombers and ballistic missiles at high altitude were a relatively limited and clearly defined target set. In general, the air breathing targets would be engaged by a dedicated asset, which was generally the PATRIOT system, and the ballistic missile threat by another, THAAD. In the years since then, the air picture has become radically more complex, with new and extremely rapidly evolving threats including manoeuvring ballistic missiles, cruise missiles, micro through large UAS operating from ground level through to high altitude and most recently hypersonic weapons. Tackling this wide breadth of threats requires far more sensors and effectors with no one-size-fits-all solution, making the IBCS concept absolutely critical to an effective future air defence capability. Where historic Army air defence planning was very rigid and stressing or out-of-envelope threats would simply not be addressable, with IBCS the Army will be able tailor its air defence assets at deployment to provide a nuanced suite of sensors and effectors to the specifics of the anticipated threats. IBCS is also far more efficient. Where an existing legacy system's sensor may offer capability to detect a threat, but the associated effector cannot engage it, IBCS allows these sensors to queue other more appropriate assets. If there is an effector or sensor capability gap, it can be filled without having to procure at great expense an accompanying sensor system.

Future Opportunities

The fielding of an open architecture, "every sensor, best effector" air defence command and control system brings with it a huge beneficial capability to the US

Army. It allows any future sensor or effector to be networked into the broader network, incrementally enhancing the network with novel engagement, or sensing capabilities.

First to join the system will be the Army's newly acquired Rafael IRON DOME systems, two batteries of which were activated in November 2020 following deliveries in September. Testing through 2021 has focused on whether IRON DOME can be fully integrated with IBCS, or whether it would require further development to do so and remain 'interoperable' for the time being, whereby it has a lesser degree of integration and sharing of information and is making independent decisions rather than being commanded by the singular network.

IRON DOME was procured in 2020 as an interim capability for the Army's Indirect Fire Protection Capability Increment 2 (IFPC Inc 2), a programme seeking a system to provide defence against subsonic and supersonic cruise missiles as well as group two and three unmanned aerial systems (UAS) and rocket, artillery and mortar (RAM) threats.

Beyond air defence, the potential for the IBCS network to integrate artillery systems was suggested in 2019, with the capability to detect enemy threats and defeat them with IAMD assets before passing targeting information to tube and rocket artillery systems integrated with the network to fire back at the threat position. Admitting there would be cultural and technological hurdles to such an ecosystem, Army's Air and Missile Defense Cross Function Team office stated this would be a long-term aspiration following successful fielding of the core air defence oriented IBCS capability. ■

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