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Politics · Armed Forces · Procurement · Technology

The House of Innovative Synthetic Aperture Radars

Photos: IAI-ELTA

Background

Deployed on aircraft or spacecraft, Synthetic Aperture Radar (SAR) technology exploits the relative speed (Doppler shift) of objects in the radar beam, performing a frequency analysis to create a large synthetic antenna aperture without the need for a correspondingly large physical antenna. A cross-range Doppler image of the targeted area is processed to produce an image that is similar to an optical picture, but today's SAR systems have the ability to produce astonishingly detailed images and pick up details that even the highest resolution electro- optic systems may not detect. Israel Aerospace Industries' (IAI) Group and its subsidiary, Elta Systems Ltd., - one of the leading radar manufacturers worldwide - invested heavily in SAR technology research and development which led to significant advances in both hardware and software over the past decades, and today the company offers one of the world's most extensive ranges of high-performance SAR solutions.

Meet the Family

ELTA's comprehensive array of SAR covers the entire gamut of operational requirements, from space based strategic reconnaissance all the way through to the lightest tactical system deployed from compact, commercial drones, including ground segments. Below is a brief description of some chosen systems providing an overview of ELTA's capabilities of its SAR based systems.
TECSAR ELM-2070 is a lightweight SAR for Low Earth Orbiting image intelligence (IMINT) satellites. Using both mechanical and multi-beam electronic antenna steering, this highly agile radar can cover large areas and provide high resolution SAR images. TECSAR features wide area Scan SAR, Strip SAR, Spot SAR (mechanical steering spot imaging), Mosaic SAR (using mechanical and electronic steering), Multi-look SAR for improved image quality, and Multi-polarisation SAR for better target discrimination.
The ELM-2060P SAR/GMTI reconnaissance system is an operationally proven strategic pod designed for deployment on combat aircraft, externally mounted. The system features a SAR with Ground Moving Target Indication (GMTI) to produce high resolution images over wide areas, quickly and at long stand-off ranges. Moving targets are presented on the Strip SAR image. A true all-weather, day and night sensor, capable of penetrating clouds, rain, smoke, fog and smog, this autonomous reconnaissance system facilitates effective assessment of ground areas with the high resolution necessary for target detection and classification.
At the tactical level, the ELM-20600 RTP-Reconnaissance and Targeting Pod is an operationally proven high-performance SAR with GMTI, maritime surveillance, and air-to-air situation awareness modes. Designed for deployment on combat aircraft, RTP provides all-weather, 24-hour radar images of ground targets and terrain from standoff range, enabling targets to be detected and attacked in conditions where conventional electro-optic/ IR systems are at a real disadvantage, such as clouds, rain, fog, battlefield smoke and camouflage. Modes include Spot SAR, Strip SAR, GMTI, Ground Target Track (accurate tracking of stationary and moving targets) and SEA/ISAR for the detection and tracking of seaborne targets.

The ELM-2055DX SAR/GMTI All Weather Surveillance Ku-band radar is a versatile, high-performance sensor that provides all weather SAR imagery and GMTI capabilities on manned and unmanned airborne platforms, including UAVs and aerostats. This operationally proven system is in service worldwide, protecting borders, strategic assets, and serving additional purposes such as disaster relief, cartography, and land resources management. Key features include: real-time SAR imaging for Wide Area Surveillance (WAS); a high-resolution SAR spot mode for stationary target classification; and GMTI capability for persistent wide area surveillance.
ELM-2054 is a lightweight radar designed for small Tactical UAVs (STUAV), tactical VTOL UAVs, ultra-light reconnaissance aircraft, tactical aerostats and other compact airborne platforms. Employing the latest technologies to achieve exceptional performance, it delivers powerful, all weather, SAR/GMTI capabilities while complying with very low size, weight, and power requirements. Onboard processing of SAR images enables the use of low downlink data rates.

Turnkey Solutions

ELTA's unrivalled portfolio of operationally proven SAR/GMTI solutions are ready for deployment on the widest range of platforms; from strategic ISR satellites, multi-mission aircraft, fighter jets and MALE UAVs through to small tactical drones. These innovative solutions benefit from the unremitting commitment to maximise performance by leveraging the latest techniques and technologies. These ongoing efforts enable ELTA to offer customers worldwide the widest range of class leading, turnkey SAR/GMTI solutions at the strategic and tactical levels.

French Politics Gets Complicated


Photo: author

Cast your mind back to 2017. The primary centre-left political grouping, the Parti socialiste (PS), was in turmoil despite holding the French presidency, after François Hollande decided that he would not run for a second term in the face of massive unpopularity. On the centre-right Les Républicains (LR) has their own problems, as their leader François Fillon became embroiled in a scandal. All of which made the 2017 presidential election suddenly very open as the traditional parties were pre-occupied with internal problems.

Into this political chasm emerged Emmanuel Macron, a former minister in the Hollande PS government, who in April 2016 had formed a new political party La Republique En Marche (LREM), later simply known as En Marche (EM). Macron was able to organise and fund EM and then start an effective presidential campaign, portraying him as occupying the political centre ground. In the first round of the election held on 24 April 2017, Macron obtained 24% of the votes cast, with his nearest challenger being Marine Le Pen with 21% of the votes cast. Macron and Le Pen then advanced to the second round of the election held on 7 May 2017, where Macron won with 66.1% of the votes cast compared with 33.9% for Le Pen.

A Political Chasm

A major victory for Macron, but to govern he really needed a majority in the National Assembly, meaning winning more than 289 out of the 577 seats that would be decided by elections on 11 June and 18 June. The results of this election were a major endorsement of Macron; his EM party and its allies won 350 seats. The centre-right won 136 seats (down from 229 in 2012) and the centre-left won 45 seats (down from 331 in 2012). Extreme parties on the left and right on the political spectrum won a minimal number of seats.

Then, the 2022 Presidential Election held on 10 April and 24 April for the decisive second round came down to Macron versus Le Pen and, as before, Macron won with 58.5% of the vote compared to 41.4% for Le Pen. Something to note is that in the first round of the election, the centre-right LR candidate only got 4.78% of the vote and the centre-left PS candidate an embarrassing 1.75% of the vote. Macronism had obviously remade centrist politics in France.

The political battle then moved to the National Assembly election. The two rounds were held on 12 and 19 June, and the end result has placed major obstacles to Macron's plans for his second term and could have consequences at a European-level, as Macron will be forced to concentrate on domestic politics rather than his grand plans for Europe.

In May 2022, major elements of the political left in France formed an alliance known as the Nouvelle Union populaire écologique et social (NUPES). This included La France Insoumise (LFI), a far-left party led by Jean-Luc Mélenchon (Mélenchon got 21.95% of the vote in the first round of the presidential election), the Greens, the French Communist Party (PCF), the PS and various anti-capitalist green-left factions. They would face off against Macron's Ensemble grouping, the UDC centre-right grouping (including the LR) and the Rassemblement national (RN), the Le Pen party.

The results were a major blow to Macron as his Ensemble grouping only obtained 245 seats (down from 350 in 2017). The centre-right LR only won 61 seats, a loss of 51 on 2017, but what has gained the most attention is that NUPES won a total of 131 seats, a seemingly decisive boost to left politics. Of that total of 131 seats, 72 were won by Mélenchon's LFI up from 17 in 2017. Arguably as significant, perhaps even more so, is the fact that Le Pen and the RN won 89 seats. Back in 2017 the RN won eight seats and before that only two in 2012. If the extreme right had formed a coalition how many more seats might they have won?

A President can govern with only a minority of seats in the National Assembly, but it is very, very difficult. To avoid this Macron needs to find 44 or more seats in the National Assembly that will support his government agenda. Macron has governed since 2017 as an 'Imperial President,' and there is very little good will towards him from opponents in the political centre and he can hardly turn to the extreme left or right. Macron and his people are going to have to negotiate rather than dictate to form a favourable government and it will not be easy. Unfortunately, Paris being focussed on internal affairs is not really what Europe needs right now, but that is the reality of the situation.

All of this is happening at precisely the wrong time, as with everywhere else in Europe, France has to confront an energy crisis, a supply chain crisis and inflation. It needs its economy to grow, because if it does not that puts immense pressure on the French government due to the size of the national debt. Add in French private debt and things look even worse. Both Mélenchon on the left and Le Pen on the right share pseudo-socialist economic views, none of which will help France navigate troubled economic waters. This situation will inevitably see demands to cut government spending in non-essential areas and the French defence budget, which is already under pressure, could find itself having to delay or even cancel major programmes. What happens in France, for better or worse, will inevitably have a major impact on Europe.

David Saw

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Strength through capability, commitment and collaboration.

Eurofighter Typhoon

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Effective Proven Trusted

General Christopher Cavoli Confirmed as SACEUR

Photo: NATO

(hum) On 24 June, the US Senate confirmed Army General Christopher Cavoli to serve as NATO's Supreme Allied Commander in Europe (SACEUR) and to lead US forces in Europe. Cavoli, currently Commander United States Army Europe and Africa, will succeed Air Force General Tod Wolters. The inauguration ceremony on 1 July followed the NATO summit in Madrid (29-30 June). Born in 1964 in Würzburg, Germany, General Wolters joined the US Armed Forces as an infantryman in 1987. Before that, he finished his biology degree at Princeton University. His CV lists positions in the US, Europe and Asia, including command assignments in the infantry and an armoured division. He served as deputy commander of Regional Command West in Herat, Afghanistan, and as deputy to the commanding general operations of the 82nd Airborne Division.

At the Pentagon, he was, among other things, the Russia Division Chief, Deputy Executive Assistant to the US Chief of Staff and Director of the Coordination Group of the Army Chief of Staff. A four-star general, he speaks French, Italian and Russian and holds a Master's degree in Eastern European Studies.

Naval Group Signs Framework Agreement with Mevaco

(jh) Naval Group and the Hellenic company Mevaco have signed a framework agreement related to mechanical systems for the FDI HN (Hellenic Navy) frigates. Following the preliminary phase launched a few years ago for the localisation of production activities in Greece, Naval Group has identified Mevaco as a key supplier for mechanical systems and metalwork equipment, Naval Group writes in a press release. Within the scope of the framework agreement, Mevaco will produce part of the mast, hull and mobile equipment.

Image: Naval Group

According to Naval Group, other agreements are on track to be signed with several other Greek companies in the coming months. The company's objective is to further develop its footprint in Greece through partnerships with local industry, research and academic partners.

Hanwha and Kongsberg to Cooperate on IFVs and Long-Range Precision Fires

(jh) The Norwegian Defence Material Agency (NDMA) has issued a Request for Information (RfI) for additional Infantry Fighting Vehicle (IFVs) and a RfI for Long-Range Precision Fire Systems (LRPFS) will be issued later this year, Hanwha writes in a press release. Against this background Hanwha's three defence business subsidiaries - Hanwha Defense Corp., Hanwha Defense Australia (HDA), and Hanwha Corporation - and Kongsberg Defence & Aerospace signed a Memorandum of Understanding for the joined development and implementation of related technologies. According to the company, Hanwha developed and delivered the K21 IFV in service with the Republic of Korean Army and is bidding the REDBACK IFV for the AUD$18-27 billion project of the LAND 400 Phase 3 for the Australian Defence Force (ADF).

Photo: Hanwha

Hensoldt Optronics and Theon Sensors Establish New Company

(jh) Hensoldt Optronics and Theon Sensors are establishing a joint company called Hensoldt Theon NightVision GmbH. The company is headquartered in Wetzlar, Germany. Both companies are already cooperating within the framework of a bidding consortium for a contract to manufacture and supply 9.550 pairs of night vision goggles, (5.000 for the German and 4.550 for the Belgian armed forces) on behalf of OCCAR. Now both partners are complementing their capabilities in the field of thermal imaging and night vision systems. Specifically, new products are to be created on the technological basis of Theon's night vision goggles and Hensoldtr Optronics' weapon-adapted night vision attachments, Hensoldt writes in a press release.

Photo: Hensoldt

MV Werften Acquired by TKMS

(jh) Thyssenkrupp Marine Systems (TKMS) is to take over the shipyard location of MV Werften in Wismar, Germany. The employees were informed about this development by the insolvency administrator Dr Christoph Morgen in the presence of the Minister of Economics of Mecklenburg-Western Pomerania Reinhard Meyer, TKMS CEO Oliver Burkhard and the IG Metall union's District Manager Daniel Friedrich. With this move, one of the most traditional shipbuilding locations in Germany once again has a long-term perspective, TKMS writes in a press release. According to the company, TKMS could produce submarines in Wismar from 2024.

The main impetus for this is an order for more submarines from the German Government and the resulting investments in an upgrade of the shipyard facilities. The extent of such a commitment by TKMS depends on the scope of the programme, the company writes. More orders generate more jobs. If production ramps up in the course of 2024, some 800 new employees could be hired by TKMS. Moreover, if additional orders are received in the surface sector, this number could even increase to over 1,500 employees at the Wismar site, TKMS emphasises.

Photo: MV Werften

Cyprus Orders Six H145M Helicopters

(gwh) The Government of Cyprus has ordered six H145M light multi-role helicopters from Airbus Helicopters for use by the National Guard, Airbus Helicopters has announced. A further six aircraft are considered as an option. Another source revealed that Cyprus has earmarked up to €140M for the twelve helicopters, armament and support.

Photo: Airbus Helicopters, Cara Irina Wagner

Cyprus will receive the latest version of the H145M with a five-blade rotor and the option to arm it with the HForce weapon fit. With HForce, the full range of weapons from machine guns to unguided and guided missiles is available with fire control via integrated observation means.

Cyprus becomes the fifth H145M operator in Europe after Hungary (20), Germany (12), Serbia (9) and Luxembourg (2). Other H145s are used in Thailand (5) and the USA. The US has over 460 UH-72s in service, which are derived from civilian H124s and intended for military use.

Spain to Receive 20 more EUROFIGHTERs

(gwh) At the Berlin Air Show (ILA 2022) Airbus announced that the NATO Eurofighter and Tornado Management Agency (NETMA) has signed a contract with Airbus for the delivery of 20 latest-generation EUROFIGHTERs. According to Airbus, the acquisition, valued at €2.043Bn, was already approved by Spain's Council of Ministers on 14 December 2021 and includes the aircraft, engines, a simulator and the necessary support services. Known as the HALCÓN programme (Falcon), the order covers the delivery of a fleet of E-Scan (Electronically Scanned) radar equipped fighter aircraft consisting of 16 single-seaters and 4 twin-seaters. Spain will use the new aircraft to replace the F-18s in the Canary Islands and expand its EUROFIGHTER fleet to 90.

Reportedly. the aircraft will be assembled and tested in Getafe and are to be delivered between 2025 and 2030.

With the new aircraft, Spain plans to establish a third EUROFIGHTER base on Gran Canaria, in addition to Moron and Albacete.

Photo: Airbus

Renk Contracted for Gear Units and Electric Motors for German Class F126 Frigates

(jh) Prime contractor Damen Naval and Renk have signed a contract for the delivery of reduction gears and electric propulsion systems for the first four new class 126 (F126) frigates for the German Navy, Damen writes in a press release. Among others, the predecessor classes F125 and F124 were already equipped with Renk gensets. Renk can refer to a long partnership with Damen Naval, for example in the construction of frigates and offshore patrol vessels for the navies of the Netherlands, Mexico, Morocco and Indonesia. The new propulsion system is expected to provide a top speed of over 26 knots through combined diesel-electric propulsion (CODLAD).

Image: Damen

Renk's transmissions connect one diesel engine simultaneously with each of the two drive shafts. The company supplies both the gearbox and the electric traction motors with the Renk Advanced Electric Drive (AED). According to Damen, the units can then drive the propellers individually or in parallel. This propulsion concept is used for the first time in the German Navy.

Diehl and Rafael to Cooperate on SPICE Missiles

(jh) Diehl Defence and RAFAEL are going to cooperate on the recently-unveiled SPICE 250 ER, alongside the gliding SPICE 250 as a system intended to be manufactured in Germany by Diehl Defence, Rafael writes in a press release.

Image: Rafael

SPICE 250 is the smallest of the SPICE family, which includes the SPICE 250, SPICE 1000, and SPICE 2000. According to Rafael, SPICE is a stand-off, air-to-surface weapon system that strikes targets with pinpoint accuracy and at high attack volumes, independent of GPS, by applying scene-matching algorithms. SPICE is combat-proven and in service with the IAF and with a number of international customers.

SPICE 250 ER preserves the same characteristics as SPICE 250, incorporating a small turbojet engine to provide range extension, thus enabling stand-off range while retaining the same mission-planning system, aircraft interfaces, and aircrew operation.

SPICE 250 and the ER variant provide an array of homing modes which are to maximise mission success rate while minimising collateral damage. They also incorporate a net-enabled digital data link which allows a Human-in-the-Loop capability, abort-mission command, and BDI.

Teledyne FLIR to Deliver UGVs to German Army

(jh) Teledyne FLIR Defense, part of Teledyne Technologies Incorporated, has announced that it is completing deliveries of 127 PackBot 525 Unmanned Ground Vehicles (UGVs) to the German Army. Final shipments are expected in July. Contract award and deliveries were facilitated through Teledyne FLIR's partner, European Logistic Partners (ELP), based in Wuppertal, Germany. According to Teledyne FLIR, the PackBot 525 is the most advanced model of the company's signature ground robot, used by US and international defence forces since 2001. Deployed in com-

Photo: Teledyne FLIR

bat zones including Afghanistan and Iraq, the 27 kg PackBot has been used for tasks, such as bomb disposal, close-in surveillance, and situations involving hostages or hazardous materials.
Employed in 57 countries, PackBots have helped defeat more than 70,000 IEDs, the company emphasises. The UGV offers communications, a tablet-based controller, and a common architecture that allows users to connect cameras and other attachments to suit different mission needs. PackBot accepts a variety of sensors to detect chemical, biological and nerve agents, radiation levels, and explosives.

Senop to Supply Optical Equipment to the Finnish Armed Forces

(jh) Senop Oy has received a purchase order from the Finnish Defence Forces Logistic Command for deliveries of laser sights and image intensifiers, the company writes in a press release. The order is in continuation of procurement contracts awarded in 2020

Photo: Senop Oy

and 2021. The order value is more than €24 M excluding VAT and delivery of the new systems is scheduled for the years 2023 and 2024. The contract covers of LUKE laser sights, tactical laser sights, and monocular image intensifier NVGs. According to Senop, the LUKE Soldier's laser sight is a light, simple, and robust laser sight to withstand high recoils and extremely challenging use in military conditions. The LUKE Tactical laser sight is a multi-functional device with a visible laser, an IR laser, and an IR illuminator. The EVA 40 NVG is said to be among the lightest high-performance NVGs on the market.

Safran Awarded Contract in the Scope of the FURIOUS Programme

(jh) The French defence procurement agency DGA (Direction Générale de l'Armement) has announced a new "optional tranche" contract awarded to Safran Electronics & Defense for FURIOUS (FUturs systèmes Robotiques Innovants en tant qu'OUtilS), a science and technology programme that aims to develop innovative robotic systems for mounted and dismounted warfighters, Safran writes in a press release.

Photo: Richard Brives, Safran

The DGA's announcement follows field trials of the FURIOUS robotic system, carried out in late 2021 at the French Army's urban combat training centre (Sissone military base). During this phase participants focussed on the modular architecture concept (hardware and software), designed to ensure the autonomous operation of any terrestrial platform, whether manned or unmanned. According to the company, Safran Electronics & Defense was able to deploy this architecture on three very different types of platforms as part of the FURIOUS system. The optional tranche announced by the DGA aims to optimise this architecture and make the autonomous functions developed more robust (tracking passage points, replaying trajectories, monitoring the leader, autonomous target homing, etc.) in more complex and even unstable environments.

Nexter to Support Indonesia's CAESAR Fleet

(jh) PT Len and Nexter have announced the signature of a multiannual In-Service Support (ISS) contract for the CAESAR fleet in

Photo: Nexter

service within the Indonesian Army (TNI-AD). According to Nexter, this ISS features a comprehensive package of services, including on-site technical assistance, delivery of spare parts and training to ensure the readiness of the CAESAR fleet.

China: Third Aircraft Carrier Launched

(hum) On 17 June 2022, China floated its third and most modern aircraft carrier in its dry dock at the Jiangnan shipyard in Shanghai. The ship was christened FUJIAN, a southeastern coastal province, hull number 18. The ceremony was broadcast by the CCTV public television station, Chinese online media showed photos.
A veil of silence still hangs over details. Western military analysts attribute the FUJIAN a displacement of about 100,000 tonnes. The Center for Strategic and International Studies estimates its length at about 318 metres. It seems certain that the new ship will be equipped with electromagnetic catapults. So far, only the US Navy uses electromagnetic catapults, EMALS (Electromagnetic Aircraft Launch System). Catapult launches enable the use of the KJ-600 reconnaissance and early warning aircraft, the Chinese version of the E-2D HAWKEYE. Presumably, the FC-31 will also be used. The stealth aircraft, which resembles the American F-35, can be used as a fighter and a fighter-bomber. Western analysts estimate that there will be room for

Photo: CCTV

between 48 and 60 aircraft on the FUJIAN. The FUJIAN is believed to have integrated or fully electric propulsion (IEP/FEP). Experts expect a nuclear propulsion system for Type 004.
Once operational, FUJIAN will be the third aircraft carrier of the People's Republic, hence the designation Type 003. It is the second one built in the country after SHANDONG (Hull Number 17). LIAONING is the Ukrainian-built VARYAG, a KUZNETSOV-class carrier built for the Soviet Navy.
Chinese commentaries refer to Type 003 FUJIAN as the answer to the US Navy's modern aircraft carriers such as the USS GERALD R. FORD. For comparison, a FORD-class aircraft carrier has about 74 aircraft on board, including 44 F/A-18E/F and F-35C fighters. Length 333 metres, displacement 100,000 tonnes.
With the FUJIAN, Beijing wants to demonstrate its continuous progress towards its intended global maritime supremacy. Even if it will still take time for it to reach operational capability, earlier Pentagon analyses assumed 2024, Type 003 also represents China's growing military power. Whether the PLA-N achieves a similar power projection capability with its aircraft carriers as the US Navy does with its carrier groups rotating

across the globe implies more than ambition and imagination. They are certainly useful as a means of enforcing a political will or impressing possible partners.

Avon Protection Unveils EXOSKIN CBRN Range

(jh) Avon Protection has developed a new range of products to protect military personnel operating in CBRN environments: the EXOSKIN-B1 High Traction CBRN Boots and EXOSKIN-G1 Tactile CBRN Gloves, the company writes in a press release. Avon Protection developed the EXOSKIN range of boots and gloves to supplement its CBRN respiratory protection products to protect personnel without compromising the wearer's tactical agility in the field. Designed to allow for the handling and operation of electronic touch screen devices, the EXOSKIN-G1's ambidextrous glove features a rubberised outer layer textured to maintain grip in wet conditions, with an inner knitted liner that has a conductive tip on both the thumb and forefinger.

Photo: Avon

According to Avon, the EXOSKIN-B1 boot provides improved durability and agility in the field, with quick-release straps to secure the garment over standard footwear and is 100 per cent leak tested. Manufactured from Avon Protection's rubber technology, both the EXOSKIN-G1 glove and EXOSKIN-B1 boot offer chemical warfare agent and toxic industrial chemical protection and are impermeable to biological agents, the company emphasises.

Naval Group Lays Keel for Second Belgian-Dutch rMCM Vessel

(jh) Naval Group has laid the keel for the second of the 12 Mine Countermeasure (MCM) vessels of the Belgian-Dutch rMCM programme, HNLMS VLISSINGEN, intended for the Royal Netherlands Navy, Naval Group writes in a press release. The keel laying ceremony took place in Lanester, in the presence of:

- Vice Admiral René Tas, Commander of the Royal Netherlands Navy
- Commodore Harold Boekholt, Director of Projects of the Netherlands Defence Materiel Organisation
- Lieutenant General Marc Thys, Belgian Deputy Chief of Defence
- Major General Ivan De Tender, Belgian Material Resources Public Procurement

Photo: Belgian Naval & Robotics

This programme was awarded in 2019 to Belgium Naval & Robotics, the consortium formed by Naval Group and ECA Group, following an international competition. It provides for the supply to the Belgian Navy and the Royal Netherlands Navy of 12 MCM vessels and around a hundred drones integrated as part of a toolbox that will equip the vessels. Kership, a joint venture between Naval Group and Piriou, is in charge of the production of the twelve boats which are assembled in Concarneau and Lanester. They will be armed afloat by Piriou in Concarneau.

Hensoldt and Iveco Present Sensor Composite Vehicle for Civil and Military Applications

(jh) Hensoldt and Iveco Defence Vehicles (IDV) presented the Military Utility Vehicle (MUV) concept demonstrator at Eurosatory.. The MUV provides a modular sensor fusion platform that can be used in the civilian and military sectors for surveillance and reconnaissance as well as for self-protection and convoy protection, Hensoldt writes in a press release. The basis of the MUV concept demonstrator is an all-terrain 7-ton-chassis from IDV with a maximum payload of 4 tons. It integrates a sensor suite from Hensoldt with the SETAS, MUSS, Radio Direction Finder and S3 MIMO-Radar systems. All systems are connected by the Central Information Processing Unit (CIPU), which forms the backbone of the sensor suite. The system architecture provides automatic information processing that is to support decision-making and ensure operational readiness under all conditions. The sensor data network is to create complete situational awareness. Potential customers can configure their personal suite according to their wishes through the modular structure of the individual systems.

Photo: Hensoldt

Mercedes-Benz, Rheinmetall and ACS Presenting the CARACAL Vehicle Family

(jh) The CARACAL airborne vehicle family had its public premier at Eurosatory. In partnership with Mercedes-Benz and ACS Armoured Car Systems, Rheinmetall tailored the new versatile and highly mobile 4x4 vehicle family to the requirements of platforms for airborne or special operations units, Rheinmetall writes in a press release. The new family of airborne CARACAL vehicles is based on Mercedes-Benz' G-class chassis for rescue and special operations, featuring optionally mountable protection elements for countering ballistic and landmine threats and a 249 hp six-cylinder Euro III diesel engine which gives the 4,900 kg vehicle a top speed of 140 km/h. Up to two CARACAL vehicles can be airlifted in the cargo hold of a CH-53K KING STALLION or CH-47F CHINOOK transport helicopter.

Photo: Rheinmetall

According to Rheinmetall, the CARACAL can be employed in a variety of roles during airborne operations – as a basic troop carrier or medical support vehicle, for example, or as supply vehicle.

The CARACAL will be ready for full-scale production in 2023.

CATALYST Engine Displayed at ILA 2022

(jh) At this year's ILA Berlin air show, Avio Aero had the full CATALYST turboprop engine on display. In part, the engine comprises 3D-printed components and the programme continues to undergo testing for certification, Avio Aero writes in a press release

Photo: Avio Aero

Reportedly, CATALYST is the first original turboprop designed, developed, and manufactured for business & general aviation in Europe in more than 50 years. The engine made its maiden flight in Berlin in September 2021. According to Avio Aero, CATALYST has today been flight-tested more than 300 hours and achieved more than 3,700 hours of combined ground and air operations with 19 engines assembled. In March 2022, Airbus announced its selection of Avio Aero to power the EURODRONE unmanned aerial system with the Catalyst engine.

Germany to Join CAVS 6×6 Programme

(jh) Germany has signed a statement of intent to join the Finnish-led Common Armoured Vehicle System (CAVS) programme, Patria writes in a press release. The official joining agreement is due to be signed before

Photo: Patria

the end of 2022. Germany will be the fifth country to join the first stage of the multinational cooperation. Finland, Latvia and Estonia entered into the programme in 2019 and Sweden in 2021. In the scope of the programme, Patria is responsible for system development.

According to Patria, the joint programme is open to other countries sharing similar requirements with the mutual consent of the participating countries. Latvia ordered more than 200 Armoured Personnel Carriers (APC) in August 2021, of which Patria has delivered over a dozen. Finland signed a letter of intent in August 2021 for 160 APCs and pre-series deliveries will take place in June. Sweden signed an R&D agreement earlier this month for the research and product development phase.

Aselsan Unveils MEROPS Gimbal Sight

(jh) At Eurosatory, Aselsan unveiled the MEROPS (Multi-spectral Extended Range Optical Sight) air surveillance and targeting gimbal sight. MEROPS has been designed for observation and targeting applications on drones and other aircraft types, Aselsan writes in a press release.

According to the company, the system can especially perform under smoke and dust. It prioritises medium and short-wave thermal

Photo: Aselsan

to support dawn and dusk operations. Furthermore, the sight also incorporates image processing technologies including traditional image enhancement and machine vision and AI based algorithms, as well as mission enhancement capabilities such as:

- Moving target identification
- Isotherms
- False colour identification
- Threat identification.

NHIndustries and NAHEMA Sign NH-90 Support Contract

(jh) NHIndustries has signed an NH-90 support contract with the NATO agency NAHEMA, acting as the contracting authority on behalf of the Direction générale de l'armement (the French Armament General Directorate) and the Direction de la maintenance aéronautique (the French Aeronautics Support Directory) for the French Ministry of the Armed Forces and the BAAINBw for the German Ministry of Defence, Airbus writes in a press release. This contract is to improve the availability rates of the NH90 naval (NFH) and tactical (TTH) helicopters.

Photo: Patrick Heinz

The NH90 Operational Support (NOS) contract, which will be performance-based, will see both nations delegating a major part of their logistics and maintenance activity to NHIndustries, enabling them to focus on their operations. The agreement was also designed in a way that allows additional nations to join at any time.

Through the contract, NHIndustries takes full responsibility for ensuring the continuous flow of spare parts to France and Germany through a flight-hour-based service, Airbus emphasises. The company will manage the inventories of both nations, while also allocating resources to ensure that scheduled inspections and maintenance run seamlessly. Additionally, the contract includes a variety of catalogue services that can be activated as required by the entire community or by individual nations.

The agreement covers five years of support with two optional extensions of five years each, for a total duration of 15 years. It will serve up to 100 NH90s in France and up to 131 NH90s in Germany.

Israeli MoD to Test UGV

(jh) The Israeli Ministry of Defence (MoD) will begin testing the Medium Robotic Combat Vehicle (M-RCV), developed by the Ministry's Directorate of Defence Research and Development (DDR&D), the Tank and APC Directorate and Israeli security industries, the MoD writes in a press release. The vehicle features:

Photo: MoD Israel

- A new type BLR-2 robotic platform
- A 30 mm autonomous turret developed by the Tank and APC Directorate for the EITAN APC
- Elbit's IRON FIST APS
- Fire control and mission management systems
- Robotic autonomous kit
- Situational awareness systems
- A capsuled drone for forward reconnaissance missions
- A passive sensing kit.

According to the Israeli MoD, the technological demonstrator integrates a number of cutting-edge technologies including advanced manoeuvring capabilities, the ability to carry heavy and varied mission loads, and a built-in system for transporting and receiving UAVs. It will also incorporate:

- Sights
- An IAI missile launcher
- Rafael's SPIKE missiles.

Reportedly, the M-RCV's capabilities include autonomous forward reconnaissance and controlled lethality in all-terrain conditions. It is operational around the clock in all-weather scenarios. The system was developed as part of the autonomous battlefield concept led

by the DDR&D in collaboration with the Tank and APC Directorate. Field tests of the M-RCV are expected to commence next year.

GREEN LOTUS Multi-Sensor System Unveiled

(jh) Israel Aerospace Industries (IAI) has unveiled its latest tactical multi-mission, multi-sensor system designated GREEN LOTUS (ELI-2139). Designed to provide high performance Counter-Rocket, Artillery & Mortar (C-RAM) and air and ground surveillance capabilities to manoeuvring as well as stationary forces, GREEN LOTUS features a unique array of active and passive sensors that maximise situational awareness and countermeasures efficiency, IAI writes in a press release.

Image: IAI

GREEN LOTUS integrates several of IAI-Elta's sensors for detection, tracking, classification and identification of aerial targets, from very low Radar Cross Section (RCS) mortar, rocket and artillery fire and small drones, to manned and unmanned fixed and rotary wing aircraft. According to IAI, it also performs ground surveillance, detecting and tracking vehicles and slow-moving personnel.

The multi-sensor data is collected and processed within the system's unified Command and Control console, which employs AI to enhance detection, classification, and identification capabilities. The combined data is to provide users with a clear and comprehensive Situational Awareness Picture, integrating with countermeasures systems, thus facilitating target acquisition and discretion.

MERLIN Introduced by GDELS

(jh) At Eurosatory, General Dynamics European Land Systems (GDELS) presented its the 4×4 MERLIN Light Tactical Vehicle (LTV), designed to respond to the operational requirements of modern airborne, special and light infantry forces. The vehicle is based upon the same engineering principles as the combat-proven EAGLE, the company writes in a press release.

Photo: GDELS

A new member in the GDELS wheeled vehicles family, MERLIN fits inside CH-47 and/or CH-53 transport helicopters and can accommodate up to ten soldiers. The driveline and suspension technology of the vehicle is a derivate of GDELS`DURO / EAGLE 4×4 chassis. MERLIN can be configured in different variants for:

- Personnel transport
- Ambulance
- Logistics
- Combat missions.

Another first presented by GDELS in Paris is the DURO-e 4X4 (DUrable and RObust) all-electric, all-terrain military vehicle. According to the company, the new DURO features newest technologies like hybridisation, electrification, on-board power generation and drive technologies needed for MUM-T capabilities with automated/autonomous operation features.

Spectra Group Supports UK Peacekeeping in Mali

(jh) Spectra Group, in partnership with Inmarsat, is supporting strategic communications for the UK peacekeeping mission in Mali (Op Newcombe) with its SlingShot satellite communications system, the company writes in a press release. According to Spectra, the SlingShot system is low n size,

Photo: Spectra

weight and power and can be integrated with current in-service UHF and VHF tactical communication systems. Reportedly, it can extend radio range from 30 km to 1000(+) km and deliver true Beyond Line of Sight (BLOS) and Communications on the Move (COTM) on all platforms and in all conditions with one system.

Op Newcombe is the UK contribution to the United Nations Multidimensional Integrated Stabilization Mission in Mali (MINUSMA) and is in support of UK Defence Priority Outcome 3 – Enhance global security through persistent engagement and response to crises. Since October 2020, the United Kingdom has deployed a long-range reconnaissance task group, using the Supacat JACKAL 2 reconnaissance vehicle, to provide detailed reconnaissance information to the UN mission, to enhance security for the Mali population and deter insurgent activity. SlingShot was developed for and is used by specialist forces globally, Spectra emphasises. As such, it is suited to the demands of long-range reconnaissance in Mali, where personnel are deployed in remote locations.

Rigaku Raman Analyser for US

(jh) Rigaku Analytical Devices has announced that its ResQ CQL 1064 nm Raman analyser has been accepted for chemical identification as part of the US Joint Program Executive Office for Chemical, Biological, Radio-

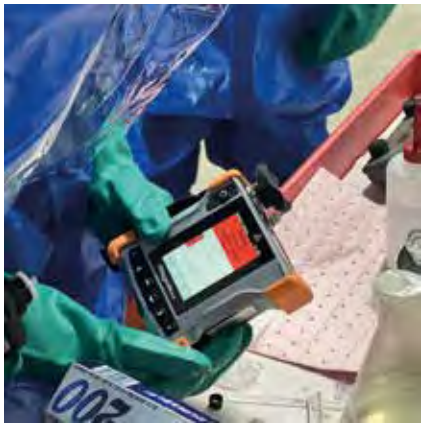

Photo: Rigaku

logical and Nuclear Defense (JPEO CBRND) programme to modernise the military's Dismounted Reconnaissance Sets, Kits and Outfits (DR SKO) systems, Rigaku writes in a press release The DR SKO system modernisation programme deploys new and improved kits of technology to Department of Defense (DoD) locations around the world for characterization of suspected chemical, biological, radiological, and nuclear (CBRN) hazards. Rigaku's original handheld 1064 nm Raman-based analyser, the ResQ, was selected in the scope of this this programme in 2019. Following extensive head-to-head evaluations of a variety of technologies, Rigaku's portfolio was chosen based on its accuracy, ease of use, ruggedness, and features, Rigaku emphasises.

The Rigaku ResQ CQL analyser was launched in 2018. The 1064 nm Raman-

based technology is in use by first responders, border protection, law enforcement, and the military located around the world for identifying chemical threats – such as explosives, chemical warfare agents (CWAs), precursor chemicals, household hazardous chemicals, narcotics, and more. According to the company, unique features of its product line include 4C technology which monitors individual results for precursors that could be used in recipes to manufacture greater threats. The optional QuickDetect Mode allows for the detection of non-visible amounts of a substance based on automated colorimetric technology available on-board the ResQ CQL. This provides both detection and identification on one device.

Bittium Releases TOUGH MOBILE 2 Tactical

(jh) Bittium complements its offering with Bittium TOUGH MOBILE 2 Tactical, a complete tactical solution that enables soldier mobile communications, the company writes in a press release. The solution is based on the TOUGH MOBILE 2 smartphone that is connected with either Bittium TOUGH SDR Handheld radio or third-party tactical radios. According to Bittium, the solution is compatible with different battle management systems, which enables real-time and efficient creation and sharing of situational awareness in tactical networks.

Photo: Bittium

The solution is completed by software that enables secure communication and accessories designed for military use:

- Bittium SECURE CALL application enables end-to-end encrypted voice and video calls and messages with attachments in closed IP networks with no dependency on public Internet or cloud services.
- Bittium SECURE SUITE device management and encryption software enables efficient utilization of the information security features of the smartphone as well as reliable mobile device management, remote attestation, and securing the network connections of the device.
- Bittium TACTICAL POWER PACK enables uninterrupted field use for the smartphone and Bittium TOUGH SDR Handheld radio combination.
- Rugged tactical case designed for TOUGH MOBILE 2 smartphone protects the phone and enables easy use and mounting to soldier gear together with its PALS/MOLLE mount.

Carboteh Introducing BANS

(jh) At Eurosatory, Slovenian Carboteh unveiled what the company calls a revolutionary approach to air defence: BANS – Battlefield Anti-aircraft Non-lethal VSHORAD

Photo: Guardiaris

System. Reportedly, BANS introduces effective anti-aircraft defence without a single shot fired. The light shoulder weapon simulates a missile launch pattern that digitally stimulates an aircraft's missile launch warning and detection system and triggers its alarm. The combat aircraft or helicopter is forced to immediately dispense countermeasures with flares. Extensive use of flares leaves the combat aircraft vulnerable to anti-aircraft missiles. Pilots must then either abort their mission or remain under VSHORAD missiles.

Jankel Receives Pre-Orders for Armoured Toyota LC300

(jh) Jankel has announced the receipt of a number of pre-orders for the armoured Toyota LC300, in advance of the formal product launch, the company writes in a press release. The orders have come from a number of undisclosed existing customers who previously purchased armoured variants of preceding Toyota LC200.

Photo: Jankel

According to the Jankel, the LC300 has also been added to a number of in-place customer framework contracts in anticipation of the product launch. This will allow existing LC200 customers to immediately order the new LC300 vehicle that has been designed to meet the known demanding specifications and requirements of the established framework contracts, Jankel emphasises.

iXblue INS Selected for U212CD Submarines

(jh) Kongsberg Defence & Aerospace (KDA) has selected iXblue to provide the MARINS M8 inertial navigation systems (INS) for the new U212CD submarines for the Norwegian and German Navies, iXblue writes in a press release. Built by Thyssenkrupp Marine Systems (TKMS), the Norwegian Navy will receive four, and the German Navy two newly built class U212CD (Common Design). The MARINS M8 INS will be interfaced with KTA Naval Systems' ORCCA combat management system. The MARINS series are the highest-grade Inertial Navigation Systems (INS) produced by iXblue. According to the company, naval units to be equipped with the system include:

Image: TKMS

- The full fleet of the UK Royal Navy submarines
- The Swedish Navy's A19 and A26 boats
- The newest French FDI,
- Spain's F110 multi-mission frigates
- The US Navy's FREEDOM-class Littoral Combat Ships
- Finland's four multi-role corvettes (SQUADRON 2020 project)
- The Polish Navy's KORMORAN II class MCMVs,

IAI Awarded Contract for Several Hundred Combat Vehicles

(jh) At a ceremony held at the IAI's Land Division production line in Be'er Sheva, the Deputy Director General and Head of the DOPP in the Israeli Ministry of Defence, Avi Dadon, signed an order to produce hundreds of combat vehicles for the IDF, IAI writes in a press release. As part of the more than 100

Photo: MoD Israel

million NIS agreement, IAI will manufacture Z-MAG and ZD vehicles for IDF special forces missions in cooperation with Ido Cohen and The Armored Group (TAG).
According to the company, the new commando vehicles have exceptional all-terrain capabilities, such as carrying combat soldiers and equipment weighing 1.5-2.5 tons (depending on the type of vehicle), in a variety of missions including delivering supplies and evacuating wounded soldiers. The vehicles will be based on commercial elements, among other things, that are expected to ensure reliability and relatively inexpensive operation.
The vehicles will be manufactured at the Land Division production line in Be'er Sheva which, requiring an investment of tens of millions of NIS by the Ministry of Defence. The production line is part of IAI's Elta Division.

Galvion Introducing Nerv Centr® Hub Application

(jh) Galvion has announced the introduction of the Nerv Centr® hub application at Eurosatory 2022. Developed to support their recently launched man-worn power and data capabilities, the hub application offers users the ability to monitor real-time power usage in order to more effectively plan for future missions. Galvion writes in a press release.
On the battlefield, radios, NVGs, GPS, smart phones, laptops, drones, and other surveillance equipment all demand power. According to the company, the ability to manage that power efficiently is mission-critical. The Nerv Centr® hub application is designed specifically to make the job of real-time power management for the modern operator easier, Galvion emphasises
Some features in live power mode include estimated remaining run time based on attached power and devices, low power alert and voltmeter to enable optimal solar blanket positioning. The application also allows for after-mission power analysis which offers a more detailed understanding of power usage and allows for comparisons to be made across users. Mission data can then be included in the Power Modelling tool, which analyses historical and modelled power usage in order to predict future mission needs and enable more precise logistic and support planning.

Photo: Galvion

Allen-Vanguard Launches ATAK ECM Plug-In

(jh) Allen-Vanguard has announced the launch of an Electronic Countermeasure (ECM) plug-in for the Android Tactical Assault Kit (ATAK) platform. The application is to unify the command and control (C2) of all their ECM products and simplify the training, operational and maintenance burden for mission commanders, Allen-Vanguard writes in a press release.

Image: Allen-Vanguard

The ATAK ECM plug-in was developed by Aries Defense and launched at Eurosatory 2022. ATAK is an Android smartphone geospatial infrastructure and military situation awareness application. It allows for precision targeting, surrounding land formation intelligence, situational awareness, navigation and data sharing. Aries Defense have developed over 50 ATAK plug-ins. They are currently fielded by US agencies, SOCOM and the US Marine Corps. ATAK has a plug-in architecture allowing developers to add specialist functionality. At the same time, it also provides an easily customisable intuitive interface making it adaptable to the divergent needs of Allen-Vanguard's wide end user base; whilst maintaining commonality to ease the training burden, the company emphasises

Avon Protection Unveiling the MCM100 Multi-Role Rebreather

(jh) Avon Protection's MCM100 is a fully closed circuit, electronically controlled, mixed gas rebreather CE tested to 100m and suitable for a large range of tactical diving disciplines including shallow or deep Mine Counter Measure (MCM), Explosive Ordnance Disposal (EOD), Mine Investigation and Exploitation (MIE) and Special Operations Forces (SOF) underwater vehicle use, the company writes in a press release. According to Avon, the system's critical advantage lies in its advanced electronics architecture. With multiple redundancy electronics, it features digital oxygen sensors and has a moisture tolerant digital carbon dioxide sensor. This combined with data acquisition facility with Bluetooth capability, and a backlit colour handset with automated pre-dive and command-based alarms enables missions of greater duration than traditional systems at extreme work rates and depths, the company emphasises.

Photo: Avon Protection

Indra Awarded Contracts in the Scope of TIGER MkIII Programme

(gwh) As part of the Mid-Life Upgrade (MLU) programme for the French and Spanish TIGER combat helicopters to the MkIII version, OCCAR has awarded three supplementary contracts to Indra, OCCAR writes in a press release.
According to OCCAR, the Identification Friend or Foe (IFF) system will be hardened against interference to meet the requirements of the future NATO Mode 5 standard. To increase the survivability of the Spanish TIGERs, the electronic combat system will be upgraded with chaff and flare for both low altitude and short-range operations and high altitude and long-range operations. The Spanish battle management system will receive an adapted command & control (SpC2) software that enables tactical data exchange via data link connections with other aircraft or with ground forces.
64 French and 18 Spanish TIGER MkIII aircraft are scheduled to be deployed from 2030.

Photo: Indra

The EU's Role in Reconstructing Afghanistan

Andreea Stoian Karadeli

The US troop withdrawal and the Taliban comeback marked a new chapter for Afghanistan and also for all those international actors that have played their part in the long Afghan war. Although its role in the country's history has never been as powerful as that played by the US, the EU still holds a moral responsibility to now fulfil its promises to the Afghan people, precisely when it is most needed.

Currently pre-occupied with the Russian-Ukrainian war, challenging not only its security, peace, and stability, but its own existence, the EU is forced to prioritise its long list of commitments. Meanwhile, the promises made to the Afghan nation seem to be kept on hold, in the shadow of a triple dilemma: (1) Should the EU engage in reconstructing Afghanistan? (2) If the EU becomes part of this new Afghan chapter, what is the correct strategy to follow? (3) Is the EU prepared to deal with the change of local players in Afghan politics?

The EU needs to take the time to reflect on its overall involvement in Afghanistan before the 2021 Western withdrawal, to understand the flaws in its own strategy and to address them. Unfortunately, the past two decades of EU policy interventions in Afghanistan have demonstrated a dangerous lack of contextual understanding of the developing situation in the country, a superficial one-size-fits-all democracy support strategy, and a counteractive security approach. Without an official, honest, detailed, well-resourced, and publicly available critical assessment of the EU's actions and involvement in Afghanistan since the 1990s, a new commitment towards the Afghan nation will be doomed to fail.

Photo: ISAF Media

An RAF airman hands a bottle of water to a local child during an ISAF patrol in July 2008. The RAF routinely patrolled the area surrounding Kandahar Air Field to prevent rocket attacks against the base

Photo: Ben Barber / USAID / Pixnio / CC0

Afghan citizens building a school supported by USAID.

Author

Dr. Andreea Stoian Karadeli is an independent researcher based in Turkey, an Associate Fellow at the Geneva Centre for Security Policy and a Visiting Researcher at the University of South Wales. Her interdisciplinary research varies from cultural and intercultural studies to conflict resolution and focusses on national security and terrorism, with a specific expertise in the Middle East.

Afghanistan in 2022

Photo: ISAF Media / Daniel Stevenson

In 2020, the then-German Minister of the Interior Thomas de Maiziére (centre, dark suit) observes German forces assisting in the instruction of the Afghan National Police at a basic training facility in Mazar-e-Sharif.

Ten months after the Taliban takeover of power, chaos in Afghanistan deepens, and all in a painful silence, overshadowed by the war between Russia and Ukraine and its global consequences. With a population of almost 40 million at home and more than 5 million abroad, the Afghan nation seems to have been left alone to face its fate – the hardest challenge so far in 40 tumultuous years.

Current reports from the ground point towards a cessation of armed hostilities in many parts of the country and a consequent reduction in conflict-related casualties since the Taliban takeover. Other sources highlight the ongoing extrajudicial and revenge killings of ex-members of the former security forces and officials and systematic searches for citizens who collaborated with foreign governments before 2021. Afghan society has taken back the path of "absolute control" and is currently being ruled by fear, witnessing the suspension of girls' secondary education, together with severe forms of gender segregation, limits on freedom of movement, association, and expression, lack of employment opportunities, and a deepening economic crisis resulting in poverty, hunger, and humiliation for the Afghan people. The Taliban initially tried hard to masquerade as defenders of human rights, but their return to power has immediately highlighted the gap between their words and deeds.

According to the U.N., since the Taliban's takeover, the economic catastrophe is

only deepening and moving towards a point of irreversibility despite more than US$2Bn spent in aid. The Islamic State Khorasan Province (ISKP) has increased both recruitment among the Afghan population and attacks in the country. The reduction in the international counterterrorism and intelligence footprint in Afghanistan (specifically, counterterrorism operations against ISKP) has provided the group the perfect opportunity to develop its resources on the ground and strike. Moreover, the Pakistani Taliban (Tehrik-i-Taliban Pakistan / TTP) have also became more active in the region, conducting several attacks within Pakistan. The humanitarian situation inside Afghanistan deteriorated in 2021 with significant consequences for the most vulnerable among the population. Some 3.4 million people are currently displaced by conflict. UNHCR is responding to this emergency while in neighbouring Iran and Pakistan, there are 2 million registered Afghan refugees.

EU's Involvement in Afghanistan before September 2021

The European Community and later the EU have been active in Afghanistan since the 1980s. The EU is the second largest donor to Afghanistan, and its efforts towards achieving Afghan security, stability, and democratisation started in 2001, marked by the first international conference on Afghanistan, held in Bonn. Back then, the European Commission committed €4.93M from the Rapid Reaction Mechanism (RRM) to help legitimise the political transition. The primary objective of this funding was to support the political changes under way and extend the control of the new Afghan authorities over the territory of the state.

This first initiative was followed by several other aid programmes between 2002 and 2006, aimed at strengthening the credibility of the Provisional Administration of Afghanistan among the public and to prepare democratic elections, reconstruction, and democratisation. In the period of 2002-2006, the EU contributed €3.7Bn (EC budget and EU Member States) in aid to Afghanistan (EUPOL Afghanistan, 2007), which accounted for almost 30 per cent of global financial aid for the post-war reconstruction of Afghanistan and its development.

While more funding continued to be provided by the EU, situation evolution assessment documents from 2007 emphasise that the financial commitments and international effort has not been efficient enough to provide "real progress towards creating a democratic, stable and prosperous Afghanistan is seriously threatened by the significant deterioration in security and by the exponential growth in opium poppy production" (European Commission, National Indicative Programme of European Community Support 2005-2006: Afghanistan). The report also emphasised several other significant issues from the ground such as insurgency, persisting insecurity, drug trafficking networks, and weak law enforcement agencies that led to deteriorating conditions and in turn resulted in the suspension of projects in high-risk areas.

In 2017, the EU and Afghanistan signed a cooperation agreement for partnership and development, that specified the main pillars of the support framework to be applied during the so-called decade of transformation (2015–2024), such as: building peace and strengthening international security, developing the platform for regular political dialogue ensuring the protection and promotion of human rights and the creation of civil society, economic cooperation and development through increasing EU investments in Afghanistan, cooperation in the field of justice and home affairs, aimed at strengthening the judiciary and police forces and at combating organised crime and irregular migration. While focusing on the vital role of establishing economic development, democratisation and internal stability in Afghanistan, the EU acknowledged that addressing peace and security constituted vital interlinked challenges needed to form the foundation of any new strategy.

By 2021, the EU and its Member States had contributed approximately €11Bn (US$13Bn) to multilateral efforts to rebuild Afghanistan, an amount that even exceeded the US$10Bn contribution that the United States had made to these international reconstruction efforts. The EU and its Member States collectively became the largest donor to the international organisations helping to rebuild Afghanistan, contributing around 34 per cent of the funds for these multilateral reconstruction efforts between 2002 and 2021.

On paper, the EU developed a perfect strategy to support Afghan reconstruction and democratisation efforts. In fact,

Photo: Isaak Lexandre-Karslian / Unsplash

A girl looks on among Afghan women lining up to receive relief assistance during the holy month of Ramadan in Jalalabad, Afghanistan.

Photo: Unsplash

Children back to school in Kabul, Afghanistan

the EU lacked a contextual understanding of the reality on the ground, promoting a model of democracy that centralised the reconstruction project and legitimised top-down, elite-centric processes. The largest funds were processed by centralised state building, while the local democratic empowerment was allocated less. If the EU understood the Afghan system of power and politics during that time and took into consideration all the significant characteristics of local Afghan society, it would have developed its strategy accordingly and might have had better chances to succeed.
Unfortunately, the EU proved unaware of the true use of the provided funding. For instance, a month before the Taliban takeover, the EU maintained donor pledges for 2021–2024 to the Afghanistan Reconstruction Trust Fund and had already disbursed about US$188M of those pledges for 2021, ignoring the fact that over half the districts in Afghanistan were already under Taliban control.
Moreover, the power dynamics on the ground were never truly known by the EU and its international partners who supported the formally democratic system, while the Taliban built informal parallel state structures and gained support from local populations facing an elected but corrupt authoritarian government.

US Troop Withdrawal, Taliban Takeover, and EU Concerns

The events in Afghanistan in August and September 2021 caught most of the international actors on the ground unprepared. The Taliban takeover closed many of the opportunities available for foreign officials and local collaborators to leave the country. For the EU, the rapid developments reflected their dependence on American capabilities, vital for ensuring the evacuation of Europeans and their Afghan partners from Kabul.
Beyond the chaotic aftermath of the Taliban takeover, the new chapter of Afghanistan's history started in 2021 and developed as a challenging task not just for the country, but also for the foreign actors involved to date. Therefore, Afghanistan is currently a hard and demanding examination that has the potential to reflect, paradoxically, the EU's potential for strategic autonomy, measured through information, decision, and action.
Information from the ground about plans to seize Kabul and the rapid advance of Taliban forces was deficient. At the same time, the US decision to leave was announced in the spring and prompted no EU response at the time. As a result, the EU potential to act in such a vulnerable, uncertain, complex, and ambiguous context, was limited. However, this does not have to be a fatal setback for European policy on Afghanistan. On the contrary, it should provide important lessons to develop better objectives and strategy, based on relevant, verified, coherent information that can provide a contextual understanding of the region/local/ground situation. Nevertheless, just like the US, the EU joins the geopolitical competition game surrounding Afghanistan whose actors include China, Russia, and Pakistan, among others. It must take the decision to be an influential force in the region: coordination between Member States – regarding information gathering, decision-making and contributing to the development-security nexus – will be essential.

The EU's Involvement in Afghanistan after September 2021

To begin with, the EU's decision in January 2022 to provide "humanitarian plus" aid through UN agencies to meet the Afghans' basic needs was a first step towards developing practical solutions to the crisis. However, the road ahead is paved with obstacles and unknown traps that demand a more coherent strategy for ending the humanitarian crisis and ensuring Afghanistan's sustainable development is therefore imperative.
In the current context, bearing in mind the most recent global challenges brought about by 2022, the EU is facing a triple dilemma in relation to its developing strategy regarding Afghanistan: responsibility and timing (should the EU engage in reconstructing Afghanistan?), manner (if EU becomes part of this new Afghan chapter, what is the right strategy to follow?), and recognition of local-actors / players (is the EU prepared to deal with the change of local players in Afghan politics?).
While the EU is already facing internal and external pressure, mainly due to the consequences of the war in Ukraine, a vocal involvement in the Afghan crisis might not be seen as a strategic priority. Although the commitment to help and support the Afghan people was clearly emphasised through declarations and action plans, a clear strategy is yet to be drawn up. Secondly, the lack of feasible sources able to provide valuable information from the ground pushes the EU back to the position of taking the wrong course of action, based on inaccurate assumptions of the Afghan crisis. Therefore, acknowledging that the best strategy is the one developed based on a contextual understanding of the reality on the ground, the EU currently needs to first develop its capacity to obtain the necessary information. Thirdly, avoiding any formal recognition of the Taliban while working to tackle Afghanistan's growing humanitarian crisis is a hard task for the EU and for other governments. Although some members of the interim Taliban government may have been posing as more moderate and open to complying with donors' concerns, there is an enormous gap between the Taliban's words and deeds, seeking recognition and financial aid for its government, while using the humanitarian crisis to achieve its goals. Nevertheless, as emphasised by European Commission President von der Leyen, while Europe does not recognise the Taliban and disapproves of its hardline policies and especially its treatment of women and girls, it cannot look the other way as the country faces economic and social collapse.

Conclusion

Although currently at a crossroads, and challenged from all directions, the European Union is still expected to play a key role in leading the global effort to secure vital help for Afghanistan and fulfil its promises to the Afghan people. Beyond humanitarian assistance, the EU and all other foreign actors committed to engaging in this new chapter need to develop a contextualised, ground-based, interlinked approach to normalise the economy and stabilise the political scene. ■

Global Britain – The First Year of Britain's New Strategic Direction

David Saw

Sixteen months after the publication of the British strategy document "Global Britain in a Competitive Age", our objective is to look at the reality of the British situation as regards its defence environment and the challenges that it faces.

The release of the British strategy document "Global Britain in a Competitive Age, the Integrated Review of Security, Defence, Development and Foreign Policy," in March 2021 was without doubt an important moment in British defence and foreign policy planning. When you generate a strategy document like 'Global Britain' you inevitably working on a future environment that is based on a certain set of assumptions. But what happens when those assumptions are challenged by real events? A famous quote derived from the Greek philosopher Heraclitus seems to cover this eventuality: "Always expect the unexpected!" And "unexpected" is certainly the right word for what has happened since March 2021.

Photo: Crown Copyright

The aircraft carrier HMS PRINCE OF WALES (R09) enters Portsmouth. The Royal Navy has two aircraft carriers, the first to enter service being HMS QUEEN ELIZABETH (R08). Possession of such assets gives Britain the ability to operate in support of its 'Global Britain' strategic concept.

Unexpected

The name of the future strategy document "Global Britain" made a lot of sense, as a country like the UK has global economic, political and military interests. Whilst it may suit many to diminish the importance of Britain, especially since Britain left the EU, and it is a view that is certainly popular amongst certain elite circles in Britain, the fact remains that Britain inhabits the top-end of a listing of the top ten global economies. Within the European strategic space, Britain, along with Germany and France, is one of the top three national economies.

The point to grasp here is that the fact that Britain is outside the EU does not make it irrelevant! Again, there are many who wish that Britain had become irrelevant after leaving the EU, but that is a demonstrably false position to take, as evidenced by the continuing economic importance of Britain. Then the military importance of Britain must be factored into the equation. Britain has one of the most important military capabilities within the European strategic space. It should not be forgotten that Britain has a strategic nuclear deterrent primarily invested in the four VANGUARD class SSBN equipped with UGM-133 TRIDENT II D5 missiles. This is the second generation of Royal Navy SSBN taking over from the first generation RESOLUTION class SSBN equipped with UGM-27 POLARIS A3 missiles that were retired in 1996.

In the early 2030s, the VANGUARD class will be replaced by the third generation Royal Navy SSBN to ensure that Britain retains the Continuous At Sea Deterrence (CASD) capability that it has had since 1969. This is the new DREADNOUGHT class, originally known as the SUCCESSOR programme. The industrial aspects of the SSBN programme are being run by the DREADNOUGHT Alliance of BAE Systems, Rolls-Royce and the Submarine Delivery Agency.

The DREADNOUGHT Class

Four DREADNOUGHT class boats are to be built, with the first two units, HMS DREADNOUGHT and HMS VALIANT, currently under construction at BAE Systems in Barrow-in-Furness, the remaining two boats will be, HMS WARSPITE and HMS GEORGE VI. Once it enters service, the DREADNOUGHT class will provide the British CASD capability for the next 30 years.

Without doubt, this is an immensely costly defence programme, but there are actually extremely positive economic implications from the programme. According to BAE Systems, the DREADNOUGHT programme supports nearly 30,000 jobs across Britain, this is accounted for as follows; "nearly 8,000 are directly employed by BAE Systems, with 11,800 jobs in the programme's supply chain and a further 10,200 (induced) jobs supported across the country." On top of that, it is estimated that some £7.5Bn will be spent with 1,500 supply chain companies across England, Scotland, Wales and Northern Ireland. By the end of the first quarter of 2021, the DREADNOUGHT Al-

liance had placed contracts worth £2.5Bn with British industry.

The French Question

There are parallels with France here, with France launching its own third generation SSBN programme, SNLE 3G, in February 2021. Although politically relations between Britain and France are problematic at this time due to personal animosity between the two national leaders and the fact that President Macron is not well disposed towards Britain anyway, an attitude made worse by the fact that Britain left the EU, there is no benefit to anybody in a negative relationship between Paris and London. Indeed, more positive relations would be more beneficial to European security as both countries are permanent members of the UN Security Council and both have a strategic nuclear deterrent force. More than that, both countries have the ability to react and rapidly deploy military force to deal with crisis situations, something that is all too rare in Europe.

It is clear that Anglo-French defence industrial cooperation delivers results and that it is in the interests of both to deepen active defence cooperation. This can be achieved at a government-to-government level or under the auspices of NATO. However, President Macron has made it quite clear that he would like to see a European military force separate from NATO to provide the EU with 'strategic autonomy' in the defence realm. If an EU military force does emerge that is going to be problematic for London considering that Britain has left the EU, but it is also going to be problematic for Paris and for Brussels, for the simple reason that Britain has military capabilities that Europe needs.

Photo: Andrew Parsons / No 10 Downing Street

British Prime Minister Boris Johnson visits Thales in Belfast, who are responsible for the manufacture of the NLAW anti-tank and STARSTREAK air defence missile systems. Johnson has been at the forefront of supplying weapons to the Ukraine, including both NLAW and STARSTREAK.

The Reality Construct

The beginning of a new grand strategy for defence and foreign policy is a serious commitment, especially as it requires new thinking about the operations to which the British military might be called and the provision of the appropriate equipment and personnel to carry out those missions. Assuming this can be achieved, all well and good. But as the British government has developed the outlines of a new defence and foreign policy under the heading of "Global Britain", it is truly unfortunate that it has decided to embark on this process at such an incredibly difficult time.

When Boris Johnson and the Conservative Party won the December 2019 election with a huge majority of 80 seats in parliament, they saw it as their main task to complete BREXIT, which they succeeded in doing, albeit not perfectly. After BREXIT, they could then focus on the British strategy under the new conditions, and this attempt led to "Global Britain". All of this made a great deal of sense at the time, but events in the real world would present the Johnson government with a profusion of unanticipated challenges.

Then in January 2020 came COVID. By the end of that month, it had reached Britain and after that point, any plans that the British government had became a victim to the struggle against COVID. This dominated affairs in Britain through to the end of 2021, with the last COVID-inspired restrictions being lifted in April 2022. The COVID death toll, the massive social and economic dislocation, the vast and unplanned increase in government expenditure, the unwinding of global supply chains and the dislocation of global economic systems became the challenge for the British government.

Photo: Crown Copyright

RAF TYPHOON aircraft, from 3 (Fighter) Squadron, based at Mihail Kogalniceanu Air Base in Romania, participating in the NATO Swift Response exercise over the Krivolak training area in North Macedonia in May 2022. NATO commitments remain central to British defence planning.

A New Set of Challenges

As the pandemic gradually subsided, the government faced a new set of challenges to repair the damage. But the world had changed. For the first time in many years, inflation had returned as an economic threat. Equally dangerous was a perceptible rise in oil and gas prices. These would add to inflation and restrict economic recovery.

Photo: RBSL

That the threat of high intensity conflict is now a reality in Europe could force Britain to rethink some of its strategic priorities, in particular paying more attention to the British Army which remains under resourced to face high intensity threats.

It was clear that the post-COVID recovery would take time and in British politics, time was a luxury that the government did not have. The best they could hope was for affairs to not get that much worse before they got better. The bad news was that matters were tending towards the worse trajectory rather than the best.

One noticeable trend in British politics is the increasing disconnect between London political elites and the legal and media elites that form part of what is often called the 'Westminster Bubble' and ordinary people. The obsession with the Prime Minister breaking COVID lockdown regulations, known as 'Partygate' and then the discovery that the Leader of the Opposition had demonstrably broken the regulations as well, have led to an upsurge in tedium. Amongst other reasons, it is all part of the fact that the elites are still looking to refight BREXIT, while practically everybody else has moved far beyond that. At the voter level, the key issue is the economy, inflation and rising prices. If things continue as they are, ordinary people are going to be worried about heating their houses and keeping their lights on next winter, most likely the elites will be worried about decarbonisation!

At the time of writing, 'Partygate' refuses to go away. Thus, Boris Johnson could be the subject of a 'confidence vote' by MPs of his own party. If he loses he would have to resign as Conservative Party leader and in turn resign as Prime Minister. There is no doubt that Boris Johnson is a frustrating character. On the other hand, he did deliver a massive election victory in 2019 and his two terms as Mayor of London demonstrated that he could get elected in hostile terrain for a Conservative politician. At his best, he is decisive; prior to the Russian invasion of the Ukraine, he reacted and provided the Ukraine with NLAW anti-tank weapons. Britain continued to supply the Ukraine with weapons and ammunition, including more NLAW and the STARSTREAK air defence missile amongst other equipment. At his worst, he is lazy and accident-prone.

Future Imperfect

If they do decide to remove Johnson, what will it change? Not very much. The current Conservative government is not exactly over-burdened with persons of talent and electability. The same logic applies to the Conservative members of parliament. Even if they manage to find a half-way competent alternative to Boris Johnson or Boris Johnson stays as Prime Minister, the problem is that Britain remains mired in problems. Mind you the same goes for its European neighbours as well.

The Russian invasion of the Ukraine has unleashed economic turmoil on a global scale. Inflation, fuel prices rising, shortages, supply chain problems, major food price rises – the list of negatives is endless, with all of this coming on top of the economic damage caused by COVID. At this point, there is also a lack of faith that the British government has the strategy and the policies necessary to restore economic equilibrium, get inflation under control and create the conditions for future economic growth.

In these circumstances, it is difficult to believe that the promised funding boost to support increased defence expenditure that was promised in parallel with 'Global Britain' will actually materialise. A government with a strong majority, little internal dissension and one not facing a developing economic crisis could most likely deliver on a significant rise of defence expenditure. If the Johnson government survives, then 'Global Britain' survives as a strategy and there is a possibility of an uplift in defence expenditure. Should the government fall and a new Prime Minister emerge, 'Global Britain' and an expenditure uplift remain doubtful. If there are new elections and the Labour Party manages to get elected, then 'Global Britain' is dead in the water and significant cuts in defence expenditure should be expected.

Let us assume that the current government manages to overcome its myriad crises and somehow survives to move forward with the 'Global Britain' strategy. Let us also assume that more money is made available for acquisition programmes – put this together and one might think that real progress is possible. Unfortunately, that brings us to the great weakness of British defence acquisition. Put simply, the British defence acquisition structure does not appear to be very good at successfully procuring defence equipment on time, on cost or to specification.

On 11 May 2022, the House of Commons Public Accounts Committee issued its "Fifty-Second Report - Ministry of Defence Equipment Plan 2021–31." While the report acknowledges that the 2020 Spending Review promised a £16.5Bn increase in the Ministry of Defence budget through to 2024/2025. It also commented on acquisition culture: "We are also frustrated to see the complacency with which the Department assumes its [Equipment] Plan is now affordable for the first time in four years. This is despite its worrying inability to control costs in its large programmes, including the Dreadnought class of nuclear submarines, and its reliance on billions of pounds of future cost reductions, many of which have no plans supporting how they might actually be delivered. The prospect of rising inflation will only make pressure on affordability worse."

To summarise then, Britain has a strategy, that strategy is the product of a government whose future is uncertain and therefore the future of the strategy remains uncertain. Beyond that, Britain continues to suffer from defence acquisition problems meaning that it might not be able to acquire the equipment it needs to support its strategic goals. This demonstrates that it is easy to write a new strategy, attempting to turn that into a reality is where the difficulties begin. ■

Viewpoint from London

Photo: author

Searching for Balance – Funding and Programmes

David Saw

It would be fair to admit that Europe has not invested enough in defence in recent years. In consequence, military capabilities have been neglected. Then, in the aftermath of the Russian invasion of the Ukraine in February of this year, we see European political leaders suddenly discovering the importance of having effective defence capabilities and surprisingly indicating that new funding will be found to improve these capabilities.

An immediate reaction to this would be that this is a positive development. It is good news, but an increase in defence expenditure does not happen in isolation. There are numerous factors that impact on the process. These include the state of the national economy and the state of and sustainability of government finances. Here is where the problem comes; after COVID European economies were already in a dangerously vulnerable situation. The reality is that we have low or no economic growth in Europe at the present time and government expenditure risen massively as a function of the struggle against COVID. Added to which, inflation is rising and a recession of undetermined severity is becoming ever more likely. Since February, the economic situation has become worse. Rises in oil and gas, further disruptions to global supply chains, major challenges in terms of food security, and remember – all of this is happening on a global basis. In these circumstances, can we really expect European governments to find extra money for defence?

A Boost in Defence Funding

On the other hand, there are those in Europe who have been planning their future defence acquisitions based on a promise of a significant boost in defence funding. Britain is an example of this. In May, the House of Commons Public Accounts Committee issued a report on the Ministry of Defence Equipment Plan 2021–31. The Defence Equipment Plan has been published annually since 2013 and contains the intended investment in defence equipment over the next ten years. The report notes that the Ministry of Defence "has allocated a budget of £238Bn to its 2021–31 Plan, which represents a 25 per cent (£48Bn) increase on last year's Plan. This follows the Spending Review 2020 announcement that the Department would receive a £16.5Bn budget increase over four years to 2024–25 above its standard annual increase." That sounds like good news. Indeed, it is said that for the first time in four years the Defence Equipment Plan is affordable and the Committee notes they have been told that there is a "headroom of £4.3Bn of budget over cost." Except the Committee commented that the MoD "clearly finds it difficult to control the costs of the largest programmes." They expressed particular concern about cost control on the MoD`s largest procurement effort, the DREADNOUGHT SSBN programme, and the related replacement nuclear warhead programme. They are also concerned about the Future Combat Air System (FCAS) programme, fearing that FCAS could fall victim lack of cost controls. However, FCAS is in the very early stages of its life as a major programme and there is time to put the programme on a solid financial footing. The warning here is that even if you have more procurement money, you will have to spend it wisely.

Budgetary Concerns

Ironically, there are similarities between these defence budgetary concerns and the situation in France. France is embarking on its own SSBN replacement programme, SNLE 3G, and France is also involved in the Système de combat aérien du futur (SCAF/FCAS) future combat aircraft system in collaboration with Germany and Spain. It is still early days for the SSBN programme, but inevitably this will be a costly and complex programme. As for SCAF, the programme is currently mired in disagreements between the two main industrial partners, which means that the French and German governments need to get involved and put the programme back on track.

France does have breathing space on SCAF thanks to the Dassault RAFALE and its success in export markets. Recent orders include 80 RAFALE F4 for the United Arab Emirates (UAE) and 42 for Indonesia. Future prospects include a second batch for the Indian Air Force, the Indian Navy and Serbia, India could account for some 80 extra aircraft and Serbia for 12. All of which can provide a solid basis for the French aerospace industry until the SCAF situation is resolved.

Back in Britain, matters are less encouraging. The Public Accounts Committee noted that 48 F-35 Joint Strike Fighters (JSF) had been purchased, and that the MoD now intended to buy an additional 26 for delivery at the end of the decade. The original plan was to purchase 138 JSF, but it seems that only 74 will ever enter service. However much you plan, defence procurement remains an inexact science.

Missile Defence by NATO's Air Forces

Robert Czulda

NATO's missile defence capabilities are still in a development phase. Russia's aggression has only confirmed the importance of such systems and highlighted NATO's vulnerabilities.

Regardless of the final outcome of the war in Ukraine and the undeniable underperformance of the Russian military, NATO member countries must not underestimate their potential enemy. The Russians will most likely learn lessons and implement further reforms. In the face of financial difficulties and a lack of access to modern technologies, it is highly unlikely that the Russians will be able to develop conventional aviation assets capable of threatening NATO. The Alliance's air forces will still be able to achieve air superiority over Russian pilots or even air domination – not only locally, but also strategically.

Photo: US DoD

A PATRIOT missile battery at a Turkish army base in Gaziantep.

Threat Assessment

Therefore, it is entirely plausible that in the coming years, the Russians will invest more resources in alternative systems, such as cruise and ballistic missiles, UAVs and artillery. In fact, these systems are already Moscow's weapons of choice. According to Kiev, between February and May 2022, Russia fired more than 2,100 missiles at targets in Ukraine, including TOCHKA-U, ISKANDER-M short-range ballistic missiles, Kh-55 and Kh-101 air-launched cruise missiles, KALIBR-M ship-launched cruise missiles and Kh-47M2 (KINZHAL) hypersonic aero-ballistic missiles. Only between late February and mid-March, Ukraine was attacked with more than 1,000 ballistic, cruise and anti-aircraft missiles.

Even if they are often inaccurate and technologically less advanced than modern aircraft, they can still result in indiscriminate killing and mass destruction. For instance, a single missile strike on Kramatorsk resulted in 57 fatalities and more than 100 wounded. Their neutralisation is a significant challenge and this can be seen in Ukraine. While the Ukrainian air defence systems have been able to neutralise conventional Russian aircraft – and force them to fly higher in order to avoid MANPADS – the efficiency of Ukrainian S-300V1 and S-300PS/PT batteries against ballistic missiles is less impressive.

So-called hypersonic missiles create a particularly challenging threat. Apart from the KINZHAL missile, Russia has also developed the 3M22 ZIRCON anti-ship hypersonic cruise missile. It was once again tested in May 2022, when a ZIRCON was launched from the ADMIRAL GORSHKOV frigate and hit a target in the White Sea thousands of kilometres away. It cannot be ruled out that Russia may even stage a provocation and launch ballistic missiles into NATO territory, to later present it as an accident. This is not only a theoretical scenario. Russia attacked the Yavoriv training base in western Ukraine near a major border crossing point into Poland used by refugees fleeing the conflict. On another occasion, the FORPOST UAV (a licence-produced version of the Israeli IAI's SEARCHER II) violated Polish airspace and was later shot down by Ukrainian forces.

According to MDAA (Missile Defense Advocacy Alliance), "recent incursions from Russian drones into allied airspace reveals another NATO vulnerability in detecting, tracking and eliminating unmanned aerial systems. It is more than a wake-up call; it is a make or break call for NATO, which has to rapidly apply lessons learned from integrated missile defence efforts in Ukraine and the recent drone penetrations of allied airspace. This must lead to the development of a fully integrated air and missile defence architecture, otherwise NATO risks accepting the threat of deadly destruction of infrastructure and the indiscriminate killing of civilians".

EPAA

An important element of enhancing missile defence capabilities within NATO is the EPPA (European Phased Adaptive Approach), initiated by President Obama in 2009. It replaced the previous project of President George W. Bush, who wanted to deploy in Europe, i.e., in the Czech Republic (radar) and Poland (launchers), parts of the Ground-Based Mid-course Defense (GMD) missile system, which protects the United States.

During the first phase, the United States deployed the US Navy's Aegis BMD-equipped warships in the Mediterranean Sea and the AN/TPY-2 land-based X-band portable radar in Kürecik (Turkey). The second phase was marked with the establishment of the Deveselu NSF (Naval Support Facility) in Romania (a former air base, closed in 2003),

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Photo: Kongsberg Defence Systems

Test firing the NASAMS by Kongsberg Defence Systems

which is under the operational control of the US Navy's Sixth Fleet based in Naples. Romania hosts a land-based version of the Aegis SPY-1 PESA radar and 12 SM-3 Block IB missiles.

A third phase, which has been delayed, is devoted to the establishment of a similar facility near Redzikowo (in the north of Poland). Initially it was planned that during a fourth phase, Redzikowo would be armed with more agile and faster (with a burnout velocity between 5-5.5 km/s) SM-3 Block IIB interceptors with some anti-ICBM capabilities. However, in March 2013, that phase was cancelled due to – at least officially – technical problems and high costs. The United States decided to put more funds into the GMD system and add more interceptors to Alaska to protect its territory against the emerging threat from North Korean ballistic missiles. As a result, Redzikowo was armed with 24 SM-3 Block IIA missiles. It also has the SPY-1D(V) 3D AESA fixed-array radar.

Roughly US$850M has been spent so far to develop facilities in Poland. While the first base – in Romania – was opened in late 2015, the one at Redzikowo experienced a four-year delay, partially as a result of the COVID pandemic; according to current plans, it is expected to be operational by the end of 2022. It is already operated by 200 personnel.

The Americans assure that missiles located at the Redzikowo NSF do not possess any offensive features. It means that the base cannot be involved in any neutralisation of Russian missiles launched from the Kaliningrad Oblast. Nevertheless, Moscow invariably sees a base in Polish Pomerania as a threat to its strategic forces. In fact, the SM-3 Block IIA has some anti-ICBM capabilities. In November 2020, the United States successfully intercepted a threat-representative ICBM target during a flight test demonstration.

EPAA and NATO

While the EPAA is a US-designed and financed project, which serves primarily the US forces (including US EUCOM), it was undertaken in cooperation with its allies. Moreover, it is simultaneously part of a much wider NATO air and missile defence umbrella, known as the IAMD (Integrated Air and Missile Defence), which is implemented through the NATINAMDS (NATO Integrated Air and Missile Defence System), a network of interconnected national and NATO systems comprised of sensors, command and control assets, and weapons systems. NATINAMDS comes under the authority of NATO's Supreme Allied Commander Europe. NATO IAMD detects, tracks, identifies and monitors airborne objects (aircraft, helicopters, UAVs and ballistic missiles). In addition, if necessary and possible to do so, it intercepts such objects using surface-based or airborne weapons systems.

During the Lisbon Summit in November 2010, it was agreed that NATO would develop a missile-defence capability to protect all NATO European members, including their territories and citizens. This goal was reaffirmed during the Warsaw Summit six years later. During the same event, the IOC (Initial Operational Capability) was declared. Already in Lisbon, it was agreed to expand the ALTBMD (Active Layered Theatre Ballistic Missile Defence) framework, which was established in 2005 to develop the capability to protect only NATO deployed forces against short- and medium-range ballistic missiles. The currently envisioned NATO theatre ballistic missile defence (TBMD) system is designed to protect NATO and allied forces against short- and medium-range threats.

In Lisbon, NATO assumed responsibility for establishing a joint air command and control system, while interceptors and radars were intended to be deployed mainly by NATO member countries. While Romania and Poland host AEGIS ASHORE sites, Turkey (at Kürecik) hosts a US-owned AN/TPY-2 X-band radar. At the same time, Germany provides a location for a command-and-control system at the Allied Air Command at Ramstein Air Base. Rota in Spain is home for four US Navy BMD-capable destroyers: the ROSS (DDG-71), ROOSEVELT (DDG-80), PORTER (DDG-78) and ARLEIGH BURKE (DDG-51). Under so-called "higher-tier" defence, the United States intends to deploy communication and tracking sensors, such as satellites, which NATO does not possess and does not plan to acquire.

Photo: Kongsberg Defence Systems

Wih its medium-range capabilties, NASAMS has been selected by six NATO countries.

Photo: MBDA

Components of a THAAD Fire Control and Communications (TFCC) System - Two Tactical Operations Stations (TOS) and two Launch Control Stations (LCS)

Photo: MBDA / Pesco Mourad-Cherfi

The TWISTER endoatmospheric intercepter

In September 2011, the Netherlands announced a plan to upgrade four DE ZEVEN PROVINCIËN class air defence and command frigates with an extended long-range radar. This plan was presented as a national contribution to the NATO system. The first ship received Thales' SMART-L Multi Mission AESA radar in March 2019. It can detect ballistic missiles up to 2,000 kilometres away, while at the same time it maintains its air-defence capabilities. This was confirmed two years later, when the Royal Netherlands Navy used – for the first time – an onboard radar to eliminate a ballistic missile (interception was carried out by the US Navy's destroyer, PAUL IGNATIUS).

Additional Capabilities

In most cases, NATO systems can neutralise conventional threats at short or very-short ranges. These systems are the most common. When it comes to medium-range capabilities (defined as up to 50 km for NATO), the NASAMS becomes a relatively popular solution. This medium to long-range surface-to-air missile defence system, jointly developed by Raytheon and Kongsberg, is composed of Raytheon's AMRAAM and AMRAAM-ER missiles and SentinelTM radar, and Kongsberg's Fire Distribution Centre (FDC) and canister launcher. It is used by Lithuania, Norway, Spain, the United States and the Netherlands. In May 2020, Hungary became the sixth NATO nation and the twelfth country in the world to acquire NASAMS.

France and Italy are both equipped with the ASTER 30 SAMP/T, while the United Kingdom has just deployed the SKY SABRE system, which is intended to replace its RAPIER air defence system. The first unit equipped with the SKY SABRE was the 16 Regimental Royal Artillery. The same missile – MBDA's CAMM – was selected by Poland for its NAREW programme. Various versions of the PATRIOT are used by Germany, the Netherlands and Spain. Although these are different systems to those supplied by several producers, they are interoperable and can work as a part NATO's BMD structure. This does not, however, apply to Turkey, which has procured the Almaz S-400 mobile, surface-to-air missile system in a highly controversial deal with Russia (however, it has not become operational yet). For obvious reasons, systems such as the S-300 are not fully compatible with NATO standards (the S-300 is in service in Bulgaria, Greece and until recently, also in Slovakia). The same applies to ex-Soviet systems, still used by several post-Warsaw Pact states (SA-5/S-200 ANGARA/VEGA/DUBNA, SA-6/2K12 KUB or short-range systems: SA-3/S-125 NEVA/PECHORA and the SA-8/9K33 OSA).

Some further investments are planned. For instance, Estonia is poised to receive some medium-range air defence capabilities. A procurement of between two - four systems in the next decade has been under consideration. Due to financial constraints, the national defence committee of the Estonian Parliament proposed to take out a loan to fund this project. This idea, however, was not welcomed by Estonian Minister of Defence, Kalle Laanet nor by Estonian Defence Forces' Commander, Lt. Gen. Martin Herem, who said that Estonia has more urgent needs.

Photo: Missile Defence Agency

The ARROW 3

Poland, which seems to be a leader when it comes to procurements in this field, has invested in several tiers. Apart from very short-range (indigenously designed and manufactured GROM/PIORUN MANPADS) and short-range (NAREW with the CAMM-ER missiles), Poland has been introducing new, long-range radars, such as the P-18PL, which is now being tested. According to the producers, it can detect ballistic missiles over Ukraine. Poland has been building its medium-range system, codenamed WISŁA which will be based on the PATRIOT. During the first phase, Warsaw ordered two batteries of the PATRIOT PAC-3+ Build 8. In May 2022, Poland sent a Letter of Request for six additional batteries with the LTAMDS (Lower Tier Air and Missile Defence Sensor) 360-degree AESA radars and the PAC-3 MSE missiles.

Poland will also acquire the IBCS (Integrated Air and Missile Defense Battle Command System), designed by Northrop Grumman, which is to be fully integrated with the US Army, which has requested 3,376 PAC-3 MSE missiles and has already launched a development effort to replace them with new capabilities. Regarding the LTAMDS, the first Raytheon radar has already been delivered to the US Army and is now being tested at White Sands Missile Range, New Mexico. However, according to the House Armed Services Strategic Forces sub-committee, at least 11 years are needed to fully field LTAMDS.

At the same time, Germany expressed interest in the ARROW 3 system with a reported range of up to 2,400 km. As noted by Azriel Bermant (ASPI, Australian Strategic Policy Institute), "This is an intriguing development (…) Unlike Eastern European countries such as Poland and Romania that have enthusiastically supported US missile-defence deployments in Europe, Western European countries have traditionally been sceptical of and even hostile towards the idea of fielding missile defences". According to German press reports, this procurement would cost at least €2Bn. It could be deployed around 2025.

Photo: Missile Defence Agency

An MDA SM-3 Block IIA is launched from the USS JOHN FINN, an AEGIS ballistic missile defence system-equipped destroyer, in November 2020

Room for Improvement

Despite some important accomplishments, there is still a lot of work to be done if NATO wants to be better protected (100 per cent protection, however, will never be possible). There are two urgent, long-term goals that have to be pursued. First of all, NATO needs to improve integration on at least two levels – the first one includes better communication between various member states, while the second one requires full interoperability (technological, human and procedural) and cooperation among various systems (short-range, medium-range, UAVs etc.).

Photo: Raytheon

A PATRIOT launcher

"We also need to create an integrated network of fire units" – a leading Polish expert on missile defence Marcin Niedbała believes – "data from virtually any sensor would then be used to intercept targets by using any means, regardless of country of origin". A second long-term goal is a need to boost long-range capabilities, which at the current moment are not sufficient. Niedbała adds that "an important element of any defence against hostile means of air attack is an ability to destroy the enemy's means on its own territory. Destroying ballistic missile launchers on land is also a part of defensive activities. In this regard, the information advantage of NATO members, combined with modern air forces equipped with precision weapons, will be decisive".

Moreover, there are also some short-term urgencies, which are a result of the current Russian aggression against Ukraine and uncertainty as to the Kremlin's further intentions - as it was said earlier, it cannot be ruled out that the Russians would escalate tensions in order to obtain some concessions from the West. In this scenario, Central-Eastern Europe remains the most vulnerable – Russia can launch an attack both from its own territory (Kaliningrad Oblast) and Belarus. The Kremlin has already threatened to launch an attack against those who providing aid and materiel to Ukraine.

According to US Navy Rear Admiral (Ret.) Mark Montgomery, now a senior fellow at the Foundation for Defense of Democracies (FDD), NATO must prioritise upgrading air defence in that sub-region. "They should resemble the quantity and exceed the quality of weapons stationed in West Germany and its NATO neighbours during the Cold War". There are some developments in this regard. For instance, when Slovakia donated its S-300 systems to Ukraine, Germany and the Netherlands moved their PATRIOT batteries to Slovakia. The United States deployed two PAC batteries to Poland, while the United Kingdom temporarily sent their SKY SABRE system. At the same time, London declared its intention to create a "no cross air line" along the Polish border.

Secondly, situational awareness must also be improved. This gap became more obvious in March 2022, when a Ukrainian Tu-141 UAV flew unnoticed deep into NATO territory before crashing in Croatia. "Unfortunately, the radar coverage in Europe is far from satisfactory" – Niedbała argues – "continental Europe does not have long-range, high-resolution anti-missile radars, such as the AN/TPY-2, used by the THAAD system. A widespread introduction of mobile radars would significantly increase NATO's effectiveness in detecting hostile targets at high altitudes".

NATO has 14 E-3A AWACS aircraft, which are the backbone of NATO's surveillance and early-warning capabilities, but also a fleet of five heavy, long-range RQ-4D AGS (Air-Ground Surveillance) UAVs. MDAA suggests that the E-3 aircraft, used also by the US Air Force and several NATO member states, should be replaced by the E-7 WEDGETAIL, since "the AWACS is poorly equipped to detect cruise missiles, as the AN/APY-1/2 radar inside the E-3's rotating radome is limited in its ability to detect hypersonic threats and those missile threats with a small radar cross-section". Niedbała points out, however, that AWACS aircraft are not always "a cost-effective sensor. Detections of low-flying targets should be supported by aerostats, such as those acquired by Poland in the BARBARA programme, or medium/large UAVs equipped with appropriate radars".

In this context, it is important to mention the TWISTER (Timely Warning and Interception with Space-based TheatER Surveillance) initiative, which was approved in November 2019 by the Council of the European Union. Project members are: Finland, France (coordinator), Germany, Italy, the Netherlands and Spain. MBDA is involved in developing the endo-atmospheric-interceptor. TWISTER "aims at strengthening the ability of Europeans to better detect, track and counter threats", such as ballistic missiles, hypersonic cruise missiles, UAVs, aircraft and helicopters "through a combination of enhanced capabilities for space-based early warning and endo atmospheric interceptors". Although it will be developed within the EU's Permanent Structured Cooperation (PESCO) framework, assets and capabilities will also be available to NATO. The aim is to have the system available by 2030.

Another potentially important framework is NATO's GBAD, which intends to bring a modular solution for very short/short-range, and medium-range ground based air defence. It was launched by ten members in late 2020, and later joined by five additional partners. It is expected that it could be fielded by 2028. At the same time, NATO wants to build a C2 capability for surface-based air and missile defence at the battalion and brigade level. This programme is known as the GBAD C2 Layer and is expected to "reduce the number of systems currently in use by NATO Allies and therefore increase interoperability and resilience" ■

Photo: Rheinmetall

The PSS AEROSTAT by Rheinmetall

A Lot at Stake: The Ukrainian Air Force

Alex Horobets

Is the Ukrainian Air Force on the Verge of Transitioning from the Soviet-era to Western Fighters?

The Ukrainian Air Force had to face huge challenges at the start of the ongoing large-scale Russian invasion. With their first missile strikes, the Russian Armed Forces intended to destroy the Ukrainian aviation fleet and its air defence network. Moreover, the Ukrainian air defence system is armed with lower-range weapons than the Russian S-400 TRIUMF. The most powerful Ukrainian systems are the S-300PS and S-300PT, medium-range BUK-M1, and short-range TOR-M and S-125. Moreover, the Russian Aerospace Force has a larger number of combat-ready aircraft. Despite this, the Russians failed to completely destroy the multi-layered air defence, so their aviation now operates mainly in the frontline zone and at low altitudes. In general, Russian pilots are reluctant to fly deep into Ukraine's rear areas, following cases when their aircraft were downed. Furthermore, Russian warplanes launch missile strikes from Russian airspace. Meanwhile, Russian defence officials have repeatedly claimed they have destroyed Ukrainian aviation. In more than a hundred days of war, the embattled nation's Air Force is still out there, performing combat missions. The current situation raises questions about the future development of the Ukrainian Air Force and what shape it will take.

Photos: Pixabay

A Russian Su-34

From Independence in 1991 to 2014

Upon declaring independence, Ukraine boasted of one of the world's most powerful aviation components, outnumbered only by the United States, Russia, and China. At that time, 669 Air Force units with 122,000 men and women in service were stationed in Ukraine. It was difficult to maintain such a number of aircraft in the grave economic conditions in which Ukraine found itself, while the issue of further modernising the fleet of combat aircraft was seen as an even more challenging task. Moreover, Ukraine has facilities for the independent production of military transport aircraft, but not fighters or bombers. After the fall of the Soviet Union, these production facilities remained in Russia. However, the problem wasn't seen as acute in the 1990s, but manifested itself more clearly in the early 2000s.

From 2010 onwards, the situation of the Air Force began to gradually improve, including in terms of ensuring repair and extension of aviation service life, more flight hours for pilots, and running military exercises. However, this never solved the main problem – fighter jets and frontline bombers would mainly have their life extended or undergo modernisation, but since 2014, with the start of the Russian aggression, Ukraine has seen its aviation repair capacities reduced sharply, as the nation could no longer cooperate with Russia in the military-technical sphere and it became more difficult to obtain parts that were not produced in Ukraine. Although Ukrainian enterprises did have opportunities to modernise and repair combat aircraft, spare parts still had to be purchased from Eastern Europe, where some Soviet-era fighter jets remain in service.

With the launch of the Anti-Terrorist Operation (ATO) in the east of Ukraine, the Air Force also became involved. At first, it was military transport aviation and reconnaissance aircraft, but after the downing of the first plane, permission was obtained to employ tactical aviation. These were mainly Su-25 attack aircraft, as well as MiG-29s, Su-27s, and Su-24Ms. At the same time, amid combat losses, Ukraine's defence companies started to actively modernise, restore, and repair the existing aircraft stock. After the Minsk agreements were signed, aviation was no longer used in the ATO zone. However, Ukrainian pilots used this time to enhance their skills, including by taking part in multiple military exercises, including jointly with their allies.

The problem of updating the aviation fleet persisted, becoming more and more acute each year. Even by extending the service life of existing fighter jets for another 10 years, the command realised that the need to eventually replace aircraft would not' lead anywhere. On 15 May 2020, a long-term defence planning document, the Air Force Vision 2035, approved by the Military Council of the Air Force Command, was adopted. In fact, it was about shifting away from Soviet models and purchasing modern universal fighters, as well as developing an unmanned component. As part of the strategy, it was planned to re-equip the force in three stages with new 4++ generation aircraft, where the first deliveries were to begin as early as 2023-2025. As an option, Saab's JAS-39 E/F GRIPEN or the F-16 Block 70/72 were considered. Ultimately, the Air Force was set to receive 72–108 multirole fighters.

Before the Invasion

The plans were ambitious indeed, but with the start of a large-scale war, all plans were torn up, so Ukraine was forced to fight using only existing aircraft. According to the

World Air Forces 2022 data by FlightGlobal, there are 43 MiG-29s, 26 Su-27s, 12 Su-24s, and 17 Su-25s in the Ukrainian Air Force's active fighter and front-line aviation fleet. By comparison, the same report says Russia has 240 MiG-29/35s (plus 31 ordered), 131 MiG-31s, 273 Su-24s, 192 Su-25s, 350 Su-27/30/35s, 125 Su-34s (plus 20 ordered), a Su-57, as well as strategic bombers. According to the General Staff of the Armed Forces of Ukraine, as of early June, Russia had already lost 212 warplanes and 178 helicopters in the ongoing war. It should be taken into account that the Ukrainian Armed Forces shot down the most capable aircraft manned by hardened high-ranking pilots, whose training takes much longer than one year. For example, one of the pilots of the Su-34 attack aircraft downed over Chernihiv was captured after he survived and ejected. This turned out to be Major Aleksandr Krasnoseltsev, who, before bombing Ukrainian cities, also participated in the Russian bombings of Syria and was even awarded a personal meeting with Bashar al-Assad. There are also cases where even more modern Russian multi-role supermanoeuvrable Su-35 fighter jets were shot down. Once it was a 9K38 IGLA short-range man-portable air defence system and another episode involved air combat with a Ukrainian MiG-29.

It is worth mentioning the downing of modern Ka-52 ALLIGATOR attack helicopters, worth nearly US$17M per unit, which have been in service with the Russian Army since 2011 and were set to be exported from 2017. As has transpired in combat, these machines suffer from significant vibration when heavily laden with missiles and other weapons, which can lead to the rapid wear of equipment and shorter service life of weapons installed. This was reported by a US-based outlet, The Warzone, citing several anonymous experts in the field of aviation. Also, among the features of the Ka-52, the focus is on the onboard defence system, capable of protecting the vehicle from all types of anti-aircraft missiles, while the armour is supposed to withstand 20 mm shells.

The Ukranian Air Force operates 26 Su-27 combat aircraft.

Ukraine is mulling acquiring retired US Air Force F-16 fighter aircraft.

RT footage from the post-battle inspection of a Ka-52 attack helicopter proves that it has issues with armour, which appears to be easily penetrated even by 7.62 mm bullets. Therefore, it is no surprise that a bunch of helicopters of this model were shot down over Ukraine, including with Ukrainian STUGNA-P anti-tank guided missiles and 9K33 OSA short-range tactical surface-to-air missiles.

Prospect of Switching to Western Fighters

So, while outnumbering Ukrainian defence forces, Russian commanders are in no hurry to deploy warplanes deep into Ukraine even in the fourth month of the war, since they do not have full control of the country's airspace. However, the problem is that, despite having enough experienced pilots, Ukraine is short of modern fighters to counter Russia in the sky. The situation is similar with their air defence. And it is in this area that Kyiv is on the verge of switching to Western models of weapons. As a Ukrainian pilot (call sign "Juice") told Radio Liberty, there were cases where 6, 12, or even 24 Russian fighters would scramble against one or two Ukrainian pilots at once, thereby completely blocking the manoeuvring space. But even with the outdated fighters available, Ukrainian pilots, in close coordination with air defence capabilities, provide a deterrent for Russian air operations and prevent the Russians from doing whatever they want in the air domain. According to the Russian Ministry of Defence, as of early May, they have

allegedly downed 149 Ukrainian warplanes and 112 helicopters. The problem with these statistics though is that they represent even more units than Ukraine initially had at the onset of Russia's invasion, including inactive aircraft. Despite victorious reports by Russian defence officials, the Ukrainian Air Force apparently remains a problem for the Russians.

Ukraine has now reached a stage where the transition to non-Soviet fighter jets and Western weapons in general is no longer an element of a 10-year strategy, but an important demand requiring rapid decision-making. According to available data, it is quite possible that these could be F-16 fighters. After all, the lend-lease deal greenlighted by the US administration allows Ukraine to look into this option optimistically. These may be new upgrades of the F-16V Block 70/72, since in 2020 the Pentagon signed a large-scale contract with Lockheed Martin for 1,000-1,500 F-16Vs intended for foreign armies, which will be distributed under the Foreign Military Sale programme.

Also in early May, it became known that the Ukrainian authorities in their negotiations with partners called for them to launch training programmes so that Ukrainian Air Force pilots could start mastering Western aircraft as soon as possible. After all, as soon as it became clear that Russia was opting for a long war, all talk about giving Ukraine exclusively Soviet-era military equipment became irrelevant. The situation is developing in such a way that now the need for the rearming of Ukraine's Air Force has become much more urgent than presented in the Air Force Vision 2035 master plan.

A similar situation is developing with air defence. For example, the latest German air defence system IRIS-T (Tail/Thrust Vector-Controlled Infra Red Imaging System), developed by Diehl Defence, can be delivered to Ukraine this autumn. It is capable of shielding an area the size of the capital, Kyiv. Supply plans have been confirmed by German Chancellor Scholz. According to Ukraine's Ambassador to Germany, within three to four years, Ukraine will be able to install such systems around large cities and critical infrastructure objects.

It should also be mentioned that, as per dpa agency sources, an informal agreement may exist between NATO allies to stop short of supplying Ukraine with certain types of weapons, including main battle tanks and fighter jets. This should apparently minimise the risk of a direct military confrontation between NATO and Russia, since the latter may allegedly see such supplies as evidence that the bloc has joined the war. Firstly, it should be borne in mind that there is no official NATO statement on the issue and, secondly, the West is already supplying heavy weaponry, so Russia may as well invent any pretext to accuse anyone, if the situation so requires.

Moreover, the Alliance previously stated that the decisions on the supply of certain weapons are made by member countries independently, beyond NATO's auspices. And the meetings of defence chiefs of more than 40 nations in Ramstein, Germany (this month, the third such meeting will be held in Brussels) consider specific requests from the Ukrainian military in accordance with the developments at the front, where Ukraine has recently stated an acute need for artillery, self-propelled howitzers, as well as M270 and HIMARS M142 MLR systems to counter massive Russian artillery fire. The issue of aviation supplies requires more detailed research, at least due to the need for appropriate infrastructure, maintenance personnel, and trained crews. However, in the future, NATO needs capable Ukrainian aviation and compatible air defence systems, which will become an additional defence element on NATO's Eastern flank.

Wild Blue Yonder: USAF at 75

Sidney E. Dean

By being at the constant forefront of strategic and tactical developments, the United States Air Force managed to hold its own in the constant battle for budget shares, as well as prestige at the Pentagon table.

The official United States Air Force Song was composed and accepted in 1939, nearly a decade before the USAF became an independent military service. The first verse of the song goes like this:

Off we go into the wild blue yonder,
Climbing high into the sun;
Here they come zooming to meet our thunder,
At 'em now, Give 'em the gun!
Down we dive, spouting our flame from under,
Off with one helluva roar!
We live in fame or go down in flame.Hey!
Nothing'll stop the U.S. Air Force!

While technology has changed since then, the service's esprit de corps remains unchanged as the US Air Force marks its 75th anniversary during yet another transitional phase of its existence.

Photo: USAF

The P-38 fighter aircraft entered service in 1941, and retired in 1949 as USAF transitioned to jet-powered tactical aircraft.

Photo: U.S. Air Force / Heide Couch

From left to right, a U.S. Air Force F-35A LIGHTNING II, F-16 VIPER, P-51 MUSTANG and P-38 LIGHTNING perform a heritage flight during the air show rehearsal at Travis Air Force Base, Calif., May 13, 2022. Heritage flight brings together premier fighter aircraft spanning USAF's 75 year history.

75 Years of Innovation

USAF's roots reach back to the Aeronautical Division of the US Army Signal Corps, an organisation that stood up in 1907 as the world's first heavier-than-air military aviation arm. As the force grew and military aviation's potential was increasingly recognised, the unit was re-flagged numerous times within the US Army, finally becoming the US Army Air Forces (USAAF) in 1941. During much of this time, the aviation community fought the headwind of traditionalist army officers who dominated the senior ranks, sometimes seeing airpower as little more than an adjunct to artillery.

The postwar reorganisation of the US defence establishment recognised the significant contribution which tactical, strategic and logistical airpower had made to the war effort of all belligerents, and perhaps most significantly to the US war effort. The National Security Act of 1947 became effective on 18 September 1947, a date which is still observed as the official "birthday" of the US Air Force as an independent and co-equal military service. Almost immediately institutional rivalry within the defence establishment intensified, especially with the US Navy which traditionally laid claim to be the nation's primary power projection tool. By being at the constant forefront of strategic and tactical developments, USAF managed to hold its own in the constant battle for budget shares, as well as prestige at the Pentagon table.

The past seven-plus decades have seen tremendous technological development, from early jet-powered combat aircraft to development of stealth fighters, digi-

Photo: U.S. Air Force / Master Sgt. Christopher Boltz

A Vietnam-era AC-47 SPOOKY and a present-day AC-130J GHOSTRIDER fly in formation. The AC-47, nicknamed "Puff the Magic Dragon," was USAF's first fixed-wing gunship designed for close air support of ground forces. The AC-130J primary missions are close air support, air interdiction and armed reconnaissance.

Photo: USAF

A USAF F-15A launches an ASM-135 Anti-Satellite Missile in 1985 during a test series which validated the capability of fighter aircraft to function as ASAT launch platforms.

tal cockpits and sophisticated unmanned aerial systems. Two arms of the US strategic triad, nuclear bombers and intercontinental ballistic missiles, have been consistently managed by the Air Force. Military satellites and other space systems have also been disproportionately found in USAF's portfolio; reconnaissance and surveillance satellites as well as space-based navigation and communications systems alone have revolutionized warfare.

Airpower has contributed significantly to shaping the face of military operations over the past decades. The 1948 Berlin airlift permitted the West to withstand Soviet pressure without resorting to arms. Over the next decades, airlift of military forces repeatedly convinced aggressors to stand down, or enabled the US and its allies to master the tyranny of distance. USAF fighter and bomber sorties were essential elements of all wars and military engagements, ranging from Korea in the 1950s to the most recent counterinsurgencies in the Middle East.

USAF's first three-quarters century also reflects significant social change. Segregation in the US military ended in 1948 under President Harry Truman's Executive Order 9981. The first African American cadets entered the Air Force Academy in 1959. Daniel James, who joined the USAAF in 1943, became the first African American four-star general in 1975. In 1976, women earned the right to attend the Air Force Academy and to apply for pilot training; in 1993 combat aviation was also opened to women. While these developments paralleled those in the other services and in American society generally, the prominent achievements of minority and female Air Force personnel also served to inspire young people in the civilian community.

As a result, the demographics of today's USAF reflect significant gains for equal opportunity. Women represent 22.8 percent of active duty officers and 20.9 percent of enlisted personnel in 2022, a significant change from 1950 (2.7 and 1.1 percent, respectively) or even 1990 (13.3 and 14 percent). Racial and ethnic minorities are largely represented in the Air Force proportionately with their percentage of the population at large, although African-American and Hispanic personnel remain seriously under-represented in the officers' corps.

The Air Force at 75 - A Snapshot

USAF's operational forces are currently organised into ten major commands

Photo: US Air Force / Staff Sgt. Jacob Wongwai

Multiple C-130J SUPER HERCULES fly in formation during the 37th Airlift Squadron's 80th anniversary at Ramstein Air Base, Germany, May 25, 2022. The celebration consisted of events including a mass airdrop, a static display including C-130J and a Douglas C-47, and a show-of-force formation.

Photo: U.S. Air Force / Shelimar Rivera Rosado

An F-16 FIGHTING FALCON flies over the Alaska Range Complex during exercise Red Flag-Alaska, in May 2022. The complex provides more than 77,000 square miles of airspace, making it the world's largest instrumented air, ground and electronic combat training range.

Photo: U.S. Air National Guard / Charles Vaughn

A KC-135 STRATOTANKER alongside F-15 EAGLEs over Alaska, in April 2022.

(MAJCOMs) as well as numerous field operating agencies and direct reporting units. Each MAJCOM is assigned either a functional responsibility (for instance, Air Combat Command is responsible for maintaining and providing tactical warfighting units, air-battle management and cyber operations, while the Globl Strike Command is in charge of all strategic forces including Intercontinental Ballistic Missiles and long-range bombers) or a geographic area of responsibility (Pacific Air Forces, US Air Forces in Europe/Africa).

Subordinate to the MAJCOMs are a total of 26 numbered air forces (roughly the functional equivalent to an Army division or corps) and command centres, 144 air wings (including air base wings and training wings), and 312 operational squadrons. The total manned aircraft inventory stands at circa 5,500 (including aircraft flown by the Air Force Reserve and the Air National Guard or ANG). By mission type, this breaks down to: Bomber: 158; Fighter/Attack: circa 2,094; Special Operations: circa 154; ISR/BM/C3: 491; Tanker: 526; Transport: 668; Helicopter: 198; Trainer: 1,179. (These FY 2021 figures will have changed incrementally in some categories.)

While the majority of forces are stationed in the United States, USAF maintains a sizable overseas presence, either at US-controlled installations or through basing or transit rights at partner-service installations. Fiscal Year 2022 (FY2022) active duty USAF personnel strength is 336,700. Air Force Reserve and ANG add 98,600 and 108,300 reservists, respectively. US Space Force active duty currently stands at 8,400.

Challenging Crossroads

USAF remains a power player in Washington politics, but suffered a recent blow with the extraction of space assets (including thousands of active duty and reserve personnel) to form the new, independent US Space Force (USSF) in 2019 – the first new service since USAF's creation in 1947. As a minor consolation, the Space Force remains under the purview of the civilian-led Department of the Air Force, mirroring the USMC's position under the Department of the Navy. To date, USAF leadership is touting the Air and Space partnership between the two services, with a focus on continued efforts to assure dominance across the entire aerospace and electromagnetic spectrum.

Like all the services, USAF is struggling to secure sufficient funding to simultaneously maintain readiness while paying

for modernisation and acquisition programmes. This has led to concerns over a potential multi-year capabilities gap before new, advanced weapon systems become operational in significant numbers.

According to an analysis by the American Enterprise Institute (AEI), funding for USAF weapon sustainment programmes has fallen below Fiscal Year 2020 (FY2020) levels. The budget request for FY2023 only funds 85 percent of USAF's stated requirement for weapon system sustainment investments, even without factoring in recently increased inflation, the AEI's Mackenzie Eaglen wrote in May 2022. Flight training hours have also declined by roughly 25 percent over the past five years (as reflected in the FY2023 budget request).

Force structure is also impacted. In order to free up funding for vital modernisation programmes, USAF plans to divest 1,500 legacy aircraft through 2028, while acquiring only one-third that number of new airframes over the same time period. Procurement requests for new combat aircraft including the F-35 and the new F-15EX fall 35 and 44 percent below previous years' planning. Combat enablers are also effected, with USAF suggesting retirement of nearly half the E-3 AWACS fleet in FY2023, four years before the first E-7 replacement aircraft join the fleet. Lieutenant General Joseph Guastella, Air Force Deputy Chief of Staff for Operations, testified before Congress that the retirement would have little impact on operational readiness because the targeted airframes are only marginally functional. "The aircraft is exhausted," Guastella told the House Armed Services Committee on 17 May 2022. "It is been deployed continuously – much of the Air Force's fleet is in that condition. It's not maintainable out there in the field, and it has significant capability gaps."

In fact, the average age of all USAF airframes is now 29 years, with the bomber and ISR/BM/C3 categories well above this average; only the special operations aircraft average less than 20 years of service. Age alone is not a determinant of readiness or even capability. Many airframes have been thoroughly overhauled or put through Service Life Extension Programs (SLEP), sometimes including installation of new engines and wings. Even without SLEP, many older aircraft have received upgraded sensors and avionics, enhancing survivability and the capacity to interoperate with newer aircraft.

However, upgrades cannot counteract the fact that older airframes are more

Photo: U.S. Air Force / Senior Airman Nicholas Larsen

Two T-38 TALONs fly in formation with two F-16 FALCONs, in April 2022.

Photo: U.S. Air Force

The AC-130J GHOSTRIDER will provide close air support, special operations armed airborne reconnaissance, and ordnance delivery to precise targets in support of ground forces.

Credit: USAF

A QX-58A VALKYRIE test aircraft performs the first release of an internally carried smaller UAV.

Photo: U.S. Space Force

An Air Force Global Strike Command unarmed MINUTEMAN III intercontinental ballistic missile launches during an operation test in February 2021.

maintenance-intensive and have, in aggregate, lower operational readiness rates. An inordinate percentage of the fleet is due, nearly due, or overdue for replacement due to "decades of neglect," according to retired Lt. General David Deptula. The former USAF deputy chief of staff for intelligence stated that over a period of three decades, Pentagon leadership deferred modernisation in favour of "near-term priorities," providing the Air Force with less funding than the Army or Navy. Without adequate modernisation funding, USAF's ability to execute the national defence strategy could be limited, Deptula stated in a November 2021 interview with Air Force magazine. Recent statements by Air Force Secretary Frank Kendall indicate that he largely concurs. "Given the threats that we face, the idea that we can do a major war and a major contingency simultaneously is a stretch," he said on 1 June, 2022 during a Hudson Institute forum.

A Combat Force for Tomorrow

During a different event a month earlier, Kendall clearly stated that he is prioritising capabilities over volume, cancelling the unofficial goal – formulated by USAF leadership in 2018 – to increase the number of operational squadrons by 25 percent for a total of 386. This is part of the effort to shift the department away from the two-decade long focus on counterinsurgency, back to the capabilities needed for the so-called "high-end" fight. "I'm not focussed on counting end-strength or squadrons or airplanes [but] on the capability to carry out the operations we might have to support [toward] … defeating aggression," Kendall said. His goal is the ability to either deter or quickly defeat aggression to prevent development of a protracted conflict during the Brookings Institution event in May. The current situation in Europe notwithstanding, USAF's greater concern is the systematically strengthening Chinese military and the need to potentially wage a war thousands of miles away from major US bases. Fielding more capable new technology – including so-called 6th Generation aircraft – as quickly as possible is seen as the key to prevailing in the anticipated scenarios of a Pacific war.

One operational imperative is developing and fielding the Next Generation Air Dominance (NGAD) "family of systems." NGAD will be centred around a manned air-superiority fighter which will be supported by numerous smaller unmanned platforms serving as reconnaissance

Photo: DoD

A B-52 releases a test version of the Massive Ordnance Penetrator (MOP) over White Sands Missile Range, N.M. in 2009. The 14,000 kg heavy, 6.2 metre long bomb can penetrate to a depth of 61 metres to destroy command centres and other hardened targets.

scouts, armed escorts configured for air-to-air and air-to-ground operations, and/or electronic warfare platforms. This concept of teaming manned and (much lower cost but sophisticated) unmanned aircraft employing – in Kendall's words – "a distributed, tailorable mix of sensors, weapons, and other mission equipment operating as a team or formation" is being touted as the key to future battlefield superiority.

The same concept is envisioned for the next generation strategic bomber, the B-21 RAIDER, which is expected to enter service circa 2026. The manned B-21 is to be augmented by an unmanned bomber with comparable range and speed. This "B-21 long-range strike family of systems" could be accompanied by additional, smaller unmanned escorts to enhance survivability and targeting.

Turning these concepts into reality will require significant advances along the technology and materials spectrum, including very-low-observable coatings as well as improved thermal and electronic shielding for airframes; artificial intelligence capable of autonomous operations at all mission levels; long-range sensors and weapons; and an interference-proof communications and connectivity architecture to maintain the operational integrity of the combined force. More efficient engines will be required to increase unrefuelled range and permit operations along the Pacific area of operations. New payloads – including air-launched hypersonic missiles and stealth-enabled cruise missiles – are also being designed to overcome the tyranny of distance and to evade sophisticated enemy air defence systems. Open architecture is expected to be a vital attribute of all new major systems, simplifying back-fitting and upgrades with new mission systems in order to keep airframes at state-of-the-art capability for the duration of their service life.

USAF is displaying significant confidence in the rate o technology development. While details of the developmental combat systems and weapons remain largely classified, the Pentagon revealed in 2020 that an unspecified demonstrator aircraft had already flown in support of the NGAD program, while that program was still at the conceptual stage. On 1 June 2022, Kendall announced that NGAD had entered the engineering and manufacturing development (EMD) phase, with a potential entry into service possible by 2030. The B-21 program enjoys a lead over NGAD, with first flight of the operational prototype expected in 2023, and a possible IOC in 2026. Fielding of both new aircraft families (and their respective enablers) in operationally significant numbers is expected to take place during the 2030s. ■

Photo: U.S. Air Force / Samuel King Jr.

The HEXA, an electric, vertical takeoff and landing aircraft, hovers in the air during its first test flight in April 2022. The single-seat aircraft, which used 18 motors and propellers, flew for 10 minutes and reached a height of 50 feet. It is being tested as part of USAF's Agility Prime programme.

Credit: Boeing

USAF is replacing the E-3 AWACS system with the Boeing E-7 WEDGETAIL which is already in service with the Australian RAAF.

Photo: Northrop Grumman

This 2015 Northrop Grumman concept image shows a Next Generation Air Dominance fighter firing an air-to-air laser. USAF has not publicly spoken about arming the planned NGAD with energy weapons.

European Combat Aircraft SITREP

Giulia Tilenni

Two groups of European states are working on the development of a Future Combat Air System programme. The UK-led programme is progressing more rapidly than the Franco-German one, but the completion of the two remains far from being achieved, thus the prospect of a possible merger has been raised.

In the last five years, six European countries decided to join the race of next generation fighters and work on a Future Combat Air System (FCAS). On the one hand, the UK, Italy, and Sweden, are developing a system-of-systems called TEMPEST with an eponymous fighter at its core. On the other, Germany and France, joined by Spain, have committed to the development of a Future Combat Air System/Système de Combat Aérien du Future (FCAS/SCAF) that includes a New Generation Fighter (NGF). The two programmes are to be developed in a similar timeframe, but their technical features, and especially their status, do not go in the same direction.

TEMPEST

After the unveiling of a full-scale concept model at the 2018 Farnborough Air Show, the UK, Italy and Sweden signed a Memorandum of Understanding for the development of a next-generation fighter in December 2020. The document outlines cooperation on R&D and establishes a €6Bn-worth, equally shared conceptualisation of the programme. It also schedules the launch of a Concept and Assessment Phase in 2021, followed by a full development phase to begin as of 2025. The TEMPEST fighter at the heart of the programme is expected to reach Initial Operation Capability (IOC) by 2035.

In July 2021, the British Defence Minister signed a £250M (€295M) contract with the so-called Team TEMPEST, led by the British BAE Systems and Rolls Royce, with the participation of Leonardo UK and MBDA UK. This marked the on-schedule launch of the Concept and Assessment phase, mainly focused on the development of relevant sensor fusion. The idea is to provide TEMPEST with the capacity to act as a flying C2 node for the other assets operating within the same system-of-systems, similarly to what happens with Lockheed Martin F-35 fighters. Lessons learned with the development of this latter and previous development programmes will be taken into consideration, as confirmed by British officials during the 2019 DSEI conference. A mock-up of the TEMPEST fighter and of two unmanned jet models supposed to fly together in formation were unveiled at the 2021 DSEI exhibition in London. In speeches delivered at that time, British experts reaffirmed that participating companies were not in a rush to fly a demonstrator or to lock down the design. Rather, the Team preferred to focus on developing relevant technologies and capabilities through model-based system engineering and design. On that occasion, Air Commodore Jonny Moreton, the director of the future combat air programme at the Royal Air Force, affirmed that the "digital engineering revolution" will help "to break the forty-year cycle" usually needed for the conception, development, and construction of a new programme, thus helping to reduce the development cycle to ten to fifteen years. To maximise the programme's efficiency, Team TEMPEST will also work on how to "future proof" the programme. The idea is to solve one of the main issues usually affecting complex and long-lasting development programmes: the fact that operational requirements are usually identified in early stages and then considered as granted, meaning that aircraft might finally be outdated when fielded.

By boosting the role of digital technologies, TEMPEST partners seek to include ambitious experimental systems while managing costs and keeping deadlines.

Leonardo UK will be in charge of the TEMPEST's Multi-Function Radio Frequency System (MFRFS) data collection protocols, expected to be "four times as accurate as existing sensors in a package 1/10th the size", according to the company. The MFRFS' onboard processor suite will allow for filtering the information gathered on the battlefield to generate its dynamic picture. The British branch of the Italian company will be in charge of leveraging

Photo: Airbus

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

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Photo: 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 (NGWS).

and repackaging commercial technologies such as 5G networks to reduce the size and weight of sensors and the energy needed to power them.

Team TEMPEST is also tasked with the development of a "wearable cockpit" interface, to replace analogic and digital inputs with an augmented reality display, supported by a network of Artificial Intelligence (AI) features.

Rolls Royce is working on the "Integrated Power System" (IPS), a hybrid system that will combine gas turbines and on-board electrical systems. The IPS will serve as a "flying power station" for sensors, avionics and directed energy weapons. The engine is intended to generate ten times the electrical power as the Eurofighter TYPHOON. AI simulator tools will be used to design thermal flows and hotspots. According to the company, the use of AI, simulators and hardware testing might help to reduce the development time by 50 per cent.

Unorthodox technologies are also expected on the weapons loadout, which might include directed energy weapons, in addition to hypersonic missiles.

Advancements are also reported on Project Alvina, focused on defining the scheme to deploy small drones in swarms, and on the Intrepid Mind Robotics' modular MOSQUITO airframe, to allow for five different wing shapes to be interchanged with a fuselage in 10 minutes.

Costs vs Benefits for the UK

In 2021, a Command Paper submitted to the British Parliament reiterated that the TEMPEST fighter will be among the major procurement programmes of the next decades. On the one hand, it will allow the country to exploit its industrial base to develop a UK-centred system. On the other, it will help in modernising the base, as the use of disruptive technologies will increase the production pace while lowering costs. According to a PWC report, the programme will have a significant impact on the British economy, with a contribution of £26.2Bn (€30.8Bn) between 2021-2050, set to reach £100Bn (€118Bn), including partners and the supply chain. Moreover, the programme is supposed to support about 21,000 employees per year.

The UK has almost fully funded the initial phases of this joint programme so far. The Italian multiannual defence planning document (Documento Programmatico Pluriennale della Difesa) for 2021-2023 devotes €2Bn to the programme's R&D in line with the 2018 MoU. However, the amount is distributed over the next 15 years, with only €60M to be invested in the next three years, the biggest instalment being scheduled from 2027.

Concerning Sweden, Saab, as the main contractor, established a centre of excellence to research relevant technologies in 2020 and was recently contracted to conduct preparatory studies concerning the development and the realisation of future combat air capabilities. However, the SEK250M (€24M) deal signed on 1 June with the Swedish Defence Materiel Administration (FMV) is intended to benefit not only the cooperative programme with the UK and Italy, but also the national-produced GRIPEN fighters. Indeed, Stockholm has not yet committed to participate in the development of the TEMPEST fighter.

All this considered, the UK might be forced to reorganise its procurement priorities, especially concerning the F-35 programme. As the only Level 1 partner, London was initially expected to purchase 138 fighters, but only 48 have been ordered so far. The MoD is expected to place additional orders, but this might remain beyond the expected number of units.

The Franco-German FCAS Programme

While the UK is progressing well and on schedule with the development of the TEMPEST programme, the FCAS is lagging behind mainly due to skirmishes between main industrial partners.

In 2017, France and Germany, later joined by Spain, agreed on the development of a cooperative Future Combat Air System (FCAS), with first technological demonstrators expected in 2026, then delayed to 2027, for a final commissioning in the 2040 timeframe. Berlin and Paris signed the two year-long, €65M-worth Joint Concept Study in February 2019, and Spain officially joined the programme some months after. Due to diverging political priorities between France and Germany, however, the launch of the 18 month-long, €155M worth Demonstrator Phase1A, crucial for the development of the New Generation Fighter (NGF), at the core of the FCAS system-of-systems, took place one year beyond schedule, in April 2021. To keep 2027 as the deadline for the first demonstrators, partner countries were required to rapidly find a deal on the Demonstrator Phase1B, to build up on the previous phase and mark the

Photo: MBDA

Artist`s impression of an FCAS in Luftwaffe colours

official debut of Spain in the programme. Intergovernmental negotiations between France, Germany and Spain ended in May 2021, when countries agreed to pledge €1.2Bn each for Phase1B, to last until 2024. They accepted to continue their collaboration and launch Phase2, with investments for up to €8.6Bn (or even more) until 2027, when a demonstrator is expected to be ready. However, the contract that relevant companies and the French directorate general of armaments (Direction générale de l'armement, DGA) are required to conclude for outlining the conditions and the detailed funding scheme for this Phase has not been signed yet, thus putting the completion of the whole programme at risk.

As extensively analysed in ESD issue 06/2022, the management of intellectual property rights was at the core of the debate concerning the 1A Phase. Germany asked France for access to all co-funded research in the light of an increased Airbus participation due to Spain entering the programme, but Dassault Aviation refused to share the know-how acquired with the development of other programmes, such as RAFALE. The comprehensive listing of all intellectual property rights to be necessarily shared for the completion of cooperative projects allowed for differences to be overcome and to kick off that phase. On similar grounds, the workflow share is the main cause of the stalemate on Phase1B, still ongoing at time of writing. Airbus is reported to be blocking the final signature of the contract for this phase as it seeks an equal role with Dassault in the development of the fighter, without making concessions in other technological pillars. As a reminder, the whole FCAS programme consists of seven technological pillars: fighter (New Generation Fighter, NGF), engine, combat cloud, remote carrier, missile system, sensors system and stealth, each one to be led by one of the three main contractors according to the "best athlete" principle. The development of the NGF was initially assigned to Dassault Aviation, with Airbus Defence and Space as main partner. The German company leads the remote carrier, combat cloud and stealth pillars. The Spanish Indra is the lead company on the sensor systems, while the European military engine team (EUMET, a 50/50 joint venture between the French company Safran and the German MTU) is in charge for the engine, in partnership with Spain's ITP Aero, a Rolls-Royce Group owned corporate entity.

Photo: Giulia Tilenni

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

Photo: Giulia Tilenni

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

Due to partial overlap in contracts for the different pillars, the whole programme is suffering from delays, and real progress might be registered only on the engine. Last January, the DGA announced that the prototype engine derived from the Snecma/SafranM88 currently powering RAFALE's fighters was successfully tested thanks to the heat-sensitive paint Thermocolor, which allows it to measure the temperature due to colour changes. The prototype will pass "durability" tests in several months.

Does a Merger Between the Two Programmes Make Sense?

In November 2021, Italy's Air Force Chief of Staff, General Luca Goretti, said that the TEMPEST and the FCAS programmes might eventually merge. Indeed, the programmes share a similar expected delivery timeframe (between 2035 and 2040) and are both inspired by the F-35's system-of-systems philosophy. In the next paragraphs, we will try to assess which political, military, and industrial considerations might justify (or not) the merger of the two programmes.

Considerations in Favour

Being Level 1 and Level 2 partners in the F-35 programme, respectively, the UK and Italy are among the European countries that have acquired the most relevant experience in 5th generation fighters, in both industrial and "philosophical" terms. British companies are in charge of building or developing about 10 to 15 per cent of the components of each fighter. For instance, BAE systems collaborates with Lockheed Martin in the development of the latest software updates. As part of the close collaboration between the US and the UK on this programme, UK engineers and test pilots have participated in the Joint Strike fighter programme since its very beginning. For instance, British and US pilots have validated together the first prototype in 2001. Both Italian and British F-35s reached the land IOC in 2018, and the British ones reached the maritime IOC in 2020. However, this know-how alone is insufficient for developing a next generation fighter from scratch but gives the two countries a more practical understanding of what flying a 5th generation fighter brings to the battlefield. Indeed, the added value of fighting a next-generation fighter goes beyond its remarkable technical capabilities, such as advanced stealth and exceptional manoeuvrability. Sensor fusion is one of the most crucial features of next generation fighter programmes, and the UK would be the country with the most relevant first-hand experience, followed by Italy.

With defence spending increasing once again among Western countries after decades of underfunding, several armed forces will need to modernise their inventories and to purchase new weapon systems. Some European countries have already chosen between the F-35 (Finland, Switzerland, Belgium, Poland, Denmark, Norway, and the Netherlands) and RAFALE (Croatia and Greece), but export opportunities within and outside Europe are more significant than in the past. By reducing competition among the most important European companies in the aerospace sector, a merger of the two programmes might help to maximise the positive results of this window of opportunity. The fact that the Italian company Leonardo acquired a 25.1 per cent stake in the German Hensoldt might be an interesting driver for reducing competition, as this would increase commonalities in the radar systems for the two programmes.

A merger would also increase defence cooperation among participants, with France and the UK probably being the countries set to benefit the most. Since the signature of the Lancaster House Treaties in 2010, Paris and London committed to strengthen their collaboration in numerous sectors, including high-value, complex weapons. Considering the positive results obtained, especially on armed forces' interoperability, the two partners reaffirmed their willingness to push cooperation forward at the 2018 Sandhurst summit. They agreed to continue joint efforts on the development of Future Cruise/Anti-Ship weapons (FC/ASW), aimed at replacing French SCALP and British STORM SHADOW airborne cruise missile on the one hand, and EXOCET and HARPOON maritime missiles on the other. They also committed to jointly assess the "emerging conclusions before decisions are taken on future phases" of the development of respective future combat air systems. "We will also pursue opportunities for Combat Air cooperation, and our capability analysis of the Future Combat Air Environment including how manned and unmanned systems might operate together and establish a high level of interoperability across the most important European Air Forces", the final declaration of the 2018 summit states.

Considerations Against

If industrial and military considerations might justify a merger, there are relevant political and strategic arguments in favour of keeping two separated programmes.

Both the British-led and the Franco-German FCAS programmes are intended to increase the strategic autonomy of participating countries and keep them in the race for next generation fighters. However, the UK seeks to find a solid balance between capabilities and time needed for development, while Germany and France seem more focused on finding the best technical features possible rather than in timing. The first results of these different views can already be observed: while Team TEMPEST has already progressed well in the develop-

ment, R&D for the other programme is lagging behind. Consequently, it is hard to imagine that merging the two projects will allow the different parties to reach their respective objectives, especially considering the negative outcome of past cooperative programmes, such as the A400M. Indeed, as the number of participants increases, the timing and technical capabilities will be increasingly negatively affected, as finding a compromise among participants might become extremely difficult.

Brexit and European defence are another important factor to keep in mind. It is well known that France is the EU country that pushes the hardest for developing a stronger EU defence, while the UK has historically blocked stronger cooperative efforts. Not surprisingly, several examples of progress on joint EU defence have been made after Brexit. It is still too early to assess their real impact, but the recent international developments have convinced EU countries of the need to gain more strategic autonomy through joint defence programmes. Kicking off a new cooperative programme with a non-EU country might undermine the results obtained so far, and will be complicated by the new legal framework in place.

In a similar context, the participation of third countries to the programme and the export policy to follow might be significant obstacles to a merger. Collaboration with non-European countries is not taboo for TEMPEST members. The Japanese Government is considering picking BAE Systems instead of Lockheed Martin to support Mitsubishi Heavy Industries in the development of the country's F-X next-generation fighter. Japan and the UK are already collaborating on engine parts and sensor technologies for their respective next generation fighters. Moreover, India might be invited to join the programme as part of a bilateral agreement to strengthen cooperation, and which includes transferring advanced technology to produce fighter jets. Considering that the FCAS/SCAF programme is conceived as being European, combined with the fact that quarrels about know-how and workflow shares are continuing, and that Germany has stricter export rules compared to other countries, the participation of third countries represents a major obstacle to a merger.

Final Remarks

The race for European next generation combat aircraft is far from being over, and success is not guaranteed. Considering the status of the two programmes, the British FCAS is more likely to succeed. The use of disruptive technologies to speed up the different development phases will probably be an effective approach, but funding might be a main obstacle for the conclusion on the programme. For the time being, the FCAS/SCAF is at stake, as skirmishes among the main contractors will likely continue for the whole duration of the programme. In an interview given on 7 June during the Paris Air Forum, Dassault's CEO Eric Trappier declared that the FCAS/SCAF will likely be delayed by ten years. He also recalled that France might therefore find alternatives, which might include continuing the modernisation of the RAFALE fleet to extend its operational life.

All this considered, a merger between the two programmes, which might make sense in mere industrial terms, will lack the sufficient political support, and will probably prove ineffective. ■

Marketing Report: PBS

PBS TJ80: The Perfect Fit for Various Platforms

PBS Velka Bites has supplied aerospace products and services to global customers for more than 50 years. The beginning of the PBS TJ100 turbojet engine programme in 2002 marked the decision to enter the turbojet engine market.

Following the unprecedented success of the PBS TJ100 engine programme (more than 1000 units sold) PBS decided to launch a new turbojet engine development. The programme was to be called TJ80 and the goal was very clear – to deliver an unrivalled engine solution for the fast-emerging UAV market in both civil and defence segments. In 2018, after only two years of R&D efforts, the first TJ80 engine was introduced. The compact state-of-the-art engine had a thrust rating of 900 N and weighed only 12.5 kg.

Only two years after the introduction of the original TJ80 further innovations were investigated. After a thorough internal analysis it was decided to launch a new R&D programme focused on new fuel system and innovations of the flow parts. Stepping up from 900 N thrust rating to 1200 N resulted in a thrust increase of 35%. The globally leading thrust-to-weight ratio makes the PBS TJ80-120 the world's most efficient gas turbine engine on today's market.

Image: PBS

PBS Velka Bites is offering its TJ80 in various modifications which have different technical specifications ranges and engine features. The specification range includes up to 2250 W of el. power delivered to the onboard systems, flight envelope enhanced to more than 32,000 ft. and maximum starting altitude of almost 20,000 ft. The features of the engine include the possibility of salt water recovery, very short start sequence and in-flight restart.

All the key features highlighted above make the TJ80 the perfect fit for various platforms including class 3 Unmanned Aerial Systems (UAS), single use applications (cruise missiles, anti-ship missiles, PGMs, missile guidance kits) or aerial targets.

F-35: Markets and Partners

Suman Sharma

It is said by some observers that "In the F-35 LIGHTNING II, fighter pilots move with impunity." The fifth generation F-35 LIGHTNING II Joint Strike Fighter (JSF), considered the world's stealthiest and most lethal jet, forms the mainstay of not just the American fighter fleet but also of its eight partner nations and other NATO and non-NATO allies, totaling more than a dozen global operators of this magnificent, and technologically advanced machine from Lockheed Martin Aeronautics.

This 35-tonne (with full load) single-seat, single engine, fighter, powered by the American Pratt & Whitney F135 afterburning turbofan, has the international market heating up as demand for sales increase, broadening the F-35 family of users from its nine original partners, who joined the programme at its inception.

Partnered by NATO allies, the fighter jet programme now includes close US non-NATO allies such as Israel, Japan and South Korea, all of whom have declared the fighter combat ready. From being stationed strategically across the US to Australia and aboard warships in the Western Pacific, with nations like Italy and Israel declaring their first 'kills', the F-35 LIGHTNING II JSF appears poised to dominate air power from the Mediterranean to the Indo-Pacific in the foreseeable future.

Photo: Lance Cpl. Michael Thorn / USMC

Three F-35B LIGHTNING II Joint Strike Fighters fly in formation during fixed-wing aerial refuelling training over California, in August 2022.

Original Partners

Founded by nine international partners: the United States, United Kingdom, Italy, Turkey, the Netherlands, Norway, Australia, Canada and Denmark, the programme, which began in 1995, attracted Israel, Japan, South Korea, Singapore, Belgium and Poland as foreign military sales (FMS) customers, taking the tally to more than a dozen, as Lockheed Martin eyed expansion of its global footprint in the aerospace sector, with more nations showing interest.

United States

The US is the world's largest operator and primary consumer of the F-35 LIGHTNING jets. According to the Pentagon's long-term procurement plans, the US Air Force plans a total of 1,762 F-35As, while the US Marine Corps and the US Navy would be armed with 693 F-35Bs and F-35Cs respectively.

Turkey

Turkey was suspended from further participation in the programme after Ankara's decision to acquire the Russian S-400 surface-to-surface missile defence system. Turkey's contribution amounted to about seven per cent of the fighter jet's supply chain.

United Kingdom

The UK is currently operating 18 F-35Bs, and has planned up to 138 jets, with 48 out of those by 2025. Jeremy Quin, Minister of Defence Procurement, has spoken of the UK's intention to purchase around 60 F-35B LIGHTNING jets, which might increase to 80.

Aircraft carriers HMS QUEEN ELIZABETH and HMS PRINCE OF WALES are capable of housing 36 F-35B jets each.

Italy

Italy's order for 60 F-35As for the Italian Air Force and 30 F-35Bs for Italian Navy, totaling 90 was a reduced order from the original 131, most of which have been delivered. Italy is the second most important partner in the programme, after the UK, with a contribution of 4.1 per cent workshare in the design and development stage.

The Netherlands

The Netherlands became a partner in the F-35 LIGHTNING programme in 2015 and placed an order of 46 F-35As as a replacement for the Royal Netherlands Air Force's F-16s, out of which 24 have been delivered to the Dutch Air Force. The supersonic, multirole, stealthy, F-35 LIGHTNING II comprises components manufactured by Dutch firms, with more than two dozen suppliers from Dutch industry contributing towards the programme.

Australia

The Australian order to equip four Royal Australian Air Force squadrons with F-35As, is well in place, with 72 fighters expected to be fully operational by 2023. The first squadron became operational in

2021. Australia, which joined the programme as a Level 3 partner, had plans to spend approximately US$16Bn on the four squadrons.

Norway

The first deliveries for Norway's order for 52 F-35A LIGHTNING IIs began in 2015, with the first two undergoing a two-year training period at the American Luke Air Base, before joining their permanent home at the Ørland Air Base in Norway in 2017. Half of the order has been completed. Norway's contribution in the programme has been in the System Development and Demonstration (SDD) phase.

Canada

An industry partner of the F-35 JSF programme for more than two decades, Canada has an order of 88 F-35s to replace its ageing CF-18s. Canada also enjoys the advantage of being awarded the programme's high value contracts as part of the F-35 global supply chain amounting to approximately US$2Bn.

Denmark

The first F-35A from an order of 27 for the Royal Danish Air Force, to replace the ageing F-16 Fighting Falcons, is expected in 2023. The deliveries for the full order are expected to be completed by 2026.

The Three Variants

The F-35 JSF LIGHTNING II clan comprises three variants. The F-35A is a conventional take-off and landing (CTOL) variant, the F-35B is a short take-off and vertical landing (STOVL) variant, while the F-35C is a carrier variant. All three are single-seat and single engine planes and share the same advanced avionics and performance characteristics.

The most common variant is the F-35A, designed to operate from conventional runways. The US Air Force and the majority of F-35 international partners operate the F-35A version.

The F-35B boasts the distinction of being the first fighter to incorporate stealth technology with supersonic speed and STOVL capabilities. It can land vertically like a helicopter and take off at very short distances. This allows it to operate from austere, short-field bases and a range of air-capable ships. The F-35B is operated by the United States Marine Corps, the United Kingdom, and the Italian Air Force.

The F-35C LIGHTNING II, the first low-observable, long-range stealth strike fighter designed and built explicitly for aircraft carrier operations, was basically aimed at replacing the US Navy's carrier-based F/A-18C/D Hornet, as the carrier strike group's primary offensive combat aircraft for the dual role of close air support and aerial defence.

The F-35C is operated by the US Navy and US Marine Corps.

FMS Customers

Israel became the first country outside the partner nations, to order 50 F-35As for the Israeli Air Force, through the US Government's FMS route in October 2010, with the first deliveries beginning in June 2016. Israel has its first fleet successfully operational.

Japan announced an increase from 42 to 147 F-35 fighters in 2018, comprising 105 F-35As and 42 F-35Bs, to be based at 302nd Squadron, Misawa Air Base.

Deliveries of F-35As for the South Korean Air Force, under a Letter of Offer of Acceptance (LOA) for 40 JSF LIGHTNING IIs, signed in 2014, began in 2018, with pilot training in the US. The fighters, after formally entering service, are based at Chongju Air Base. To date, 13 out of the 40 F-35As ordered have been delivered.

In 2019, Singapore declared its intention to replace its ageing F-16 fleet, through an FMS purchase of 12 F-35Bs. The order was kept small, with the aim to first evaluate suitability and capability, before going for larger numbers. This was approved by the US State Department a year later. Singapore has been cleared to acquire four F-35Bs with an option clause of an additional eight.

Belgium is all set to receive its order of 34 F-35As, under FMS, valued at approximately US$5Bn, to replace its F-16 fleet.

Poland became the tenth NATO member to join the programme after signing a LOA with the US in 2020 for 32 F-35As.

Finland has become an industrial participant in the programme after the signing of the LOA this year for 64 F-35As valued at US$10Bn.

Switzerland is expected to close its own deal before March 2023 for 36 F-35As worth US$5.5Bn.

Germany has shown interest in buying 35 F-35A jets.

Photo: USMC / Sgt. April L. Price

A U.S. Marine F-35B LIGHTNING II prepares to land aboard the USS ESSEX

Spain on the other hand has decided to go for the Eurofighter TYPHOON instead of the F-35.

Greece, which has just bought 18 French RAFALE fighters, has said that the Greek Air Force's next fighter would be the F-35, but only after 2028.

Romania too has shown commitment to buy F-35s after 2030, while it is making do with second-hand planes bought from Portugal and Norway.

The Lockheed Martin communications team has said, "Interest in the F-35 continues. Last year both Switzerland and Finland selected the F-35 for their new fighter jet programmes. Canada recently announced the F-35 is the preferred bidder moving into the Finalization phase of their competition, and Germany stated its intent to acquire 35 jets. We continue conversations here in Greece and are in early conversations with other interested European countries. Follow-on buys continue to be of interest, too. In each of

Photo: U.S. Air Force / Staff Sgt. Keith James

A US Marine Corps F-35B LIGHTNING II receives fuel from the drogue basket attached to the boom of a U.S. Air Force KC-135 STRATOTANKER during an aerial refueling mission near the Horn of Africa, Sept. 15, 2018. The F-35B combines next-generation fighter characteristics of radar-evading stealth, supersonic speed, fighter agility and advanced logistical support with the most powerful and comprehensive integrated sensor package of any fighter aircraft in the U.S. inventory.

these countries a formal procurement process has yet to be launched."

Potential Customers

Meanwhile, there are regions where the F-35s have not yet entered, to the extent that deals have been cancelled. Last year, UAE cancelled the US$23Bn deal for 50 F-35 multirole stealth JSFs. Saudi Arabia, on the other hand, has been keen on acquiring the lethal fighter, but Washington has not given the nod to Riyadh.

Thailand, interested in acquiring at least eight F-35s, valued at US$413M, is still awaiting the green light from Washington, as was enunciated by Tim Cahill, Lockheed Martin's senior vice president for Global Business in February this year at the Singapore airshow.

The Global F-35 Enterprise

From enhancement of national security to powering economic growth, the F-35 LIGHTNING II JSF promises a strengthening of global partnerships, through its traits of being the most networked, most connected, least observable and most highly survivable, giving its pilots an edge over rivals.

A fifth-generation fighter is best known by its efficacy in network connectivity, information fusion, reduced visibility stealth and advanced sensors. The F-35 has not just proven its prowess in the mentioned characteristics, but has also displayed superiority in gathering, analysing and disseminating data, thereby enhancing all surface, airborne and ground-based assets in the battlespace.

The stealth design in the F-35 provides a matchless quality of evading enemy detection and entering contested airspace successfully.

Sustenance of the world's most advanced fighter includes training modules for the pilot and maintainer, base operations; round-the-clock repair and upgrade facilities, regional warehouses, supply chain management and the Autonomic Logistics Information System (ALIS).

Wargames held in 2021 established the F-35 as a well-suited warfighting machine capable of defeating adversaries and ground targets, conveying intelligence and supporting other services in a multi-domain warfare scenario.

The F-35 programme falls under the Pentagon's F-35 Joint Programme Office, the US Navy, US Air Force and the US Marine Corps; Lockheed Martin remains the prime contractor with a global supply chain of more than 1,500 American companies.

Sensor Suite, Speed, Range, Electronic Warfare (EW) System and Cockpit

The F-35 boasts the most advanced sensor suite than any fighter in history, comprising the Active Electronically Scanned Arrays (AESA) radar, Distributed Aperture System (DAS), Electro Optical Targeting System (EOTS) and Helmet Mounted Display System. The aircraft's advanced sensor fusion creates a single integrated picture of the battlefield that greatly enhances awareness, survivability and lethality.

At Mach 1.6, the F-35 is known for its supersonic speed and long range, with a full complement of fuel and internal weapons. The fighter's advanced EW capabilities can locate and track enemy forces, jam radars and disrupt attacks.

However, there has been some talk about displeasure with the engine, resulting in Lockheed Martin's decision to improve the F-35 LIGHTNING II's performance through an upgraded engine. Evaluations are being carried out for the same.

The F-35 cockpit is truly a modern fifth generation fighter cockpit, providing the pilot with data, location, enemy position, through advanced situational awareness. The real-time data is a major leap forward from earlier fighters. The earlier generation fighter pilots, romanticised by characters like Maverick and Ice Man in the movie "Top Gun", largely focused on evading the enemy during a dogfight, but the current crop of fighter pilots have a full picture in front, in order to decide to make the kill through their access to a usable data link.

Comparison with Other Fighters in the Same Class

The only fifth generation aircraft flying in the world today are the American F-35, F-22, Chinese J-20 and the Russian Su-57.

Meant only for the US Air Force, the F-22 RAPTOR is considered the stealthiest fighter jet in the world, boasting a smaller cross radar section compared to the F-35. The RAPTOR is considered superior to F-35 in dogfighting,

The Chinese fifth generation twin-engine J-20 is often compared to the F-22 and F-35 by military analysts in terms of its stealth profile and design.

However, former Indian Air Force (IAF) Chief, B.S. Dhanoa had mentioned in a press conference that the Sukhoi-30MKI radars were capable of detecting a J-20 from several kilometres away, thereby rubbishing any comparison.

The Russian Su-57, which was formally unveiled at the biennial airshow MAKS-2021, has been flying combat sorties in Syria. The Su-57 is believed to be faster than F-35 with a maximum speed of 1,616 mph compared to F-35's 1,199 mph. The Su-57 also has more than double the range which is 3,107 miles versus the F-35's 1,379 miles.

As per American laws, the F-22 cannot be sold to any other country, while potential customers for the Chinese fifth generation stealth J-20 are Pakistan, and countries in the Middle East, Latin America, Southeast Asia and Africa. As per reports, Russia has been eyeing Turkey, Algeria, India, Vietnam and China as probable custom-

ers for its stealth fifth generation fighter. While former IAF Chief RKS Bhadauria has said that India will focus on its indigenous platform - the Advanced Medium Combat Aircraft (AMCA) and will not import Su-57 or any other fifth generation fighter. Turkey's interest in the Russian jet is understandable after its ouster from the F-35 programme.

Still on the drawing board are conceptual projects like the Future Combat Air System (FCAS), the BAE Systems' TEMPEST, and India's indigenous fifth generation AMCA. FCAS is a European combat system of systems under development with France in the lead, partnered by the UK, Germany, Italy, Sweden and Spain, with leading manufacturers being Dassault Aviation, Airbus, Thales Group, MBDA and Safran.

The UK-led BAE Systems TEMPEST, supposedly a sixth generation fighter jet under development is also under the FCAS European consortium. TEMPEST, expected to be operational by 2035, is primarily a BAE Systems project with the UK Ministry of Defence, Rolls-Royce, Leonardo, MBDA and Saab pitching in.

Though the metal-cutting for the first prototype of India's AMCA has taken place, its maiden flight is only scheduled for 2024-25, with series production slated for 2030; IAF's Air Marshal (retd) B Suresh, himself a former fighter pilot, says, "The F-35 and F-22 are fusion platforms that can be optimally employed in a networked environment. In my assessment, the J-20, does not quite match up to these two. The stealth characteristics of J-20 too are also a little overplayed. The AMCA will be a fusion ready five plus generation platform that should turn out better than its competitors. The TEMPEST and FCAS are sixth gen concepts. They can be manned or unmanned and can be used in combo as a MUMT. The concept of employment will be different. That is the future of air combat."

F-35 in Combat:

Israel was the first country to get the first air-to-air kill when it shot down two Iranian drones using the F-35 in March 2021. An Italian Air Force F-35 intercepted a Russian transport plane in the Baltic Sea while on a NATO policing duty in Estonia in early May 2021.

Future

Lockheed Martin eyes Europe as a crucial market. The F-35 order book saw an increase in 2020 from 120 to 142 in 2021, as per reports, with an even greater increase in numbers expected in 2022.

Despite a more than two-year long global pandemic, Lockheed Martin, along with its team, has seen that its vision of replacing a Cold War tactical fighter with a modern, networked, stealthy warfighting machine, largely among US allies and American armed services, could well become a reality.

According to a Lockheed press statement, the F-35 is on track. It is a mature programme, whose efficiencies are increasing and 93 per cent of the JSF's parts have far exceeded performance expectations. Lockheed Martin has delivered over 790 aircraft, and trained more than 1,655 pilots and 12,080 maintenance personnel worldwide. The F-35 fleet has already surpassed more than 517,000 cumulative flight hours.

Eurofighter TYPHOON Update

Jack Richardson

Few aircraft have had a more turbulent journey than the Eurofighter TYPHOON. Initially designed in the 1980s to provide the UK, West Germany, Italy, Spain and France (the latter pulled out to develop what became the Dassault RAFALE) with an air superiority fighter, it had to contend with this role vanishing when the Cold War ended.

As the 1990s progressed, it had to face up to issues ranging from the distribution of work share to the in-service name of the completed platform. The first prototype made its maiden flight in 1994, after which the partner nations reduced their aircraft requirement. For example, the UK's requirement shrunk from 232 to an eventual in-service total of 107 examples. The aircraft were delivered in tranches. Tranche one was an initial configuration focused on the core air defence roles whereas tranches two and three have enabled multi-role capability. The aircraft entered service in the middle of the 2000s in the air defence role, policing events such as the 2006 Turin Winter Olympics. Air policing missions in Albania, the Baltic States and Iceland followed before a multi-role capability was established from 2008 with the ability to drop the Enhanced PAVEWAY II laser-guided bomb. In 2011, RAF TYPHOONs were required to do this for real when helping enforce UN Security Council Resolution 1973 over Libya. This was followed in 2015 when the RAF sent its TYPHOONs to take part in missions over Iraq and Syria against the so-called Islamic State. By this time, the tranche two aircraft had been cleared for operational duties and were able to deploy the PAVEWAY IV 500 pound bomb which can be guided using both GPS and lasers. Ever since embarking on this operation, the RAF's TYPHOONs (Italy's have also been deployed in a reconnaissance capacity) have seen their capabilities evolve.

Photo: Eurofighter

The RAF is now deploying its Eurofighter TYPHOONs in a multi-role capacity as seen here prior to taking off for a sortie over Iraq and Syria.

Evolution

One of these has been the integration of the METEOR Beyond Visual Range Air-to-Air Missile (BVRAAM). A pan-European venture by MBDA, this is equipping increasing numbers of combat aircraft. This ramjet-powered weapon has been seen fitted to TYPHOONs patrolling Eastern European borders during the current War in Ukraine. The TYPHOON is also fitted with a 27mm Mauser cannon but due to the current emphasis on precision guided bombs and missiles, it was unclear for many years whether this would ever be used operationally. However, in one Close Air Support sortie during the campaign against ISIS, an RAF TYPHOON was called upon to deploy its gun. As this campaign progressed, the need for the UK to equip the TYPHOON for air-to-ground combat intensified. This was done under the aegis of Project CENTURION where the aircraft has been upgraded to take over the ground attack capabilities of the Panavia TORNADO GR4. At the centre of this was the integration of MBDA's BRIMSTONE anti-tank guided missile and STORM SHADOW cruise missile. Having been declared operational with both of these weapons by the end of 2018, the TYPHOON used them operationally shortly afterwards with BRIMSTONE in February 2019 (against a small IS craft in the Euphrates River) followed by STORM SHADOW in March 2021 (to destroy an IS cave system in Northern Iraq). Significantly, in December of that year, a TYPHOON used an Advanced Short-Range Air-to-Air Missile (ASRAAM) to destroy a small IS drone over Syria, marking its first successful air-to-air engagement (and the first by the UK Armed Forces since the 1982 Falklands War). The increasing versatility of the TYPHOON in different roles is also being exploited by the other partner nations.

Germany will order additional TYPHOONs to replace older examples. A contract was placed for 38 examples (30 single seat and eight twin seat for training) in November 2020. These will feature the European Common Radar System (ECRS) Mk1 Active Electronically Scanned Array (AESA) radar being developed by leading companies from across the partner nations to improve situational awareness. Some of 110 examples on order will be used to retrofit tranche two and three aircraft. Through using electronic nodes instead of a physical rotating dish, an AESA radar grants extensive improvements in terms of range and situational awareness. Germany's new TYPHOONs, acquired under the project name 'Quadriga', will have

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enhanced air-to-ground capabilities with weapons including the TAURUS cruise missile and laser guided Joint Direct Attack Munition (JDAM). The latter is particularly significant because the addition of laser guidance will allow JDAM equipped munitions to prosecute moving targets.

More New Roles

Another important mission for German defence policy is the capability to deliver US owned B61 nuclear freefall bombs as part of the NATO deterrence mission. The country originally intended to fulfil this mission using the Boeing F/A-18E/F SUPER HORNET. However, following questions over the timeframe it would take to equip this aircraft for the nuclear delivery mission and the evolving situation in Ukraine, the new government of Chancellor Olaf Schulz changed this decision. In March 2022, as part of this pledge to raise Germany's defence spending to the required NATO level of two per cent of national GDP, he announced Germany would purchase 35 examples of the F-35A in order to carry out the nuclear role from 2030. This is not the only mission Germany currently relies on the TORNADO to deliver because it also operates several in the electronic warfare role. The previous plan envisaged this being conducted in the future by the EA-18G GROWLER, a specifically modified version of the SUPER HORNET. However, as Germany has moved away from the Boeing aircraft, it now intends to order 15 TYPHOONs specially equipped for this role.

Photo: Eurofighter

Other partners in the programme such as Germany and Spain are taking advantage of the aircraft's versatility and ordering new examples.

Few details are available at this stage but in 2020, Airbus Defence and Space unveiled a specific variant called the Eurofighter Electronic Combat Role (ECR). This twin seat concept offered several features including a rear cockpit with a wide area display to carry out its mission and two underwing jammers to provide survivability. Weapons offered included the MBDA SPEAR EW to confuse air defences and specialist missiles including the AGM-88E Advanced Anti-Radiation Guided Missile (AARGM) to destroy them.

In addition to Germany, Spain has a requirement for new aircraft with ground attack capability. The country currently operates

Photo: Eurofighter

Eurofighter is offering several enhancements for the aircraft including the ability to carry a larger payload.

legacy EF-18 HORNET multi-role aircraft (E denoting Spain specific changes) from a base in the Canary Islands. These aircraft are due for replacement and Airbus was contracted in November 2021 to supply 20 examples of what it calls 'Tranche 3+' which also feature the Mk1 radar and other air-to-ground enhancements (the radar will also be fitted to some aircraft in the existing fleet).

The Export Market

Throughout its time in service, the nations behind the TYPHOON have been seeking to export it around the world. These have had varied levels of success. Austria became the first export customer with an order for 15 tranche one examples limited to air defence duties by virtue of the IRS-T missile. Following its controversial sale of TORNADOs to the country in the 1980s under the 'Al Yamamah' deal, the UK successfully sold the TYPHOON to Saudi Arabia around the same time under the 'Al Salam' deal. This has also been highly controversial due to the Kingdom's role in Yemen conflict since 2015. However, the TYPHOON has also faced a series of setbacks on the global fighter market. One of the most notable was in 2012 when it lost out to the RAFALE in India's Medium Multi-Role Combat Aircraft competition. Singapore also chose the F-15SG STRIKE EAGLE over the TYPHOON while more recently, it has lost to the proliferating F-35A LIGHTNING II when trying to supply Switzerland and Finland with new aircraft. The partner nations have not given up hope however of further exports. For example, there are reports that Turkey is in talks for 80 examples after it was removed from the F-35 programme. Serbia has also reportedly expressed an interest in the aircraft while Egypt is said to be negotiating a purchase from Italy. Follow up orders in existing customers such as Saudi Arabia are also being chased while it has been suggested Poland could receive Italian TYPHOONs to backfill for ex-Soviet aircraft the country is sending to Ukraine. On a similar theme, various countries around the world have reportedly expressed an interest in purchasing tranche one aircraft as the original partner nations decommission them. It is the quest to market the aircraft more broadly though, that has driven attempts to improve its capabilities.

One of the most recent customers for the aircraft is the Gulf state of Kuwait, which ordered 28 examples (22 single seat and six twin seat for training) in 2015. Deliveries commenced in late 2021 with pilots and ground crew being trained by the Italian Air Force (the country where the aircraft was assembled). These are multi-role models with extensive air to ground capabilities including the Lockheed Martin SNIPER pod for prosecuting air-to-ground targets. Perhaps the most significant feature of Kuwait's TYHOONs however is the radar, as they are the first to be equipped with an AESA radar in the form of the ECRS Mk 0. This is a precursor to the Mk1 being inducted by Germany and Spain. In order to future-proof the TYPHOON, for both its own use and the export market, the RAF will equip its TYPHOONs with the ECRS Mk2 radar. This goes further than the existing Mk 0 and Mk 1 AESA radars and could potentially give the aircraft an electronic attack capability. Although the TYPHOON has still struggled to attract orders, with potential customers such as Switzerland and Finland both opting for the fifth generation F-35 LIGHTNING II, the aircraft will be upgraded with several new capabilities to keep it competitive on the export market.

Future Roadmap

One, which was offered to Finland during the failed BAE Systems marketing campaign, is MBDA's SPEAR 3 missile. This is a derivative of previously mentioned BRIMSTONE missile with the key difference being that it is powered by a turbojet rather than a rocket motor. This reportedly gives the weapon, four of which can be carried on a single TYPHOON hardpoint, the ability to act as a 'mini cruise missile' to prosecute a wide range of targets. This can include fast moving targets of opportunity such as small vehicles in both land and sea environments. If deployed in a 'swarm', SPEAR 3 could also be used to destroy small to medium sized warships. As a development of this weapon, MBDA also offers a 'SPEAR EW' variant which can be used to jam and confuse air defence systems before they are targeted, therefore giving the TYPHOON a Surpression/Destruction of Enemy Air Defences capability. This can be fitted both to existing single seat TYPHOONs and the proposed twin seat ECR version discussed earlier.

For most customers, the TYPHOON currently replies of the Rafael LITENING III pod to acquire ground targets (though others such as Kuwait use American solutions). RAF TYPHOONS however are on the cusp of an improvement in this capability in the form of the LITENING V. This will provide aircraft with higher definition imagery, potentially improving its reconnaissance capability. For the UK, one of the main enhancements should appear early in the 2030s with the induction of the Future Cruise Anti-Surface Warfare (FC/ASW) capability. An Anglo-French project, this aims to produce a missile to replace both countries STORM SHADOW/SCALP missiles in addition to UK HARPOON and French EXOCET anti-ship missiles (HARPOON, and various other anti-ship missiles such as MBDA's MARTE have been offered for integration on the TYPHOON but none have been ordered to date). The exact form FC/ASW will take is not clear but both a stealthy subsonic and hypersonic version have been speculated. In answer to Parliamentary question, UK Defence Procurement Minister Jeremy Quin said in July 2021 that TYPHOONs would field FC/ASW from 2030.

Several other upgrades such as thrust-vectoring engine nozzles and conformal fuel tanks (to free up space under the wings for stores) have also been proposed for the TYPHOON. Another possible upgrade is replacing the tradition three screen cockpit with a single large display, similar to that on the F-35 (and also offered for the latest iterations of the Saab GRIPEN, F-15 STRIKE EAGLE and F/A-18E/F SUPER HORNET). Going from the fifth generation of aircraft to the sixth, Europe's Future Combat Air System partners of France, Germany and Spain all envisage the TYPHOON operating within this 'system of systems' as it enters service from the middle of the next decade until the TYPHOON leaves service sometime after 2040.

Conclusion

As instability from the War in Ukraine to growing tensions in the Asia Pacific continues to reign, forcing countries to spend more on defence, the need for high end military aircraft able to conduct a wide range of roles will grow. Despite several early setbacks and missed opportunities, the Eurofighter TYPHOON is set to evolve and play an important role in industrial competitions to meet competitions for several decades to come. ■

Global MALE & HALE UAV

Key Developments Across Global Top 10 Defence Spenders

Mandip Singh

The overall life cycle cost of UAVs are minuscular compared to traditional air platforms aircraft; the lack of onboard crew reduces the fatality in a combat environment. In 4D scenarios, UAVs can also be used to collect massive volumes of data (Dull, Deep, Dirty and Dangerous). They have previously proven their impressive capabilities in ISTAR (Intelligence, Surveillance, Target Acquisition, and Reconnaissance) and armed ISTAR missions. UAVs also give quick air support to ground forces and they have a favourable impact on both mission planning (commanders receive more information) and military operations (as UAVs provide immediate air support to ground forces).

Photo: BMVg

The EURODRONE is the first unmanned aerial vehicle (UAV) to be built for non-segregated airspace flying.

Source: Aviation and Defense Market Reports

Global HALE and MALE Market Size, 2022-2032 (in US$ Billion)

UAV Classes

There are three UAV classes (less than 150 kg, 150 kg to 600 kg, and 600 kg and up) and the end users select the UAV platform based on their operational needs and budget. However, weight and size tend to affect technical features such as maximum service ceiling and range, as well as the payloads that may be carried. As a result, each class typically offers three types of user support: operational, tactical, and strategic. MALE (Medium Altitude, Long Endurance) vehicles are more powerful and cost-effective than manned aircraft. In light of this, the armed forces of most the countries are expanding the use of these weapons for both armed and unarmed missions.

US is a matured market in this segment. However, the EU is comparatively lagging behind in terms of indigenous programmes. The Eurodrone is the first unmanned aerial vehicle (UAV) to be built for non-segregated airspace flying. The Eurodrone will promote European sovereignty by building and expanding an independent technological foundation in the field of unmanned aviation, as a four-nation project. Under the management of the international armaments agency OCCAR (Organization Conjointe de Coopération en Matière d'Armement), the programme between Germany, France, Spain, and Italy promotes European security and defence cooperation and confirms the initiative to increasingly rely on multinational armament projects. OCCAR has signed a contract worth $8 Billion with Airbus Defence and Space for developing and building 60 drones. Similarly, other countries across the World are investing in indigenous technology to reduce dependency in foreign OEMs.

According to recent estimates by Aviation and Defence Market Reports, the Global HALE and MALE UAV market is estimated at around US$3.5Bn in 2022 and is expecting US$8.61Bn in 2032. The market will be driven by cross-border tension between nations and increasing demand for cost-effective defence systems that are capable of acting as a credible deterrent in conventional warfare. The key programmes and procurement across the top 10 defence spenders are discussed below.

Poland

Poland is planning to purchase MALE MQ-9 REAPER drones due to its concerns in the Eastern border. The acquisition is expected to be completed as an urgent operational requirement. Procurement of MALE UAVs is being pursued both within the context of the ZEFIR programme, which would satisfy future needs for the growth of Armed Forces capabilities, and within the framework of the urgent acquisition of MQ-9 REAPER UAVs - in light of the situation on Poland's eastern border. The initial plan was to procure four sets of three UAVs for the Zefir programme.

Author

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The MQ-9 REAPER is a MALE unmanned aerial vehicle (UAV) that is used to carry out reconnaissance and combat missions. The REAPER is powered by a Honeywell TPE331-10 turboprop engine, which gives it a flight endurance of up to 27 hours, albeit this is halved when the UAV is fully armed. The base model has a range of around 1,800 kilometres.

Photo: US Air Force

An RQ-4 GLOBAL HAWK unmanned aircraft flying non-military mapping missions over South, Central America and the Caribbean

India

India's RUSTOM - 2 MALE is expected to reach 30000 feet and have an endurance of 18 hours. The military considers UAVs to be a top priority, particularly given the standoff with China in Eastern Ladakh. The military forces heavily rely on Israeli SEARCHER and HERON drones and require more of these unmanned aerial vehicles. A total of 76 RUSTOM - 2 drones are expected to be bought by the Indian armed forces, with 60 by the Army, 12 by IAF and four by the Navy. Indian Navy is also planning to induct 10 MQ-9B SeaGuardian, these drones have an endurance of 33 hours and can fly at more than 40,000 feet. The Indian Navy has leased two SeaGuardian drones to test the capabilities and its operational parameters. It is also expected that India would procure 30 SeaGuardian/ SkyGuardian systems.

Germany

The German Bundeswehr plans to lease up to five Israeli-made HERON TP MALE UAVs, which will be equipped with air-to-ground precise bombs. The primary mission of the HERON TP will be intelligence, surveillance, and reconnaissance (ISR). Although this is a significant signal from the new German administration to its allies and partners, the operational relevance of the armed HERON TP would add capability. Despite a renewed focus on NATO's eastern flank, the HERON TP will be limited in its operational utility in any high-intensity fight with a peer enemy like Russia, and will most likely be relegated to low-intensity missions. The Bundeswehr operates a variety of ISR UAVs, including three more HERON 1 MALE UAVs leased from Israel. They have been used in Afghanistan and Mali, but yet to prove their full operationally capability in a high-intensity combat.

France

France is expected to purchase an extra MQ-9 REAPER Block 5 unmanned aerial aircraft through the Foreign Military Sales (FMS) channel from the United States. The work of General Atomic Aeronautical Systems Inc (GA-ASI) is expected to be completed by March 29, 2024. Six REAPER Block 1 and six REAPER Block 5 UAVs are currently deployed in France. It wants to add six more Block 5 models to its stockpile, with the latter being equipped with precision-guided bombs GBU-12 PAVEWAY and air-to-surface missiles AGM-114 HELLFIRE. These systems will also have an FMS pod for gathering electronic intelligence. The purchase of REAPER MALE surveillance drones was originally meant to serve as a stopgap measure while France worked with the United Kingdom to build a new-generation MALE UAV system that would be introduced between 2020 and 2025. However, the project stalled and was eventually abandoned in February 2019.

Photo: US Air Force

The US-made General Atomics MQ-9 REAPER UAV

UK

For surveillance missions, the HALE concept allows for flight altitudes of over 65,000 feet and endurance which is considerably above the 30-hour endurance limit. The term 'Zephyr' refers to a family of solar-electric-powered unmanned air vehicles (UAVs) being developed by the British multinational defence technology company QinetiQ and the UK Ministry of Defence as part of a jointly sponsored initiative. In 2013, Airbus Defence and Space (then known as EADS Astrium) purchased the development programme. This autonomous unmanned high-altitude, long-endurance (HALE) system can collect high-quality surveillance data over large areas in real time. The UAV weighs less than 75kg and has a wingspan of up to 25 meters, thanks to its ultra-lightweight carbon-fibre construction. The device is capable of capturing and disseminating data at altitudes of up to 18 kilometres. It also has a solar charger and a custom auto-pilot system designed entirely by QinetiQ.

US

The RQ-180 is a twin-engine flying wing aircraft with slim laminar-flow optimised wings. Highly advanced, broadband, all-aspect, very low-observable (stealth) requirements drive its overall design. It is designed to fly for lengthy periods of time at very high altitudes in contested airspace, at or over 70,000 feet.

In the High Altitude/ Long Endurance UAV industry, Northrop Grumman's RQ-4 GLOBAL HAWK UAV has developed a

strong position. An example of the superior performance of RQ-4 can be understood from Operation Iraqi Freedom. The system flew 5% of the US Air Force's high-altitude reconnaissance flights during Operation Iraqi Freedom (OIF), but it generated more than 55% of the time-sensitive targeting images used to assist attack missions. The RQ-4 GLOBAL HAWK was also a strong competitor and ultimate winner in the Broad Area Maritime Surveillance (BAMS) UAV competition. The GLOBAL HAWK Maritime Demonstration Programme (GHM-D or BAMS-D) aims to use the well-proven RQ-4 GLOBAL HAWK airframe as a test bed for operational concepts and technologies that will eventually make their way into BAMS, as well as contribute valuable knowledge to the new field of maritime surveillance with high-flying UAVs. The US Defence budget had allocated around US$2Bn annually for procurement of new UAV platforms in the past 3 years and this trend is expected to continue.

South Korea

A medium-altitude, long-endurance (MALE), locally developed Korean Unmanned System (KUS)-FS unmanned aerial vehicle (UAV) and it has been successfully deployed. The KUS-FS first flew in 2012 and was created by Korean Air Aerospace Division (KAL-ASD) for the Korean Agency for Defence Development (ADD). With an endurance of up to 24 hours, the locally produced KUS-FS is intended for armed land and marine intelligence, surveillance, and reconnaissance (ISR) missions. Similar to the US-made General Atomics MQ-9 REAPER UAV, KUF-FS has a V-tail and a vertical ventral fin. It is said to have a wingspan 25 meters wider than the REAPER and a 1200 horsepower Pratt & Whitney PT6 turboprop engine. Additionally, it has four underwing weapon stations, one of which is equipped with a trial munition. A chin-mounted EO/IR turret, a belly-mounted maritime radar with 360-degree capability for detecting targets at sea, and electronic support measures (under the fuselage, behind the wings) for identifying and locating signals from maritime vessels are among the onboard sensors. The KUS-main FS's landing gear retracts into the wings rather than the fuselage, in contrast to the REAPER. South Korea also operate the US delivered RQ-4B GLOBAL HAWK HALE and is also working on an indigenous HALE programme which has a flying wing design and it is likely to be deployed by 2031.

Russia

At the MAKS 2017 Trade Expo, Russia debuted its first medium-altitude, long-endurance (MALE) UAV system. However, the privately owned Kronshtadt (KT) Group, which showcased the ORION, claims that the UAV has flown on multiple occasions and is prepared for production. It has been created by KT as a result of a 2011 contract with the Russian MoD. Only a few details regarding the ORION were made public by KT, including its payload capacity of 200 kg (440 pounds), top altitude of 7,500 meters (24,750 feet), operational radius of 250 km (135 km), and maximum endurance of 24 hours. Russia is also working on an indigenous HALE programme named ALTIUS. The ALTIUS is a High Altitude Long-Endurance (HALE) drone that can fly 39,000 feet high for up to 48 hours while surveying the ground with its electro-optical turret and side-looking radar. However, unlike the RQ-4, it can carry weaponry ranging from small guided bombs to 75-mile-range GROM missiles. Two drones connected with satellite communications for long-distance control make up an ALTIUS UAS, which can also operate autonomously for long-endurance operations.

Photo: Vitaly Kuzmin

Frontal view of an armed Chinese-made WING LOONG II UAV at the MAKS Airshow in Russia in 2017

China

The TB-001 combat drone is 10 meters long, with a wing length of 20 meters, a height of 3.3 meters, a maximum range of 6000 kilometres, and a flying altitude of 8000 meters, with a maximum load capacity of 1.2 ton, three times that of China's famed RAINBOW 4B UAV. It also has a battle radius of 3000 kilometres, allowing it to annihilate an enemy from a distance of 3000 kilometres. The performance is highly advanced. The UAV has an endurance of 35 hours. The "double-tailed scorpion" is a nickname for this drone because it has two tail support pieces that extend below the wing and are each connected to a vertical tail. To generate a similar force structure, the top of the vertical tail can be combined with a flat tail. This design strategy can make the fuselage stronger and lighter, allowing it to fulfil functions at a higher altitude. It can transport a number of missiles, including the 20-kilogram AR-2 missile, which can be steered in a variety of ways. This missile can be carried on a four-mounted pylon and can destroy ground targets. This permits the same hanging point that formerly held one AR-2 missile to now hold four, thereby improving firepower continuity and making it easier to transport. It can also carry four long-range missiles that can be launched from a height of 7000 meters to kill a thousand-ton destroyer.

Japan

The RQ-4B GLOBAL HAWK surveillance drone has been acquired by Japan, however it has generally avoided combat drones. In its fiscal 2022 budget, it set aside only JPY30M (US$231,000) for gadget research. Beginning in fiscal year 2023, Japan's Defence Ministry is considering incorporating attack drones into its plans. On 30 March 2022 Japan announced that it will create military-grade unmanned aerial vehicles (UAVs).

Saudi Arabia

Saudi Arabia currently operates MALE UAVs procured from China. The CH-4B RAINBOW is manufactured by China Aerospace Science and Technology Corporation (CASC). It has an endurance of 40 hours. It can carry a wide range of sensors such as infra-Red (IR) and Electro-Optical (EO) cameras, and laser designator in sensor ball and payloads such as AKD-10 air-to-surface anti-tank missile, BRMI-90 90mm guided rocket, FT-7/130 130kg glide bombs, FT-9/50 50kg bomb, FT-10/25 25kg bomb, GB-7/50 50kg precision-guided munition (PGM), and GB-4/100 PGM. Saudi Arabia also operates the Wing Loong II MALE UAV manufactured by Chengdu Aircraft Industry Group (CAIG). It has an endurance of 32 hours. Payload and sensors are similar to CH-4B rainbow.

With successful deployment of drones by both Russia and Ukraine in the ongoing conflict, there has been growing interest for MALE UAVs that can carry out ISR and Strike missions. The relatively low cost of operation and operational versatility when compared to manned aircrafts make them feasible for future development and frontline deployment. HALE UAVs will continue to be predominantly used for ISR missions to collect critical data with advanced sensors. ■

Main AESA Radar Solutions on Both Sides of the Atlantic

Luca Peruzzi

All new generation fighters are produced with the Active Electronically Scanned Array (AESA) radar, and many already in-service fighters have been, or are being retrofitted with this system.

Industry on both sides of the Atlantic have invested heavily on the AESA fire control radar for the latest larger combat aircraft. They have done so due to the main advantages in these systems, including the greater control of a beam by using hundreds of solid-state transmit and receive modules (TRMs) rather than a large single unit, alongside the enabling of aircrews to employ air-to-air and air-to-ground modes simultaneously. There is also the ability to track multiple targets while continuing to scan rapidly large volumes of airspace for additional threats, as well as the graceful degradation and therefore higher availability and efficiency compared to conventional mechanically scanned radars. AESA radars are not only used for air-to-air and air-to-ground operations, but also for Electronic Warfare (EW), including Electronic Support Measures (ESM), Electronic Attack (AE) and Electronic Support (ES). While in the past, gallium arsenide (GaAs) was the common latest generation TRM-applied technology, more recently the higher efficiency and more powerful gallium nitride (GaN) is applied to the airborne fire control radar and the trend is a larger diffusion.

Photo: U.S. Air Force photo/Samuel King Jr

The US Air Force launched flight test activities in 2011 for the F-15E Radar Modernization Program (RMP) to replace the legacy APG-70 mechanically scanned radar with the current AESA-equipped APG-82(V)1.

Main US AESA Radar Developments

Raytheon has been pioneering the AESA technology, being the first company to provide such a capability to a US combat aircraft, having provided the AN/APG-63(V)2 as a major upgrade for 18 US Air Force Boeing F-15C aircraft. It combined the proven AN/APG-63(V)1 'back end' - which represented a significant improvement in terms of performance and reliability compared to the original model thanks to the adoption of the first airborne radar software programmable signal processor - with a new AESA antenna. The latest AN/APG-63(V)3 radar version builds upon the previous (V)2 model technology and the hardware advance of the F/A-18 E/F Super Hornet's APG-79 AESA radar. In addition to the upgrading of the US F-15 C/Ds, the (V)3 radar has also found export applications, having being deployed in Singapore's new-build F-15SG and Saudi Arabia's new F-15SA aircraft. In January 2011, the US Air Force launched flight test activities for the F-15E Radar Modernization Program (RMP) to replace the F-15E legacy APG-70 mechanically scanned radar with the AESA-equipped APG-82(V)1. According to US Defense Department (DoD) documentation, the RMP is designed to expand mission employment capabilities, including near-simultaneous interleaving of selected air-to-air and air-to-ground functions, enhanced air-to-air and air-to-ground ground classified combat identification, longer range air-to-air target detection and enhanced track capabilities, alongside longer range and higher resolution air-to-ground radar mapping. The APG-82(V)1 antenna and power supply come from the (V)3 programme, while the radar receiver/exciter and the Common Integrated Sensor Processor are based on the F/A-18E/F AESA system. In addition to the upgraded F-15E, the APG-82 has been integrated into the new F-15EX model, and is used on the Israeli Defence Forces/Air Force F-15I and the Japan Air Self-Defence Force's F-15J upgrade. In June 2021, the USAF awarded Raytheon a study contract for unspecified upgrades to the F-15EX's APG-82(V)1 to be completed in September 2021. The Raytheon APG-79 radar family became the leading and first programme for the AESA-based gallium nitride (GaN) technology fire-control radar. A derivative of the APG-79 radar family, the APG-79(V)4 AESA radar version with GaN TRMs is being procured to replace the APG-73 on board the US Marine Corps F/A-18 Hornets with the first flight of pre-production radar hardware conducted last May.

In June 2021, Jordan signed a letter of offer and acceptance (LOA) covering the procurement of eight F-16 C/D Block 70 aircraft, becoming the newest customer of the latest version of the Lockheed Martin combat aircraft. The Block 70/72 and similar F-16V

Photo: Raytheon

The F-15E's APG-82(V)1 antenna and power supply come from the (V)3 programme, while the radar receiver/exciter and the Common Integrated Sensor Processor are based on the F/A-18E/F AESA system.

upgrade package features an advanced avionics centred on the new APG-83 radar, a modernised cockpit and avionics suite, advanced weapons, conformal fuel tanks, improved engine performance and service-life extended airframe. The Northrop Grumman APG-83 Scalable Agile Beam Radar (SABR) provides 4th generation F-16s with 5th generation fighter radar capabilities by leveraging hardware and software commonality with the F-22's APG-77 and F-35's APG-81 AESA radars. Building on Northrop Grumman's 40-year legacy of producing radars for the F-16, the APG-83 SABR integrates within the F-16's current structural, power and cooling constraints without Group A aircraft modification. Production of the APG-83 is underway for a worldwide F-16 upgrade and new aircraft production programmes, as well as having recently completed installation on the United States Air National Guard F-16s to meet a US Northern Command Joint Emergent Operational Need (JEON) for homeland defence. The APG-83 is an official programme of record for equipping both the US Air Force's active, Guard and Reserve components. The SABR-based APG-83 AESA radar provides autonomous, all-environmental stand-off precision targeting, greater target detection and tracking range, alongside interleaved mode for greater situational awareness, maritime modes and three to five times greater reliability and availability compared to current fire control radar systems. The SABR features a larger area, high definition, synthetic aperture radar capability called 'Big SAR', according to Northrop Grumman. This mode provides pilots with unprecedented large target area details in a single image on the cockpit digital map displays that can be tailored with slew and zoom features. The advanced capability enables greater situational awareness and flexibility, according to the manufacturer, alongside quicker all-weather targeting. The system's advanced processing and proprietary algorithms, automatically scan entire SAR maps, precisely locating and classifying targets of interest, thereby greatly reducing pilot workload, according to Northrop Grumman.

Building on Northrop Grumman's long experience with AESA fire control radars, including the AN/APG-77 long-range, active and passive, multi-function AESA radar developed for the Lockheed Martin F-22 RAPTOR combat aircraft, the US company also provide the APG-81 AESA radar for the F-35 LIGHTNING II 5th generation stealth aircraft. The manufacturer describes the APG-81 as 'the latest and most capable AESA in the world and acts as the cornerstone to the F-35 LIGHTNING II's advanced sensor suite'. In addition to long-range active and passive air-to-air and air-to-ground modes, 'the AN/APG-81 epitomises the F-35's multi-role mission requirement showcasing the robust electronic warfare (EW) capabilities and can operate as an EW aperture utilising the AESA's multi-function array (MFA)', underlined the manufacturer. With a 1,676 TRMs-populated array based on GaAs technology, according to Lockheed Martin and Northrop Grumman documentation, the APG-81 is a 3rd gen tactical AESA radar supporting multiple interleaved tasks with air-to-air, passive and active modes, allowing the pilot to detect, track, identify and shoot multiple threat aircraft before the adversary detects the F-35, together with air-to-ground modes allowing for all-weather, precision targeting thanks to an ultra-high-resolution SAR (Synthetic Aperture Radar) mapping mode, which allows it to identify and engage military targets with outstanding reliability, claims Northrop Grumman. Moreover, in addition to navigation support modes, the APG-81 provides Electronic Warfare capabilities including ESM, EA, ES and advanced electronic protection and identification modes. These enable the F-35 the unparalleled capability to suppress and destroy the most advanced enemy air defences. The F-35's APG-81 radar sensor track information are sent into the aircraft's integrated core processor (ICP) and mission systems software fuses radar data with that sent from the Distributed Aperture Systems (DAS), the Electro-Optical Targeting System (EOTS) and the Electronic Warfare (EW) system to provide what Lockheed Martin describes as 'unparalleled situational awareness'. The overall sensor suite, cockpit, networking and airframe/propulsion capabilities will be further enhanced through the Continuous Capability Development and Delivery (C2D2) programme which manages the development and qualification of the new Block 4 software and hardware package. The latter includes a new integrated core processor (ICP) which, although hit by technical and funding programme problems, is expected to be included since Lot 15 aircraft production in 2023 together with a panoramic cockpit display (PCD), Electronic Unit (EU) and Advanced Memory System (AMS), alongside new software and hardware testing, integration and qualification, thereby requiring more time than foreseen. With the Block 4 upgrade, the radar is expected to feature improved electronic protection in the air-to-ground and maritime modes, longer-range SAR identification especially suitable in the Suppression of Enemy Air Defence/Destruction of Enemy Air Defence (SEAD/DEAD) strategic and tactical operation, extended-

Photo: Raytheon

Together with other sensors, communications and protection systems, the Raytheon APG-79 radar provides the mission flexibility offered by the Boeing F/A-18 E/F SUPER HORNET Block III.

Photo: Northop Grumman

The F-35 LIGHTNING II's radar builds on Northrop Grumman's long experience with AESA fire control radars, including the AN/APG-77 long-range, active and passive, multi-function AESA radar developed for the Lockheed Martin F-22 RAPTOR combat aircraft, here depicted.

range and enhanced identification alongside wide-area search in maritime environment and within-visual-range mode for offensive/defensive counter air missions.

European Solutions

In December 2021, the French Presidency and Dassault Aviation announced that the United Arab Emirates had signed a contract for 80 RAFALE combat aircraft in the F.4 standard. This contract represents the first export order and has been followed by Indonesia last February for the latest standard RAFALE due to be rolled out to the French Armed Forces.

Thales AESA RBE2

The previous F3-R standard was officially declared fully operational by the French Armed Forces on March 2021. Among the enhancements introduced with the latter standard was the integration of the new MBDA long-range METEOR air-to-air missile with the Thales AESA RBE2 airborne radar, providing the French platform the air superiority it needs for beyond visual range engagements in all weather, as required for handling a wide variety of targets. Equipping all production RAFALE aircraft delivered since mid-2013, the Thales AESA RBE2 is Europe's first-ever AESA radar delivered to customers. According to Thales, the active electronically scanned array equipped with an undisclosed number of TRMs based on GaAs technology, offers very low-side and scattered lobes in azimuth and elevation together with very high reliability and offers multipole waveforms, coherent X-band frequency generation, excellent spectral purity, wide bandwidth and full monopulse capacities. The open architecture and fully programmable signal processor and data processor offers advanced target detection and ECCM processing, together with tracking computation and high-resolution map generation. Performing several radar modes simultaneously, the AESA RBE2 provides all-aspect look-down/look-up detection and tracking of multiple air targets for close combat and long-range interception and in jammed environment in all weather, real-time generation of 3D maps for automatic terrain following and avoidance. It also offers real-time generation of high resolution maps for navigation and targeting, detection and tracking of multiple sea targets. Key operational benefits include extended range capabilities supporting low-observable target detection and full use of new weapon systems such as the METEOR missile, higher reliability and greater waveform agility for SAR (Synthetic Aperture Radar) imaging and improved resistance to jamming. In addition to the French Air Force and Navy, the new radar equips the aircraft in service or under delivery to Egypt, India, Qatar, Greece and ordered by Croatia, UAE and Indonesia. With a contract awarded by the French MoD in 2019, Dassault Aviation is leading the development of the F.4 standard which, in addition to a new generation communications and connectivity suite, new weapons integration and availability enhancements, includes upgrades to the sensor suite. The AESA RBE2 will see the introduction of two new air-to-surface modes: a ground-moving target indicator (GMTI) to detect and track moving targets over land and an ultra-high resolution SAR (UHR-SAR) mode, replacing the current HR functionality, offering superior radar image quality at very long distances. The interleaving of radar modes will be enhanced, providing the crew with even better situational awareness. Later on, the AESA radar is also expected to be enhanced to track small radar-cross section (RCS) targets, which can be identified as mini- and micro-UAVs. The weapon package will also be expanded, introducing among others, the MBDA MICA NG (Next Generation) equipped with new AESA RF and IR seekers technology. The F4 standard full package validation is planned to be completed in 2024 with first platform deliveries in 2025, while some capabilities will be available earlier. A further evolved RAFALE standard could see the focus on multi-function arrays (MFAs) based on GaN technology to be used for different purposes including detection, jamming and communications.

Photo: Thales

Equipping all production RAFALE aircraft delivered since mid-2013, the Thales AESA RBE2 is Europe's first-ever AESA radar delivered to customers. The Indian RAFALEs see local industrial contribution to the Thales radar production.

CAPTOR-E or ECRS Family Developments

Having equipped the Eurofighter TYPHOON with the CAPTOR-M mechanically scanned multi-mode radar provided by the EuroRADAR consortium led by Leonardo and including Hensoldt and Indra companies, the Eurofighter consortium has long recognised the integration of an AESA radar as a fundamental enabler for capability growth in both more conventional and new domains. Launched in 2010, the CAPTOR-E, also known as Radar 1+ and later known as the European Common Radar System (ECRS) Mk0, retains the 'back-end' of its progenitor but replaces the mechanical scanner with a new AESA antenna mounted on a double swashplate repositioner. The latter has a scan volume about 50 per cent wider than traditional fixed plate systems (with over +/-90° on either side of the boresight). The first ECRS Mk0 customer was Kuwait, which re-

Photo: Leonardo

Launched in 2010, the CAPTOR-E (also known as Radar 1+) and later known as the European Common Radar System (ECRS) Mk0, retains the 'back-end' of its progenitor but replaces the mechanical scanner with a new AESA antenna mounted on a double swashplate repositioner.

ceived the first two Eurofighter TYPHOON aircraft in December 2021, to be followed soon by Qatar platforms.

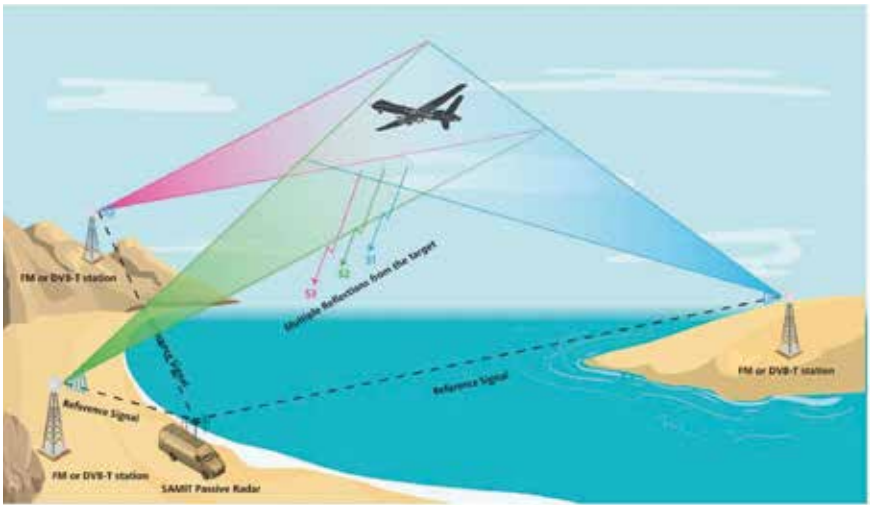
In July 2020, Airbus Defence and Space awarded Hensoldt a contract to develop and produce the new Mk1 version of the AESA-equipped ECRS for German and Spanish Eurofighter customers. Jointly funded by these partner nations, the programme sees the procurement of the ECRS Mk1 to equip the 38 Eurofighter TYPHOON Tranche 4 aircraft on order for the German Air Force under project 'Quadriga', alongside a large-scale retrofit programme for earlier aircraft from Tranche 2 and 3 plus the same radar version for the 20 Eurofighter TYPHOONs being procured for the Spanish Air Force, under a contract awarded at ILA 2022 to the Eurofighter consortium by the NATO Eurofighter and Tornado Management Agency. For the first time, Hensoldt leads a consortium with Spanish partner Indra assuming the role of radar design authority under a technology transfer agreement with Leonardo, to develop the new radar version which is to be implemented in the middle of the decade. The ECRS Mk1 answers new operational requirements of the two customers by adding, according to Hensoldt, considerable capability to the first iteration or ECRS Mk0 of the Eurofighter E-scan radar, developed and produced by the EuroRADAR consortium, which is being continuously supported by Hensoldt. While using 'legacy' Mk0 components, the Mk1 introduces a new fully digital multi-channel receiver and new TRMs based on GaAs technology that offer a greater frequency range and that have a larger bandwidth. Both capabilities are needed for improved agility within the frequency band, which together with new digital waveforms provide low probability of intercept (LPI) capabilities, as well as enabling the radar to have better recognition capabilities. Initially installed in the so-called 'Step 1' configuration, which significantly expands the existing capabilities of the Mk0, its successor will include ESM and electronic warfare capabilities including EA and ES, while target recognition and detection are also improved. Other notable features are the ultra-high-resolution imaging SAR (UHR-SAR) imagery and ground-moving target indication through STAP processing, which are the basis of on-board artificial intelligence (AI) and threat classification accuracy, according to Hensoldt. The industrial consortium is, however, already planning for the 'Step 2' iteration. This is essentially a major software upgrade that will further exploit the processing capabilities inherent in the system, adding task-based management, electronic warfare as well as other advanced features, according to the company. Equipped with the new Mk1 radar - particularly in its "Step 2" variant – the TYPHOON, according to Hensoldt, will be an ideal 'legacy' partner to the Next Generation Fighter, being developed by France, Germany and Spain to participate in complex operations utilising the Air Combat Cloud, as well as Remote Carrier capabilities. The UK's BAE Systems, as prime contractor and responsible for equipment design, was awarded in August 2020 a £317M contract by the Eurofighter consortium under which it is working with Leonardo's UK arm to develop the so-called ECRS Mk2 (previously also known as Radar 2) to a standard ready for integration with TYPHOON. This programme represents a major capability enhancement for the TYPHOON, as the new multifunction array (MFA) radar introduces an EW capability, including wide-band EA functionality, in addition to more traditional radar functions, ensuring the UK retains the freedom to deliver air power wherever and whenever needed. In September 2021, Italy joined the UK with the creation of an Industrial Joint Team (IJT). According to the recently released programme updates, the prototype radar hardware is on track to be delivered by Leonardo to BAE Systems for integration into the TYPHOON by late 2022, while first flight trials are planned for late 2023. To take the programme through to service, fresh funding has to be allocated. According to the UK Defence Equipment and Support agency, an initial operating capability covering the radar, training, infrastructure and other requirements is set for 2030 due to the necessary integration with the defensive aids sub-system that is part of the broader capability upgrade programme on TYPHOON called P4E. While commonality across the ECRS variants is being maintained in terms of interfaces with platform systems, the Mk2 radar is essentially a totally new system forward of the common power supply. It consists of the AESA antenna including a new rotating positioner mechanism, a multi-channel receiver, a multi-channel processor, the antenna auxiliary unit which hosts dedicated EW receiver and techniques generation functions, and the antenna power supply and control. The ECRS Mk2 is characterised by a new high-power MFA that, thanks to the large TYPHOON radome, is able to host a significantly greater number of TRMs in the array face than comparable AESA radars, according to Leonardo. Differently for the ECRS Mk0 and Mk1, the repositioner design for the Mk2 is a larger variant of that used successfully by Leonardo as the production solution for the Raven ES-05 on the newest GRIPEN. Among the solution benefits is the ability to both stabilise the antenna boresight and optimise the polarisation of the antenna radiation with respect to the threats being engaged. This has a number of advantages in SEAD missions, according to Leonardo, in addition to optimising maximum power on targets across the field of regard, a key feature for extended range missile guidance. The ECRS Mk2 makes use of GaN where needed to deliver a particular function, as well as GaAs in other parts of the radar system, without Leonardo providing any further technical details. While the multi-channel receiver and high-capacity multi-channel processor incorporated in the ECRS Mk2 are key to realising the performance of the MFA, providing the ability to receive greater information on both the targets and the operating environment, the dedicated EW receiver and the EA techniques generator provides the EW and EA functionalities within the ECRS Mk2.. The ECRS Mk2's wider bandwidth required the introduction of a new nose radome by Meggitt developed in conjunction with BAE Systems and Leonardo. ■

Radars That Stay Silent

Doug Richardson

Unless detected by optical or radar reconnaissance sensors, passive radar remains covert. Even when it has been located, its operating frequency remains unknown. Since the enemy does not know which emitter is being used by each passive radar installation, it will be difficult to devise effective electronic countermeasures.

Photo: PSDSARC



This diagramme published by Saudi Arabia's Prince Sultan Defense Studies and Research Center (PSDSARC) illustrates the basic principles of passive radar. The system samples the RF output from one or more transmitters, and detects energy from these transmitters that has been reflected from objects of interest.

Early in 1944, Britain faced an intriguing problem. Reconnaissance photographs of the coast of Northern France had identified no less than six massive antenna installations of a new type. It was reasonable to assume that these were for some new type of German long-range radar, yet these antennas never seemed to emit any form of radio-frequency (RF) emission. It was not until the interrogation of a captured German radar operator in the autumn of that year that the solution to this mystery emerged. Designated KLEIN HEIDELBERG, these installations were indeed early-warning radars, but of a new and novel type. They did not emit any RF energy because that function was unwittingly being provided by Britain. Reflected by aircraft operating over the North Sea, the radar energy from Britain's CHAIN HOME radar network had allowed targets to be detected at ranges of 300 km or more from the KLEIN HEIDELBERG antennas.

Today, this concept is known as passive radar, and although now little more than a footnote in 20th Century history, the KLEIN HEIDELBERG illustrates a major advantage of this technique. Unless detected by optical or radar reconnaissance sensors, the radar remains covert. Even when it has been located, its operating frequency remains unknown. Since the enemy does not know which emitter is being used by each passive radar installation, it will be difficult to devise effective electronic countermeasures.

'Hitchhiking'

A conventional monostatic radar has its own dedicated transmitter, and uses a single antenna for both transmitting and receiving. Passive radar exploits existing RF signals, such as broadcast, communications, or radionavigation services as their transmitting source, despite the fact that these signals are optimized for a non-radar purpose. In some cases, signals from an existing radar is used in a process often dubbed 'hitchhiking', but this faces potential problems in that these sources often use a high-gain scanning antenna, and emit waveforms tailored to conventional radar operation – features which make their output less than ideal as an illumination source.

Digital Beamforming

A dedicated receiver channel is used to monitor the signal received directly from one or more transmitter(s), and to dynamically sample the transmitted waveform. Other receiver channels monitor the area under surveillance and look for energy reflected by targets. Digital beamforming can be used to determine the direction of arrival of signals and to reject troublesome in-band interference. Target range is calculated by measuring the time difference between the arrival of the signal from the transmitter and the much weaker version created by reflection from the target. The location, heading and speed of each target are calculated using the Doppler shift and direction of arrival of the reflected signal. Altitude coverage is usually limited due to the fact that most illuminators radiate their RF energy at relatively low elevation angles.

Direct Signal Interference

The direct signals transmitted by the illuminators are almost certainly going to be many orders of magnitude stronger than those reflected by targets, a phenomenon known as direct signal interference (DSI). This interference largely determines the usable sensitivity of a passive-radar system, so it needs to be suppression of DSI and clutter prior to range-Doppler processing in order to maximise detection range.

Author

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

In order to remain covert, a passive radar must avoid betraying its location by emitting other forms of detectable energy. Since it does not incorporate a transmitter, a passive radar will have a relatively low thermal signature, so would be hard to detect using an IR sensor. However use of an RF communications link could provide a recognisable target for hostile elint systems, while the local oscillator of any superheterodyne receiver used as part of the overall system needs to be a well-shielded to prevent its output leaking at detectable strength.

Many methods of reducing a target's radar signature are optimised for the microwave frequencies typically employed by military surveillance. A passive radar can exploit many existing very high frequency (VHF) radio and ultra high frequency (UHF) television transmissions at which stealth technologies may prove less effective.

While the direct path between the exploited transmitter and the target, and between the target and the passive radar will account for most of the RF energy, multipath signals are likely, and some energy will be scattered from the terrain or sea surfaces. Most active radars operating at VHF or UHF tend to have antennas that are physically large, but if a passive radar is to remain convert, it must use a much smaller antenna that inevitably has a lower gain, a wider main lobe, and more potentially-troublesome sidelobes – deficiencies that will reduce detection range and create increased multipath problems.

SILENT SENTRY

Although used during the 1960s and 1970s for some specialised role such as the monitoring of ballistic missile tests by what was then the Soviet Union, passive radar was not a viable concept until advances in computer and microelectronic technologies lowered the cost of the large amounts of digital data processing needed to make the technique more effective.

The concept of passive radar was given a major boost in 1998 when Lockheed-Martin Mission Systems announced the SILENT SENTRY, a system that exploited the output of frequency modulation (FM) radio and analogue television transmitters. SILENT SENTRY was tested for several years, but the results of these tests was never publicly released. But they did lead to improvements to the system, and to further trials.

In the UK, Roke Manor and BAE Systems teamed to develop CELLDAR, a system designed to exploit the signals from 900 MHz mobile phone base stations. It covered a 100 degree sector, and demonstrated ranges of up to 60 km.

Foto: Photo: Airbus

The mast-mounted antenna array of an Airbus Defence and Space passive radar system.

First shown at the 2007 Paris Air Show, Thales Air Systems' HOMELAND ALERTER 100 (HA 100) was developed in conjunction with ONERA. Designed to detect and track air threats operating at low and medium altitudes, it exploits FM and TV broadcast transmissions. Similar technology was also used to create Thales' GROUND ALERTER 10 (GA 10) anti-artillery radar.

AULOS

The AULOS PASSIVE COVERT LOCATION RADAR was launched in 2012 by what was then Selex Sistemi Integratti, and is now part of Leonardo. The original version completed in 2012 used FM-band transmissions, but under an Italian Ministry of Defence contract awarded later that year the coverage was extended to include Digital Video Broadcasting - Terrestrial (DVB-T) sources. This involved mounting two circular array antennas on the same telescopic mast.

In 2014, the UK Civil Aviation Authority (CAA) awarded Airbus Defence and Space a contract to study the feasibility of using the company's passive radar technology for air traffic management. The company had already demonstrated a working system able to detect large aircraft at ranges of up to 200 km, and ultralight aircraft at ranges of a few kilometres.

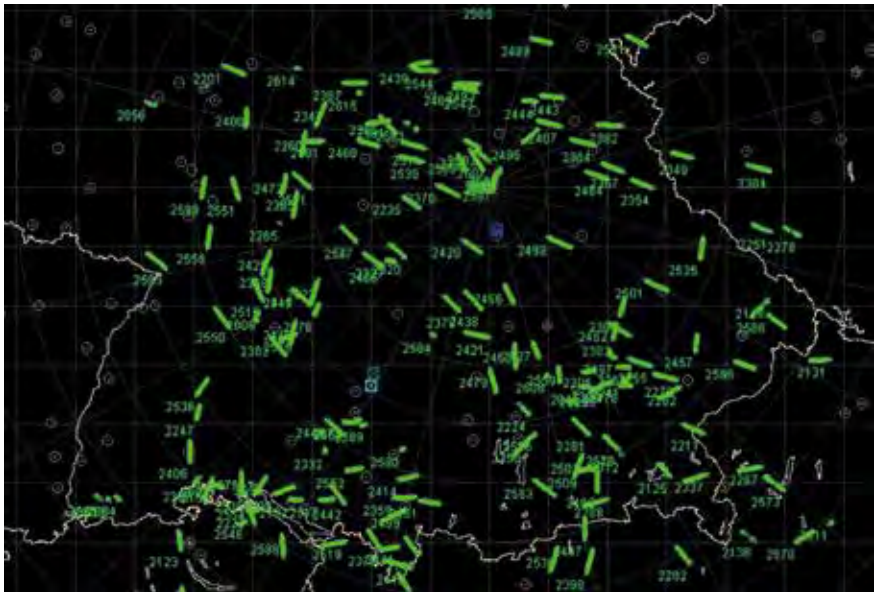
TWINVIS

Hensoldt's TWINVIS passive radar is designed to exploit analogue FM radio, and digital radio or television transmissions. The distance between these transmitters and the TWINVIS sensor can be anything from a few kilometres to more than 100 km, depending on the operational scenario. Maximum instrumented range is 250 km, but instrumented altitude is more than 40,000 ft.

Following the 2018 Berlin Air Show, the company used a Twinvis system to track the departure of Lockheed Martin F-35 fighters that had been exhibited at the show, but which had not taken part in the flying programme. Like all low-observable aircraft, the F-35s had been fitted with radar reflectors in order to ensure that they can by tracked by conventional air-surveillance and air-traffic-control radars, but it is not known whether these reflectors would have had a significant effect on the aircraft's RCS at the frequencies being used by Twinvis.

Working under the sponsorship of the European Defence Agency (EDA), the Spanish company Indra teamed with Italy's CNIT (National Telecommunications Engineering Consortium) and Vitrocise, plus the University of Alcalá in Spain, the University of Cyprus, and the Hungarian Science Academy to develop a passive radar system that would use inverse synthetic aperture radar (ISAR) techniques. This APIS (Array Passive ISAR Adaptive

Photo: Hensoldt



This air situation picture of the airspace of southern Germany was generated by Hensoldt's passive radar tracking system.

Photo: Daronmont

Working under a contract from Australia's Defence Materiel Organisation (DMO), Daronmont developed, installed and conducted site trials of the SECAR High Frequency Surface Wave Radar

Photo: NCSINST

Taiwan's National Chung-Shan Institute of Science and Technology (NCIST) developed this vehicle-mounted passive radar.

Processing) programme lasted for two years, and the development and demonstration of a passive high-resolution radar system that utilised Digital Terrestrial Television signals was completed in 2013.

A passive radar that exploits FM transmissions was announced by ERA in the Czech Republic. Known as the MULTI-STATIC PRIMARY SURVEILLANCE RADAR (MSPSR), it was unveiled in 2013, by which time it had already participated in a military exercise on the Western Bohemian border. It can be teamed with the company's PET (VERA-NG) Electronic Support Measure (ESM) system. The demonstrator could process up to eight FM radio channels.

MAVERICK

Under a contract from Australia's Defence Materiel Organisation (DMO), Daronmont developed, installed and conducted site trials of the SECAR High Frequency Surface Wave Radar. The system uses a Frequency Modulated Continuous Wave (FMCW) waveform at frequencies of 4-16 MHz, and can detect both air and surface targets.

Following an Australian Phase 2 Army Innovation Day contract for research and development of passive radar systems for land tactical environments, in 2020 Silentium Defence was awarded an AU$2M contract to further develop and field-test its MAVERICK M series passive radar to demonstrate land tactical situational awareness. In July 2021, the company won an AU$7.4M contract to supply MAVERICK M to the Australian Army for capability development and evaluation activities.

In February 2022, Silentium Defence announced that it would integrate its passive radar onto airborne platforms, starting with small to medium-sized UAVs. These small air vehicles are have limited payload capacity and available power, but passive radar is a potential solution that exploits megawatts of existing RF energy in the environment and does not draw attention to the UAV's role.

Currently being conducted under the European Defence Industrial Development Program, the international PASSIVE ACQUISITION BY DIGITAL CONVERGENCE (PADIC) programme is intended to develop an open-architecture coastal radar network able to exploit the target reflections created by RF emissions by TV and radio stations, mobile-network base stations, and other transmitters in order to detect land, sea and air targets. Four companies are involved – Saab (Swe-

den), Patria (Finland), and Rantelon and CAFA Tech (Estonia), with Saab being responsible for project is co-ordination. In 2022 (the first year of the programme), the team will conduct scenario analyses, devise a functional requirements definition, and develop a system concept and architecture. 2023 should see the development of a prototype, leading to tests and demonstrations in Baltic coast environments.

Taiwan's National Chung-Shan Institute of Science and Technology (NCIST) had developed what it describes as a MOBILE PASSIVE RADAR SYSTEM. The vehicle-mounted installation incorporates what NCIST describes as an "advanced phased array structure", as well as locally-developed synchronising, digital beam forming and parallel processor technology. According to reports in the local press, it will be teamed with active radars to create an overall system intended to detect China's Chengdu J-20 stealth fighters.

SAMIT

Saudi Arabia's Prince Sultan Defense Studies and Research Center (PSDSARC) has developed a passive radar designated SAMIT. Designed to exploit FM or DVB-T (Digital Video Broadcasting - Terrestrial) transmissions, this has demonstrated ranges of up to 250 km with VHF frequency-modulated sources, or up to 80 km with UHF DVB-T sources. Up to 5,000 instantaneous target tracks can be maintained. The system's 360 degree circular antenna array can be located on rooftops or fitted on a vehicle-mounted 20 m hydraulic mast. The task of manufacturing the system have been passed to what the Center describes as "a national industrial company which is qualified to produce the system with the quantities, specifications, and requirements of the Armed Forces".

SPYGLASS

Under a European project designated SPYGLASS being conducted by Elettronica GmbH, Universita di Roma La Sapienza, and the University of Birmingham trials are under way of a passive radar demonstrator that uses the signals radiated by the constellation of Galileo navigation satellites to detect surface ships. The system uses a single receiver installed on a buoy or on a tethered balloon to detect Galileo signals reflected by ships and to estimate their range and speed. The sheer number of spacecraft used for Galileo, GPS, and other GNSS result in several satellites simultaneously illuminating the same point on Earth from multiple aspect angles. These individual signals can be compared, or used collectively to form a multistatic passive radar.

Photo: PSDSARC

The Prince Sultan Defense Studies and Research Center (PSDSARC) has packaged its SAMIT passive radar in a vehicle-mounted configuration.

The growing deployment of fifth-generation (5G) broadband cellular networks has seen the deployment of large numbers of base stations, particularly in urban areas, so these could provide the illumination needed in order to use passive radar to detect and track UAV threats. Following successful trials that demonstrated the feasibility of using 5G signals in this role, in 2021 the US Department of Homeland Security awarded the Texas-based company Cobalt Solutions a US$750,000 contract to build and demonstrate its planned PR 1000 sensor against drone threats in urban environments. The company anticipates that this work will result in an affordable and portable sensor suite that can be offered as a commercial product.

Another potential source of RF energy that could be exploited for passive-radar purposes are the ubiquitous WiFi networks that typically use 2.4 GHz UHF and 5 GHz signals to interconnect desktop and laptop computers, tablet computers, smartphones, smart TVs, printers, smart speakers and wireless routers, and to provide wireless Internet access points in public places like coffee shops, hotels, and airports. These all involve low-power transmissions designed to have a modest range, but could provide the RF energy needed to allow short-range passive radars to see though walls and detect persons located in nearby rooms.

One thing seems certain – the pioneering KLEIN HEIDELBERG may have had little tactical effect eighty years ago, but the range of frequencies and RF sources being used by today's passive radars will create problems for future suppression of enemy air defence (SEAD) operations. ■

Strategic Bombers: Still Relevant?

Sidney E. Dean

Strategic bombers are designed for deep penetration missions into enemy airspace to destroy high-value targets in order to significantly degrade the opponent's warfighting capability and will. While the term "strategic bomber" is often used synonymously with nuclear armed bomber, conventionally armed aircraft are equally capable of striking strategically significant targets deep within enemy territory.

The United States Air Force (USAF) is the only western service to operate strategic bombers. They form part of the US nuclear triad, augmenting Intercontinental Ballistic Missiles (ICBMs) and Submarine Launched Ballistic Missiles (SLBMs). Official US nuclear doctrine eschews a no-first-use policy on the ground that it could undermine the credibility of US security guarantees for allies, and maintains that the nuclear deterrent is a bedrock of US national security. At the same time, Washington tends to present the US nuclear arsenal in terms of a strategic deterrent. The maintenance of a triad rather than a one- or two-element nuclear force is said to enhance this deterrent function by providing flexibility, survivability and redundance should deterrence fail and deployment of nuclear weapons become necessary.

Photo: US Air Force / Zachary Wright

A US B-52H STRATOFORTRESS assigned to the 69th Bomb Squadron at Royal Air Force Fairford, United Kingdom, flies over the Alpine Mountains during a Bomber Task Force operation, in March 2022.

Strategic Bomber Vulnerabilities

The renewed focus on great power rivalry and conflict has reinvigorated the significance of the US strategic deterrent and strategic operational capabilities. The Pentagon is pursuing upgrades of the current strategic systems and is also pursuing acquisition of new, high-performance strategic weapon systems designed to keep pace with offensive and defensive developments in rival nations. Given the scarcity of resources and the long-standing debate in the United States regarding the appropriate strategic posture and force mix, it is inevitable that pundits question the necessity of retaining three strategic arms. Strategic bombers have frequently been singled out as potentially superfluous.

Several arguments have been made regarding purported drawbacks of strategic bombers, especially when compared to the stealthy and highly survivable strategic

Photo: U.S. Air Force / Jerreht Harris

A US Air Force B-52H STRATOFORTRESS flies alongside Royal Air Force of Oman Eurofighter TYPHOONs above Oman, in March 29, 2022.

Photo: U.S. Air Force / Colin Hollowell

A B-1B LANCER at Ørland Air Force Station in Norway in March 2021.

ballistic submarine leg of the triad. These arguments include: The home and forward operating bases of strategic bombers are known; this makes the planes and their support infrastructure vulnerable to preemptive attack. Unlike ICBMs and SLBMs, bombers performing an attack run require additional support forces including aerial refuelling. While an ICBM needs 30 minutes to destroy a target, aircraft need many hours to approach their weapons deployment zone; the enemy has considerable time to detect and monitor the bomber, and take defensive measures. In this context, bombers are vulnerable to air defence missiles, interceptor aircraft, electronic warfare and even electromagnetic pulse bursts; this raises questions about their capability to reach well-defended targets in the current age of high-performance air-defence systems.

Flexible Option for Great Power Conflict

Advocates of strategic airpower counter these arguments. Home bases and forward operating locations can be protected by air- and missile-defence artillery; additionally, they argue, pre-emptive strikes on bomber bases alone would make little sense as long as the US retains its nuclear missile forces. While bombers might be detected by enemy satellites or long-range sensors, this does not automatically reveal their target; aircraft can change course multiple times before releasing their payload. This gives them the ability to remain unpredictable and to pursue numerous angles of attack, unlike ballistic missiles which – to date – must remain on a set trajectory. While enemy air defences are increasingly sophisticated and far-reaching, modern bombers frequently deploy cruise missiles rather than gravity bombs, enabling them to release their ordnance from the edge of the enemy's effective air defence zone. In aggregate, the offensive capacity of strategic bombers continues to exceed their vulnerabilities.

In addition to their basic combat power, strategic bombers feature a level of flexibility, which significantly enhances their importance. This begins with payload options. While ballistic missiles can be armed with a wide variety of payloads ranging from a few kilotons to more than a megaton, switching warheads is complicated and time consuming; loading a mission specific selection of nuclear or conventional ordnance on a bomber offers significantly greater flexibility. More important, however, is the ability to deploy bombers as highly visible power projection platforms short of warfare. A president can signal resolve by deploying them to a crisis zone or ordering them to fly near another nation's airspace in an effort to encourage de-escalation, or to dial up pressure to match an opponent's intimidation tactics. And should a president feel the need to order a strategic strike, there remain several hours for continued analysis or negotiation before the aircraft reach their launch zone. Unlike missiles, bombers can be recalled at any time prior to weapons release.

This flexibility alone proves the strategic bomber's continued relevance. The return of great power conflict underscores the need to retain a robust, balanced strategic triad of mutually reinforcing elements.

The Current Bomber Force

USAF's current strategic bomber fleet consists of three aircraft types: the B-52 STRATOFORTRESS, the B-1 LANCER, and the B-2 SPIRIT.

B-52H STRATOFORTRESS

The first B-52 bombers achieved Initial Operational Capability (IOC) in 1952. The extant aircraft operating today belong to the B-52H variant, of which 102 units were acquired in 1961-1962. The current active duty force consists of 58 planes, of which

Photo: U.S. Air Force / Hannah Malone

A weapons systems officer uses a land mobile radio as he watches a B-1B LANCER land in support of a Bomber Task Force mission at Naval Support Facility Diego Garcia, in October 2021. Operating with a variety of aircraft and units in the Indo-Pacific, Pacific Air Forces maintains ready and postured forces prepared to respond to and support global operations.

Photo: U.S. Air Force / Jordan Castelan

A US Air Force 509th Bomb Wing B-2 SPIRIT approaches a 351st Aerial Refuelling Squadron KC-135 STRATOTANKER during the Bomber Task Force training exercise over England, in August 2019.

Photo: U.S. Air Force / Victoria Hommel

Three B-2 SPIRIT stealth bombers at Keflavik Air Base on Iceland in August 2021

Photo: Northrop Grumman

Concept image of the B-21 RAIDER

four are reserved as test aircraft. An additional 18 units are operated by the Air Force reserve. The fact that the B-52 still constitutes the backbone of the US strategic bomber fleet – and is effectively being flown by the grandchildren of the original pilots – attests to its robustness.

The B-52H has an operational ceiling of 15,000 metres, achieves speeds of Mach .84, and has an operational range of 7,500 nautical miles (NM). The payload capacity is 31,500 kg carried inside the bomb bay and on underwing pylons. The plane carries both cruise missiles and gravity bombs, and is rated for both conventional and nuclear ordnance. Since the plane cannot penetrate modern air defence systems, it can only engage strategic targets by deploying stand-off weapons. The B-52 can carry up to 20 AGM-86B nuclear armed cruise missiles with a range of circa 1,500 NM, or up to 12 nuclear-capable, stealthy AGM-129A cruise missiles with over 2,000 NM range. The STRATOFORTRESS will also deploy the Long-Range Stand-Off (LRSO) nuclear armed cruise missile which is expected to replace the AGM-86B by 2030. The LRSO's combination of speed, manoeuvrability and stealth-configuration is expected to enable deep penetration of enemy air- and missile defences even when launched by non-stealthy aircraft. The combined range of strategic bombers and the LRSO will permit engagement of targets at any spot on the globe.

Ongoing and planned modernisation will extend the B-52H's service life into the 2050s. Currently the bombers are being outfitted with new Rolls Royce F130 engines. In January 2022, Collin Aerospace announced a contract to upgrade the B-52's power generation system. Taken together these upgrades will reduce fuel consumption by 30 percent, extend mission range and loiter time, and permit faster ascension to cruising altitude. The increased power production associated with the new equipment will support future upgrades including new Active Electronically Scanned Array (AESA) radar, as well as upgraded avionics, pneumatics and defensive systems.

B-1B LANCER

The B-1 LANCER achieved IOC in 1986. The blended wing/body configuration, variable-geometry wings and supersonic-flight-capable engines combine to make the aircraft highly manoeuvrable at both low and high altitude. The LANCER holds nearly 50 class-specific world records for speed, payload, range, and climb rate. Performance parameters include a 9,150 metre service ceiling, Mach 1.2 top speed, and "inter-

continental" mission range. The currently deployed B-1B's 34,000 kg payload capacity is the largest of any US combat aircraft. Originally a dual-capable bomber, the B-1 was converted in 2007-2011 to exclusively carry conventional ordnance. Operationally the LANCER is still capable of attacking strategically significant targets from stand-off range using the low-observable AGM-158A JASSM cruise missile (range 230-1,200 NM depending on variant).

B-2 SPIRIT

The B-2 SPIRIT, which entered service in 1997, is USAF's only strategic bomber with fully-developed stealth characteristics encompassing reduced acoustic, thermal, electromagnetic, radar and visual profiles at all altitudes. As such, it is the only true deep-penetration bomber currently in the fleet. However, USAF expects peer-level adversaries' developmental air defence systems to diminish the effectiveness of the B-2's low-observable technology in coming years.

The aircraft has an unrefuelled 6,000 NM operating range, and has in the past self-deployed directly from the united States to the Balkans or Afghanistan, conducted ground strikes, and returned to its home base without landing. The 18,150 kg payload encompasses nuclear and conventional weapons including B61 and B83 variable-yield thermonuclear gravity bombs and the conventionally armed JASSM. Original plans had called for 135 aircraft, but the end of the Cold War induced the Pentagon to cap production at 20 operational units.

Photo: USAF

An artist's rendering of the B-21 in a hangar at Ellsworth Air Force Base

The 21st Century Bomber

The B-1 and B-2 will begin to retire in the 2030s as the new B-21 RAIDER bomber enters service. These earlier-than-planned retirements reflect the budget- and manpower-driven need to maintain a steady-sized total bomber force of approximately 175 aircraft (although such top-level figures are subject to change, and have recently trended upward). USAF's choice to replace the two younger airframes rather than the B-52 reflects the latter's large and versatile payload capability, simpler maintenance, and – not least of all – the ability to deploy new long-range weapons currently being developed.

Photo: U.S. Air Force photo / Aaron D. Allmon II

Loading an AGM-86B air-cruise launch trainer missile onto a B-52H STRATOFORTESS underwing pylon at Minot Air Force Base, N.D.

The B-21 is being designed by Northrop Grumman to operate in a highly contested environment marked by advanced enemy sensors and air defence systems. Its stealth technology will be three decades more advanced than that of the B-2, and is expected to enable deep penetration missions even against peer-level opponents. The open-architecture design will facilitate frequent upgrade of aircraft systems to ensure that the aircraft's capabilities keep pace with new technologies and quickly adapt to changes in the threat environment. Most technical and performance details of the new bomber remain classified. Concept graphics released by the Air Force show a batwing design similar to the B-2; some analysts conclude that the depicted RAIDER appears somewhat smaller than the SPIRIT.

The RAIDER will accommodate a broad range of nuclear and conventional standoff and direct-attack munitions. The operating concept calls for integrating the bomber with various support platforms including Intelligence/Surveillance/Reconnaissance assets. Unmanned combat aircraft and electronic warfare aircraft, controlled by the B-21 crew, will escort or collaborate with the bomber, according to statements made by Air Force Secretary Frank Kendall in December 2021. The B-21 itself will be configured for optionally manned or unmanned operation, although that capability will not be found on the earliest production aircraft.

The first six aircraft are currently in production, with the first unit nearly complete externally. This first test aircraft is reportedly halfway through ground testing, having successfully completed the first and most critical load calibration test. Flight-line ground testing – including testing of engines and high-speed taxi tests – are expected over the coming weeks to months. First flight has been postponed to 2023, a delay of approximately six months. Neither USAF nor Northrop Grumman provided a reason for the delay, saying in May 2022 that the program remains within the established cost, schedule and performance baselines.

USAF continues to estimate mission availability of the first aircraft in the "mid-2020s". While the production rate remains classified, Northrop Grumman revealed in April 2022 that the Low-Rate Initial Production phase will begin in 2023 and run concurrently with the Engineering and Manufacturing Development phase "for a period of time" in order to accelerate acquisition; full-rate production should begin in the 2025-2026 timeframe. USAF's official acquisition goal is a minimum of 100 aircraft (and perhaps as many as 145). When inventory reaches sufficient depth it will relieve the B-52 as the backbone of the US strategic bomber force, but will continue to partner with the STRATOFORTRESS, with each aircraft's respective strengths contributing to the comprehensive mission.

Photo: U.S. Air Force photo / Giancarlo Case

A B-52H STRATOFORTRESS undergoes pre-flight procedures at Edwards Air Force Base, in August 2020. The aircraft conducted a captive-carry flight test of the AGM-183A Air-Launched Rapid Response Weapon Instrumented Measurement Vehicle 2 at the Point Mugu Sea Range off the Southern California coast.

Are Unmanned Bombers Over the Horizon?

In addition to the optionally manned B-21, USAF also plans to introduce a cheaper, fully unmanned bomber to partner with the RAIDER. Speaking at the Air Force Association Airpower Symposium in March 2022, Air Force Secretary Kendall introduced the concept of the "B-21 long-range strike family of systems" with an unmanned strategic bomber complementing the B-21. The unmanned component would need to match the B-21 in range and speed, and have a "reasonable payload." Kendall stressed that concept development is in early stages, and that no decision had been made regarding nuclear or conventional payloads for the "potentially attritable" UAS.

Speaking at the same forum, Randall Walden, director of the Rapid Capabilities Office, which oversees the B-21 development, confirmed that USAF is serious about developing the unmanned bomber. He postulated that the UAS could act as a pathfinder for the B-21, neutralising enemy air defences for the manned bomber. "We would take more risk with an unmanned system that is not as expensive as the manned system," he said. The Pentagon plans to request research and development funding for the unmanned aircraft in 2023 and 2024. If the risk reduction phase and design competitions provide positive results, the UAS could be available by the end of the current decade, Walden said, adding that his office "is pretty good at doing that piece in a relatively fast way." ■

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Stealthy Airborne Communications

Thomas Withington

Low observable airborne communications help ensure that combat aircraft can safely perform their missions while minimising their chances of detection and location via their radio emissions.

No one would doubt how vital radio is to airpower. It is the only way two or more aircraft can communicate with each other. It is the only way a pilot can communicate with those on the surface and vice versa. Radio not only carries voice traffic, but also data. This data includes everything from coordinates for targets on the surface or in the air to weather information and even radar pictures.

Yet radio has one glaring disadvantage. The moment a radio transmits that signal can theoretically be detected in the same way that one cannot speak without producing sound, no matter how quietly one whispers. Radio communications were first used en masse by airpower during the Second World War. Ever since, efforts have been ongoing to reduce the chances that signals from airborne radios can be detected. The reason why detection must be minimised is simple. Once a transmission is detected, the radio's location can be determined and identified. If you find the source of a hostile aircraft's radio transmission, you find the aircraft. A large part of air defence focuses on finding that hostile aircraft in the first place.

Photo: Ericsson

Millimetric wave communications are being embraced by the civilian domain, particularly for fifth-generation cellular networks in urban areas.

Millimetric Wave Communications

One way to reduce chances of detection via radio signals is to use Millimetric Wave (MMW) radio communications. These are at the heart of the techniques that aircraft like the Lockheed F-22A RAPTOR and F-35A/B/C LIGHTNING-II combat aircraft use to keep in touch with one another. As they are intended to flight in highly contested airspace it is imperative these planes are not located via their radio signals.

All aircraft produce a lot of radio signals. These signals are produced by radars, along with the aircraft's radios. Radio signals are used by the plane's Satellite Communications (SATCOM) to send and receive voice and data traffic at beyond line-of-sight ranges. High Frequency (three to 30 megahertz/MHz) radio is used for similar purposes. Aircraft carry transponders to share information with Air Traffic Control (ATC). These transponders send details of an aircraft's identity, altitude and speed on frequencies of 1.090 gigahertz/GHz. Military aircraft transmit similar information using Identification Friend or Foe (IFF) transponders. North Atlantic Treaty Organisation aircraft frequencies of 1.030GHz and 1.090GHz to carry IFF data. An Electronic Support Measure (ESM) on the surface, or in another aircraft like an airborne early warning platform could detect these signals. Once the ESM detects these transmissions, it may be possible to determine an aircraft's location.

MMW communications aim to reduce the likelihood of an aircraft being located via its radio signals. All radio signals mentioned above exist in wavebands of circa three megahertz up to 36GHz. MMW signals are at the upper end of this range. Typically, they exist in frequencies of 30GHz and above. They are so-called because their wavelengths are very short. Wavelength refers to the distance between a radio wave's peaks and troughs. For example, a frequency of 30GHz has a wavelength of 9.99mm. A wavelength of 40GHz will measure 7.49mm.

Millimetric wave signals have several properties making them ideal for combat aircraft needing to shield themselves from detection by ESMs. Firstly, MMW radio signals are difficult to detect as they use very narrow beams. This makes them very sharp and precise. An ESM's receiver is unlikely to detect these beams unless its' antenna is looking directly at them, or the beams are pointing directly to the antenna. MMW signals are comparatively much shorter range than other frequencies lower down the radio spectrum. This is not a problem for a formation of F-35s or F-22As flying relatively close together. Their radios will have sufficient power to ensure traffic reaches their comrades nearby. However, unless you are very close by these aircraft you are unlikely to be to detect their MMW radio signals using an ESM. Furthermore, if the ESM is on a hostile aircraft, it is likely this will have already been engaged by the fighter's own ordnance before getting near the formation.

Secondly, highly directional radio antennas used by the fighters precisely steer the MMW signals to their intended recipient. This level of precision makes it unlikely that a hostile ESM will be capable of detecting

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the signal unless it is in the same locale as the recipient aircraft. "Directional data links have the distinct advantage of radiating minimal energy in the direction of the adversary, resulting in low probability of intercept/low probability of detection," says a written statement from Northrop Grumman. The company is involved with the F-22A's Intra-Flight Data Link (IFDL) and the F-35A's Multi-Function Advanced Data Link (MADL).

The advent of MMW radio has been helped immeasurably by the advent of Active Electronically Scanned Arrays (AESAs). Initially, this technology was used in military radars from the 1990s onwards. AESAs electronically steer their signals in a certain direction. This is in contrast as to the antenna needing to be physically moved to point at its target. For MMW communications this is particularly important as it gives the high precision needed to ensure that the signal's fine beam reaches its intended recipient. Moreover, AESAs can independently move several beams in several directions. This lets individual MMW-equipped aircraft simultaneously communicate with several other planes within range.

AESAs have another advantage. As they can use a flat construction, akin to a solar panel, they are relatively easy to mount on an aircraft's skin. Both the F-22A and F-35 have used this approach by mounting flat panel antennas for MMW communications on the aircraft's surface. This means several antennas can be used to eliminate communications blind spots. These maybe caused when the aircraft performs manoeuvres, which may cause it to obstruct the line-of-sight link between two radios. It also allows the aircraft's surfaces to remain free of protrusions, which risk compromising the jet's low radar cross section.

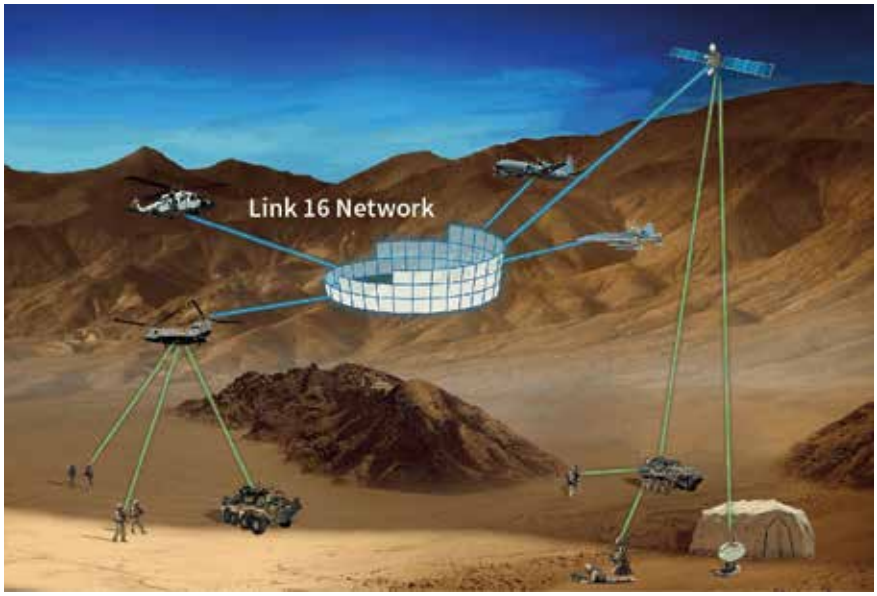

Photo: Viasat

NATO's Link-16 tactical datalink protocol has revolutionised air operations, although it remains limited in the data rates it can handle.

Usefully, MMW communications provide high bandwidths. Data rates can be in the order of several gigabits-per-second. This allows aircraft to share data-heavy traffic like real-time video imagery with relative ease. Not only can traffic be shared, but the links provide "simultaneous voice and data". This allows the passage of information "using secure, open systems for tactical edge processing for decision dominance at mission speed."

Datalinks like IFDL and MADL not only exist to ensure similar aircraft can remain in contact. They play a role enriching the situational awareness of a group of aircraft. One of airpower's greatest strengths is mass which can be focused at an optimum moment against hostile targets. By using these links, a package of F-22As or F-35s becomes noticeably stronger than the sum of its parts.

Photo: Hensoldt

Airborne radio communications are increasingly having to connect with non-traditional platforms like uninhabited air vehicles, a trend likely to deepen in the future.

"These data links allow true machine-to-machine data exchanges that enable the onboard computers to create a fused picture", says Northrop Grumman's statement. This is "a capability unsurpassed by traditional links such as Link-16". In fact, MMW data communications rates are a far cry from the 115.2 kilobits-per-second which the North Atlantic Treaty Organisation's (NATO's) Link-16 Tactical Datalink (TDL) theoretically achieves. Experts tell the author that Link-16 is usually only capable of handling noticeably lower levels of traffic.

While MMW communications have advantages regarding the traffic levels they handle and their relatively furtive attributes, they do have disadvantages. Perhaps the most serious is atmospheric attenuation. This is when atmospheric moisture absorbs radio waves at certain frequencies as they pass through the atmosphere. As MMW frequencies use very short wavelengths of 10mm or less, signals can be impeded by rain6drops and snowflakes. These obscurants will not necessarily prevent the signals reaching their recipient, but they will degrade their efficacy.

Tactics

At first blush, it might seem that the relatively short range and high precision of the MMW transmissions used by aircraft like the F-22A or F-35 prevent them from commun6icating with other aircraft outside their locale. To an extent, this is the case. However, tactics can be used to ensure the aircraft can send and receive traffic to and from other aircraft. Typically, these aircraft will work in pairs within larger formations. Perhaps three or four jets will ingress into contested

Photo: US DOD

The F-35's MADL datalink is believed to be an outgrowth of the IFDL used by the F-22A. Both systems will influence the trajectory of future low-observable airborne communications developments.

airspace. These aircraft will communicate between themselves using the MMW radio. Another F-22A or F-35 may hang back slightly from the formation perhaps remaining in friendly, or relatively safe, airspace. It will receive any traffic from the aircraft in the hostile airspace intended for recipients outside the formation. That aircraft's radios will translate the traffic from the formation into another protocol like Link-16. This will then be transmitted to its intended recipients on the Link-16 network. This process can be reversed for traffic from outside intended for the formation. On the one hand, the formation preserves its stealth, while on the other it remains in touch with other assets involved in the operation.

Developments

The two notable, low-observable communications systems in service today on are the IFDL and MADL. It is thought that MADL was essentially a further development of the earlier IFDL architecture. Details of the communications used by the Russian Air Force's Sukhoi Su-57 (NATO reporting name Felon) are harder to find. Reports from Russia's TASS news agency say that the Su-57 uses a communications system known as S-111. Precisely what this consists of remains unknown. The TASS report revealing the system in July 2019 said the S-111 "provides radio … communications and an exchange of the plane's data with other aircraft (and with) with ground, aerial and naval command and control posts". It continued that "the equipment incorporates the state-of-the-art technology (for) high-speed data transmission and features advanced network solutions." It seems likely Russian radio engineers are looking at MMW communications for combat aircraft. Such technology may indeed already be in service onboard the Su-57 in the guise of the S-111. Likewise, MMW communications may be used by the People's Liberation Army Air Force Chengdu J-20A fifth-generation fighter.

MMW technology not only relies on being difficult to detect to preserve its low-observable characteristics. While highly classified, one can assume that other techniques like encryption and frequency-hopping are used. This will help make MMW traffic hard to detect and intercept. Western airpower is now moving beyond the first generation of airborne tactical MMW architectures as enshrined in the IFDL and MADL. Europe is moving ahead on two sixth-generation combat aircraft, the multinational Tempest and Future Combat Air System. The US Air Force is developing its Next-Generation Air Dominance (NGAD) platform. Meanwhile, the US Navy is working on the F/A-XX programme. All these aircraft will enter service in the 2030s and will all include the next-generation of low-observable communications.

What will these architectures look like in practice? At this point it is difficult to say. For understandable reasons, many aspects of these aircraft's capabilities remain in classified. It is safe to assume that millimetric wave communications will continue to be favoured for the reasons given above. Whether signals move further up the radio spectrum beyond 40GHz remains to be seen. Higher frequencies will bring even more precise beams and wider bandwidths, but they will do so at the expense of range and power. MMW communications using higher frequencies maybe impractical. As frequencies increase, more power is needed to send the transmissions across equivalent distances. There is a limit to how much electricity an aircraft's engines can generate, and this power must be shared with other aircraft systems. A compromise will have to be struck between desired MMW frequencies and those practical for the aircraft.

Instead, further innovations could be rolled into MMW architecture in other ways. Transmission and communications security protocols may be improved with more robust encryption. Similarly, cognitive techniques maybe embedded into MMW processes. Cognitive radio is an emerging technology. It enables a radio to continually sense the electromagnetic environment modifying its behaviour with no human intervention. This is achieved by using artificial intelligence and machine learning. The radio is capable of continually 'learning' from its experiences and altering its comportment to ensure it remains efficient. For example, the radio may have learned it needs to use less power transmitting traffic on days when the weather is good. Correspondingly, the radio automatically moderates its transmission power when weather data tells the radio it is a fine day. Alternatively, a radio may learn which of its transmissions successfully reached their recipient during previous missions when heavy electronic jamming was experienced. Once again, the radio automatically adjusts its behaviour accordingly when experiencing similar jamming in the future.

Low-observable airborne radio technology is still a relatively young science. The IFDL and MADL can trace their lineage back to the 1980s when the US airpower community began thinking about the F-22A and F-35. MMW communications help preserve stealth while enabling secure, high bandwidth communications. The next iterations of this technology destined for forthcoming sixth-generation fighters will take things even further. ■

Photo: Airbus

The pan-European FCAS aircraft will have highly advanced and very secure radio communications which may also incorporate emerging cognitive radio techniques.

The Kill Web

John Antal

An artificial intelligence-enabled kill web will transform warfare

Striking power is the ability of any military system, unit, or force to generate offensive action to destroy the enemy. Until recently, for land combat, this capability was dominated by the concept of combined arms; primarily tanks, infantry, engineers, air defence, artillery, and aviation working together. Today, as demonstrated in the Second Nagorno-Karabakh War (2020) and the ongoing Russo-Ukrainian War (2022), striking power includes a host of new, smart, sense-and-strike weapons such as Unmanned Combat Aerial Vehicles (UCAVs), Loitering Munitions (LMs), advanced Anti-Tank Guided Missiles (ATGMs), and long-range precision missiles. These new, robotic sense-and-strike weapons are changing the nature of combined arms, increasing the tempo and precision of war, and accelerating the kill chain.

Photo: soldat-und-technik.de

During the Second Nagorno-Karabakh War, Azerbaijan used sense-and-strike UCAVs, such as the Turkish-made BAYRAKTAR TB2.

The Russo-Ukrainian War

We can observe the work of an effective kill chain in the current Russo-Ukrainian War. On April 22, 2022, near Kherson, Ukraine, the forward command post of the Russian 49th Combined Arms Army (CAA) was hit by Ukrainian missiles. The destruction of the command post resulted in the death of two Russian general officers, one of whom was the commander of the 49th CAA. The Associated Press reported, "Oleksiy Arestovych, an adviser to Ukrainian President Volodymyr Zelensky, said in an online interview that 50 senior Russian officers were in the command centre when it came under attack. He said their fate was unknown." On April 30, 2022, Ukraine hit another Russian command post in Izyum, and Ukrainian sources reported the strike destroyed as many as 30 vehicles. Ukraine reported that the Russian Chief of the General Staff, General Valery Gerasimov, was wounded in this strike and flown out of Izyum with shrapnel wounds. On May 18, 2022, the Ukrainian military reported that Ukrainian artillery destroyed yet another command post of the brigade of the Russian Black Sea Fleet. Three officers were killed and 14 were seriously injured. The Ukrainian military has been targeting Russian command posts and leadership with precision weapons from the start of the war. Russia has lost more than 31 command posts to Ukrainian strikes. The loss of so many senior officers, critical staff officers, and command-and-control vehicles would be debilitating for any army. For the Russian army, with its tight, centralised command-and-control philosophy, and no experience with mission command, these losses are disastrous. The Ukrainian kill chain appears to be very effective. "To me, and in conversations with other officers across various services, clearly the ubiquity and proliferation of sensors and the ability to close kill chains accurately, precisely on any target is a major lesson to take away," said Lt. Gen. Karsten Heckl, head of United States Marine Corps Combat Development Command, discussing the fighting in Ukraine in a May 5, 2022 interview in Seapower Magazine.

The Kill Chain

Speed is essential to wage war successfully. Operating faster than your opponent provides a winning advantage. Currently, all military forces operate human-centric kill chains. A kill chain is a sequential process that operates at human speeds. A kill chain represents the sequence of events required to sense and strike enemy targets. Traditionally Human in the Loop (HITL) or Human on the Loop (HOTL) centred, this involved identifying a target, deploying a weapon system to engage the target, , launching the munition, destroying the target, and verifying battle damage after the strike: — find, fix, fire, finish, and feedback. Christian Brose, in his book titled "The Kill Chain," simplified the kill chain as a three-step process: gain understanding of what is happening, decide what to do about it, and take action (kinetic or non-kinetic). The traditional kill chain can be slow, as the targeting system must pass through multiple human operators before the striking power is unleashed. At the very best, it is measured in minutes.

During the Second Nagorno-Karabakh War, the Azerbaijani's accelerated their kill chain by using sense-and-strike UCAVs, such as the Turkish-made BAYRAKTAR TB-2, and LMs such as the Israeli-made HAROP and ORBITER. In the case of the Azerbaijani

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kill chain, the time from target identification to verification of destruction was often measured in seconds. The Azerbaijanis accomplished this by designating a "three-dimensional strike zone" in the battlespace, essentially a "free fire box," to find and strike any targets according to a designated priority of targets. The target priorities executed by Azerbaijan were, in order: air defence, electronic warfare, command and control, artillery, tanks, armoured vehicles, wheeled vehicles, and finally, troops. By the middle of October 2020, the Azerbaijanis had been so successful that their UCAVs and LMs were hunting troops. What was equally impressive was that the high-end, Israeli-made LMs communicated with each other automatically, and when a pack of LMs struck their targets, no two LMs hit the same target. This streamlined kill chain is one of the secrets that delivered Azerbaijan a decisive victory over Armenia in only 44 days.

Photo: Raytheon

The COYOTE Loitering Munition (LM), produced by Raytheon, can be flown individually or netted together in swarms, with systems communications with each other to destroy targets at machine speeds. In March 2021, Raytheon was awarded a US$32.8M contract to produce Autonomous Swarm/Strike Loitering Munitions by the US military.

A Sequential Process

Every kill chain involves the sequential process previously described, and each of these steps operate at different speeds. The time involved to execute the combined kill chain is the sum of its parts. In war, extraordinary speed is of great importance. Accelerating the kill chain is slowed by the speed of human interaction across the process. As more weapons send data to each other during a strike, as the Israeli-made LMs can, an Internet of Battlefield Things (IOBT) will begin to evolve. Connecting these fast-moving systems and synchronizing their attack is beyond the means of the human-centric kill chain. In addition, the process is further accelerated if capabilities from all domains, land, sea, air, space and cyber, can be activated as part of the kill chain. This AI-enabled, multi-domain system is the emerging kill web.

The Kill Web

A kill web employs an Artificial Intelligence (AI)-enabled process to operate at machine speeds. This design rapidly synchronizes the effects of many networked munitions in time, space and purpose. AI has the potential to accelerate sensor-to-shooter timing exponentially in real-time. AI is the concept of how we program machines to accomplish tasks. Machine Learning (ML) is the science of applying AI to provide machines with data and then allowing them to learn for themselves. AI and ML capabilities have demonstrated effectiveness in military applications with both sensors and shooters. AI can intelligently sort through large amounts of data to discover optimal targeting parameters much faster than a human. In 2019, US Missile Defense Agency Direct Vice Admiral Jon Hill explained the need for an AI-enabled kill web: "With the kind of speeds that we're dealing with today, that kind of reaction time that we have to have today, there's no other answer other than to leverage artificial intelligence." China's military experts predict that lethal "intelligentized" weapons will be common by 2025.

Facing these realities, the United States, China, Russia, Israel, and several other nations are working on AI-enabled, multi-domain kill webs, with varying degrees of success. The goal of creating a system of connected weapons, communicating vital data to each other in real-time, and controlled by AI, is a daunting challenge. The US spends more on defence than any other nation in the world and has been the master of the kill chain for the last several decades, but its stove-piped, single branch (Army, Navy, Marines, Air Force and Space Force) systems will be difficult to mesh into an integrated kill web. "The Army has the weapons, OODA loop (Observe, Orient, Decide, and Act), and kill chain for land-based problems," reported Ray Alderman, of Vita Technologies, in a May 30, 2018 article in Military Embedded Systems. "The Navy has the weapons, OODA loop, and kill chain for sea-based problems. The Air Force has the weapons, OODA loop, and kill chain for air-based problems. There's also space, cyberspace, and electronic warfare (the electromagnetic spectrum) with their own weapons, OODA loops, and kill chains." This challenge becomes more complex if the goal is to ultimately integrate separate militaries of an alliance. "If hooking all our military platforms together is a rat's nest of problems," Alderman, who believes that there are six domains of war, adding the electro-magnetic spectrum, went on to say, "How can we hook our allies' platforms into our network?" We need to replace these two-dimensional kill chains (the static linear sequence of events) with a six-dimensional kill web (connect all six domains of warfare into a dynamic network). How do we do that? By communicating targeting data collected in one domain to all the other domains instantly, creating "shared situational awareness." A new US defence programme, the Joint All-Domain Command and Control (JADC2), is the US Department of Defense's (DOD) concept to connect sensors from all the military services into a single, multi-domain AI-enabled network. How successfully JADC2 will do so, and how soon, remains to be seen. The bottom line is that creating an AI-enabled, multi-domain kill web is an extremely challenging task that requires determined leadership, intense focus and the combined efforts of the DoD and their industry partners.

A recent example of an emerging kill web occurred during Israel's execution of Operation Guardian of the Walls against Hamas in May 2021. Israel declared that this was the first "Artificial Intelligence War" in history. Israel exists in a military situation where it cannot trade space for time, as they have no ground to give. Thus, Israel must act with alacrity in any conflict. To gain a time advantage over their opponents, and to apply lessons learned from previous wars, Israel has prioritised the development of AI and ML for military operations, especially targeting. Huge

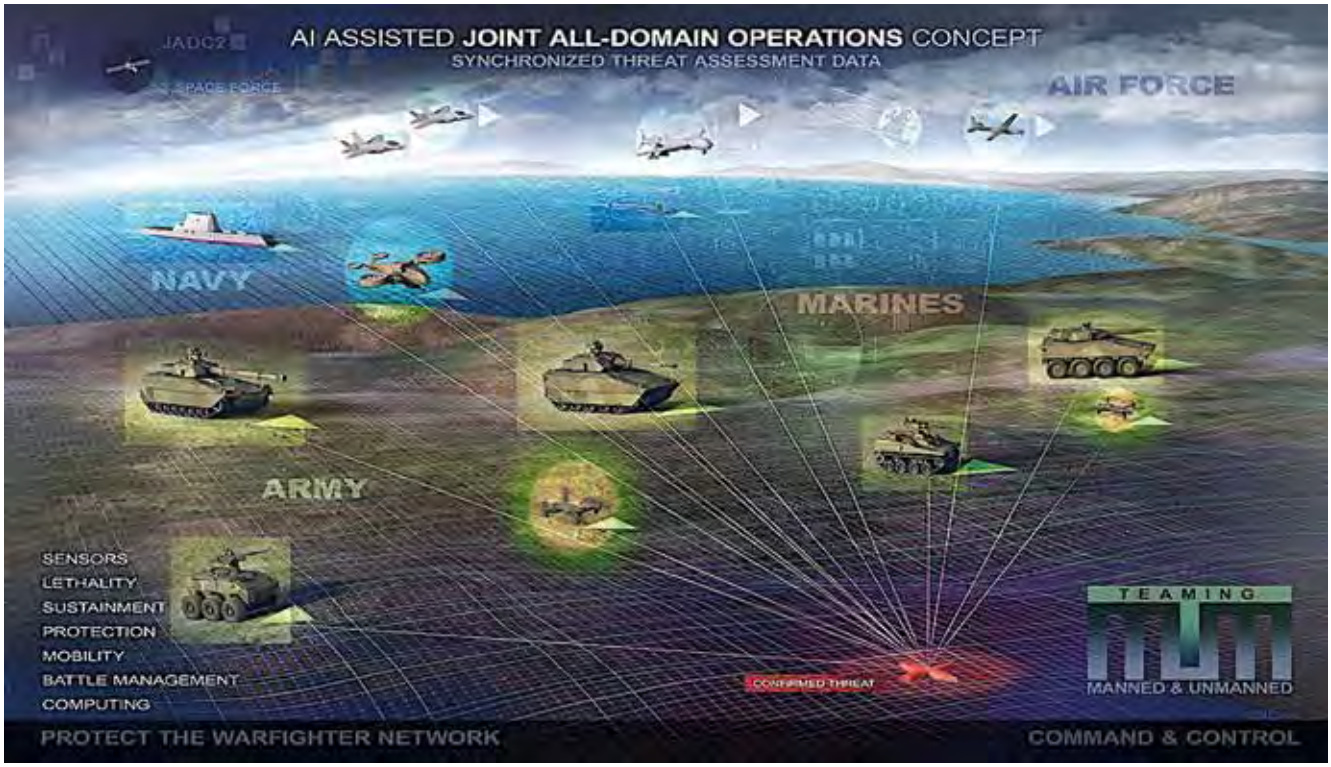

Image: US Army

A vision of a modern kill web, the Joint All-Domain Operations Concept for the US military, intends to use Artificial Intelligence (AI) to synchronise data and multi-domain responses.

amounts of data, from all forms of intelligence and surveillance, were correlated by the Israeli AI-enabled kill web. Hamas started the war by launching a non-stop rocket barrage against Israel on May 10, 2021. As the IRON DOME anti-missile system attempted to protect Israel from Hamas's arsenal of 190,000 rockets, Israel struck back by hitting 1,500 targets with speed and precision. According to a June 9, 2021, Frost and Sullivan Aerospace report by Avi Halo, "Massive AI machinery for Big Data Analytics provided support at every level – from raw data collection and interception, data research and analysis, right up to strategic planning – with the objective of enhancing and accelerating the entire process, from decision-making about prospective targets to the actual carrying out of attacks by pilots from F-35 cockpits. These targets included Hamas rocket launch sites, command-and-control centres, weapons storage sites, and tunnel systems. On May 12, 2021, IDF strikes killed 16 key Hamas leaders. "For the first time, artificial intelligence was a key component and power multiplier in fighting the enemy," reported an Israeli Defense Force (IDF) Intelligence Corps officer in the Jerusalem Post article by Anna Ahronheim, published on May 27, 2021. "This is a first-of-its-kind campaign for the IDF. We implemented new methods of operation and used technological developments that were a force multiplier for the entire IDF." The Israeli-made kill web is a combination of AI programmes, with code-names such as "Alchemist," "Gospel," and "Depth of Wisdom." These AI programmes dramatically reduced Israeli casualties in the 2021 war and ended the conflict in 11 days, with Hamas asking for a ceasefire. In an after-action-report conducted by the IDF, Chief of Staff Lt.-Gen. Aviv Kohavi said that the IDF achieved a new level of connection between sensors, intelligence and shooters: "During three days of Operation Guardian of the Walls, the Southern Command and the Gaza Division destroyed 70 multi-barrelled launchers. They destroyed a multi-barrelled launcher every hour."

Data

Data is the ammunition of the next war. Multi-domain sensors can collect mountains of data. Processing this data in time is beyond human cognition. Using AI to process the data, which is the tasks that AI does best, can dramatically truncate the sensor-to-shooter time. The goal of the kill web is to use AI to synchronise all available weapons within striking range to engage priority enemy targets with precisely the right weapons while executing the decision-making of this complex allocation at machine speeds. A description of the difference between a kill chain and a kill web was offered in "A Maritime Kill Web Force in the Making: Deterrence and Warfighting in the XXIst Century," published in 2022 by Robin Laird and Edward Timberlake: "The kill chain is a line concept which is about connecting assets to deliver fire power; the kill web is about distributed operations and the ability of force packages or modular task forces to deliver force dominance in a specific area of interest. It is about building integration from the ground up so that forces can work seamlessly together through multiple networks, operating at the point of interest." The goal is to create an AI-enabled kill web that connects all smart weapons and multi-domain effects with the greatest speed, range, and decision dominance. When this goal is realised, war will never be the same.

The cognitive and autonomous levels of the latest weapons will only become more capable in the years ahead. An AI-enabled kill web will increase the tempo, precision, and lethality of war by linking sensors and shooters as never before. Gathering, analysing, organising, sharing, and synchronising time-sensitive multi-domain targeting data is no longer effective at human decision-making speeds. An effective kill web has the potential to synchronise the attack of swarms of LMs and UCAVs to form a persistent, precision fire "kill box" over specified areas of the battlespace. Tactical victory can be turned into operational success if LMs and UCAVs are used in mass instead of penny-packets to support combined arms forces. The first to operationalise an AI-enabled kill web, even for brief periods of time, may establish fires dominance throughout a theatre and gain a war-winning advantage. The striking power of a kill web will overmatch the enemy with furious, synchronized attacks, and with such tremendous speed, it will appear as if the opponent is standing still. Understanding the kill web, therefore, is paramount to understanding the future of war. ■

Defence Against Low-Altitude Air Threats

Manfred Stangl

The Future Operational Principles for the Initial Capability of the Short-Range and Very Short-Range Protection Air Defence (SHORAD/V-SHORAD) System

As far as the protection of land forces against threats from the air is concerned, there is still an urgent need for action due to existing quantitative and qualitative capability gaps. Particularly at short-range and very short-range, the protection of mobile operations – across all tactical activities and intensities – can only be guaranteed to a limited extent, both quantitatively and qualitatively, with the weapon systems that have been introduced. Priority is to be given to closing the capability gaps with the project "short-range and very short-range protection air defence system".

Photo: Bundeswehr/Manfred Stangl

Capability spectrum of the sub-projects

Sub-projects of the SHORAD/V-SHORAD System

Sub-project 1, the so-called initial capability, comprises the development and procurement of ground-based systems for mobile operations capable of protecting three brigades and divisional troops. Sub-project 2 was included in the planning but not realised. Sub-project 3, the follow-on capability, integrates additional units with enhanced equipment configurations and improved capabilities against very small unmanned aircraft, as well as additional elements for defence against indirect fire. At target strength, the surface-to-air missile squadrons of the SHORAD/V-SHORAD system should be able to ensure the protection of a total of eight brigades, troops of three divisions, troops of one corps, as well as two airfields in the theatre of operations.

Author

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Structure of the Initial Capability

At the core of each surface-to-air missile squadron for short-range and very short-range protection will be three surface-to-air missile platoons. Of these, the first platoon will encompass the fire control group and the medium-range elements with medium-range radar and medium-range weapon carriers. As for the second and third platoons, each of them is essentially made up of three short-range self-propelled armoured air defence missile system sections.

While the medium-range weapon carriers will be armed with guided missiles of the IRIS-T SLM (Surface Launched Medium Range) type, the main armament of the self-propelled armoured air defence missile system will be based on the IRIS-T SLS (Surface Launched Short Range) type. As a further weapon for self-protection against enemies on the ground and small unmanned aircraft systems, a remote-controlled weapon station is to be adapted to the self-propelled armoured air defence missile system and integrated into the command, control, information and weapons control system.

In addition to the surface-to-air-missile platoons, each squadron will also have a squadron operations centre, an air defence cell as a liaison element to the brigade or division and extensive organic support components. The aim is to ensure that each squadron will be able to independently provide the necessary command support elements as well as weapon system maintenance in a sustainable manner.

The current situation demands a high degree of mobility and adequate protection from all elements of the surface-to-air missile squadron for short-range and very short-range protection. It is particularly the self-propelled armoured air defence missile systems that, in terms of mobility and armour, must be designed in such a way that they can be deployed together with the mechanised combat troops and can also conduct fire fights against airborne enemies while on the move.

Employment of Initial Capability

A squadron of the SHORAD/V-SHORAD system will generally be able to provide autonomous and sustainable protection against attacks from the air. Using modern tactical data links, it will also be able to keep up a permanent connection to the NATO Integrated Air Defence System and generate a joint air situation that will be used down to the level of the self-propelled armoured air defence missile systems. In addition, the na-

Photo: Bundeswehr/Alexander Feja

The OZELOT air defence system during an exercise in Poland

tive integration into the future digital command and control systems of the land forces will provide full capability for conducting operations on the battlefield of the future.

Command and control will be exercised from the mobile squadron operations centre, from which the current ground and air situation can be accessed at any time. The employment of the surface-to-air-missile platoons will also be commanded from here. The air defence cell of the squadron will maintain liaison with the respective supported force commander. Air defence cell personnel will also contribute subject matter expertise to the higher operations centre of the land forces.

Fire fights against airborne enemies will be conducted from the armoured fire control vehicle in the squadron's first surface-to-air-missile platoon. The fire control crew will primarily process priority targets, assess the higher-level air situation and employ medium-range guided missiles. The first platoon will employ medium-range guided missiles in the rear area of combat battalions, making the best possible use of the terrain. These will act against fast or large air assets. The platoon leaders of the second and third platoons will lead from protected vehicles used as mobile command posts. They will liaise and coordinate closely with the combat battalions to be protected. The platoons' employment will be integrated into the intent and battle management of the units to be protected based on the principle "directed to cooperate".

Each platoon will have its own reconnaissance team, which will be employed by order of the platoon leader to reconnoitre alternate positions, march routes and areas. Like the command posts, the platoon leaders and the self-propelled armoured air defence missile systems, the reconnaissance teams will also be linked to a joint secure command, control, information and weapons control system. All information will thus be immediately available to the squadron as a whole.

The second and third platoons will have three self-propelled armoured air defence missile systems each. In addition to the active crew, two alternate crews will be available and follow the respective self-propelled armoured air defence missile system in a protected personnel carrier and a reloading vehicle. The alternate crews will ensure uninterrupted accomplishment of the air defence mission.

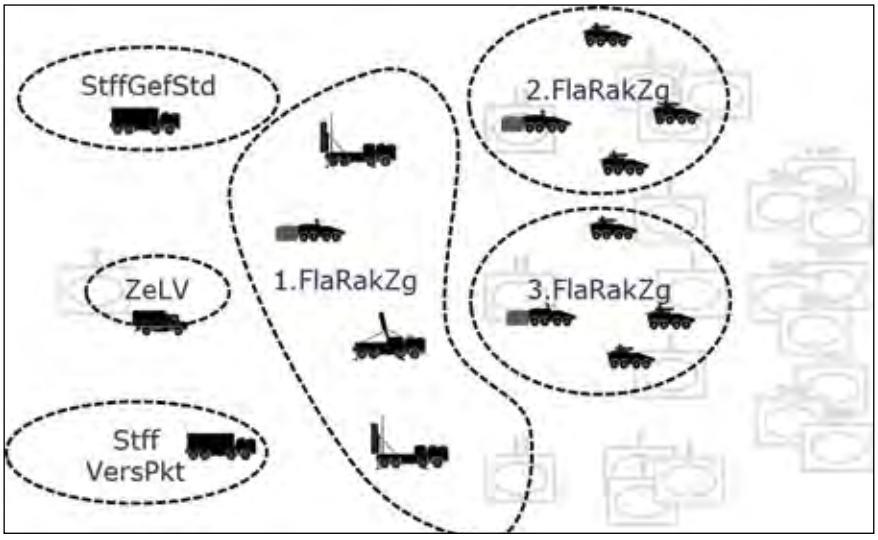
The crew of a self-propelled armoured air defence missile system will consist of the commander (senior non-commissioned officer), a gunner and a driver. Depending on the type of mission, the commander, together with the gunner, will conduct decentralised fire fights against air assets on the basis of the instructions provided and according to the rules of priority for engaging aerial targets. The three self-propelled armoured air defence missile systems will essentially fight as part of the closed-formation operation of the surface-to-air-missile platoon. They will be tactically led by the platoon leader in all phases of combat.

The first technical milestone of the initial capability is the network-enabled command, control, information and weapons control system IBMS (Integrated Battle Management Software) which, among other things, will connect all platforms via radio links and provide data usable for fire control. The second milestone comprises the advanced radar sensors and deeply integrated powerful electro-optical devices on the self-propelled armoured air defence missile systems. Even at the stage of initial capability, they will already allow the detection of the full threat spectrum, including unmanned air assets and indirect fire. The third milestone describes the significantly increased ranges achieved with modern surface-to-air guided missiles. The final milestone is the system architecture, which, as part of the follow-on capability, will make it possible to equip the platforms with specific weapons against small unmanned aircraft and to easily integrate separate defending systems against indirect fire.

Outlook

In 2021, the much-discussed use of unmanned aircraft in the Nagorno-Karabakh conflict provided renewed impetus to the issue of effective air defence in Germany. Tightening budgetary constraints and competing large-scale projects, however, have made it difficult to date to provide adequate funding. The technical proposal for ground-based air defence presented by the Federal Ministry of Defence in March 2021 clearly prioritised the short-range and very short-range protection air defence system and anchored it in the planning up to follow-on capabilities. Despite continued difficult budgetary conditions, it was possible to obtain a funding commitment for the development portions of the initial capability in June 2021. The aim is to conclude the contract as soon as possible and to accelerate procurement so that an urgently needed capability will be available to the Bundeswehr by 2027 at the latest. ■

Photo: ES&T



Employment of the initial operational capability

RAFALE-M v. F/A-18 SUPER HORNET

India's Naval Fighter Deal

Suman Sharma

India experienced its 'Top Gun' moment recently when two F/A-18 Block-III SUPER HORNETs from the US Navy roared over the skies of the western Indian state of Goa at Indian Naval air station, INS Hansa. By doing so, they completed their operational demonstration for the Indian Navy's fighter jet deal for 26 aircraft valued at US$6Bn. These fighters from the American aircraft giant Boeing Defence, 'turned and burned' to their optimal capacity for this contest where the other contender was the French Dassault aviation's RAFALE-M fighter, which completed its trials in January 2022.

The heated contest, which couldn't have come at a better time with the release of the latest Top Gun movie, has had everyone's eyes on the performance of both rivals, though interested agencies are tight-lipped about performance results. These extensive trials were held at the ski-jump platform at INS Hansa's shore-based test facility (SBTF), in order to test operational capabilities aboard Indian aircraft carriers.

The 26 fighters would be split into 18 single-seat and eight twin-seat aircraft, in a deal to be processed through the government-to-government (G2G) route, so that further production can be carried out here in India, through licence, to facilitate the Indian Government's flagship initiative of 'Self-Reliant India', popularly known as 'Atmanirbhar Bharat'.

The Navy's sole aircraft carrier INS VIKRAMADITYA operates Russian MiG-29K fighters, but performance dissatisfaction and multiple other issues reportedly faced by the Indian Navy is said to have forced the service into scouting for other fighters. India's indigenous aircraft carrier (IAC-1), INS VIKRANT, currently undergoing sea trials, is all set to be commissioned into service by Prime Minister Narendra Modi on 15 August 2022, coinciding with India's 75th Independence Day anniversary celebrations.

The Indian Navy's initial need for 57 twin-engine deck-based fighters, reduced to 26, was for both carriers. The Indian Navy's ex-fighter aviator, Vice-Adm Shekhar Sinha (retd) says, "These numbers are calculated based on the operational requirements, like how much ammunition is required to be dropped on target, hence how many sorties by an aircraft will be needed to achieve that etc. These calculations determine the numbers, as a specific number of fighters are kept serviceable, while others are either reserve or under maintenance, as per laid down procedure."

Photo: Boeing / USN / via author

A US Navy F-18 taking off from a ski-jump platform during trials in 2020

RAFALE-M vs. F/A-18 SUPER HORNET

Earlier this year, the marine version of the French RAFALE, called the RAFALE-M, participated in a two-week operational demonstration, followed by two US Naval F/A-18 SUPER HORNETs undergoing a similar drill in the last week of May.

Keeping the evaluation under wraps, sources have revealed that both fighters have been fairly tested within various parameters.

The twin-seater version of the RAFALE-M is believed to be capable of operating only from shore and not from a carrier, while both versions of the SUPER HORNET, single and twin seat, can operate from a carrier.

Boeing is also reportedly trying to leverage the SUPER HORNET's interoperability aspect owing to the aircraft's compatibility with other Indian naval assets of American origin, such as the long-range maritime reconnaissance aircraft P-8I from Boeing and the newly acquired MH-60 ROMEO anti-submarine helicopters, which will lend more potency to the F/A-18 in terms of data sharing, connectivity and communicating with other assets in the region.

The F/A-18 is also said to be capable of carrying a large number of anti-ship missiles compared to the RAFALE-M.

The RAFALE-M's advantage over Boeing's F/A-18 stems from the fact that the Indian Air Force (IAF) has already inducted two squadrons of the fighter, with maintenance facilities for the same and may contract more RAFALEs in the future.

Both RAFALE-M and the F/A-18 have so far operated from nuclear-powered carriers, as American and French aircraft carriers have nuclear propulsion, unlike the two conventionally-powered carriers that India will operate, and which come with a ski-jump platform, unlike the cat-

apult-capable American and French carriers. Vice-Adm Sinha adds, "It doesn't matter which carrier these fighters have been operating from, as here in Goa, they were both tested from the SBTF and the most important feature to be seen was whether they could take off from a ski-jump, as the pressure is tremendous on a moving carrier."

To qualify for the deal, the two fighters will have to demonstrate the ability to take off from a ski-jump platform. It has been reported that the F/A-18 had demonstrated the capability to take off from a ski-jump platform during trials in 2020, at the US Navy's Patuxent River Naval Air Station in Maryland.

India's Indigenous Naval Fighter Programmes

India's indigenous Light Combat Aircraft (LCA) TEJAS Mk-1 naval version, called LCA-Navy, carried out its maiden landing onboard INS VIKRAMADITYA in January 2020, which was considered no mean feat. The single-engine, delta-winged LCA-Navy, which made history through this landing, is a technology demonstrator exhibiting technologies for the proposed twin-engine fighter.

The LCA-Navy programme, which began in 2003, has had its fair share of hiccups. The fighter has been plagued with design issues with the 'nose of the aircraft', undercarriage and landing gear, among others. The naval LCA prototype, designed by state-owned agencies like Aeronautical Development Agency (ADA), in collaboration with Aircraft Research and Design Centre ((ARDC) of Hindustan Aeronautics Limited (HAL) had its first flight in April 2012.

Over a period of time, the nose of the aircraft has been modified for better landing visibility and the undercarriage has been reinforced along with the landing gear for increased airframe stress built during carrier operations. As per reports, these alterations in the naval TEJAS carried out for carrier operations have diminished its capability to carry fuel tanks and heavy weapons under the wings, thereby reducing the jet's combat capability.

India's Government-owned defence research agency, the Defence Research and Development Organisation (DRDO) had offered a more powerful engine for the LCA-Navy, aimed at sorting out these issues.

Meanwhile, the Indian Navy has shown reservations in accepting the LCA-Navy Mk-1 on grounds that it doesn't meet the service requirements.

Photo: Steve Lynes / CC BY-SA 20

A French Navy Dassault RAFALE

India has also embarked on another ambitious programme to develop a home-grown fighter for aircraft carriers — the Twin-Engine Deck-Based Fighter (TEDBF), which is progressing well and is a joint effort by DRDO and ADA. Expected to fly by 2026, the TEDBF is poised to meet the requirements of the Indian Navy's present and future aircraft carriers. The proposal for indigenous TEDBF was confirmed by former Naval Chief Adm Karambir Singh (retd), formally at an earlier press conference, who expressed hope that the TEDBF would enter service sometime by the early 2030s.

Lessons from LCA-Navy regarding under carriage and arrester hook are expected to be incorporated in the TEDBF prototype.

Regarding India's indigenous naval fighter programme's progress, Vice-Adm Sinha (retd), says, "We have not reached that stage to have a fully operational aircraft by ourselves. There are engine issues. Numbers also are important, only if India is going for large numbers, would there be transfer of technology and manufacturing in India would be profitable."

The Indian Navy was initially looking to combine its fighter programme with the IAF. The IAF programme for 114 multi-role combat aircraft (MRCA), valued at US$15Bn, was recently brought down to 54 after a Government decision. Under the IAF deal, 18 aircraft are meant to be bought off-the-shelf, while 36 are to be manufactured in India under a joint venture with the foreign Original Equipment Manufacturer (OEM) to sustain the 'Make in India' policy. It is largely perceived that a combined deal would increase numbers for the manufacturer and enhance chances of putting up a manufacturing plant in India by the foreign OEM, in a bid to economise the deal for both sides, if both services zero in on a common fighter.

The Indian Navy's fighter deal has been reduced to 26 from its initial projection of 57 made in 2017, for budgetary reasons. Hence, the combined programme was aimed at economy and logistics. The IAF, which is already operating two squadrons of the 36 French RAFALEs purchased under a 2015 deal, has two separate simulator bases for training purposes, which are functional, and they can be used if the Navy goes in for the RAFALE-Ms. According to a widely held perception, it is believed that in a combined IAF-Navy deal, the French Dassault RAFALEs stand a greater chance of winning, as the IAF's feedback about the RAFALE performance has been good, and the Boeing SUPER HORNETs have the edge if the Navy decides to go it alone with its own fighter procurement process rather than aligning itself with the IAF. ■

Powerplants for Mach 5 and Beyond

Doug Richardson

The quest for speed has always spurred the development of aircraft and missile powerplants, and the growing need for speeds of at least Mach 5 within the atmosphere has resulted in new and novel solutions for what is termed hypersonic flight.

Although NASA's North American X-15 regularly achieved hypersonic speed during the 1960s, this was an air-launched research aircraft powered by a rocket motor, so did not represent a viable long-term route to hypersonic flight. To date, no hypersonic military aircraft or UAV is known to have flown.

In 1986, the US embarked on an ambitious programme to develop the NATIONAL AERO-SPACE PLANE (NASP), a single-stage-to-orbit (SSTO) spacecraft. Envisaged as an advanced technology demonstrator project, the planned Rockwell X-30 would have been powered by an integrated scramjet burning slush hydrogen. The response by what was then the Soviet Union was the Tupolev Tu-2000. This would have been powered by a less-sophisticated powerplant installation that combined four turbojet engines, a ramjet, and two liquid-propellant rocket engines. Neither of these programmes resulted in a prototype aircraft. NASP and the Tu-2000 were both cancelled in 1993.

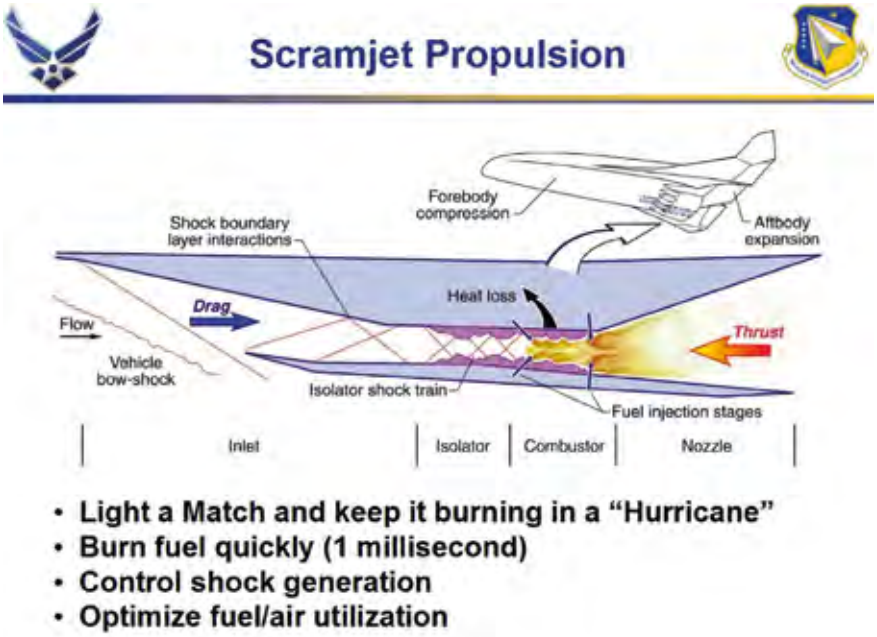


Photo: US AFRL

This diagram by the US Air Force Research Laboratory shows the layout of a typical scramjet motor, and summarises the difficulty of maintaining combustion in a supersonic airflow (AFRL).

Hypersonic Missiles

Therefore, for the moment, hypersonic flight is the realm of the missile. This level of performance is not new – speeds approaching this class were obtained by the German A-4 (V-2) ballistic missile around 80 years ago during a trajectory that carried this pioneering weapon high above the atmosphere. Although Russia boasted about having attacked several targets in Ukraine by means of hypersonic missiles in March, April, and May 2022, the weapon used was the Kh-47M2 KINZHAL, an air-launched version of the ground-launched 9K720 ISKANDER (SS-26 STONE) short-range bal-

Photo: Lockheed Martin

In 2013, Lockheed Martin showed this concept for a hypersonic UAV. Often referred to as the SR-72, this would have been powered by turbine-based combined cycle (TBCC) powerplants in which a turbine engine would have been used at low speeds and a scramjet engine at high speeds. These would have had separate airflow paths, but share a common inlet and nozzle.

Author

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

Photo: Russian MoD

This artist's impression shows stage separation of a Russian heavy ICBM being used to boost the AVANGARD hypersonic glide vehicle to its operating speed.

listic missile. KINZHAL is understood to use the same propulsion system and payloads as the ground-based weapon.

Most ballistic missiles reach hypersonic speeds, but follow a predictable trajectory. The new generation of hypersonic weapons combine high speed with the ability to manoeuvre in the mid or late stages of flight. This allows them to fly low enough to avoid being engaged by anti-ballistic missile defences, and without following a predictable trajectory. They are also fast enough to avoid being engaged by surface-to-air missile systems.

Hypersonic Glide Vehicles

There are two basic forms of hypersonic missile. The simpler technique involves mounting one or more unpowered Hypersonic Glide Vehicles (HGVs) onto a single-stage or multi-stage rocket booster. The second and more complex class of weapon is a hypersonic cruise missile (HCM) with an air-breathing propulsion system.

As its name suggests, an HGV obtains all its energy from an initial rocket-powered boost. Once this has been completed, the HGV begins its glide phase of flight. HGVs are typically released at altitudes from around 50 km to more than 100 km; the precise altitude, velocity, and flight path angle being chosen to enable the vehicle to glide in the upper atmosphere until the vehicle reaches its target.

The aerodynamic configuration of an HGV is designed to generate lift from the rarefied atmosphere that is equal to its weight, or slightly higher than its weight if the vehicle is manoeuvring. It will encounter drag, so that energy will begin to dissipate, resulting in the gradual loss of speed, and the need to fly at a slowly-decreasing altitude so that increased air density can maintain the required lift.

If an extreme range is needed, an HGV could be fitted with a small rocket motor or some other form of propulsion in order to minimise the reduction in velocity caused by drag, and allow a greater degree of attitude or directional control. Inevitably, there will be a trade-off between these additional capabilities and the increased weight and complexity of the vehicle.

The Russian AVANGARD (Vanguard) HGV illustrates the simplest method of boosting such systems to hypersonic speed – mounting one or more as the payload of an existing ballistic missile. Originally designated Yu-71 and Yu-74, AVANGARD is reported to have begun flight tests in 2015 or 2016. For these early trials, the vehicle was mounted on UR-100UTTKh (SS-19 Mod 3 STILETTO) ICBMs launched from Dombarovsky Air Base in Orenburg Oblast, but an R-36M2 (SS-18 Mod 5 SATAN) heavy ICBM was launched from the same site was used in October 2016 for what is reported to be the first fully-successful test.

AVANGARD is 5.4 m long, weighs about 2,000 kg, and can deliver nuclear or conventional payloads. It can be carried as a MIRV payload by the UR-100UTTKh, R-36M2 and the new RS-28 SARMAT. While it probably does not have any form of independent propulsion system, AVANGARD can make sudden horizontal and vertical evasive manoeuvres as it approaches its target at speeds of around Mach 20–27.

For its DONGFENG 17 missile, China adapted its existing DONGFENG 16 (CSS-11), a single-stage solid-propellant missile with a maximum range of 800–1,000 km. In place of the 1,000–1,500 kg warhead of the DF-16, the DF-17 carries a DF-ZF hypersonic glide vehicle.

Using an existing ballistic missile as a booster for an HGV payload is probably the simplest engineering route, but if necessary, the missile can be modified for its new role. In September 2021, North Korea flight-tested a hypersonic payload similar in configuration to that carried by China's DF-17. This was launched using what seems to be a shortened version of that country's HWASONG-12 intermediate-range ballistic missile.

On-Demand Thrust

The optimum solution is probably to mount the HGV on a custom-designed booster. Under DARPA's OPERATIONAL FIRES (OpFires) programme, an Aerojet Rocketdyne throttleable solid-propellant second stage motor developed under the Agency's Operational Fires (OpFires) program successfully completed a full-scale static test firing in mid-2021, demonstrating the technology needed to provide on-demand thrust termination. Under a contract modification awarded to Lockheed Martin Missile

Photo: Lockheed Martin

This artwork shows a Lockheed Martin AGM-183 Air-Launched Rapid Response Weapon preparing to release its hypersonic glide vehicle after burnout of the booster.

Photo: US Navy / Lockheed Martin

This test firing confirmed the performance of the solid-propellant rocket motor that will be used by the US Navy's Conventional Prompt Strike (CPS) and US Army's LONG RANGE HYPERSONIC WEAPON (LRHW) programmes.

& Fire Control, the OpFires programme has moved to Phase 3b, in which a ground-launched intermediate-range hypersonic missile will be built and flight tested. Thrust termination capability is needed to allow the weapon to deliver a hypersonic boost glide weapons to varying ranges after being launched from a mobile ground launch platform capable of rapid deployment and redeployment.

On 27 May 27 2021 Lockheed Martin and Northrop Grumman successfully conducted live-fire ground test of the first-stage solid rocket motor planned for the USN's Conventional Prompt Strike (CPS) and US Army's Long Range Hypersonic Weapon (LRHW) programmes. CPS and LRHW are expected to use a common missile suitable for use from surface ships, submarines, and land-based mobile launchers.

Two concepts for an air-launched hypersonic missile were studied by the USAF, but in early 2020, the Lockheed Martin Missiles and Fire Control AGM-183 Air-Launched Rapid Response Weapon was selected rather than the Hypersonic Conventional Strike Weapon from the Space division of Lockheed Martin Space. The AARW was smaller than the HCSW, so could be carried on the centreline hardpoint of an F-15 EAGLE. An aeroshell used to protect the hypersonic glide body payload is jettisoned after booster burnout at a speed of around Mach 5.

The Ramjet

Early flight-tests of the AGM-183 failed, with the missile either failing to separate from its B-52H STRATOFORTRESS launch platform, or separating but failing to ignite its booster. During a trial conducted on 14 May 2022, the missile separated from the B-52H, ignited its booster, and achieved a speed of more than Mach 5.

The search for an air-breathing powerplant able to cope with ever-higher speeds has continued since the birth of the jet age. Afterburning turbojets or turbofans met the propulsion needs of supersonic flight to Mach 2 and beyond, but as aircraft speeds moved close to or beyond Mach 3, this technology was barely able to cope.

At speeds of Mach 3 or greater, the ramjet can be a useful powerplant. It is of relatively simple configuration and relies on the forward motion of the engine to produce thrust. The inlet is designed to compress and slow a supersonic airflow down to subsonic speed before routing it to the combustion chamber.

The air temperature in the inlet increases with the speed that the ramjet-powered vehicle is required to fly. This reduces the difference between the inlet temperature and the exhaust temperature, thus reducing the energy can be extracted in the form of thrust. As a result, most ramjet-powered air vehicles fly at speeds of not more than around Mach 4.5.

The Scramjet

To obtain higher flight speeds, the incoming air must be slowed and compressed much less than is normal in a ramjet, in order to minimise the rise in temperature. As a result, the combustion chamber must be designed to handle a supersonic airflow. The resulting powerplant is classified as a supersonic-combustion ramjet, a term usually abbreviated to scramjet.

Scramjet engines are more efficient than rocket motors for hypersonic propulsion, and will allow long-duration powered flight. However, they need to be boosted to high speed in order to operate. The simplest way of doing this is by using a rocket booster as a first stage. Since its task is limited to the initial post-launch phase of flight, the booster will be smaller than that needed by an HGV. This makes the entire weapon smaller and lighter than a boost-glide solution of similar range.

Hypersonic Cruise Missiles

This initial rocket boost does not need to bring the vehicle up to its planned cruising speed, but only to the minimum speed needed for scramjet operation. Once started, the scramjet can raise the missile to its planned cruising speed, then maintain that speed all the way to the target. HCMs are likely to fly at altitudes of between 20 km and 30 km, heights defined in part by the need to maintain appropriate pressures for combustion within the scramjet engine.

When NASA set a new speed record for an air-breathing vehicle in March 2004, its

Photo: NASA

A PEGASUS solid-propellant rocket booster was used to accelerate this NASA X-43A scramjet-powered UAV during a test flight in March 2004.

Photo: NASA

A Pratt & Whitney Rocketdyne SJY61-2 scramjet engine is tested at simulated Mach 5 flight conditions. This hydrocarbon-fuelled powerplant was selected for use on the Boeing X-51 WAVERIDER UAV, which demonstrated Mach 5.1 flight in May 2013.

X-43A unmanned air vehicle flew at a speed of Mach 7 under the power of a hydrogen-powered scramjet. A second flight conducted in November of the same year saw another hydrogen-powered X-43A reach a speed of Mach 9.64 (10,240 km/hr) at an altitude of approximately 110,000 ft.
Hydrocarbon fuel is a more attractive option than hydrogen when designing an HCM powerplant. It is simple to handle, and offers both low cost and a high volumetric energy density. However, the engine designer faces the problem that the time needed for vaporisation, mixing, and burning of hydrocarbon fuel is hard to meet given the very high speed of airflow through the scramjet.
The Boeing X-51 WAVERIDER was designed to be air-launched from a B-52 to an altitude of about 50,000 ft. A solid-propellant rocket motor of the type used by the Lockheed Martin MGM-140 Army Tactical Missile System (ATACMS) was used to boost the vehicle's speed to close to more than Mach 4.5 before being jettisoned, allowing the hydrocarbon-fuelled Pratt & Whitney Rocketdyne SJY61 scramjet to be ignited. The first three flights were unsuccessful, but on 1 May 2013, the final example flew under scramjet power for 210 seconds, reaching a speed of Mach 5.1 (5,400 km/h).
A free flight test of a Raytheon Technologies Hypersonic Air-Breathing Weapon Concept (HAWC) technology demonstrator was successfully conducted in September 2021 by DARPA and the USAF. After being air-launched, the vehicle used a solid-propellant booster, then successfully started its hydrocarbon-fuel scramjet, and demonstrated flight at Mach 5. A second vehicle configuration that had been developed by Lockheed Martin was successfully flight-tested in early 2022. This cruised at more than Mach 5 under the power of an Aerojet Rocketdyne scramjet sustainer, reaching altitudes greater than 65,000 ft and flying for more than 500 km.
Late in 2021, the USAF released brief details of a planned US$371M project to develop and demonstrate an air-breathing hypersonic powerplant. Known as Mayhem, this is intended to produce expendable testbeds for new propulsion concepts such as turbine-based combined cycle powerplants and dual-mode scramjets able to operate at speeds in the subsonic, supersonic, and hypersonic regimes.

Photo: AFRL

A multi-stage configuration using TERRIER and ORIOLE solid-propellant rocket motors was used to launch this HIFiRE 2 (Hypersonic International Flight Research Experimentation Program 2) vehicle and bring it to the speed needed to start its scramjet engine.

Russia's 3M22 TSIRKON (SS-N-33) is a scramjet-powered HCM currently undergoing final trials. A solid-propellant booster stage accelerates it to supersonic speeds, after which its scramjet engine (reported to use hydrocarbon fuel) is used to take the missile to a cruising speed of up to Mach 9. The initial version is intended for naval use, and has been tested from the frigate ADMIRAL GORSHKOV, the nuclear submarine SEVERODVINSK, and a land-based coast-defence mounting. It can be used to attack ship or land targets at ranges of up to 1,000 km.

2022 should see the first flight trials of Russia's OSTROTA, an air-launched HCM designed for use on the Su-34 and Tu-22M3. Developed by Raduga, this uses an Article 7 scramjet engine developed by the Turaevsky Machine-Building Design Bureau 'Soyuz'. Few details of the missile and its powerplant have been released, but OSTROTA is expected to weigh less than 1,000 kg and to have a range of several hundred kilometres.

Other reports have mentioned a longer-ranged air-launched HCM with the acronym GZUR (GiperZvukovaya Upravliemaia Raketa) and the designation GREMLIN. The powerplant has been credited to Turaevsky Machine-Building Design Bureau 'Soyuz', and has a reported designation PRODUCT 70.

MBDA is working with ONERA on a planned follow-on to France's current ASMP-A air-launched nuclear missile. Currently referred to as the ASN4G, this could take the form of a scramjet-powered weapon able to cruise at hypersonic speed. Under a project designated LEA, the two companies had been developing an experimental hypersonic demonstrator, and had planned to flight test this with Russian help in 2014-15. LEA was to have been air launched from a Tupolev Tu-22 M3 BACKFIRE bomber, then boosted to scramjet-compatible speed by an adapted liquid-propellant propulsion section from a RADUGA Kh-22 (AS-4 KITCHEN) air-launched antiship missile. A more recent plan called for LEA to be flight-tested on the US east coast, but this has yet to happen.

During a HIFiRE 2 (Hypersonic International Flight Research Experimentation Program 2) test launch conducted in 2012, a hydrocarbon-fuelled scramjet developed by the US Air Force Research Lab (AFRL), NASA, and the Australian Defence Science and Technology Organisation (DSTO) was boosted to operating speed by a three-stage launch system made up of two TERRIER solid-propellant boost motors and an ORIOLE solid-propellant sustainer motor. When the scramjet was operating at Mach 6, its internal airflow was still subsonic, but became supersonic once Mach 8 had been achieved.

To boost its Hypersonic Technology Demonstrator Vehicle (HSTDV) to scramjet-operating speed, India's Defence Research and Development Laboratory used the rocket motor of an AGNI-I medium-range ballistic missile as a booster. During a test flight conducted on 12 June 2019, a cruise vehicle flew at Mach 6 under scramjet power. A launch on 7 September 2020 resulted in 20 seconds of scramjet-powered flight, and a velocity of almost 2 km/sec.

At sea level, Mach 5 corresponds to around 5,600 - 6,000 km/hr, gradually diminishing by around 5-6 percent at high altitude. A traditional subsonic cruise missile flies at around Mach 0.6 - 0.7, so the total flight time from launch to impact at a location some 1,200 km away is about an hour. A hypersonic missile flying at Mach 5 could cover that distance in around 10 minutes. But whether a hypersonic threat is based on HGV or HCM technology, a combination of high speed, high altitude, manoeuvrability, and minimal warning time will stress even the best of today's air defences. ■

Europe's Collaborative Conundrum

David Saw

The two major European collaborative defence programmes, the Système de Combat Aérien du Futur (SCAF) or Future Combat Air System (FCAS) and the Main Ground Combat System (MGCS), were supposed to set the scene for European defence collaboration, strengthen European strategic autonomy and sustain European technological and defence industrial capabilities into the future. SCAF and MGCS might still achieve these goals, but at the recent Eurosatory exhibition, French industrial sources expressed growing concern over the two programmes and the fact that the lack of real progress could have increasingly negative implications for the European defence industry. In addition, as SCAF and MGCS have inherent political implications, failure with these programmes would be a major blow to Franco-German relations.

Concerns over the SCAF situation came into the open when Eric Trappier, the Executive Chairman of Dassault, addressed an aerospace conference in Paris on June 7. Lack of progress on getting an agreement between the two primary industrial partners for Phase 1B of the programme, under which a technology demonstrator for the New Generation Fighter (NGF), the combat aircraft element of SCAF/FCAS would be built, leading to a first flight in 2027, was the crux of the matter. Trappier warned that due to the fact that Phase 1B was not signed, the objective of an In-Service Date (ISD) of 2040 in unlikely to be met, the ISD is now more likely to be in the 2050s.

Essentially, the issue is that Dassault see themselves as the prime contractor and system architect for SCAF/FCAS and this is supported by the French authorities. Airbus rejects this assumption and seeks to be the joint prime contractor along with Dassault. Resolving all of this has to be done at the political level, government-to-government between Paris and Berlin. If these issues cannot be resolved, there are suggestions that France might develop its own national SCAF/FCAS led by Dassault.

Lack of progress is also being seen in the MGCS programme, which has an ISD of 2040. Again, issues over industrial leadership and workshare are to blame.

The longer these programmes remain uncertain, the worse it becomes for European industry because how long can you sustain design, development and production resources if there is no real work to for them? Then the solution becomes either national programmes led by a national prime or, more disturbingly, a withdrawal from certain areas of advanced defence technology by Europe in the face of excessive costs. ■

The Hypersonic Arms Race

Can Banning Such Systems Increase Strategic Stability?

Debalina Ghoshal

In March 2022, the Russian Defence Ministry announced that it had used the hypersonic missile, KINZHAL in Ukraine. While KINZHAL is a hypersonic aero ballistic missile and ballistic missiles travel hypersonic speeds during their trajectory, the event raised concerns about future of hypersonic weapon systems.

With hypersonic cruise missiles and hypersonic technology vehicles (HTVs) now in use, the hypersonic arms race is not just confined to hypersonic cruise missiles, but on hypersonic glide vehicles too. This article focuses on these two developments.

Photo: CC BY-SA 3.0 / Kirill Borisenko

A Russian experimental hypersonic aircraft mockup at the "Armiya 2021" exhibition near Moscow

Photo: CC BY-SA 3.0

The Russian hypersonic X-31AD missile at the MAKS airshow

Why Hypersonics

Hypersonic systems are those that can travel at a speed of more than Mach 5 but less than Mach 25. Though the birth of the concept of hypersonic weapon systems date back to the Cold War era, the realisation for hypersonic systems and the revolution in hypersonic technologies began only when the United States realised the need to possess weapon systems that could reach targets in any part of the world within sixty minutes.

This realisation took place when in 1998 the US Tomahawk cruise missile missed its target in Afghanistan during a counter-terrorism mission, allowing Osama Bin Laden to escape from his hideout. Hence, the need to reach time-sensitive targets became a crucial reason to focus more on hypersonic systems under the US strategy of Conventional Prompt Global Strike (CPGS).

The second reason to develop these weapon systems was to be able to target hard to reach and deeply buried targets. For example, China's hypersonic glide vehicle systems mounted atop ballistic missiles can deliver nuclear warheads and can make 'bunker busting' an easier task. Moreover, hypersonic cruise missiles with earth penetrating weapons can make these hard and deeply buried targets easy prey to adversaries' attacks.

The Ukraine conflict is also proving how various kinds of defence systems have become integral to a state's coercive diplomacy strategy. Use of hypersonic systems to achieve decisive results on the battlefield can become the future norm in conflicts and wartime situations. During the conflict, after reportedly using the KINZHAL in Ukraine, Russia successfully tested the ZIRCON hypersonic cruise missile in May. This was probably a message to Ukraine that Russia was not short of sophisticated weapon systems, including hypersonic systems.

Types of Hypersonic

Hypersonic glide vehicles (HGVs) are like all weapons delivered by medium- and longer-range rocket boosters. Boost glides extend the range of ballistic missiles as opposed to counter measures like multiple independently targetable re-entry vehicles (MIRVs) that reduce the range of missile systems.

Hypersonic Glide Vehicles

An HGV on a MIRV-ed ballistic missile will help to negate the range limitations. Though difficult to intercept, ballistic mis-

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siles carrying HGVs like MIRVs can be intercepted at boost phase interception.

The United States, China and Russia have focused intensively on HGV technology for missile defence evasion. However, unlike China and Russia that focus on nuclear capable HGVs, the United States has focused on conventional HGVs as a component of their CPGS. China's HGV is called DF-ZF mounted on the DF-17. However, in the future, China could also mount it upon the DF-21s and considering that these missiles are dual capable, it would only add to more uncertainty in nuclear strategic stability.

In addition, reports claim that China is focusing on Fractional Orbital Bombardment System (FOBS) to integrate it with HGVs and develop a credible 'deterrence by punishment' mechanism. As stated by Lt. General Saltzman, deputy Space Force chief of space operations, "[a] fractional orbit means it can stay in orbit as long as the user determines and then de-orbit it as a part of the flight path."

One of the biggest problems with FOBS is that they would violate existing international legal mechanisms that aim to reduce the threat of nuclear weapons. The 1967 Outer Space Treaty (OST) could be violated if China pursued FOBS, something that could lead Russia and therefore, the United States to also focus on the same.

It must be noted that during the Cold War, the erstwhile Soviet Union also developed and deployed a nuclear capable FOBS, but gave up such systems under the Strategic Arms Limitation Talks II (SALT II). But the Soviets did not place FOBS on HGVs unlike China, thereby making the task of interception

Photo: CC BY-SA 4.0

One of the Chinese hypersonic gliding vehicle projects. This configuration was first displayed on CCTV-7.

a highly complicated process due to the high manoeuvrability of the HGVs. What makes it even more dangerous is the accurate re-entry from orbit which is very difficult to achieve with FOBS, thereby, making HGVs with FOBS a threat to strategic stability and leading to space weaponisation.

The US Army is also focused on the Long Range Hypersonic Weapon (LRHW) system. This will enable the US Army to possess a ground-launched ballistic missile system with glide vehicles of hypersonic speeds. Now that the Intermediate Range Nuclear Forces (INF) Treaty is defunct, the United States could choose ballistic missile systems of medium and intermediate ranges to equip them with HGVs.

The LRHW will be integrated with the Army's Advanced Field Artillery Tactical Data System (AFATDS). It would be similar to the Army's Common Hypersonic Glide Body (C-HGB) that was tested in 2020 by the US Army, in cooperation with the US Navy. These can be launched from both ground-based and submarine-base ballistic missiles. However, reports suggest that NAY is also in need of an air-launched Offensive Anti-Surface Warfare Weapon (OASuW) as a "natural imperative to maturing hypersonic capabilities.

Russia on the other hand has developed the 6,000km-range AVANGARD HGV that could carry a nuclear warhead and probably be mounted upon a silo-based RS-28 SARMAT ICBM, though in the future it could be also mounted on the road-mobile RS-26 RUBEZH to increase its survivability.

With China developing HGVs, in December 2021, Indian Defence Minister, Rajnath Singh urged the Defence Research Development Organisation (DRDO) to develop such systems in order to keep pace with China and strengthen its deterrence. However, in February 2021, there were reports that the private firm HTNP Industries had showcased a scale model of HGV-202F with a range of 5,000 km.

Japan also wants to keep pace with China's modernisation in weaponry, and hence, in 2020, it decided to focus on Hypersonic Velocity Gliding Projectile (HVGP). The HVGP will possess a solid-fuel rocket engine that will boost its warhead payload to a high altitude before separation, "where it will then glide to its target using its altitude to maintain high velocity until impact."

In 2022, North Korea test fired the HWASONG-8 which is believed to be an HGV, though it is only a short range to target

Photo Credit: U.S. Army

The US Army Rapid Capabilities and Critical Technologies Office RCCTO), which takes the products out of the lab, transitioning them into prototypes with combat utility, has been tasked to field a prototype long-range hypersonic weapon by fiscal year 2023. Collaborating across services, RCCTO must produce a common hypersonic glide body, existing trucks and modified trailers with new launchers, and an existing Army command structure.

South Korea and Japan. However, the reliability of North Korea's HGV programme remains an open question.

Hypersonic Cruise Missiles

In addition to hypersonic glide vehicles, some countries have also focused on hypersonic cruise missiles (HCMs). These scramjet powered missile systems work with the help of air breathing technologies, thereby negating the need to carry oxygen aboard the aircraft, making the weapon lighter and faster.

The United States is working on scramjet powered hypersonic cruise missile systems but have faced severe technical hurdles since 2010. But there were reports in April 2022, that the United States had successfully tested its Hypersonic Air-Breathing Weapon Concept (HAWC) from a B-52 bomber. In fact, just how prevalent the hypersonic arms race is, can be witnessed by the fact that right after the United States conducted the testing of its hypersonic weapon, Russia followed suit.

Amid the Ukraine crisis, Russia successfully tested its 1,000 km range ZIRCON hypersonic cruise missile. India's DRDO is also working on the hypersonic version of the BrahMos cruise missile. India has already conducted successful testing of its Hypersonic Technology Demonstrator Vehicle (HSTDV) by integrating scramjet engine technology. Given the sophistication of Iranian missile systems such as bottleneck warheads, multiple re-entry vehicles (MRVs), they could in the future develop hypersonic delivery systems.

North Korea too may develop hypersonic cruise missiles in the near future. Iran and North Korea's hypersonic weapon systems pose a different threat as they could be proliferated to non-state actors. South Korea on the other hand, has already announced in 2022 its plans to develop a hypersonic cruise missile called the HYCORE.

Hypersonic missiles are also crucial in the AUKUS partnership (Australia, United Kingdom and the United States.) According to former Australian Prime Minister, Scott Morrison, hypersonic cruise missiles will suit its defence needs to acquire long-range strike capabilities. In June 2022, there were reports that the British Armed Forces would be better equipped against future threats by developing weapon systems operating at hypersonic speeds.

France and Germany have also focused on the development of hypersonic capabilities. Japan is also focusing on hypersonic cruise missiles and aims to focus on the dual-mode scramjet engine (DMSJ), a combination of a ramjet and scramjet engine. Japan's hypersonic missiles will form an integral component of its proposed 'counter-strike capabilities.'

Ban on Hypersonics?

Both developed and developing countries are focusing on hypersonic systems in order to enhance their deterrent and strike capabilities. Given the threat they pose, a ban on this class of weapon systems could be suggested. However, banning hypersonic systems would also bring ballistic missiles into the legal framework, unless specific treaties are considered such as the Treaty on Prohibition of Hypersonic Glide Vehicles. A legal framework on banning hypersonic cruise missiles would be an impossible task as most countries would attach pride and status to their hypersonic programmes. ■

Masthead

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Electromagnetic Pulse – The Great Switch Off

Thomas Withington

The crisis in Ukraine and resulting Russian nuclear threats have thrown the spotlight back onto a little known, but devastating effect of nuclear explosions.

In 1984, the British Broadcasting Corporation aired what has been acknowledged as perhaps the most depressing drama ever screened. The film "Threads" was dubbed as "the closest you'll ever get to a nuclear war", a dubious invitation. The film depicts a nuclear attack on the city of Sheffield, northern England, and its horrific aftermath. In one scene, shortly before the main attack, electrical equipment in a nuclear bunker stops working. Suddenly, the facility which is used by the local council has no telecommunications linking it with the outside world. The lights flicker, a generator gets all the electrical equipment functioning but only after the bomb has hit the city, and the bunker is damaged. Communications are restored, but are patchy. Unbeknownst to the occupants, their communications have been badly affected by the Electromagnetic Pulse (EMP).

Photo: Rafael

Rafael Advanced Defence Systems' BNET-LMR very/ultra-high frequency radios are protected against the electromagnetic pulse. In February 2021, the company announced it had supplied these radios to a US power company.

Effects

The EMP accompanies a nuclear explosion. It was anticipated by the physicist Enrico Fermi prior to the first detonation of an atomic weapon on 16 July 1945 in New Mexico. Professor Fermi took the precaution of shielding telecommunications cables near the explosion. Further observations of the phenomenon were noted by the British during their nuclear weapons tests in the 1950s. An audible clicking noise was heard on radio receivers in the vicinity of the detonation immediately after the explosion. The British referred to the EMP as 'Radioflash'. Arguably a cooler name, but it is the EMP moniker that has stuck.

The EMP affects electrical equipment by releasing a very sharp and intense burst of electromagnetic energy when a nuclear explosion occurs. When a nuclear warhead detonates, it produces gamma radiation. Gamma radiation has frequencies above 300 exahertz. This radiation contains photons. The photons travel at the speed of light and excite atoms of nitrogen and oxygen in the atmosphere. In 1925, the physicist Dr. Arthur Compton posited his theory that photons could remove electrons from atoms with low atomic numbers. A glance at the periodic table of elements shows that oxygen and nitrogen, both plentiful in our atmosphere, have comparatively small numbers of electrons, seven and eight respectively.

These now-free electrons interact with the earth's magnetic field creating a fluctuating electric current in the form of Radio Frequency (RF) energy. The problem is that this RF energy couples to exposed conductive material inducing a voltage. This can include powerlines, television and radio antennas for instance. These will conduct this current into any appliances connected to them. The reason why those in the bunker lose their telecommunications is because the EMP is conducted by the 'antennas' connected to their radios into the radio's electronics. The strength of this current is much larger than the radio would usually handle, causing it to short circuit. As telephone lines also carry electric currents they can conduct the EMP. Telephones physically connected to the network would suffer similar damage. Even cellphones, laptops and tablets may not escape as they have antennas connecting them to the local network and/or Wi-Fi signals. As the radio signals connecting these devices are also electric currents, they would be at risk of conducting the EMP. The damage could be considerable. Most household appliances use national grid voltages of 110 volts or 220 volts. A nuclear EMP can create field strength levels of up to 200,000 volts-per-metre/vpm.

The power of the EMP and the time it reaches you will vary according to how close you are to the explosion and the explosion's altitude. In nuclear warfare, an airburst detonation occurs at altitudes of above 330 feet/ft (100 metres/m) and below 100,000ft (30,480m). Airbursts exploit the reflection of the detonation's shockwave back into the air by the ground directly below the point of detonation. This creates a more powerful shockwave compared to the bomb being detonated on the ground. In the latter, the ground will absorb some of the blast, creat-

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ing a crater. High altitude detonations occur above 100,000ft altitude. These cause almost no damage on the ground, but they will trigger a widespread EMP. Generally, the reach of the EMP is proportionate to the blast's altitude. The US National Aeronautics and Space Administration calculated that the EMP from a 157,480ft (48,300m) airburst cover most of the midwestern United States. A detonation in space at 633,530ft (193,100m) would cover most of the continental US. This would extend to most of Canada and almost all of Mexico for a detonation at 1.5 million feet (482,700 metres). Conventional protection against lightning strikes, such as the lighting conductors on tall buildings offers little protection. A nuclear-generated EMP moves much quicker and is more powerful than the lighting accompanying a storm.

The EMP is not one pulse but three, known as E1, E2 and E3 denoting where the pulse will reach relative to the explosion's epicentre. E1 occurs almost instantaneously with the explosion and produces the strongest pulse. E2 follows E1 milliseconds later. It is weaker than E1 but covers a longer distance. E3 reaches the farthest distance of all: A nuclear weapon detonated at high altitude above Texas would see the EMP hitting both the US eastern and western seaboards, however it would take up to 30 minutes to get there. If you are directly under the explosion, your electrical equipment will be hit by all three EMPs. If you are some distance away, only E1 and E2 will reach you. If you are on the coast, you will only experience E3. Worryingly, however, the low frequency E3 pulse can penetrate the ground. This means it can be conducted along buried power and non-fibre telecommunications cables to electrical equipment. Back in March 1975, the US Air Force's Institute of Technology at Wright-Patterson airbase, Ohio published a paper written by Louis Seiler looking at EMP calculation methods. The paper stated that EMP duration was determined by measurements known as 'shakes'. One shake equals 0.00000001 seconds, or ten nanoseconds. The duration of an EMP, the paper said, was typically one shake. The paper noted that the EMP's strength would increase the higher the weapon's yield and burst height. Curiously, this was not the case for lower yield weapons. The higher the burst height for these latter warheads, the lower the strength of their EMP. Moreover, if a nuclear weapon is detonated at altitude nearer the poles than the equator, then the EMP will be more powerful. This is because the Earth's magnetic field is twice the strength in these regions compared to equatorial latitudes.

Photo: Architectural Elements

Although looking like steampunk furniture, this Faraday Cage was used to protect electrical equipment. It is now an exhibit in the Spark Museum of Electrical Invention, Bellingham, Washington State.

Other Causes

Nuclear weapons are not the only EMP source. It can be caused by the sun's behaviour, notably via solar storms and corona mass ejections. The latter is a phenomenon by which the sun suddenly and violently releases plasma (ionised gas). The plasma hits the sun's corona which constitutes its atmosphere and which contains a magnetic field. The sun produces the solar wind. This

Photo: Davidson Scott

This graphic demonstrates how widespread the electromagnetic pulse caused by a high-altitude detonation of a nuclear weapon would be. Using an attack on the United States as a template, much of North America would be affected.

stream of charged particles flows outwards from the sun. The plasma and magnetic field are then carried by the solar wind towards Earth. There, they reach the Earth's magnetic field surrounding our planet. This impact releases terawatts worth of electricity as an EMP with similar effects. In 1859, the 'Carrington Event' was a geomagnetic storm which hit Earth's magnetic field causing significant disruption to the global telegraph system. The sunspots causing the storm were witnessed by the astronomer Richard Carrington.

Alongside naturally occurring EMPs, efforts are ongoing to harness the phenomena without recourse to a nuclear explosion. US government documents have mooted that China is working on ways to produce a powerful EMP without needing to detonate a nuclear warhead. Russia is also thought to be very interested in weapons capable of generating an electromagnetic pulse. In January 2021, the US Department of Homeland Security (DHS) published a report entitled "The Russian Federation's Military Doctrine, Plans and Capabilities for Electromagnetic Pulse Attack". The report concluded that "Russia has 'Super-EMP' weapons specialised for (EMP) attack that potentially generate 100,000vpm or higher, greatly exceeding the US military hardening standard (of 50,000vpm)." The United States is also strongly suspected to be working on similar technology.

Photo: USAF

During the Cold War the US Air Force used the Air Force Weapons Lab Transmission-Line Aircraft Simulator, better known as ATLAS-1, for testing the resistance of aircraft electronic systems to the EMP. Housed at Kirkland airbase, New Mexico, it was the world's largest wood and glue laminate structure.

The effects of the EMP can be mitigated using a relatively simple approach. In 1839, the scientist Michael Faraday invented his eponymous cage. A Faraday Cage uses a metallic mesh surrounding whatever needs protecting from the EMP. This could be a single item of equipment like a transformer or communications system. Equally, it could be an entire building. Should the interior of the Faraday Cage need to be connected to an external power source or telecommunications, holes are drilled into the cage. This lets these services be connected to the interior. However, these holes risk causing an entry point where the EMP can get into the cage.

In late 2021, The Face Companies developed an innovative approach called PulseStar. PulseStar uses acoustics to move electrical power and communications signals through a Faraday Cage. The approach employs acoustic transmitters and receivers inside and outside the cage. Suppose we have a computer which needs to be enclosed in a Faraday Cage. Our computer will need electricity. It may also need to be connected to the internet using cables and/or WiFi. Normally, this would need holes drilled into the Faraday Cage creating the type of risks discussed above.

Handily, electrical power can be converted into acoustic signals. This includes the computer's standard electricity supply and its communications signals. After all, these are also electrical signals. Incoming power to the computer is turned into an acoustic signal and transmitted through the cage. Once inside the cage, the acoustic receiver turns the signal back into electrical power feeding it into the computer. Inside the cage, the computer sends internet protocol data to the interior acoustic transmitter. This is converted into an acoustic signal and transmitted to the acoustic receiver outside. There, it is turned back into an electrical signal and sent across the internet.

The beauty of PulseStar is that it works equally well for electrical signals coming into and out of the Faraday Cage. Moreover, the frequency of these acoustic signals is inaudible to humans and the acoustic signals are not affected by the EMP. PulseStar technology can support a range of systems needing Faraday Cage shielding, from those needing a few watts of power to megawatt class equipment. PulseStar technology is currently at technology readiness level-4. US and European Union definitions say that this shows the technology has been demonstrated in a laboratory environment. The company is confident of having PulseStar systems ready for market later this year. Brad Face, president of The Face Companies, says that PulseStar can handle EMP

levels exceeding 200,000vpm. This will help shield systems from nuclear-generated EMPs and from the non-nuclear 'Super EMP' weapons discussed above.

Government Responses

The EMP threat is being taken seriously at the government level. The United States' National Coordinating Centre for Communications (NCC) regularly publishes EMP protection and resilience guidelines. The NCC is part of the DHS' National Cybersecurity and Communications Integrating Centre. These are regularly updated. In its own words, the document "provides guidelines to assist federal, state, and local officials and critical infrastructure owners and operators to protect mission essential equipment against electromagnetic pulse threats." Similar efforts are ongoing in the United Kingdom and the European Union to raise EMP threat awareness. In the UK Lord Tony Harris of Harringey, an expert on the EMP, chairs the country's National Preparedness Commission (NPC). The NPC works to promote preparedness for a major crisis or incidents like an EMP event. In 2012, the British Government published a document entitled Developing Threats: Electromagnetic Pulse. This was published by the House of Commons' Defence Select Committee, a cross-party group of parliamentarians monitoring government defence policy.

Likewise, the EU's Community Research and Development Information Service (CORDIS) is involved in EMP protection efforts. Initiatives have included CORDIS' HIPOW initiative which looks at protecting Critical National Infrastructure (CNI) against high-powered microwave threats like the EMP. HIPOW is developing hardware that can be used to counter or mitigate EMP effects, according to CORDIS. It is also drafting reference materials and documentation advising businesses and organisations how to protect themselves.

Governments clearly understand the EMP threat and are keen to share advice and guidelines, as EU, UK and US illustrate. Moreover, CNI providers are often mandated to include electromagnetic pulse protection for key systems. This is also the case for the military which, for understandable reasons, must have EMP protection built into platforms and systems. The challenge is the wider community where businesses and organisations may have a need, but not a legal requirement, for EMP protection. The challenge here is that such protection may seem a deferrable cost for an event perceived as unlikely to happen. Nonetheless, it is something everyone think about because of our heavily reliance on electronics and connectivity. The ongoing war in Ukraine and Russia's nuclear threats of Russia's should concentrate minds. Better to think the unthinkable now, than try to make amends if it happens. ■

Photo: US DOD

The US 'Starfish Prime' high-altitude nuclear test saw a nuclear weapon detonated in space in July 1962. The glow from the explosion was seen in Hawaii, where the resulting EMP affected electrical and electronic systems in the archipelago.

Thermobarics – Developments and Deployments

Tim Guest

Thermobaric weapons, also known as fuel air explosives (FAE), vacuum or aerosol bombs, dual-stage explosives or enhanced-blast weapons, have been developed and deployed by various militaries for a range of applications since WW2. Their latest high-profile appearance has, of course, been their documented use by Russia in its war on Ukraine.

From FAE mine-clearing systems deployed by armoured vehicles, to air dropped bombs, artillery rockets, shoulder-launched grenade systems and more, thermobaric weapons have taken on many forms since the first attempts at FAE weapons appeared in WW2, used by the Germans. Their onward development gathered pace with the US Air Force following its development of conventional systems that incorporated a thermobaric-type fuel component, for use in clearing swathes of jungle to enable helicopter landings in Vietnam in the 1960s. These applications were only made possible by the enhanced blast effects from the additional fuel and since then, many different thermobaric munitions have been developed and deployed by several militaries, primarily China, Russia, the UK and the US, though with some other national developments.

This article takes a brief look at certain thermobaric weapons, their effects, evolution from conventional munitions and some recent systems and developments, as well as a snapshot on their latest battlefield deployment by Russia in its unjust war on Ukraine.

Thermobaric Mechanism Overview

Thermobaric weapons are volumetric systems, relying on the creation, pervasive dispersal and detonation of a large volume of fuel of varying types, to deliver enhanced terminal effects, making this class of weapon particularly effective against enclosed targets such as bunkers, caves and tunnel

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Photo: Air National Guard / Tech Sgt Jorge Intriago

Any kind of explosion is horrendous for any object caught in its blast, but a thermobaric munition also has a vacuum effect from its fireball, which creates a negative pressure that 'sucks' all the available oxygen from anywhere within its radius. Pictured: An AH-64D APACHE attack helicopter and wall of fire, South Carolina National Guard Air and Ground Expo, May 2017.

Photo: USAF/US DoD

The BLU-82, a conventional weapon, can be said to have spawned certain thermobaric developments due to its partial use of aluminium powder as a small part of its payload. Pictured: An MC-130E drops the last operational BLU-82 bomb at the Utah Test and Training Range in July 2008.

systems. Various explosive compositions count as fuel in these weapons, which have either been used and/or are being developed for thermobaric applications; they include liquids, gelled and solid compositions, as well as reactive metals such as aluminium, nano-particles and, more recently, metastable intermolecular composites (MICs).

While typical conventional explosive munitions comprise a fuel-oxidizer pre-mix that is largely oxidizer, such as TNT or RDX, a thermobaric system comprises almost all fuel, making it significantly more energetic than a conventional condensed explosive of similar size. Their reliance on atmospheric oxygen to deliver their blast effects, however, does make them unsuited for use at high altitude, in certain poor weather conditions, and underwater.

Whether a larger thermobaric system launched as a rocket or dropped as a free-falling bomb from an aircraft, or a shoulder-launched blast grenade, thermobaric munitions will typically comprise a fuel container with two separate explosive charges. When a thermobaric munition hits a target, its first charge, or 'scatter' charge, explodes to open the fuel container, widely dispersing the contents as a cloud of droplets or aerosol, which covers the target area and, unless a structure is extremely well sealed, penetrates crevices, cracks, windows, doors, tunnels, trenches and buildings. Milli-seconds later a second 'combustion' ignites the fuel cloud and atmospheric oxygen to produce a huge blast and fireball, which not only destroy structures and equipment, but also incinerates organic matter caught in the direct blast, or, at the very least, causes devastating injuries to anyone in the area of the explosion. One of the reasons for their terrible effects on humans and animals is the vacuum effect a thermobaric fireball has, creating a negative pressure that 'sucks all' the available oxygen from anywhere within its radius, including the oxygen inside the lungs of any souls caught in the blast. The weapon uses the oxygen to generate an intense, high-temperature explosion, which has a sustained blast wave longer in duration than conventional, condensed explosive munitions.

These weapons inflict much of their damage by maximising shockwaves and overpressures, creating waves of energy that cause casualties and damage by crushing, bending, tumbling, and breaking, compounding any effects caused by the fireball. These extraordinary pressures negate many forms of cover and protection used by troops, including underground facilities,

Photo: USAF/Capt Patrick Nichols

Along with its ammonium nitrate oxidizer the BLU-82 incorporated aluminium powder to enhance its blast effects, hence being wrongly classed a thermobaric weapon; Pictured: The last BLU-82 bomb detonates at the Utah Test and Training Range in July 2008.

Photo: Army Maj Joseph Bush/US DoD

The lethal area produced by Russian Artillery thermobaric rockets is said by some to be up to 10 times greater than that produced by a US Army MLRS battalion delivering equivalent, conventional fires. Pictured: US soldiers fire an MLRS during a live-fire certification at Grafenwoehr Training Area, Germany, February 2021.

trenches and more, and the weapons, in general, have the potential to cause causalities that overwhelm military medical facilities and casevac logistics.

Modern Origins

Since the 1960s, China, Russia, the UK the US and others have developed various thermobaric weapons delivered by platforms such as MLRS, aircraft, as well as shoulder-launched grenades for use by infantry. Modern FAE systems were influenced by, or can be traced back to the 1960's arrival of the US' BLU-82. Known as the Daisy Cutter, this was actually the largest conventional munition at that time, though did comprise a percentage of aluminium powder alongside its main explosive; the bomb consisted of ammonium nitrate oxidizer and aluminium powder to enhance blast effects, which is why it is sometimes confused with a thermobaric weapon; it had a 970 mm-long fuze extender, which effected detonation above the ground to ensure optimum

Photo: USN/Petty Officer 3rd Class J Alexander Delgado

The AGM-114N HELLFIRE metal augmented charge (MAC) variant, i.e. thermobaric, is in use with British forces, which call it an enhanced blast weapon. Pictured: US sailors load an AGM-114 HELLFIRE missile onto an MH-60R SEAHAWK helicopter.

destruction at ground level, but without forming a crater that would have impeded helicopter landings. It delivered an overpressure of 1,000 pounds per square inch near ground zero. The BLU-82 was used in Vietnam initially to blast clearings in the jungle for helicopters, as well as for artillery emplacements, but it was also later used for clearing minefields, against troops in defensive positions and in the open, and against logistics supply lines, warehouses and vehicle parks. First dropped on 22 March 1970 by a C-130 in Vietnam, the BLU-82 was finally retired in 2008. Its replacement, the more powerful Mother of All Bombs (MOAB), GBU-43/B, had already been developed and first tested in 2003. Its explosive mixture initially trialled was tritonal, 80% TNT and 20% aluminium powder and said to be some 18% more powerful than just TNT on its own, though this was still not a thermobaric weapon per se, but the evolution towards such systems was clear.

Thermobarics

The US produced some of its first thermobarics for use in Vietnam, including the CBU-55 cluster bomb, developed by the US Naval Weapons Center. Though seldom used, the 340 kg air-dropped CBU-55 was fuelled mainly by propane. It is understood the US currently has at least seven thermobaric munitions in its inventory, including the SMAW-NE (see below), the BLU-73, BLU-95 230 kg FAE-II and the BLU-96 910 kg FAE-II bombs. Its AGM-114N Hellfire II missile is also a thermobaric munition as is the XM1060 40-mm grenade, which is a small-arms-delivered device, in use by US forces since 2003. The Hellfire warhead contains a thermobaric explosive fill of aluminium powder mixed with polytetrafluoroethylene layered between the charge casing and a PBXN-112 explosive. Rapid burn of the aluminium and sustained high pressure blast makes the weapon effective against personnel and structural emplacements.

The Russians have some of the most recent extensive pedigree in the use of thermobaric weapons. In the Soviet war in Afghanistan, for example, a TOS-1 MLRS thermobaric system was introduced and used during operations in the Panshir Valley, and ODAB-500S/P FAE bombs were dropped by MiG-27s at various times during the conflict. Later, during the 1990s, the TOS-1 BURATINO, as it was known, played major parts in both Chechen Wars, including in the destruction of Grozny and elsewhere against fortified, entrenched, Chechen positions. The purpose-built TOS-1 has 24 rocket tubes, (some latest versions have 30), mounted on a T-72 chassis and fires 220 mm thermobaric rockets with a full salvo capable of covering a 200 m x 400 m area. Chechnya also saw the use of the shoulder-launched RPO-A SHMEL personal thermobaric grenade.

When it comes to Afghanistan, however, Russia is not the only occupying force to have used thermobarics; during the first and second battles for Fallujah in 2004 the USMC used the Shoulder-Launched Multi-Purpose Assault Weapon - Novel Explosive (SMAW-NE) enhanced-blast weapon and, in separate operations, the USAF dropped a single 2,000 lb laser-guided thermobaric bomb on cave complexes in the Gardez region used by Al-Qaeda and Taliban fighters. Of the SMAW-NE's use in Falluja, an article in the USMC Marine Corps Gazette magazine in 2005, said: "Marines could employ blast weapons prior to entering houses that had become pillboxes, not homes. The economic cost of house re-

Photo: Navy Petty Officer 1st Class Theodore Green/US DoD

The HELLFIRE warhead contains a thermobaric explosive fill of aluminium powder mixed with polytetrafluoroethylene layered between the charge casing and a PBXN-112 explosive. Pictured: A USN MH-60R SEAHAWK helicopter fires an AGM-114N HELLFIRE missile during Exercise Baltic Operations in the Baltic Sea, June 2019.

placement is not comparable to American lives... all battalions adopted blast techniques appropriate to entering a bunker, assuming you did not know if the bunker was manned. ... SMAW gunners became expert at determining which wall to shoot to cause the roof to collapse and crush the insurgents fortified inside interior rooms. ... Due to the lack of penetrating power of the NE round, we found that our 'assaultmen' had to first fire a dual-purpose rocket in order to create a hole in the wall or building. This blast was immediately followed by an NE round that would incinerate the target or literally level the structure."

Russia's big-bomb thermobaric leap came in 2007, when it unveiled its Father of All Bombs (FOAB), a true thermobaric munition, (unlike the BLU-82), claimed to be four times more powerful than the MOAB. Russian claims have also been made that the FOAB's effects are deadlier than those of the US MOAB due to temperatures at the centre of the blast being twice as high as MOAB; FOAB's blast radius is said to be 300 metres, twice that of the BLU-82. Officially termed an aviation thermobaric bomb of increased power (ATBIP), the bomber-delivered, GLONASS-guided FOAB munition is said to have replaced certain tactical nuclear weapons in Russia's arsenal and, indeed, is reputed to deliver a yield equivalent to 44 tons of TNT using seven tons of a newly developed explosive composition. Detonating above ground, its blast and pressure wave have similar effects to a tactical nuclear weapon and unconfirmed reports by the Russian Ministry of Defence state that the weapon was used in September 2017 in Russia's Syrian campaign alongside Syrian government forces.

Today, Russian forces are equipped with a number of latest-generation thermobaric munitions, from the shoulder-launched RPO-A SHMEL rocket and launcher to a number of thermobaric ammunition variants for use by several standard weapons and platforms. The TBG-7V grenade, for example, can be launched by a standard RPG-7 and has a lethality radius of 10 m. It is one of several smaller FAE systems for use in close-quarter scenarios. In addition, upgraded man-portable RPG systems now also have thermobaric rocket munitions that, in some cases, deliver a blast equivalent to almost 6 kg of TNT with a destructive power similar to a 155 mm HE artillery round. Several Russian infantry anti-tank systems, including the 9M133 KORNET, have thermobaric warhead variants that can be used instead of a standard anti-tank missile; the KORNET's variant, for example, has a maximum range of 10 km and a TNT equivalence of 7 kg. ISKANDER-M theatre ballistic missiles, as well as a wide range of Russian Air Force guided and unguided bombs and ATGMs have thermobaric variants, some potentially in use in Ukraine. Beyond Russia and the US, China, the UK, India and Spain have all developed and hold FAE/thermobaric systems in their arsenals, though space precludes looking at these in this article.

Photo: USN/Navy Lt Samuel Hardgrove

An AGM-114L LONGBOW HELLFIRE missile launches from the surface-to-surface missile module aboard the Littoral Combat Ship USS MONTGOMERY in the Pacific Ocean, May 2022. The exercise was the first proof of concept launch of the LONGBOW HELLFIRE missile against land-based targets.

Thermobaric Use in Ukraine

The UK MoD, other western sources, as well as the Russians themselves, have now confirmed that Russia has deployed and used thermobaric weapons in Ukraine. It's impossible to know at this stage how many thermobaric strikes there have been and on what targets, but early in the war, the Russian TOS-1A was said to have been used on the battlefield, with at least one vehicle filmed by western media in the process of setting up its position, before journalists were warned off by its crew. In April, reports said Ukrainian forces had used a captured TOS-1A 'Flamethrower' – these systems have several nicknames -- against Russian forces near Izyum, having supposedly captured several of the systems during the conflict, though at time of writing only the one has been used by the Ukrainians on this one documented occasion.

In late May, Russia's Tass news agency quoted a Russian security official, saying it had fired its latest TOS-2 TOSOCHKA thermobaric system against Ukrainian targets in the Kharkiv area. (The TOS-2 also known as the TOSOCHKA BM-2, or ARMATA TOS-2, is the intended replacement for the TOS-1 Buratino). Late May drone footage did indeed show thermobaric rounds exploding on alleged Ukrainian defensive positions in the east of the country, though these were quoted at the time as being from Russia's TOS-1A SOLNTSEPEK Flamethrower system. [Seeing footage of the immense blast and fireball, far beyond that made by any standard 155 mm HE artillery round, it is hard to imagine how anyone under such a barrage could survive, knowing the effects they deliver. Ed]

The Ukrainians will not, however, be surprised by the latest use of thermobarics against them, having experienced a devastating artillery bombardment against four armoured battalions near the town of Zelonopillya in July of 2014. Thermobaric missiles and bombs were amongst a mix of munitions included in the barrage that destroyed these battalions in that one terrible event.

A sobering, final note: a former commander of the US Army Field Artillery School at Fort Sill is reported to have said that the lethal area produced by Russian Artillery thermobaric rockets is up to 10 times greater than that produced by a US Army MLRS battalion delivering equivalent, conventional fires. ■

Manned Naval Aircraft

Jack Richardson

In the naval domain, both fixed and rotary wing types perform a wide range of missions. These range from fast-jets flying from aircraft carriers for air-to-air and air-to-surface sorties to helicopters being used for anti-submarine warfare (ASW), anti-surface warfare (ASuW), Search and Rescue (SAR), Airborne Early Warning (AEW) and General logistics.

One of the most prolific users of manned naval aircraft is the United States Navy and its NIMITZ class aircraft carriers. Their air-wing of up to 100 aircraft is broken down into four squadrons of fast jets, two helicopter squadrons (stationed on both the carrier and its escorts) a squadron each for AEW and Electronic Warfare (EW) squadron and a detachment of Carrier On Board Delivery (COD) aircraft.

American Naval Air Power

The backbone of these air wings is the combat aircraft component, with the four squadrons currently made up of F/A-18C HORNETs, F/A-18E/F SUPER HORNETS and F-35C LIGHTNING IIs. These are drawn from both the US Navy and Marine Corps with the F-35C currently replacing the F/A-18C. Between them, these aircraft carry out the full spectrum of air-to-air, air-to-ground, counter-shipping, reconnaissance, and buddy refuelling missions. The introduction of the F-35C is now bringing the aircraft carriers fifth-generation combat capabilities such as fused sensors and low observable technology. The combat squadrons are supported by a squadron (consisting of around five) EA-18G GROWLER aircraft. This derivative of the SUPER HORNET is specially equipped for EW with jamming pods and anti-radiation missiles. This force will be recapitalised with the introduction of the Next Generation Jammer in the years ahead. The four combat squadrons provide the carrier's offensive power and protect it from threats as part of a layered system. This consists of the ship's own defensive weapons, surface escorts and the combat aircraft which are directed by the E-2C HAWKEYE AEW aircraft. This is a design dating back to the early 1960s but is now being rejuvenated through the introduction of the E-2D ADVANCED HAWKEYE. Entering service since 2019, this new variant features digital flight and mission controls in addition to inflight refuelling and cooperative engagement capabilities. Another key component of the strike group is the rotary wing element. This has now been standardised on the latest generations of maritime variant of the BLACKHAWK family (which has been extensively exported). The first facet of this comes in the form of the MH-60 ROMEO which is fitted with a radar and ASW sensors to conduct this mission. The helicopter can also perform ASuW missions using the HELLFIRE missile to target Fast Inshore Attack Craft (FIAC). It is also able to perform roles including utility transport, SAR and supporting naval gunfire missions. Accompanying the MH-60R is the SIERRA version, which is deployed in the Combat Search and Rescue (CSAR) mission and Mine Countermeasures (MCM).

Finally, each carrier embarks a GREYHOUND COD aircraft (using the HAWKEYE airframe but without AEW equipment) for the essential role of supplying the battle group with everything from food to letters from home. This veteran aircraft is in the process of being replaced by a US Navy specific variant of the V-22 OSPREY tilt-rotor. Currently being inducted, this aircraft has the added advantage of being able to deliver supplies to accompanying ships directly by virtue of its ability to hover.

Photo: Lockheed Martin

Lockheed Martin's F-35C has now been successfully deployed from the US Navy's NIMITZ class aircraft carriers.

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The UK

Another significant operator of naval aircraft is the UK, which last year deployed 18 F-35B Short-Take-Off-Vertical-Landing (STOVL) fighters (from both the RAF and USMC) around the world aboard HMS QUEEN ELIZABETH. Alongside the F-35B during this long-awaited deployment were a wide array of naval aircraft. One of the most prominent was the Leonardo MERLIN in both HM2 and HC4 variants. The former carried out the ASW role from the aircraft carrier itself while some carried an AEW radar. The HC4 meanwhile are utility examples transferred from the RAF and put through a navalisation process where they were fitted with features including a folding tail rotor for shipboard operations. The HC4s were based aboard the auxiliary vessel RFA FORT VICTORIA and carried out numerous roles including logistics and the deployment of Royal Marine Commandos in the 'Joint Personnel Recovery' role of rescuing downed aircrew. The other naval aircraft employed during this deployment was the AW159 WILDCAT helicopter. Based onboard accompanying frigates and destroyers, these aircraft were employed in the ASuW role, alongside various utility tasks. These helicopters marked their maturity during the voyage by test firing the MARTLET Lightweight Multirole Missile, which is designed to neutralise FIACs, for the first time. The MERLIN and WILDCAT form a key part of the UK's naval aircraft portfolio, with both having enjoyed some export success. The WILDCAT has been purchased by South Korea and the Philippines while examples of the MERLIN are currently being manufactured for Poland.

EU Navies

While the UK is basking in the glory of the deployment of its two new carriers, these remain conventionally powered. The only state outside of the US to successfully field a nuclear-powered aircraft carrier to date is France. The 40,000 ton CHARLES DE GAULLE is able to routinely deploy around 30 Dassault RAFALE multi-role aircraft. These are supported, in a fashion similar to the US Navy, by three E-2C HAWKEYE AEW aircraft (a contract has been signed for these to be replaced by the E-2D variant). Also integrated with the aircraft carrier is a wide range of helicopters including the NH-90 NATO Frigate Helicopter (NFH) variant, which is equipped with an advanced radar for surface searches in addition to a dipping sonar and sonobuoy dispenser for ASW. These aircraft (which are operated by several other European nations including Germany) are deployed around the French fleet on ASW tasking. Later this decade, the French Navy will be taking delivery of a marinised variant of the H160M for tasks including ASuW (with the Anglo-French SEA VENOM missile), maritime security and SAR. This is a joint programme with the French Army and Air Force, which intends to replace several different helicopter models with a common type.

Several other European nations rely on naval aircraft and one of the most notable is Italy. This is a country currently in the process of making more aircraft deployable at sea through NH-90 NFHs operating from several classes of surface combatant including the THAON DI REVEL class of modular Offshore Patrol Vessels. The Italian Navy has also taken advantage of the V/STOL capabilities offered of the F-35B by ordering it (for use in a joint fleet with the Italian Air Force) to replace the legacy AV-8B HARRIER II. These have been trialed during a deployment to the East Coast of the US on the aircraft carrier CAVOUR, which also carries AW101s for ASW, ASuW and AEW. Italy is currently inducting the new Landing Helicopter Assault TRIESTE, which will also be able to deploy these types.

A similar type of vessel is fielded by Spain. The JUAN CARLOS is a multi-role vessel that has a flight deck and well-dock. From it, Spain operates a small fleet of EAV-8B+ HARRIER IIs for air defence, ground attack and reconnaissance in addition to a wide range of helicopters. These include the SH-60F SEAHAWK for ASW and utility transport alongside the AB 212 (also utilised in the latter role). The ship is also compatible with Spanish Army aircraft such as the CH-47 CHINOOK and the NH-90, which the Spanish Navy also intends to operate in the ASW and ASuW roles. The design of the JUAN CARLOS has been exported as the basis of the ANADOLU class being procured by the Turkish Navy.

Photo: Lockheed Martin

The MH-60 ROMEO is used by the US Navy for roles including ASW, ASuW and logistics, it has also been extensively exported around the world.

Turkish Plans

This force is traditionally focused on rotary wing naval aircraft, in this case the SH-60 SEAHAWK for ASW from frigates, in addition to various land based maritime patrol aircraft. However, Turkey will soon be operating the SEAHAWK from the ANADOLU class, one of which is being built with a second planned. The country had originally planned to join others in deploying the F-35B from these vessels. However, in 2019, Turkey was removed from the F-35 programme when it decided to purchase the S-400 SAM system from Russia. Turkey may yet be able to deploy fixed wing manned naval aircraft because there are proposals to launch the Turkish Aerospace Industries HURJET instead. This is an indigenously developed single engine trainer aircraft that could launch from the ship's ski-jump and perform limited reconnaissance and ground attack missions before being recovered using an arrestor wire.

Russia

Turkey inhabits a particularly volatile region at a crossroads between the Middle

East and the Black Sea, where the naval element of Russia's war against Ukraine is playing out. The mainstay of Russia's fleet of naval aircraft is Kamov's family of distinctive co-axial helicopters. The Ka-27 is the variant used for ASW whereas the Ka-29 can be used to transport naval infantry from ship-to-shore. A third model is the Ka-31, which has a rotating radar array beneath the fuselage to provide an AEW capability. Most of these are deployed from destroyers, frigates and corvettes as Russia only has one aircraft carrier, the ageing ADMIRAL KUZNETSOV. The carrier, which uses a ski-ramp to launch and arrestor wires to recover aircraft, now has a multi-role capability. This comes through the Mig-29K FULCRUM, a marinised version of this medium sized twin engine fighter aircraft. The aircraft saw its operational debut in late 2016 when the ADMIRAL KUZNETSOV was deployed in the Eastern Mediterranean to conduct operations against anti-Assad regime forces in Syria. Here, the aircraft used both guided and unguided munitions to prosecute a range of targets.

Photo: Leonardo

Leonardo's AW101 family of helicopters is also deployed in a wide variety of roles, including this example, which the Italian Navy uses for AEW.

Eastern Rivalries

While Russia has had limited success modernising its naval aircraft, this is not true of its ally China. As the People's Liberation Army Navy (PLAN) moves from a force focused on defending its immediate coastline to one that has global power projection capabilities, a centerpiece of this is naval aircraft and the carriers they operate from. In 1998, China purchased an aircraft carrier that had been built in Ukraine for the Soviet Navy. The PLAN christened this vessel LIAONING and refurbished it for use in training crews in the operation of aircraft carriers. The ship, which displaces up to 66,000 tons, reportedly has an air-wing of 24 fighters. These are the J-15 FLYING SHARK, a derivative of Russia's FLANKER family, which is launched using a ski jump but recovered using arrestor wires. The LIAONING has since been followed into service by the SHANDONG, a larger vessel displacing up to 70,000 tons and carrying as many as 36 J-15s. China is currently building what is termed the 'Type 003' carrier, which will use catapults and arrestor wires similar those utilised on American vessels. In terms of naval aircraft to be carried, this would unlock a whole new range of options. In addition to a J-15 modified for launch from this vessel, the PLAN reportedly aims to deploy stealthy fifth-generation aircraft from this carrier. This could be either a navalised variant of the J-20 (the land-based version of which if broadly equivalent to the US Air Force's F-22 RAPTOR) or the a similarly adapted version of the FC-31. This is a smaller stealth aircraft designed for export and is similar in size to the F/A-18E/F SUPER HORNET, DASSAULT RAFALE, Mig-29k and F-35, the latter which it closely resembles. Crucially, this launch and recovery arrangement will enable the deployment of an AEW aircraft to improve situational awareness. Accordingly, China is said to be developing the KJ-600, a propellor powered AEW aircraft resembling the E-2D HAWKEYE. Until now, the PLAN has relied on the Ka-31 and other types (including licence built versions of European aircraft) for AEW and other support roles including ASW.

A regional rival of China and a long-term operator of naval aircraft is India. The sub-continent has been operating aircraft carriers since the early 1960s having purchased decommissioned British vessels. It broke with this trend in 2014, however, with the induction a refurbished KIEV class carrier renamed VIKRAMADITIYA. This is equipped with several examples of the MiG 29k and is supported across the naval air arm with other aircraft of British, French, Indian and Russian origin. This diverse mix of aircraft will soon become more eclectic as deliveries of the MH-60R begin. Following the VIKRAMADITIYA, India will bring two indigenous aircraft carriers into service. Called the VIKRANT class, the first, named INS VIKRANT will have a ski-ramp and arrested recovery configuration while the second, INS VISHAL, will use the catapult and wire method. India is currently considering various indigenous and overseas aircraft to operate from these alongside the Mig-29k.

As the threat from China has grown, other countries in the region, which have traditionally only operated naval aircraft from land (historically the P-3 ORION family), are now looking to deploy more of them from the sea. Under its post-World War Two constitution, Japan has been prohibited from deploying offensive weapons such as aircraft carriers. However, in October 2021, the USMC landed one of its F-35Bs on the JS IZUMO, Japan's largest warship. The country has also placed an order for this variant of the aircraft, notionally to deploy from un-prepared airstrips in the region, however, most analysts believe this is a prelude to re-establishing an aircraft carrier capability.

Conclusion

As the world becomes more unstable in light of the war in Ukraine, which itself has forced countries to reassess their priorities, one certain remains. Manned naval aircraft are in high demand for use across a wide range of roles and they are set to evolve with threats to international naval forces. ■

Austrian Airpower: Neglect and Ignorance to be Reversed?

Georg Mader

In May 2022, a weekly magazine claimed it had insight into a new Austrian MoD "Strategy Paper 2032+", drafted after the shock of Putin's invasion of Ukraine – a battlefield in a country only a five-hour drive from Vienna. What is known from this – officially not disclaimed – document, might mark a significant reversal regarding the national defence of the NATO-embedded neutral nation.

In 2002, it was a surprise to EADS (now AIRBUS D&S), when their new European EF-2000 TYPHOON was selected by a centre right government in Vienna in a deal worth €2Bn for 24 aircraft. Officers still stress to the author that the brave attempt to replace the 24 used 1960s-era Saab S-35OE Mk-2 DRAKEN aircraft with a solution for the next 30 years, was made on the grounds of the most promising option with the most potential (versus the offered GRIPEN-C/Ds which were too expensive in comparison).

TYPHOON Shockwaves Still Today

Thus, the Tranche-2 was ordered by the launch-export customer in good faith, even as this standard was to expected be agreed by NETMA and the industry only late in 2004. The first six aircraft were accepted as Tranche-1, to be upgraded or replaced later. This should never have happened. Six of the interceptors were soon cancelled to compensate the expenses incurred to cover floods later the same year, despite the fact that it was agreed to only pay in installments from 2007. Another three were then cut by the new Social Democrat Defense Minister Darabos, whose party had promised to cancel the whole deal – but legally couldn't get out of the deal. What he did instead was to mutilate the 15 remaining aircraft (now only Tranche-1 single-seaters, with six of them being used German LWs with up to ~400 hours) on their PIRATE-IRST, with the DASS self defence kit and the type's main AIM-120-BVR-armament. In July, the first of these downgraded TYPHOONs landed at Zeltweg Air Base. Despite numerous allegations and three parliamentary investigations, no corruption involving politicians and officers was found, though financial irregularities in connection to the alleged 200 per cent offsets are still being investigated today.

Despite an upgrade to software standard SRP 4.3 to use T2 drop-tanks, the ongoing integration of IFF-Mode-5 and a minor upgrade of the MIDS (datalink) interface-unit together with Italy's T1s, the actual combat effectiveness of the 15 Austrian TYPHOONs has remained unchanged from their controversial acquisition in 2003 until today. Next to the 27 mm guns, which are today only seen in single examples from a total of about 20 analog-only integrated IRIS-T WVRAAMs mounted in daytime QRA. There is still no 24/7 QRA, prompting the UK Defence Attaché recently to ask the author why this has not been addressed. The simple answer was the same as to why there were no upgrades carried out after 15 years of limited but uneventful service without any loss: Not so much a question of funds in fact, but political neglect, with nothing to be gained from this subject in elections, in addition to wicked studies issued by the MoD which sought to research how neutral Austria could be through breaking free from this expensive equipment burden and hand over the whole task to its neighbours, NATO, or whomever. – Another bizarre episode in this saga relates to a 2020 letter from Indonesia's MoD, expressing interest in acquiring Austria's unwanted 15 'ducklings' – but with no replacement in sight whatsoever. As an Indonesian Air Force officer expressed to the author in 2021: "What should we do in our security environment with your emptied birds, with no self-defence and even RWR, no BVR-missile and – above all – no two-seater?"

Photos: Georg Mader

Two Austrian TYPHOONs. The actual combat effectiveness of the 15 Austrian TYPHOONs remains rather low.

War in Ukraine Triggers a U-Turn

Since the Russian aggression against Ukraine, there have been different comments in Austrian politics and media in re-

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action to the conflict. Nothing much about the announcement to raise the meagre annual defence budget from 0.7 per cent BIP (€2.7Bn) to 1 per cent (€4Bn) or even 1.5 per cent and the establishment of a reconstruction fund for defence of €10Bn was heard in detail so far. There is, however, a clear trend to end the careless and sloppy approach regarding the Bundesheer. The old Russian (Ukrainian) supersonic recce-UAV which recently flew across NATO-Hungarian airspace before landing in Zagreb provoked considerable interest, since if Austrian territory should – as opposed to NATO-bound Finland and Sweden – have been affected, or threatened by war, it would first and foremost be its airspace. And so the author has seen planning documents showing a 180° turn regarding the approach to Austrian airpower. Now all the capabilities mutilated in the past – like the PIRATE ISR or other features such as the DASS self-defense or which AIM-120 version would be still available for T1 aircraft – should return in the next years, together with 3 or 4 used two-seaters from the German inventory. Moreover, considerations have begun about what – in the light of expected increasing running costs for T1 - should follow in the 2030s. And also in Austria – we have been looking on at Finland and Switzerland with interest – with an F-35 quietly mentioned.

Proficiency and Costs

This is the environment in which about 16 Austrian supersonic pilots are fulfilling daily air-policing duties – so far, with no losses or larger mishaps. But there is an uneasy expectation among them as expressed to the author in October, about the replacement pipeline now undergoing pilot training in Italy and Germany and whether or not they will possess the necessary proficiency and situation awareness levels, since one can no longer accumulate enough hours, because the 50 year-old Saab-105OEs were – justifiably - retired at the end of 2020 but with no replacement. After phase-II on PC-7Mk.1, the few students head to Lecce/Deci (IT) and Laage-Rostock (GER) for almost three years to earn their wings on the MB-339C/D, T.346 Master (later maybe also the T.345HET) and finally – reportedly prohibitively expensive per hour – some hours on German TYPHOON two-seaters of JG 73. Upon return, they will have never flown in an Austrian Squadron's routine with phraseology, topography, meteorology etc. And the abovementioned 'Strategy Paper 2032' also marks a U-turn here, since it calls for a squadron of advanced jet trainers, preferably – as the author has learned – the Leonardo M346FA. This also would envisage the provision of a ten-times less expensive training platform at home without the need to spend millions abroad anymore. But also as a substitute for air surveillance in TRA-events like covering summits (such as the WEF in Davos etc.) and as a sparring partner and modern target for the GBAD-troops.

The modernised AB-212 helicopters. Only half of Austria`s AGUSTA AB-212s are still operational.

An Austrian Air Force AB-212 in Police - Anti-terror Squad configuration

An Austrian AF 8T-CA in new livery at RIAT-2018

Some numbers in brief: In 2020, a total of 13 candidates successfully completed the aviation assessment centre, of which seven then passed the practical aeronautical aptitude test and were admitted to pilot training out of a total of 500 candidates who were earlier tested as fit-to-fly. "Then the four-year military pilot training

An armed Austrian Air Force PC-7-Trainer

An Austrian BLACK HAWK experiencing white-out while landing

begins, which costs several million euros per student and in which we practically no longer have any dropouts. And that is absolutely unique in Europe", Gen. Kraft, as head of the Air- and Air Defence school points out.

Golden Hat

Also being addressed and currently under discussion is the lack of special or critical ground personnel such as radar officers, Mil-ATC, fire brigade personnel, etc. thereby hampering the build-up of a 24/7 QRA capability over the next 3 to 4 years. On the contrary, the technical upgrade of the three highly self-sufficient stationary Alenia RAT-31DL radar stations at Kolomansberg (Salzburg), Großer Speikkogel (Carinthia) and Steinmandl (Lower Austria) of the 'Goldhaube' military airspace surveillance system is proceeding well, with the high elevated sensors looking from Kaiserslautern, over the southern regions of Poland down to Sarajevo. Of course, they would need to be supplemented by some kind of passive sensors, since in a conflict, these would be the first assets to be taken out by an aggressor.

Rotary Renewal

The nine existing Austrian S-70A42 BLACK HAWKs helicopters are currently equipped with new cockpits and mission computers, installed by the US-provider ACE-AERONAUTICS, and the air support wing will also receive three more S-70 aircraft by 2025. The Austrian Armed Forces are meanwhile setting another milestone with the G2G-procurement launched with Italy in late 2021 of six Leonardo AW169B helicopters for rotary training and 12 AW169M as multi-mission platforms. These will succeed the ALOUETTE-III liaison and transport helicopters that have been in use for decades. The AW169 system is larger, offers much more functionality and thus opens up completely new application possibilities for the troops. Among other things, this has to do with the additional equipment packages supplied by Leonardo, which also enable the use of the – partly weaponised – 18 platforms for special forces, SAR, and recce etc. The IOCs and FOCs for these roles/equipment configurations will run until 2025/26. The first 'B' should land at the end of the year, while an option for a further 18 AW169 units is valid also until then, with the hope for a decision to also replace the 23 1980s-era AGUSTA AB.212s of which only half are still operational.

Airlift Renewal Pending

Since 2003/2004, the air support wing in Linz/Hörsching is operating three ex-RAF C-130K aircraft, built in 1967 and 1968. A fourth ex-RAF airframe was flown to Linz on its last flight and is used as a training airframe. A working group at the strategy planning cell in the MoD was created last year to address the replacement. High-ranking AF officers informed the author that this could be either newly-built or – depending on the condition – used C-130Js like those being phased out by the RAF, or the Brazilian EMBRAER (K)C-390. Austrian PANDUR EVO APCs easily fits as well as a domestically designed Austrian MEDEVAC/intensive care container. The 390 is acquired in the EU by neighbouring Hungary and also by Portugal. The latter now hosts the Austrian C-130 for all future MRO-events at the OGMA-plant in Alverca, partly owned by EMBRAER. Moreover, AAF sources claim that the shift to OGMA was induced since Marshall Aerospace at Cambridge would – maybe due to Brexit – have had dictated prices while not being held to timelines. ■

The new ACE VL-60 cockpit in Austria's BLACKHAWK helicopters

Austria in NATO's Air and Missile Defence Architecture

Debalina Ghoshal

Given the Ukrainian crisis, there have been questions raised if Austria too would join the NATO or continue their neutral status as enshrined in their constitution.

Though the Austrian Chancellor has reiterated Austria's position claiming, "Austria was neutral, is neutral, and remains neutral", its neutrality has now been questioned and criticized by many policy makers and opposition leaders.

Defence by Denial

It is interesting to note that a state system like Austria that was once a major player in European history, now boasts of a humble military capability. Given the Ukrainian crisis and Russia's eastward expansion in Europe, Austria's military capability now becomes a concern. Austria does not possess any cruise or ballistic missile capabilities, and hence, a credible 'defence by denial' capability becomes crucial to protect Vienna. At the moment, Austria possesses anti-aircraft guns and short-range surface to air missiles (SAMs). However, given that adversaries today could possess aircraft with stand-off capability, short range SAMs are not enough for the protecting of more than one large critical infrastructure by the Austrian Air Force. Moreover, these air defence systems do not pose any threat to ballistic or cruise missiles.

Austria realises the threats posed to its territory owing to the Ukrainian crisis and it has realised the insufficiency in its military spending till date. The chancellor has assured of a 'significant increase' in Austria's defence spending now which can reach up to one percent of the Gross Domestic Product (GDP) from its current 0.74 percent. So far, however, the government has not come forward with numbers or timelines.

Despite the realisation of modernising its military, Austria lacks modern equipment and significant purchasing capabilities and its military modernisation program is underfunded. The recent Ukrainian crisis has made it clear that states without a credible air and missile defence capability would fall prey to coercive diplomacy of militarily powerful states. Not only this, the state

Photo: Georg Mader

Austrian GBAD-officers agree that with those 1980s Oerlikon-Contraves (now Rheinmetall-Air Defence) 35mm twin guns, they can only fight aircraft- and helicopter-like targets up to 3000m in elevation and 5000m in distance. But in countering UAVs there could be a 2nd life...

Photo: Georg Mader

In the mission of 'protection of objects of critical infrastructure', the one GBAD-battalion (with ~24 guns) can only cover one large Installation like Vienna international airport, or a few smaller ones. Life firing happens twice a year at Allensteig proving ground.

Author

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Photo: Georg Mader

No live firing is possible in Austria with the light SHORAD-missile MISTRAL, guided by the – earmarked for phasing-out – GIRAFFE target-acquisition radar. Therefore, life-firing exercises are conducted at Todendorf on the German Baltic coast every two years. A new radar with the operators separated from the sensor is on Austria's shopping list, same as a SAM system like IRIS-T SL.

could also become a subject to nuclear blackmailing by powerful states should it wish to make a foreign policy decision that goes against the interests of its militarily powerful adversaries.

Should Austria choose to let go off its neutral status in the near future and join NATO, there is little doubt in the fact that it would need credible air and missile defence capabilities to pose a credible threat to adversaries. Just days after Finland announced it wants to join NATO, Russia moved its nuclear-capable tactical ISKANDER missiles to the Finnish border. In fact, Finland is reported to have spurred talks with Israeli government on possible cooperation on missile defence capabilities and could choose between Israeli Barak and David Sling system. Sweden on the other hand, is the first non NATO country to operate the US Patriot air and missile systems.

Switzerland too has expressed interest to acquire F-35 Joint Strike Fighters and Patriot systems from the United States to modernise their air power and air defence needs. Hence, states those states that maintained neutral status but are now keen on joining NATO, have focused on modernising their air power capabilities for air defence roles too, as well as acquired or seeking to acquire capabilities for air and missile defence roles.

Hence, if Austria wants to let go off its neutral status, modernising its air and missile defence capabilities remain a crucial task.

Austria in NATO Activities

Despite not being a member of NATO, and opposing NATO membership, Austria has actively supported NATO in peace keeping operations in places like Bosnia, Herzegovina and Afghanistan. These activities are conducted by Austria under the NATO-Austria Partnership for Peace (PfP) framework which was joined by Vienna in 1995.

Austria has supported NATO in destruction of mines and munitions in places like Albania, Kazakhstan, Montenegro, Serbia and Ukraine, as well as providing support and preparedness for fighting accidents and disasters that could be led due to chemical, biological, radiological or nuclear agents and also providing support in disaster relief. Austrian researchers are developing an innovative detection tool for the SARS-COV-2 virus and other toxic bio-agents in workplaces.

Hence, there is always scope for Austria to participate in NATO's air and missile defence architecture with or without NATO membership or pursue their own defence capabilities. However, owing to the limitations in its defence modernisation process, it is conducive for Austria to become a part of NATO air and missile defence capabilities. It must be noted that Austria has a memorandum of understanding (MoU) on command and control (C2) sharing of GBAD system with NATO under a twelve nation MoU framework.

Austria's Views on NATO Missile Defence System

When the Obama administration in the United States reversed the Bush policy on the European Phased Adaptive Approach, and chose to develop and deploy transportable ballistic missile defence (BMD) capability that could be deployed across the world at short notices during times of crisis rather than depending on silo based interceptors in Poland as was planned by Bush administration , it must be noted that Austria's views on both cancellation of silo-based interceptors in Poland and decision to deploy mobile BMD capability both remained positive and praised the policy reversal process.

Possible Problems

However, while Austria could show keen interest in joining breader NATO air and missile defence framework, NATO members could oppose it with a veto. In 2017, Turkey for instance, vetoed Austria's cooperation with NATO owing to the fact that Austria blocked Turkey's bid to join the European Union. Not only this, Turkey is also opposing Finland and Sweden's NATO membership owing to Turkey's accusation of a Finnish and Swedish support to the Kurdistan Workers' Party (PKK) inside Turkey, a group Turkey labels as terrorists. Hence, if Austria wants to participate in air and missile defence framework of the NATO, it may meet some opposition from NATO members like Turkey. ■

The Contenders Position for the UK Medium Helicopter Requirement

Britain is to acquire a new helicopter type under the New Medium Helicopter (NMH) programme.

David Saw

The selected helicopter will be operated by the British Army and the Royal Air Force (RAF) under the auspices of Joint Helicopter Command. The official contract notification states that the MoD "is considering the procurement of up to 44 New Medium Helicopters (NMH) to replace existing rotorcraft systems for Army and Strategic Commands. The scope of the contract will also include the provision of training capabilities and a maintenance/spares package as well as design organisation scope."

Photo: RAF

The British New Medium Helicopter (NMH) programme has a value of between £900M and £1Bn and covers the acquisition of 44 new helicopters. Types to be replaced include the PUMA HC2 (shown here), the Bell 212 and 412 and the DAUPHIN.

Photo: Airbus Helicopters

The Airbus Helicopters proposal for the NMH programme is the H175M, a military variant of the H175 medium helicopter used for SAR and offshore resources missions. If selected, Airbus will manufacture the H175M at Broughton in North Wales. British-built H175M helicopters will also be offered for export to military customers.

The objective behind the NMH programme (Project 702091450) is to "rationalise its existing multiple rotary wing requirements into one platform-type, maximising commonality in order to improve efficiency and operational flexibility. NMH will provide a common medium lift multi-role helicopter, fitted for, but not with, specialist Mission Role Equipment (MRE) and able to operate in all environments in support of defence tasks." Potential contract value for the NMH programme is in the range of £900M to £1Bn, and as previously stated, the number of helicopters to be acquired is up to 44. However, when the MoD started exploring NMH possibilities in November 2021, the number of helicopters to be acquired was between 36 and 44.

The NMH will replace the current RAF fleet of 23 PUMA HC2 helicopters, 23 systems in the inventory, with 17 in service, the Army fleet of five Bell 212 helicopters based in Brunei (these currently have an out-of-service date of Quarter 3, 2022), the Army fleet of three Bell Griffin HAR2 helicopters based in Cyprus (these currently have an out-of-service date of Quarter 2, 2023) and the AS365N3 DAUPHIN II, six of which are used by 658 Squadron Army Air Corps (AAC) as part of the Joint Special Forces Aviation Wing.

Contenders

Initial industry responses to the MoD regarding the NMH programme were expected in June and it was assumed that four options would emerge as contenders for NMH. These were Airbus Helicopters with the H175M, Bell with the Bell 525 RELENTLESS, Leonardo with the AW149 and Sikorsky with BLACK HAWK. Thus far, only Airbus Helicopters and Leonardo have committed to manufacture or final assembly in the UK. Back in 2021, Airbus Helicopters announced that their NMH proposal would include manufacture of the H175M helicopter at the Airbus site at Broughton in North Wales. Broughton is the major site of wing manufacture for Airbus commercial aircraft, it also has the infrastructure to support the rapid establishment of H175M production. Should the H175M win the NMH programme then the helicopter would also be offered into military export markets and any resulting sales would be built at Broughton. According to Airbus, they are the second largest private-sector employer in Wales, added to which Airbus has numerous sites around Britain that also make an important economic contribution. NMH is as much about politics and economics, as it is about selecting a superior military helicopter.

Leonardo is another company with a strong presence in Britain, employing some 7,500 personnel across seven UK sites and they make a £1.9Bn contribution to the UK economy on an annual basis according to the company. Currently, aerostructures for the AW149 are manufactured in Brindisi, while the AW149 is assembled at Vergiate in Italy. If Leonardo win NMH they have committed to establishing an additional AW149 final assembly line at Yeovil, in addition the advanced aerostructures techniques that are needed to assemble the AW149 will allow the Yeovil site to participate in next generation helicopter programmes. Yeovil, is regarded by many as the helicopter centre of Britain, as this was the location of Westland Helicopters, a legacy company of Leonardo.

Although Airbus Helicopters and Leonardo would inevitably be seen as the top two contenders for NMH, if Sikorsky or Bell can craft a proposal that is politically and economically attractive they cannot be ruled out. On the other hand, what must concern the British government is that they will most probably have to choose between Broughton and Yeovil when they select an NMH winner. Then the concern is what would be the fate of the losing site, how serious would the economic and employment implications be? Although NMH might not be the biggest helicopter programme in the world, with a contract value of £1Bn (€1.17Bn) it is certainly a very attractive programme and will be one that each of the four contenders will want to win. ■

THE MISSION CONTINUES...

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Israeli Arms Exports to the EU: Air Systems

Eugene Kogan

The Israeli export of air systems has accelerated over the last four years, with contracts varying between US$50M and US$1.65Bn. Israeli defence companies are expanding their footprint in Europe through technologies such as avionics upgrades, electronic warfare, radar systems, UAVs and air defence systems.

Whether or not the ongoing Russian war against Ukraine will have an impact on the export of Israeli air systems to the EU remains to be seen. The German Government is considering purchasing the Iron Dome and the Arrow air-defence systems, while other EU countries are contemplating such a procurement. Israeli arms exports to the EU in general have increased from 26 per cent in 2019 to 30 per cent in 2020 and exceeded 41 per cent in 2021. The EU market plays the dominant role for the Israeli weapon systems, in general, compared to the Asia-Pacific market and a very crucial market for air systems, in particular.

Photo: Zachi Evenor / CC-BY

Israeli Air Force HERON TP UAV

Flight Training Centre and More

In April 2021, Israel signed a defence deal with Greece worth US$1.65Bn. The Israeli Defence Ministry, through Elbit Systems, will set up an international Flight Training Centre for the Hellenic Air Force based on the model of the Israeli Air Force Flying School.

Under the agreement, Elbit Systems will supply new M-346 training aircraft and will maintain the entire training fleet consisting of 10 M-346, known in Israel as LAVI and an unspecified number of the Hellenic Air Force's T-6 training aircraft for a period of about 20 years. In addition, the company will provide its latest advanced Embedded Virtual Avionics (EVA) on board the training aircraft, and deliver network flight simulators and an array of Ground-Based Training Stations. The contract also includes C2 systems to facilitate the effective management of flight training.

Author

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Elbit Systems President and CEO, Bezhalel Machlis, said: "This contract award attests to the leading position we hold in the area of pilot training solutions, providing tested know-how and proven technologies that improve operational readiness while reducing costs."

Leasing the HERON-TP Unmanned Aerial Vehicle

Back in June 2018, the German Government agreed to lease five of the HERON-TPs in a deal worth an estimated US$1.2Bn, but with the caveat that the UAV will not be armed. The overall deal, which sees the UAVs leased through 2027, is made up of two contracts. According to the IAI statement: "The first contract, worth US$600M, is between IAI, the HERON manufacturer and Airbus to manage all aspects of the project including operational support and maintenance." The second contract is the G2G; specifically, the Israeli and German Defence Ministries to provide training, infrastructure and logistics.

Finally, in April 2022, the German Government decided to arm the HERON-TP UAVs with missiles manufactured in Israel. Germany will procure 140 missiles including 80 for training and 60 for operations at a cost of about US$185M.

WANDERB and THUNDERB Vertical Take-Off and Landing UAVs

BlueBird Aero Systems, which is 50 per cent IAI owned, has completed an order for 100 WANDERB vertical take-off and landing (VTOL) UAVs. WANDERB VTOL UAV is a fully autonomous UAV while THUNDERB is a small tactical UAV. The systems were delivered to an undisclosed European customer worth tens of millions of dollars covering a total of more than 150 WANDERB and THUNDERB VTOL UAVs.

It is well known that the WANDERB VTOL is aimed at providing intelligence, surveillance, target acquisition and reconnaissance (ISTAR) mission capability to defence, security and paramilitary forces.

The THUNDERB compact UAV is, however, designed to offer long-endurance and extended range capabilities similar to those offered by larger UAVs weighing 200 kg.

Photo: CC BY-SA 3.0

The WATCHKEEPER UAV is based on the HERMES 450 of Israel's Elbit.

BlueBird Founder and CEO, Ronen Nadir, said in June 2021: "BlueBird VTOL systems provide vital intelligence and situational awareness in real-time to the end user's infantry, armoured units, artillery corps and special forces, serving as their 'eye in the sky,' effectively handling the challenges of the modern battlefield."

WATCHKEEPER X UAV

In May 2022, Elbit Systems won a contract with the Romanian Army for the delivery of the WATCHKEEPER X UAV. According to the contract details, the components for the UAV are to be manufactured in the Elbit factory in Bacau and in Magurele, a satellite city of Bucharest, with testing and maintenance provided by Romanian defence industry operators. The UAV will be used mainly for surveillance and reconnaissance missions but may also be armed. Romania will purchase seven systems which means a total of 21 UAVs. Of seven systems, six will be in the terrestrial version and one system in the naval version. The value of the contract is €300M.

According to British Colonel (Retd.) Nick McRobb, Senior Military Adviser-International at U-TacS: "Sensors and systems are much more important than the structure of the UAV. WATCHKEEPER X, in the version proposed for Romania, has state-of-the-art sensors. The UAV has two sensors under the drone and two inside the fuselage. There are no class II UAVs that have such a system, only the higher class UAVs, which are bigger, but also more expensive." In other words, Elbit's WATCHKEEPER X is the best in its class.

On 13 June 2022, after two and a half years of contemplating the procurement of UAVs, Romania decided to cancel Elbit Systems contract. Defence Minister Vasile Dincu said: "At this moment, the concrete ways of resuming the procurement procedure are under analysis."

HERMES 900 UAV

In November 2015, Elbit Systems won a contract worth about US$200M from the Swiss Government for the purchase of six HERMES 900 systems and ground systems. By the end of April 2022, deliveries of the first two UAVs and various maintenance materials arrived in Switzerland. After the UAVs had been assembled by specialists from Elbit and the first functional test had been carried out, Swiss Army specialists started the first ground and flight tests.

After completion of flight testing and approval by the military aviation authority MAA, the two UAVs will be handed over to the Swiss Air Force in the second half of 2022. The remaining four UAVs will be delivered by the end of 2023.

Electronic Warfare Suite and Logistic Support Systems

In October 2019, Elbit Systems won a contract with the Portuguese Air Force for the provision of electronic warfare (EW) suite and logistic support systems for Portugal's KC-390 transport aircraft. The contract was worth US$50M. The contract will be carried out over a five year period.

Under the contract, Elbit Systems will supply a complete EW suite consisting of radar and laser warning systems, IR missile warning system, a countermeasures dispensing system, a directional IR countermeasures (DIRCM) system and an active Electronic Countermeasures (AECM) POD system.

Photo: IAI

The ELM-2084 radar

Executive Vice President and General Manager of Elbit Systems EW and SIGINT – Elisra, Edgar Maimon, said: "The Portuguese Air Force is a long-standing strategic partner of Elbit Systems and we are proud of this contract award to provide enhanced survivability for the new fleet of KC-390 aircraft."

ELM-2084 Radar

The IAI subsidiary, Elta Systems, sold eight ELM-2084 multi-mission radars (MMRs) to the Czech Republic in December 2019 in a G2G contract worth US$125M. The radars are for the Czech Mobile Air-Defence Radar (MADR) programme. The programme includes Czech businesses, whose work will make up for about 30 per cent of the contract's value.

Under the contract, the radar will be adapted to operate with Czech and NATO C2 technology as the final delivery is expected to be made in April 2023.

IAI Executive Vice President and the CEO of Elta Systems, Yoav Tourgeman, said: "The contract with the Czech Republic will open more doors for Israeli industry to sell its surveillance and air-defence capabilities in Europe. All radar must be modernised to engage and detect and enable engagement of current and future threats."

Multi-Mission Radars

In March 2021, the Defence Ministries of Israel and Slovakia signed the agreement for the sale of 17 MMRs manufactured by IAI subsidiary Elta Systems for €148M. The deal includes the MMR radar for medium ranges and additional radars for short ranges for the Slovak Air Force, providing a variety of advanced capabilities for detecting and identifying different airborne threats.

The agreement that was signed includes the transfer of technology (ToT) and know-how from Israel to Slovakia, as well as industrial cooperation, including support of local industry. As part of the deal, the radar components will be manufactured in cooperation with local defence companies in Slovakia, under the guidance of the Israeli MoD and IAI.

Tourgeman said: "IAI is proud to provide Slovakia with this advanced technology and be an important part of Europe air-defence solutions, including supporting and integrating into NATO activities."

The Slovak Defence Minister, Jaroslav Nad, said: "I highly value the positive impact of this cooperation on the bilateral ties between Slovakia and Israel in the field of defence and security and I do believe we have now a solid basis for our next cooperation." Minister Nad decided not to elaborate further on what this cooperation might entail.

Photo: CC BY-SA 3.0

The Rafael SPYDER SAM system

SPYDER Air Defence System

In September 2021, the Czech Ministry of Defence signed a contract to acquire the SPYDER air defence system manufactured by Rafael Advanced Defense Systems. The ministry said in a statement: "The contract is worth US$627M," however, "combined with the costs of maintenance and repairs, the acquisition will cost the country's budget about US$1Bn." Czech Defence Minister, Lubomir Metnar, said: "The purchase would enable his country to replace its outdated, Soviet-designed 2K12M KUB air defence system with modern military technology."

Under the contract, the Czech defence industry will take part in the programme, supplying products and services worth more than 30 per cent of its value. It is known that the Czech technology company Retia has become the main industrial partner of Rafael and will work closely with the state-owned company VTU, which is in charge of integrating the classified part of the SPYDER system into the Army Czech Republic (ACR). The Ministry also stated: that "Deliveries of the four batteries are scheduled to be completed by 2026."

The task of the new air-defence system will be to protect the grouping of ground forces, important airports, industrial centres, nuclear power plants and other designated facilities.

Conclusion

It appears that the EU has become the top market for Israeli weapon systems, in general, and a very important market for air systems, in particular. Furthermore, the importance of the Israeli air defence systems for EU Member States is undeniable, as a result of the Russian war against Ukraine and Russia's military bombardment of Ukrainian cities, train stations and other civilian infrastructure with missiles. Whether or not we will see further contracts signed between Israeli defence companies and EU Member States with regard to the air systems remains to be seen. One thing is for sure, the EU Member States realise that as long as they are unable to manufacture air systems in the EU, Israeli air systems used in combat operations are worth considering and buying. The case of Slovakia, in particular, shows that IAI's subsidiary Elta Systems is not shy when it comes to the transfer of technology and know-how from Israel to Slovakia. The example of Elta Systems is likely to follow if the Israeli company wins a tender in a future delivery of air defence systems. ■

SKYKEEPER

David Saw

Expanding Ground-Based Air Defence Possibilities in Britain

SKYKEEPER is a Battle Management, Command, Control, Communications, Computers and Intelligence (BMC4I) system. It is designed for ground-based air defence (GBAD), Counter-Unmanned Air System (C-UAS) and Counter-Rocket, Artillery and Mortar (C-RAM) applications. The system was designed, developed and produced by Lockheed Martin UK, Ampthill, Bedford. This is significant as the system has UK Intellectual Property (IP), meaning that its export and utilisation are solely subject to UK regulations.
The roots of the SKYKEEPER system can be found in two other systems, the first of these was Automated Sense and Warn (AS&W) which entered service in 2009. AS&W is a deployable C-RAM system that detects incoming projectiles and provides warning so that personnel can take cover. The system was used in Afghanistan. The AS&W system was never linked to an effector such as a land-based CIWS; it was solely a warning system.
The second system that provided the basis for SKYKEEPER was called Land Environment Air Picture Provision (LEAPP). It entered service in 2013. LEAPP provides airspace management and surveillance for a land component commander up to divisional level, fusing data from various sensors and correlating that data. LEAPP was starting to have a number of obsolescence issues. It was based on an old Windows operating system that was becoming insecure; it was not compatible with new Link 16 terminals and there were issues with Mode 5 IFF data display.

Photo: Lockheed Martin UK

It might just look like a ruggedised computer and some screens, but the key to what is happening here is the Lockheed Martin UK SKYKEEPER software that provides a full BMC4I capability, with the system being modular in structure and sensor, effector and communications agnostic.

A Modular System

To turn back the tide of obsolescence for LEAPP, Lockheed Martin UK proposed to the MoD that they integrate their SKYKEEPER software into the LEAPP system and the resulting integration would remove the obsolescence issues and add in a host of new capabilities, for example integrating an increased number of sensors to the existing system, fundamentally enhancing its capabilities. The key element here is that SKYKEEPER is a modular system that can be configured as the operator sees fit. It is also sensor and communications system agnostic and can be integrated with a large number of different effectors. The MoD agreed to the proposal and a contract was signed in December 2021 that effectively sees LEAPP evolve into SKYKEEPER and therefore have the ability to become a fully capable BMC4I system.
As previously noted, the LEAPP system was originally designed to inhabit the land battlespace. This would allow to coverage of ground forces elements from a battle group up to a division-sized force. Lockheed Martin in the US looked at what its UK activity was doing in terms of BMC4I and saw the opportunity to develop GBAD Battle Management System (BMS) that could be scaled as a fully networked GBAD solution that could cover a country. Indeed, Lockheed Martin made a proposal for a HAWK replacement programme in the Middle East with the SKYKEEPER BMC4I system at its heart, linked to the Saab GIRAFFE 4A as its main sensor, with the Diehl Defence IRIS-T SLM missile system as its main effector.

Evolving Threats

Clearly, recent events such as the invasion of the Ukraine have forced many countries to analyse their air defence capabilities and to become very concerned about their ability to cope with evolving threats. This has seen one major UK ally located outside of Europe embark on a programme for a country-wide GBAD system combining selected sensors and effectors with a full medium-range engagement capability. It is understood that the SKYKEEPER is being seriously considered as providing the 'central nervous system' of this proposed GBAD system providing a fully networked BMC4I functionality. A decision on the fate of this GBAD requirement is expected in the near future.

Meanwhile there are GBAD developments taking place in Britain. In December 2021, 16 Regiment Royal Artillery took first deliveries of the SKY SABRE air defence system. This system consists of the Rafael SAMOC C2 system, the Saab GIRAFFE AMB (Agile Multi Beam) radar and the MBDA CAMM missile system as the effector. In March 2022, the British MOD deployed a SKY SABRE system to Poland to enhance the GBAD capability of a NATO ally. Poland will be utilising the CAMM missile as the central element of a new Polish SHORAD system.

SKY SABRE will act as the replacement for the RAPIER FSC system, but it is only part of the air defence story in Britain. The British government has committed to enhancing British air defences and are currently in the assessment phase for a new fully NATO compliant and compatible GBAD system. Potentially, this will open the way for the SKYKEEPER system to provide the BMC4I structure for this new GBAD system. ■

Photo: Crown Copyright

The three elements of the British SKY SABRE air defence system grouped together; the Rafael SAMOC C2 system, the Saab GIRAFFE AMB radar and the CAMM missile system. Britain is now looking for a full GBAD system combining multiple sensors and effectors to deal with broad spectrum threats.

GDELS Presents All-Electric DUROe

Gerhard Heiming

The DURO vehicle family by General Dynamics European Landsystems (GDELS) has received an all-electric member. At Eurosatory, GDELS presented the DUROe, which has an internal combustion engine including gearbox with tank removed and replaced by an electric drive with lithium ion batteries. Two electric motors, each with 180 kW, power the DUROe on all wheels, which is almost three times as much as provided for the basic model. The nominal power-to-weight ratio is 57 kW/t. In addition, peak powers of up to 2x400 kW are possible for short periods. Torques have increased almost by the same amount to 2x550 Nm (peak 2x1,225 Nm), leaving hardly anything to be desired in terms of pulling power.

Energy is provided by a lithium ion battery with a capacity of 120 kWh (255 kWh on request) located between the longitudinal girders. According to the manufacturer, this covers a driving range of up to 310 km with top speeds of up to 95 km/h. The battery can be charged with up to 110 kWh. This results in charging times of a good hour (or just under two and a half hours) for a full charge. After 20 minutes, the battery has enough capacity to cover a distance of around 100 km.

The total weight remains at 6.3 tonnes, of which up to 1.7 tonnes are available for payload, depending on the battery selected. The chassis can accommodate mission-adapted superstructures. According to technical data released by the company, the off-road capability is the same as with the conventional DURO. Driving performance should be significantly improved thanks to the higher engine power and torque. GDELS offers possible applications for troop carriers, command vehicles, logistic transport vehicles, ambulances and police cars.

Thanks to the electric drive, the DUROe offers almost silent and low-signature propulsion. During stationary operations such as observation, treatment of wounded or communication, the no-noise, no-heat producing engine runs in "silent-watch mode". The energy reserve allows the delivery of power to external consumers such as for charging battery packs of portable devices.

The maximum driving range of 310 km, which may be reduced by silent watch, requires precise mission planning, in which charging times may have to be included. ■

Image: GDELS

DUROe – a new member of GDELS' DURO family of wheeled vehicles

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