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Contents

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Cover Photo: A US Air Force F-16 Fighting Falcon flies during the 'Desert Falcon' exercise in Israel, 16 January 2022. Desert Falcon is a joint international exercise in which the Israeli and US aircrews trained for various aerial scenarios and strikes.
(Photo: US Air Force/Capt. Lauren Linscott)

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A Time of Growth

Photo: author

With February upon us, European Security and Defence is proud to announce that our editorial team is growing with the appointment of Peter Felstead as News Editor. Peter's name should be very familiar to everyone in the aerospace and defence industry – he is a highly experienced journalist with over 33 years spent covering the sector. After previously editing Janes Intelligence Review for three years and also serving as a special correspondent for Janes Defence Weekly, reporting from global hotspots including Kosovo and Iraq, Peter was appointed as the editor of Janes Defence Weekly in March 2004. He served in that role until he left the company in December 2021 to pursue a freelance career.

Peter's work has secured him significant acclaim. In 2018 he won the inaugural John Morrocco Award for Best In-Depth Defense Reporting at the Defence Media Awards for 'Silver Bullet Solution': a feature-length article focusing on ballistic missile defence. More recently, Peter won the award for Best Military Propulsion Submission at the 2022 Defence Media Awards for his feature 'HED Draws Closer to the Battlefield'.

The entire Mittler Report team is very excited to welcome Peter on board, and greatly welcomes his contributions. As the year rolls on, the ESD team looks forward to bringing our readers further hard-hitting analytical content, deep dives, and exclusive information. With that, it's over to you Peter!

Mark Cazalet

…and a Few Words from ESD's Latest Colleague

Photo: author

I have to say, firstly, that I'm very happy to be joining at ESD a team strongly committed to objective journalism in covering the aerospace and defence industry. Having worked so long on aerospace and defence, I really don't think I could ever step away from such a fascinating and engaging sector. Part of that fascination is with the people and the technology, of course, but the ongoing conflict in Ukraine serves to highlight what an essential sector this is in preserving the security that we all-too-often take for granted.

It is also refreshing to see that, as long as the business model remains viable, ESD remains committed to publishing in the hardcopy format when so many other publishers are closing their magazines or retreating from objective defence journalism entirely. That is not to deny the future of what ESD offers online; it's just an acknowledgement that the discipline required to publish a magazine, where the news must be curated and proofed, carries through a positive effect in all formats of publication. I thus very much look forward to contributing to ESD's output in covering the world of defence.

Peter Felstead

US Army Selects Final Four Competitors for Common Tactical Truck Programme

(gwh) On 27 January 2023, the National Advanced Mobility Consortium (NAMC), the evaluation body for the US Army, selected the American Rheinmetall Vehicles/GM Defense joint venture, Oshkosh Defense, Mack Defense, and Navistar Defence for the first phase of the US Army's Common Tactical Truck (CTT) programme.

Photo: Rheinmetall

The CTT family of trucks is intended replace 40,000 legacy heavy tactical trucks for the US Army, including the M915 Line Haul Tractor, M1088 Medium Tractor, Palletized Load System (PLS), and Heavy Expanded Mobility Tactical Truck (HEMTT). The four companies have been awarded a combined total of USD 24.24 M, to provide three prototypes each for the CTT family of vehicles, with one prototype covering the replacement for M915 and M1088, one for PLS, and one for HEMTT. The multi-phase programme is valued at approximately USD 14 Bn (EUR 12.9 Bn) in total.

In the first phase, prototypes are to be built for trials, which are due to begin at the end of 2023. Once trials have been completed from around late 2023, the supplier is expected to be selected in time for an initial production and delivery contract to be signed in 2025.

American Rheinmetall and GM Defense have entered a strategic partnership for this programme, to create a technologically sophisticated modern tactical truck which improves on the legacy vehicles with the implementation of various modern features. These include advanced driver assistance systems (ADAS) for greater safety, an open digital architecture, support for autonomous operation, increased off-road capability, cyber security, improved survivability and fuel efficiency, as well as other new technologies.

The vehicles will be based on the HX3 series from Rheinmetall's subsidiary Rheinmetall MAN Military Vehicles (RMMV), which has been unveiled in mid-2022. It is a further development of the HX vehicle family, which operationally proven and has entered service with a number of NATO member states. The HX3 series is based on the commercial truck portfolio of MAN Truck and Bus, and contains a high degree of commercially available components, which according to Rheinmetall was a priority requirement of the US Army in the CTT programme. The company stated that the design is configurable from a 4×4 to 10×10 chassis, and possesses a high level of commonality across variants.

Oshkosh Defense said their CCT prototypes are based on a modernised version of the proven Family of Heavy Tactical Vehicles (FHTV) platform. The company stated that they had already developed six CTT variants, including Load Handling System (LHS), Off-Road Tractor, Line Haul Tractor, Cargo, Wrecker, and Tanker. The company stated that their FHTV's flexible architecture allows it to support a variety of missions, and the vehicle can be scaled up or down with minimal changes. Oshkosh added that their platform offered the technologies to meet the US Army's requirements for active safety, fuel demand reduction, autonomy, mission flexibility, prognostics, commonality, and superior survivability.

Swedish Army Orders 20 Additional Mjölner Mortar Systems

(jh) BAE Systems has received a contract modification from the Swedish Defence Materiel Administration (FMV) to build 20 additional CV90 mortar vehicle, the company writes in a press release. The approximately USD 30 M contract was awarded to the BAE Systems Swedish joint venture HB Utveckling AB, which combines BAE Systems' Hägglunds and Bofors manufacturing capabilities. Production will be performed at BAE Systems Hägglunds in Örnsköldsvik, Sweden.

The original contract for 40 CV90 Mjölner systems was awarded in 2016, and deliveries of the systems started in 2019 and were completed in 2020. In February 2022, FMV awarded the first follow-on contract for 20 additional systems, as well as the upgrade of the 40 systems already in service, to bring them all to the same standard by integrating the Swedish Army's new C4I LSS Mark system.

Once the contract modification deliveries are completed in 2025, the Swedish Army will operate 80 CV90 mortar

Photo: BAE Systems

vehicles in its fleet. The vehicles, known as Granatkastarpansarbandvagn 90, are to provide indirect firepower capabilities for the mechanised brigades.

There are approximately 1,300 CV90s, in multiple variants, in service with Denmark, Estonia, Finland, Norway, Sweden, Switzerland, and the Netherlands.

Rheinmetall to Modernise the German Army's "Future Soldier – Expanded System"

(jh) Rheinmetall has been awarded a contract to modernise the command and control equipment of the German Bundeswehr's soldier systems, the company writes in a press release. A total of 14 "Future Soldier- Extended System" platoon systems are to be delivered to the troops. These comprise equipment for 476

Photo: Rheinmetall

individual soldiers. Worth a figure in the mid-double-digit million-euro range, the order was booked in December 2022, shortly after the budget committee of the German Parliament appropriated funding from the country's EUR 100 billion special procurement fund.

The VJTF 2023 version of the "IdZ-ES" soldier system links dismounted troops to the Puma infantry fighting vehicle, which serves as their "mother ship". For the German Army, the "System Panzergrenadier" represents a significant step in the process of digitisation. According to Rheinmetall, it offers two essential advantages. First, it is now possible for all mounted and dismounted personnel to access the same information. Second, they can share this information more precisely, more quickly and in a more robust manner.

DMC to Deliver Rudders for German F126 Frigates

(jh) Damen Marine Components has received the order to design, engineer and produce eight rudders for the four F126 frigates that Damen Naval is building for the German Navy, the company writes in a press release. Each vessel will be equipped with two rudders, developed to withstand extreme shocks and to improve the hydrodynamic properties of the fast vessels.

Image: Damen

According to Damen, the full spade rudders of the Atlantic type by Damen Marine Components (DMC) are purpose designed for the frigate project to fit the specific hull form and operational profile of these naval vessels. The rudders have a relatively slim profile to reduce drag and improve course keeping at high speeds, maintaining good manoeuvrability at low speeds in harbours or during special operations. The Asymmetric Rudder Technology (ART) as developed by DMC will be applied. This means that the leading edge of the rudders will be asymmetric, directing the turbulent water flow from the propellers in front of the rudders along the rudder surface more smoothly. This is to reduce cavitation, increase rudder efficiency, and reduce drag of the vessel.

Elbit Awarded Contract to Provide DIRCM Service Centre for NATO

(jh) Elbit Systems has announced the award of a five year in-service support contract with the NATO Support and Procurement Agency (NSPA) for the Direct Infrared Counter Measures (DIRCM) systems supplied to the Multinational Multi-Role Tanker Transport (MRTT) fleet. The contract includes the establishment of a service centre located at NSPA to provide support and logistics to the system.

Photo: Elbit

Equipped to provide comprehensive support to the NATO MRTT fleet equipped with the DIRCM system, the NSPA dedicated facility, in Luxembourg, is expected to become an essential resource for the fleet, providing expertise, equipment, and maintenance. The centre is to provide repair, spare parts and maintenance services.

In addition, Elbit was awarded a follow-up contract from NSPA for an additional J-Music system, part of the MUSIC DIRCM family. The laser-based system provide-sprotection against advanced heat-seeking ground-to-air missiles. To date, seven systems are already integrated, certified and operational on NATO MRTTs.

Steel Cut for Second Royal Navy Type 31 Inspiration Class Frigate

(jh) Babcock has reached a milestone on the Type 31 programme, to deliver five Inspiration Class frigates for the Royal Navy, as it cut steel marking the official start of HMS Active's build programme at Rosyth, the company writes in a press release.

16 months after steel was cut on the first ship, HMS Venturer, Babcock welcomed senior guests from the UK Government and Royal Navy, alongside international industry to witness the traditional shipbuilding ceremony. Joining the ceremony were veterans from the former Royal Navy Type 21 frigate and namesake HMS Active. A key component of the UK's National Shipbuilding Strategy, the Type 31 programme is expected to support a direct UK workforce of around 1,250 people including 150 apprenticeships and a further 1,250 people in the supply chain at the height of the programme.

Airbus to Provide Satellite Communications for Belgian Armed Forces

(jh) Airbus has signed a contract with the Belgian Ministry of Defence to provide tactical satellite communications services for a 15 year period, the company writes in a press release. The Belgian armed forces will utilise chan-

Image: Airbus

nels of the Airbus UHF (Ultra High Frequency) military communications hosted payload on-board a commercial telecommunications satellite manufactured by Airbus. As the UHF frequency band is a relatively scarce orbital resource, this offering will make up for the capacity shortage around the world, Airbus emphasises. Airbus has already signed several firm orders for this capacity, well ahead of the satellite's scheduled launch. The UHF payload will be operated from Airbus's Network Operations Centre in Toulouse. Reportedly, its 18 UHF channels will enable up to 200 simultaneous communications over Europe, the Middle East, Africa, large parts of Asia, as well as the Atlantic Ocean (to eastern Brazil) and the Indian Ocean (to western Australia).

Fuel Cell-Based AIP to Be Fitted to INS Kalvari

(jh) The 'fuel cell-based Air Independent Propulsion system (AIP) of DRDO's Naval Materials Research Laboratory (NMRL) will soon be fitted onboard INS Kalvari. An agreement has been signed between senior officials of NMRL and Naval Group France in Mumbai, Naval Group writes in a press release. The objective is to enter into the detailed design phase for the integration of an indigenous AIP for the

Photo: Naval Group

Kalvari class submarines. As part of the agreement, Naval Group France is to certify the AIP design for integration with the submarines.
The AIP is expected to enhanced the submarine's submerged endurance by several folds. According to the company It has merits in performance compared to other technologies and is unique as the hydrogen is generated onboard. This technology has been developed by NMRL with the support of Indian industry partners. The technology has now reached the stage of maturity for industrialisation, Naval Group emphasises. The land-based prototype of the NMRL's AIP has been tested successfully.

Fifth Kalvari Class Submarine for the Indian Navy Commissioned

(jh) On 23 January 2023, INS Vagir, the fifth P75 Kalvari-class submarine for the Indian Navy, was commissioned in the presence of the Chief of Naval Staff, Admiral R Hari Kumar, PVSM, AVSM, VSM, ADC and several other senior dignitaries, Naval Group writes in a press release. INS Vagir has been built by Indian shipyard Mazagon Dock Shipbuilders Limited (MDL) based on Naval Group's Scorpene design. Launched on 12 November

Photo: Naval Group

2020, INS Vagir completed all scheduled sea trials and is now entering service with the Indian Navy. She will join INS Kalvari, INS Khanderi, INS Karanj and INS Vela which had already been commissioned in December 2017, September 2019, March 2021 and November 2021 respectively. The last submarine of the P75 series, Vagsheer, is currently completing her sea trials with delivery scheduled in 2024.

Terma Prime for Danish Air Defence System

(jh) The Danish Defence Aquisition and Logistics Organisation (DALO) has awarded a contract to Terma to be the overall system integrator of integrated air and missile defence systems for the Danish Defence, the company writes in a press release. The contract is a framework agreement covering 30 years. Under the terms of the contract, Terma will be responsible for system integration of the complete air defence system, and advisor on all future air and missile defence procurement efforts across the Danish Defence for the next 30 years.
As part of the current contract, DALO is to procure an air defence system for the Danish Defence compliant to NATO requirements for the Very Short-Range Air Defence (VSHO-

Photo: Terma

RAD) capability that forms part of Denmark's medium brigade which is a NATO force target. This VSHORAD system can be procured through this new framework agreement.
The overall air defence system consists of several subsystems, such as radars, vehicles, and weapons. Terma is to integrate these subsys-

tems into a single air defence system. Many of the subsystems are off-the-shelf items procured by DALO through existing framework agreements.
Reportedly, the future elements of the air and missile defence systems will also be part of Denmark's national defence and will be compliant with interoperability requirements, including the ability to be part of different configurations of air defence capabilities within the land, sea, and air domains. Interoperability requirements follow NATO standards, procedures, and guidelines for the overall air defence domain.

IAI Unveils the Point Blank EO Guided Missile

(jh) IAI has unveiled its Point Blank electro-optically guided missile, that can be carried in a soldier's backpack. The system answers the battlefield requirement to provide tactical units ranging in size from small tactical teams to battalion level, with an independent and organic capability to increase their lethality, the company writes in a press release. Point Blank is expected to allow these units to attack a variety of targets in real time with great precision and high lethality, without the need for support. The missile is hand-launched, operated by a single soldier, and can be launched from the soldier's hand.


Image: IAI

According to IAI, the company has been competitively awarded a multi-million-dollar contract by the Irregular Warfare Technical Support Directorate (IWTSD) of the US Department of Defense (DoD) to rapidly develop and deliver "ROC-X" a version of the Point Blank system that meets specific US DoD requirements for the purpose of increasing the organic precision strike lethality and survivability of small tactical teams. IAI is to provide the first prototypes and training to DoD for operational testing and evaluation in FY 23.
Point Blank weighs about 15 lbs and is about 0.91 m (3 ft) long. Reportedly, the missile can fly at altitudes above 457 m (1,500 ft) at a maximum speed of 186 km/h (178 mph) and can hover or loiter in the air while the target's nature and exact position is confirmed prior to attack. The missile can carry electro-optical systems to validate and collect surveillance information in real time, and it is also being developed to be equipped with a warhead to destroy the target.

Hensoldt Develops SIGINT Pod Demonstrator for Eurodrone

(jh) Hensoldt is developing sensor equipment that can be integrated with a pod to give the recently commissioned Eurodrone a signals intelligence (SIGINT) capability, Hensoldt writes in a press release. The sensor technology for reconnaissance of radio and radar signals is based on a combination of the technologies in


Photo: Hensoldt

digitisation, electronic beam steering and metallic 3D printing, some of which Hensoldt has already developed in the scope of its Kalaetron product family. According to the company, the contract for the implementation and testing of a SIGINT demonstrator worth approximately EUR 15 million has been awarded by the Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw).
Under the terms of the contract, Hensoldt is also tasked with the development of a system architecture for integrating the SIGINT capability with the future mission system of the Eurodrone as part of this contract.
The Kalaetron product family is already being used as part of self-protection and signals intelligence systems of the German armed forces.

Rheinmetall to Regenerate the Bundeswehr's Modular Medical Equipment

(jh) The German defence procurement authorities, the Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support (BAAINBw), has awarded Rheinmetall a contract for the conversion of modular medical equipment (German abbreviation: MSE), the company writes in a press release. Worth an amount in the mid-single-digit million-euro range, the order has to be completed by December 2023.


Image: Rheinmetall

MSE containers comprise a family of modular ambulance facilities manufactured by Zeppelin Mobile Systeme. In the 1970s, various user states procured rescue station, rescue centre light, rescue centre and emergency hospital variants, which are now undergoing a comprehensive overhaul.
MSE rescue centres and field hospitals are used in Bundeswehr areas of operation. Individual systems are designed for special tasks such as the generation and supply of medical gases in the equipment supply container, or GVC. In deployed operations, the technical and medical equipment of the GVC supports the adjacent operating theatre. The container systems are CSC-classified, stackable and thus suitable for transport on container ships. The systems and their equipment are adapted in terms of scope and functionality.

Hensoldt to Deliver More Air Surveillance Radars to Ukraine

(jh) Hensoldt is supplying two more of its TRML-4D high-performance radars to strengthen Ukraine's air defence, the company writes in a press release. As part of an order worth a two-digit million euro sum, the two radars will be delivered in the next three months. At the turn of the year, Hensoldt had already contracted four TRML-4D radars as part of the IRIS-T SLM air defence system for Ukraine.


Photo: Hensoldt

TRML-4D uses Active Electronically Scanned Array (AESA) radar technology with multiple digitally shaped beams. According to the company, it is capable of detecting, tracking and classifying various types of aerial targets, with a focus on small, fast and low-flying and/or manoeuvring cruise missiles and aircraft, as well as helicopters. It ensures the rapid detection and tracking of about 1,500 targets in a radius of up to 250 km.

XTEND Awarded Contract to Develop Operating System for Drones

(mc) On 18 January 2023, Israeli Company XTEND announced that it has been awarded

Photo: XTEND

a USD 20 million contract by the Israeli Ministry of Defense (MoD) to further develop and provide the XTEND Operating System (XOS) for UAVs.

The joint project is being undertaken in collaboration with the Israel Ministry of Defense – Directorate of Defense Research & Development (IMOD DDR&D), and aims to enable operators to command multiple UAVs simultaneously, and also offering support for virtual reality (VR), automation, and third-party apps. XTEND had previously signed a similar contract with the US Department of Defense, aimed at enabling operators to simultaneously control multiple UAVs.

Vincorion to Improve German Puma AIFV Fleet

(jh) Vincorion has been awarded a contract to improve the power system in the Puma infantry fighting vehicle, the company writes in a press release. In the scope of the contract, the power electronics are to be reengineered with modern components to be more robust.

At the company's Wedel site in Germany, the team will be working to improve the power electronics of the Puma, thus concentrating on an area that was not affected by the recent outages. The requirement in-

Photo: Vincorion/Adobe Stock

cludes the new certification of components that are no longer available on the market; in addition, other features are to be incorporated such as the powering of an electric exhaust turbocharger and external charging of the infantry fighting vehicle.

American Rheinmetall Systems to Continue Supporting US Army CROWS Programme

(mc) On 18 January 2023, Rheinmetall announced that their subsidiary American

Photo: Rheinmetall

Rheinmetall Systems had signed a 5-year framework contract with Kongsberg Defence & Aerospace to continue the supply of components for the US Army's Common Remotely Operated Weapon Station (CROWS) programme. The total value is as of yet unconfirmed, however Rheinmetall stated that the potential value was in the "double-digit million-dollar range". American Rheinmetall Systems supplies a number of components for the CROWS programme, including HD day cameras, weapon mounts, and various others. In 2007, the US Army's selected Kongsberg's

Protector M153 remote weapon station (RWS) for their CROWS II programme. This was a variant of Kongsberg's earlier M151 design which was used with the US Army's Stryker infantry carrier vehicle. Kongsberg has continued as the CROWS programme supplier with the more modern CROWS III and CROWS-J variants, the latter of which integrates an FGM-148 Javelin anti-tank guided missile (ATGM). The Protector M151/M153 series is now referred to as the 'Protector RS4' series since Kongsberg undertook a rebranding of their RWS product line.

German Police Force Selects ESG's Elysion Software for Drone Defence

(jh) The regional police force of the German state of North Rhine-Westphalia (NRW) has announced its decision to procure ESG's Elysion software. the company writes in a press release. Reportedly, police forces in NRW will use the counter-UAS software for protection against drones. The decision to procure the software was preceded by intensive testing on behalf of the responsible State Office for Central Police Services. According to the Drone Defence Operational Advisory Centre at the NRW Central Police Office, Elysion has proven its performance during a comprehensive test phase and was also able to demonstrate its operational readiness at last year's G7 summit in Elmau, Germany, ESG emphasises. Police authorities of German federal- and state agencies, the German armed forces as well as international customers are among the Elysion users. Elysion is a further development of the Guardion software core consisting of processing core intelligence and networked, map-based situation display.

Foto: Bundeswehr

Spanish Special Forces Received Photonis 4G Image Intensifier Tubes

Photo: Photonis

On 17 January 2023, Photonis announced that the Special Forces of the Spanish Army had previously signed a contract with NVLS (Night Vision Lasers Spain) for 450 night vision binoculars, using Photonis 4G image intensifier tubes. Photonis stated the contract was valued at "several million euros", and that the products had already been delivered at the end of 2022. The Spanish Army has previously bought Photonis image intensifier tubes for AN/PVS14 type monoculars, through a multi-year contract signed in 2019.

Plasan to Supply Armour for Australian Navy's Hunter class Frigates

(jh) Plasan has announced a contract with BAE Systems Australia to armour the first three HUNTER class frigates for the Royal Australian Navy (RAN). Plasan is to deliver the armour in partnership with Australian steel manufacturer Bisalloy Steel Australia who will be responsible for the production of the ballistic steel under the contract. BAE Systems Australia is under contract to deliver nine Hunter class ASW frigates to the RAN, thus replacing the ANZAC class frigates currently in service. Plasan is also currently providing composite armour for the UK Type 26 frigates.

Image: Plasan

The Hunter class, to be built at the Osborne Naval Shipyard in South Australia, is expected to provide increased capability and flexibility through an innovative design that includes a large flight deck, an integrated mission bay and hangar able to support a range of manned and unmanned systems, and unique sonar capabilities.

Lithuania Orders CAESAR Self-Propelled Howitzers

(jh) On 15 December 2022, Nexter announced that the French and Lithuanian defence ministers signed a technical cooperation agreement in the artillery sector, including an order for 18 CAESAR 6×6 MkII self-propelled howitzers (SPHs) for the Lithuanian Armed Forces.

CAESAR 6×6 MkII is a new variant, whose development of this version was ordered in 2021 by the French DGA procurement agency for the needs of the French Army. It combines a new chassis designed by Arquus, a cabin with increased protection, and the artillery armament of the version already in service. The development of this new version was launched in December 2021 by France, and its entry into service is planned for 2026. For its national configuration, Lithuania will actively participate in the development phase of its 18 systems.

Photo: NEXTER

In 2022, contracts awarded by the DGA include 18 CAESAR 6×6 MkI to replenish the systems transferred to Ukraine from French Army stocks, and Belgium and Lithuania respectively ordered 9 and 18 CAESAR 6×6 MkII SPHs respectively. Additionally, the Czech Republic ordered 10 CAESAR 8×8 SPHs to complement the 52 systems ordered in 2021. These contracts bring the number of CAESAR systems ordered in different versions by four customers to 55.

Rheinmetall Contracted to Modernise Skyguard Air Defence Systems

(gwh) Rheinmetall announced that they are due to modernise the Skyguard cannon-based 35 mm air defence systems of an unnamed customer in a contract valued "in the low three-digit million euro range". According to the company, the systems will be upgraded to the modern Oerlikon GDF009 configuration. The work is due to commence in 2023, and will be performed by Rheinmetall Italia.

The GDF009 standard is capable of using Rheinmetall's AHEAD programmable air burst ammunition. Each round is loaded with 152 tungsten sub-projectiles weighing 3.3 g each, and contains a time-based fuze to activate the dispersion of the sub-projectiles. This will enable the customer country's armed forces to protect itself and its vital assets from a wide range of threats from the air – including small unmanned aerial vehicles (sUAVs). The GDF009 version is also typically offered with the Skyguard 3 fire control unit, which can be integrated into networked air defences.

Photo: Rheinmetall

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In modern warfare, the challenge is to have the best performance image intensifier based equipment that is always more efficient than the one of the opposing forces. The many features of Photonis products have managed to convince the vast majority of European armies these past years: lightness of equipment, longevity of tubes, ability to see farther in increasingly low levels of darkness, ultra fast auto-gating function preventing blinding...

In the European Union, night vision equipment using the 4G technology in 16mm format has become the standard: Germany, United Kingdom, Spain, The Netherlands, Poland notably.

Joachim Sucker to become Director of OCCAR EA

As of 1 February 2023, German Ministerialdirigent Joachim Sucker will become Director of the European procurement agency OCCAR EA. He succeeds Italian Vice Admiral Matteo Bisceglia, who is routinely leaving office after three and a half years.

Photo:OCCAR

Sucker is currently head of the Equipment IV sub-division in the German Federal Ministry of Defence. Since November 2014, he has been responsible for the equipment and use of air systems, from combat aircraft to transport aircraft and helicopters to unmanned aerial systems as well as airborne and space-based reconnaissance systems.

The inauguration had already taken place on 20 January by the Chairman of the Supervisory Board of OCCAR, Vice Admiral Carsten Stawitzki. Stawitzki has held the office since 1 January. Gerhard Heiming

Iveco Defence Vehicles Announces Partnership with Horiba Mira

(jh) Iveco Defence Vehicles (IDV) has announced that the company has entered into an agreement to become the majority

Photo: IDV

shareholder in Mira UGV, Horiba Mira's Uncrewed Ground Vehicle (UGV) division. The agreement is to combine IDV's expertise as a manufacturer of defence vehicles with Horiba Mira's position as a sector-leading company in delivering uncrewed ground vehicle solutions, IDV writes in a press release. The agreement is also expected to provide capital and capability to move Horiba Mira's UGV platforms and technology to the next stage of development and production.

New Rheinmetall Ammunition Factory in Hungary

(jh) The foundation stone has been laid for the new Rheinmetall plant in Várpalota, Hungary, where ammunition for various systems is to be produced by the joint venture Rheinmetall Hungary Munitions in cooperation with the Hungarian state, Rheinmetall writes in a press release. Production of 30 mm medium-calibre ammunition for the Lynx infantry fighting vehicle now being manufactured at the Rheinmetall plant in Zalaegerszeg is scheduled to start in 2024.

In a second phase, production capacity is planned to be expanded and the product range widened to include other ammunition types. Rheinmetall then expects to be able to produce ammunition for the Leopard 2 tank and PzH 2000 self-propelled howitzer at the Várpalota plant. Both of these systems are used by the Hungarian Army. Part of the production is ear-

Photo: Rheinmetall

marked for the Hungarian armed forces, with some products destined for export.

Full production capacity is scheduled to be reached in 2025. In addition, Rheinmetall also plans to conduct R&D in Várpalota. The company is thus expanding its ammunition production capacity. It recently announced the acquisition of Spanish ammunition maker Expal, which will double its manufacturing capacity in this domain. Rheinmetall also produces ammunition in Germany, Italy, Switzerland, South Africa, and Australia.

Rheinmetall Acquiring Stake in Incooling B.V. of the Netherlands

(jh) Rheinmetall has announced a strategic partnership with Incooling B.V., reportedly a Dutch specialist for IT server solutions. Under the arrangement, Rheinmetall is acquiring a share in the company. According to Rheinmetall, this investment not only constitutes a further important step in the strategic transformation of Rheinmetall's Sensors and Actuators division in the field of digitisation. Taking up a share in the Eindhoven-based company

Photo: Rheinmetall

also supports the marketing of its next-generation server solutions. Moreover, in addition to digitisation, the investment augments Rheinmetall's expertise base in four other technology clusters: automation, sensors, alternative mobility, and artificial intelligence, Rheinmetall writes in a press release.

Incooling server systems feature phase change cooling technology and AI-based control systems designed to reduce the temperature that CPUs currently operate at. As a result, Incooling servers attain the fastest processing speeds with significantly lower power consumption compared with server systems now on the market. This is especially advantageous for advanced applications such as artificial intelligence, high-performance computing, elaborate R&D simulations and high-frequency transactions for banking solutions, Rheinmetall emphasizes.

Devid Liik is CTO at Milrem Robotics

(gwh) Devid Liik has joined Milrem Robotics as Chief Technology Officer (CTO), becoming the third member of the management team. Milrem Robotics' board of directors now consists of three members: Kuldar Väärsi as founder and CEO, Devid Liik as CTO and Mikk Mägi as CFO.

Photo: Milrem

Liik comes from IT developer and service provider Twilio, whose Estonian subsidiary he co-founded. There he held senior positions building development teams and scaling the core backend systems of the communications industry's leading messaging product line. Previously, he held senior positions at communications company Skype.

Ground-Based Air Defence in the Gulf Region

Doug Richardson

The six members of the Gulf Co-operation Council (GCC) – Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates – currently supply around 20% of the world's total oil output. When the output from Iran and Iraq is added, this takes the total to around 30%. This major natural resource can make countries in the region tempting targets for aggression, as was demonstrated by Iraq's invasion of Kuwait in August 1990.

To cope with the threat of air attacks upon their cities or critical assets, or enemy air operations in support of hostile ground forces, the GCC nations have invested heavily in air defence. This capability takes the form of interceptor or multi-role fighters, supplemented by surface-to-air missile (SAM) systems, and point-defence SAMs including man-portable air-defence systems (MANPADS). In most cases, the result is a multi-tier system intended to cope with low, medium and high altitude threats, or even incoming ballistic missiles.

While it is easy to document many of the modern weapon systems deployed in the region, especially hardware supplied by the United States, information sources such as reference publications can show a measure of disagreement over exactly which systems are in service with each country. The situation is made even more complicated by the presence of ageing and obsolescent hardware that may no longer be in front-line service, yet could be in storage and potentially available for use.

Photo: US Army

THAAD hardware can be transported using the C-17 Globemaster III. This capability has allowed the US to swiftly redeploy THAAD units to and from the Gulf region.

Saudi Arabia

Four of the six GCC states now operate the Raytheon MIM-104 PATRIOT, while three have taken the concept of missile defence a stage further by adopting the Lockheed Martin Terminal High Altitude Area Defence (THAAD) system. The first PATRIOT user in the region was Saudi Arabia, which became the fifth export customer for the system in 1990 when it ordered seven PATRIOT fire units, 48 launchers, six MPQ-53 radars, six engagement control centres, and 384 PAC-2 missiles. Further deliveries then took place under a USD 1.03 Bn contract placed in December 1992. A contract in June 2011 upgraded Saudi Arabia's PAC-2 systems to the Config-3 standard, which made them compatible with the PAC-3 missile. A batch of 202 PAC-3 missiles, 36 launching station modification kits, and six fire-solution computers was requested in September 2014.

Faced with drone and missile attacks from the Iran-backed Houthi rebels in Yemen, in 2021 Saudi Arabia requested the supply of more PATRIOT missiles. A batch of 300 PATRIOT MIM-104E Guidance Enhanced Missile-Tactical ballistic missile (GEM-T) missiles, and items of PATRIOT support equipment form part of a planned sale announced in August 2022. Intended to replenish Saudi Arabia's stock of PATRIOT missiles, "these missiles are used to defend the Kingdom of Saudi Arabia's borders against persistent Houthi cross-border unmanned aerial system and ballistic missile attacks on civilian sites and critical infrastructure in Saudi Arabia," the US Defense Security Cooperation Agency (DSCA) stated.

The US approved the potential sale of THAAD missile defence systems to Saudi Arabia in May 2018. The Saudi government had requested 16 THAAD Fire Control and Communications Mobile Tactical Station Groups, seven TPY-2 THAAD radars, 44 THAAD launchers, and 360 THAAD missiles, plus support equipment and training. A USD 1.42 Bn contract awarded to Lockheed Martin in March 2022 covered additional interceptors for the US and Saudi Arabia.

Author

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

Photo: US Army

Although Russian 'military experts' are reported to consider the MIM-23 I-HAWK obsolete, in practice the system has undergone three major upgrade programmes since it was first fielded. While in truth the last of these upgrades dates back to 1989, as the War in Ukraine has demonstrated, older systems can still be effective. I-HAWK is still used by Bahrain, Iraq, Kuwait, and Saudi Arabia.

Since the 1980s Saudi Arabia has been a major user of the Raytheon MIM-23B I-HAWK medium-range system, deploying a force that peaked at 16 batteries and a total of 126 launchers, operated by the Royal Saudi Air Force (RSAF). Although 17 nations still operate HAWK, following the decision by Spain to supply Improved HAWK Phase III systems to Ukraine and the announcement of a US programme to refurbish HAWK missiles destined for use with these, there have been claims that the system is totally outdated, and not suitable for modern combat operations. However, at least two websites have that have published such allegations have identified their source as being 'Russian military experts'.

HAWK entered service in 1959, but has undergone a series of modernisation programmes, first under the HAWK Improvement Program (HIP) begun in 1966, which brought HAWK to the Improved Hawk (I-HAWK) standard, and then again under the US Army Product Improvement Plan (PIP) which received full materiel release in August 1979. PIP Phase I replaced the I-HAWK's AN/MPQ-48 Continuous Wave Acquisition Radar (CWAR) with the AN/MPQ-55 Improved CWAR, and upgraded the AN/MPQ-50 Pulse Acquisition Radar (PAR) to provide a digital Moving Target Indicator (MTI) capability. Fielded between 1983 and 1986, the Phase II version provided the AN/MPQ-57 High Power Illuminating Radar (HPIR), which replaced some of the vacuum-tube electronics of the AN/MPQ-46 HPIR with modern solid-state hardware, and added an optical Tracking Adjunct System (TAS) intended to allow operation in the face of severe electronic countermeasures. Deployed from 1989 onwards, Phase III involved more extensive changes including the replacement of the AN/MPQ-55 with the AN/MPQ-62 CWAR, and an improved AN/MPQ-61 HPIR incorporating the Low-Altitude Simultaneous Hawk Engagement (LASHE) mode, which uses a wide-angle, low-altitude radar illumination pattern to allow multiple engagements against saturation raids. Saudi systems were originally delivered at the Phase II standard, but in 1995 Saudi Arabia placed an order worth USD 118 M for upgrade kits that would allow Phase II systems to be upgraded to the Phase III standard.

For shorter-range air defence, the Saudi Army uses the Thomson-CSF (now Thales) Crotale, and is currently thought to have around 40 fire units. A custom-designed Crotale variant known as 'Shahine' is based on a tracked chassis, and is used to protect mobile forces. This exists in two versions – the original Shahine 1 ordered in 1975, and the improved Shahine 2 procured around a decade later. Shahine 1 systems were upgraded to the Shahine 2 standard in the early 1990s. Early in 2001, Saudi Arabia placed a USD 129 M contract with Thales for the modernisation of its Crotale systems delivered in 1985, as well as for the supply of logistics and support services, and began to negotiate a modernisation of the Shahine 2.

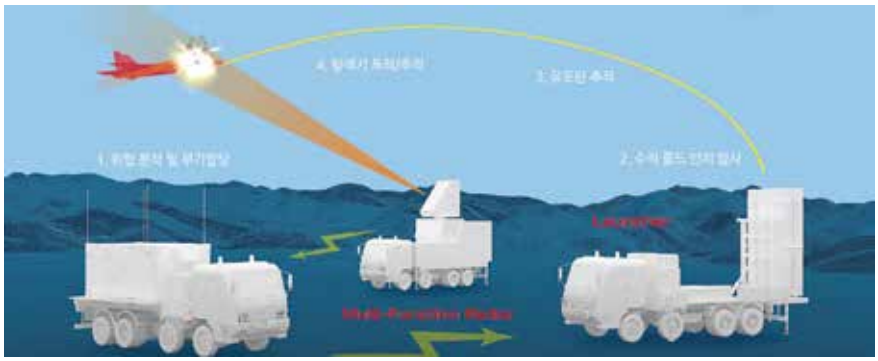
The main MANPADS presently in service with the Saudi Army are multiple variants of the Raytheon FIM-92 Stinger family, which is also used on Boeing M1097 Avenger vehicles. Five MBDA VL MICA are reported to be in service with the Saudi Arabia National Guard, along with 68 examples of the Multi Purpose Combat Vehicle (MPCV) armed with the MBDA Mistral 2.

United Arab Emirates (UAE)

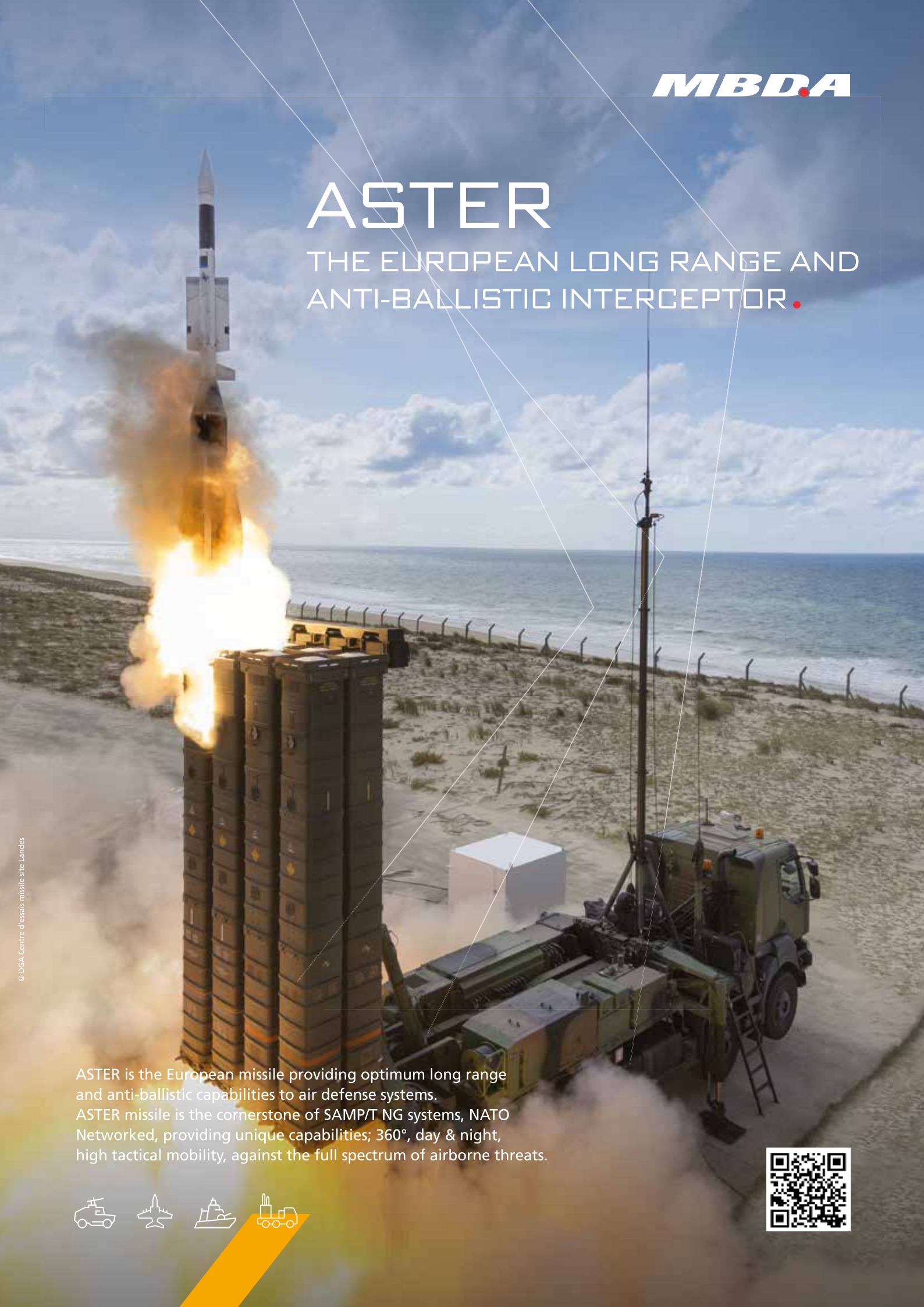
The United Arab Emirates (UAE) – a federation of seven emirates, consisting of Abu Dhabi (the capital), Ajman, Dubai, Fujairah, Ras Al Khaimah, Sharjah and Umm Al Quwain – was the first member of the GCC to deploy upper-tier SAM systems able to provide missile-defence capabilities. Abu Dhabi currently deploys a mixture of PATRIOT GEM-T and PAC-3 missiles. A total of nine batteries are reported to be deployed to defend major population centres and critical infrastructure sites.

The UAE was the first foreign purchaser of the THAAD system, placing an order in 2011. It is currently thought to have two operational THAAD batteries, one

Photo: LIG Nex1



In early 2022 the UAE placed an order for South Korea's LIG Nex1 Cheongung II missile system, which has been designed to engage air targets (as seen in this diagram) or ballistic missiles.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positioned to defend Abu Dhabi city, and the other to defend the Al-Ruwais area. In January 2022, the system made its first operational intercept of an enemy missile when it intercepted multiple threats directed towards areas in Abu-Dhabi, including Al-Dhafra Air Base. A second successful engagement was reported in the following month. August 2022 saw the announcement of the proposed sale to the UAE of two more THAAD launch control stations, two THAAD tactical operations stations, 96 THAAD missiles, and associated support equipment.

A further expansion of the UAE's air-defence capability was announced in January 2022 following the signing of a contract by South Korea's LIG Nex1, Hanwha Systems, Hanwha Defense, and the UAE's Tawazun Technology and Innovation (TTI) organisation. It covers the procurement of South Korea's Cheongung II missile system, and is expected to involve a customised version of Hanwha Systems' multifunction radar (MFR). Development of the Cheongung II began in 2012 with the aim of creating a system able to counter ballistic-missile targets.

Photo: US Army

The USAF would only describe the location of this Patriot system as being in "south west Asia".

Five batteries of I-Hawk are reported to be in service, a mix of Phase II and Phase III systems with a total of 30 launchers. These are supplemented by Bofors RBS 70 MANPADS systems purchased by Dubai in 1979, and by Matra BAe Dynamics (now MBDA) Mistral twin-round ATLAS (Affût Terrestre Léger Anti-Saturation) launchers. The Matra BAe Dynamics Rapier had been in service with Abu Dhabi, but these systems were repurchased by the company under an agreement reached in 1989.

The UAE became the launch customer for the KBP Instrument Design Bureau Pantsir-S1 (SA-22 'Greyhound') when it ordered 50 examples in May 2000. Deliveries of a small number are reported to have begun in 2007, but these showed technical problems which postponed the arrival of the remainder until 2009–2013. The chosen platform was the MAN SX 45 8×8 truck, which makes the UAE systems immediately recognisable. This was demonstrated in mid-2020 when Government of National Accord (GNA) forces in Libya captured a MAN SX 45-based Pantsir thought to be one of a batch that had been in service with of the rival Libyan National Army (LNA).

There are conflicting reports of an upgrade planned for the UAE's Pantsirs. A USD 12 million contract for an upgrade was announced by the UAE in 2019, but in 2021 Dmitry Shugayev, director of Russia's Federal Service for Military-Technical Cooperation announced that Russia and the UAE were discussing a possible upgrading of the Pantsir-S1. It is possible that the latter statement could refer to a proposal to update the UAE systems to the new Pantsir-S1M standard, which introduces an improved tracking radar and a new 57E6M-E high-speed missile that extends the maximum engagement range from the current 20 km to 30 km.

Qatar

The next overseas sale for THAAD came in 2014 when Qatar ordered 12 THAAD launchers, 150 THAAD missiles, two THAAD fire control and communications units, two TPY-2 THAAD radars, and one early-warning radar. By the end of that year Qatar was ready to become the 13th export customer for PATRIOT. The initial contract was reported to include 11 PATRIOT Configuration-3 modernised fire units, 11 MPQ-65 radars, 11 engagement control centres, 30 antenna mast groups, 44 launchers, 768 PATRIOT Advanced Capability 3 (PAC-3) missiles, 246 PATRIOT MIM-104E GEM-T, 10 PAC-3 test missiles, and two PATRIOT MIM-104E GEM-T test missiles. A contract awarded to Raytheon in 2015 covered the procurement, delivery and installation of an Air and Missile Defence Operations Centre, and the integration of this with various air and missile defence systems.

By the end of 2018, at least one PATRIOT system was operational with what was then the recently-formed Qatar Emiri Air Defences Forces (QEADF). It was initially operated with the assistance of US personnel until more trained operators become available.

Qatar procured the National Advanced Surface to Air Missile System (NASAMS) as a direct commercial sale, and in November 2018 the US DSCA announced approval for the sale of 40 AIM-120C-7 Advanced Medium-Range Air-to-Air Missiles (AMRAAM) missiles for use with the system, and the supply of classified software for the AN/MPQ-64F1 Sentinel Short Range Air Defence radar.

The main short-range SAM system currently in service is the Roland 2. Ordered in 1986 from what was then Euromissile, the deal was reported to have been for a mix of systems mounted on the AMX-30 chassis, MAN SX90 8×8 chassis, and on shelters. The arrival of these allowed Qatar to phase out its Rapier systems, and transfer these to Oman. Mistral and FIM-92 Stinger are the main MANPADS in current service, supplemented with the Chinese-developed FN-6.

Kuwait

Kuwait was an early adopter of the PATRIOT system in the region. A total of 40 launchers and 210 PAC-2 missiles were purchased in 1993 under a USD 327 M contract. A possible Foreign Military Sale to Kuwait of 209 MIM-104E PATRIOT GEM-T Missiles was reported by the DSCA in 2010, followed by an order announced in 2012 for four PATRIOT radars, four PATRIOT Engagement Control Stations, 20 PATRIOT Launching Stations, two Information Coordination Centrals, and 60 PATRIOT Advanced Capability (PAC-3) missiles. A batch of 84 PATRIOT

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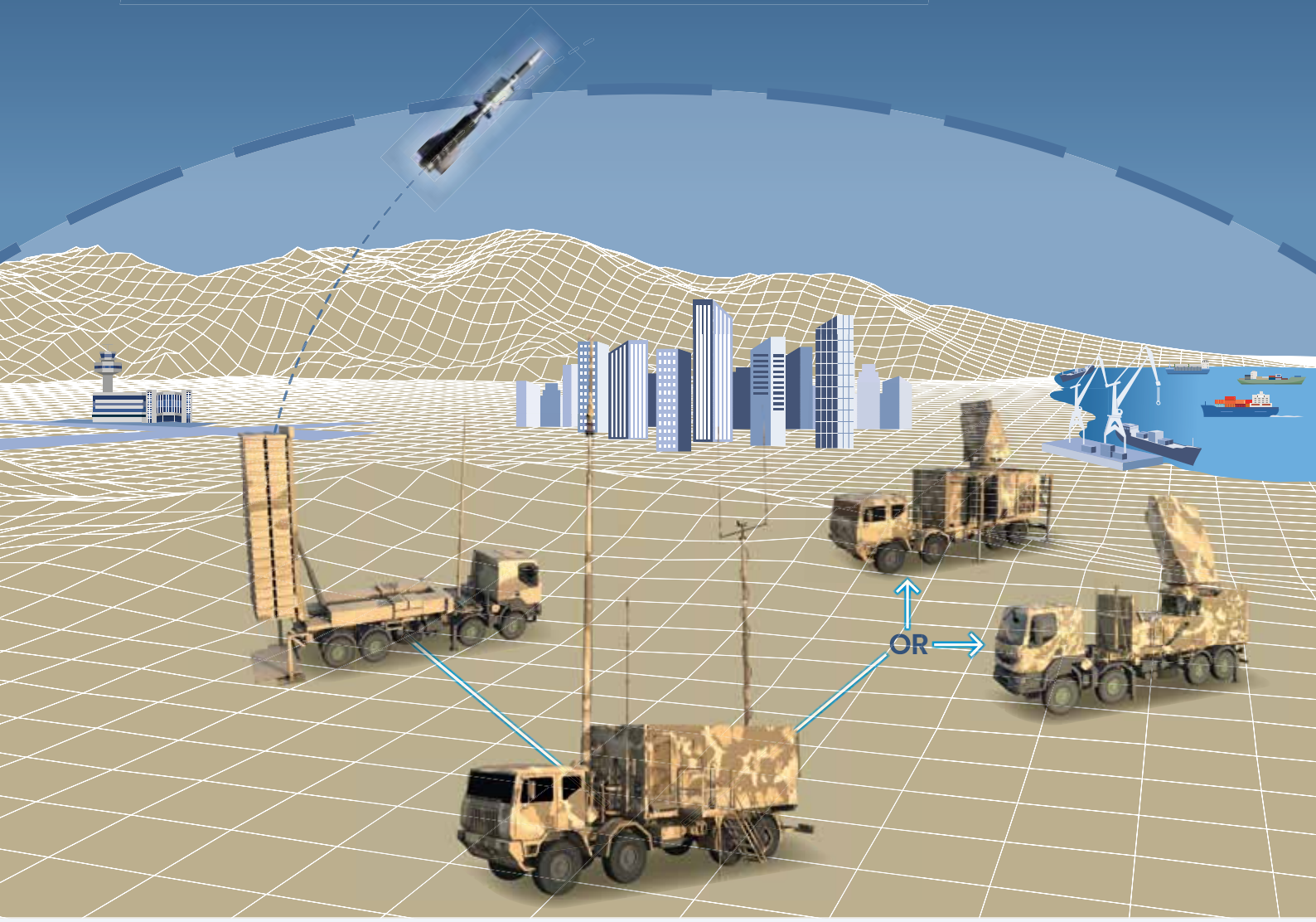

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Photo: Kongsberg

Currently in service with Oman, Raytheon's National Advanced Surface-to-Air Missile System (NASAMS) is seen here launching an AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM), but the system is known to be compatible with the AMRAAM-Extended Range missile and the AIM-9X Sidewinder.

Advanced Capability Missile Segment Enhancement (PAC-3 MSE) rounds plus related equipment were delivered under a USD 800 M package approved by the US Government in 2020.

The Air Force also operates four batteries of Raytheon Company MIM-23 I-HAWK low- to medium-altitude SAMs. Prior to the 1990 invasion by Iraq, Kuwait had five I-HAWK batteries. Three of these saw combat action, downing a total of 23 Iraqi aircraft and helicopters. The four batteries thought still to be in service are Phase III standard, and have a reported total of 24 launchers.

In 1998 Kuwait purchased five batteries of 'Amoun' low-level air-defence systems, and took delivery of five more in mid-1990. This is an Egyptian-manufactured version of the Oerlikon-Contraves Skyguard/Sparrow air-defence system, which combines the Skyguard fire-control system with Oerlikon Contraves (now Rheinmetall Air Defence) twin 35 mm towed anti-aircraft guns and four-round surface-to-air launchers for the Raytheon AIM-7 or Selenia (now MBDA Italy) Aspide missiles. These systems were seized by Iraq, and some of the hardware was returned to Kuwait after the 1991 Gulf war.

In June 2001 Kuwait Defence Minister, Sheikh Jaber al-Mubarak al-Sabah announced that up to five additional Amoun systems would be purchased, enough to equip an air-defence battalion. "We have five [batteries] and we will buy another five," the minister said. Each Kuwaiti battery consists of one Skyguard, plus two twin-35 mm guns and two Sparrow launchers. More than a decade ago, MBDA began a three-year programme to modernise the Kuwaiti air defence brigade's existing stock of Aspide missiles to the Aspide 2000 configuration, and to reconfigure the Amoun systems in order to handle the updated missiles.

The next SAM system to enter Kuwaiti service is likely to be NASAMS. In October 2022 the US DSCA reported that the State Department had approved a possible Foreign Military Sale to Kuwait of seven MPQ-64FI Sentinel radars, 63 AIM-120C-8 missiles, 63 AMRAAM-Extended Range (AMRAAM-ER) missiles, 63 AIM-9X Sidewinder Block II missiles, and related equipment for an estimated cost of USD 3 Bn.

Prior to the 1990 invasion, Kuwait had 20 Antey 9K33 Osa (SA-8 Gecko) low-altitude surface-to-air missile systems that had been purchased in the late 1980s. Following the 1991 Gulf War, these were taken to Iraq to supplement that nation's Osa systems, and were never returned.

For point-defence, Kuwait has several types of SAM system. Short Brothers (now Thales Air Defence) Starburst Lightweight Multiple Launchers were purchased under a 1994 contract worth GBP 50 M, which is thought to have covered 48 launchers (some or all of which were fitted with Thermal Imagers intended to give a 24 hour capability) and at least 250 missiles. However, given that these missiles are approaching 30 years in age, their serviceability is questionable. Additionally, Kuwait operates the FIM-92 Stinger family.

Bahrain

In October 2017, Bahrain announced was considering procurement of the Russian S-400 surface-to-air missile system, but

Photo: US Army

The technology of the newer variants of PATRIOT may be state-of-the-art, but the overall system has some conventional 'low-tech' components. The diesel-powered electrical generator of this Bahrain-based Patriot unit emits dense smoke as it is started up.

two years later the US Department of State approved Bahrain's procurement of 60 PATRIOT PAC-3 MSE missiles, 36 PATRIOT MIM-104E GEM-T missiles, and nine M903 Launching Stations.
Until the debut of PATRIOT, the longest-range SAM system operated by Bahrain had been the Raytheon MIM-23B I-Hawk. Six systems are reported to remain in service, all being the Phase III standard. Ten Crotale units are also reported to be in service.
Point defence is provided by around 40 Saab Bofors Dynamics RBS 70 low-altitude surface-to-air missile systems purchased in 1979, plus the Raytheon FIM-92A Stinger MANPADS. The procurement of 9K338 Igla-S (SA-24 Grinch) has not been confirmed.

Oman

The longest-range SAM system in Omani service is Raytheon's NASAMS. Designed to engage aircraft, helicopters, cruise missiles, and UAVs, it normally consists of three launchers, each carrying up to six missiles. NASAMS was initially designed to use the AIM-120 AMRAAM, but can use the AIM-9X Sidewinder or other missiles. Crotale NG fills the gap between this shorter-range systems.
In November 2000, Oman became the first country in the Middle East to be equipped with the MBDA Mistral 2, a version with an improved passive infra-red nose mounted seeker, digital processing, a new booster, higher top speed, greater manoeuvrability and increased range. It opted for the vehicle-mounted twin-round ALBI launcher variant, which is mounted on a Panhard Vehicule Blinde Leger (VBL) 4×4 light armoured vehicle. Oman was the first customer for the ALBI system, whose launcher can be fitted with a thermal imager, which allows day and night operation. The procurement also included a number of VBL-mounted MBDA Mistral Coordination Post (MCP) systems. Each can control the fire of several ALBI vehicles.
An initial procurement of 28 BAe Dynamics (now MBDA) Rapier battery fire units between 1974 and 1977 was followed in 1980 by an order for 12 Blindfire radar trackers. This force was supplemented by 12 launchers and six tracker radars received from Qatar. In the early 1990s, Omani systems were rotated back to the UK to be modernised to the SAHAM standard, which is the equivalent to the B1X export configuration. The upgrade fits an enhanced planar-array antenna, an automatic IFF code changer, adds ECM and ECCM improvements, and allows the system to fire the Rapier Mk 2A/2B missile.
The delivery of up to 12 Pantsir-S1 vehicles was reported in 2012, around the time that the US reported an Omani request for 18 Boeing Avenger self-propelled fire units and 266 Stinger-Reprogrammable Micro-Processor (RMP) Block 1 surface-to-air missiles.

Photo: CENTCOM

Bravo Battery of the US Army's 3-265 Air Defense Artillery Battalion is an Army National Guard unit. It was deployed in support of Operation Spartan Shield, which uses Boeing Avenger systems to provide short range air defence in Saudi Arabia and the United Arab Emirates.

Iraq

Following the 2003 war against Iraq, that country was left with little in the way of air defence – a few air surveillance radars and air-traffic-control radars, plus a number of obsolete anti-aircraft guns. But like the GCC members, it has had to invest in new GBAD systems. The key ingredients of a future integrated air defence system were set out in a 2013 request to the US that included the hardware needed to equip three batteries of HAWK XXI, including six Battery Fire Direction Centers, six High Powered Illuminator Radars, two Mobile Battalion Operation Centers (BOC), three BOC Air Defense Consoles, and 216 MIM-23P HAWK missiles. It also included 40 Avenger Fire Units, and 681 FIM-92H Stinger Reprogrammable Micro-Processor (RMP) Block I Missiles. A large enough quantity of Rapier systems were captured from Iran during the Iran–Iraq War to allow the system to be taken into Iraqi service, but these were phased out around 20 years ago.
Iraq has made some purchases of Russian air-defence hardware. The 9K338 Igla-S (SA-24 Grinch) seems to be the main MANPADS system in current use. A contact for a batch of 24 Pantsir-S1 (SA-22 Greyhound) was signed in 2012, leading to deliveries which allowed vehicles to participate in an Iraqi military parade in 2015.
Following reports that Iraq planned to procure the S-400, in May 2019 the Iraqi Ambassador to Russia confirmed that the planned purchase had been approved by his country. In 2020 the US confirmed that it had deployed PATRIOT systems to Iraq in order to defend Iraqi bases that host coalition troops.

Future Trends

With five countries in the Gulf region now operating PATRIOT, and two operating THAAD, the area probably has a greater concentration of ground-based air defence than nearly any other corner of the world. These systems are not just for show – both are seeing combat use. Meanwhile, combat operations over Ukraine are providing further evidence that in future conflicts, the air threat may not be confined to combat aircraft and helicopters, but will include ballistic missiles, ground and air-launched cruise missiles, and long-range UAVs. The shape of air warfare is changing, and GBAD will have to evolve in turn. ■

Long-Range ISR Platforms

Luca Peruzzi

The recent Russian invasion of Ukraine has seen the consistent deployment of Intelligence, Surveillance and Reconnaissance (ISR) platforms. Operations against peer- and near-peer adversaries require high-altitude and deep-sensing intelligence to ensure wide coverage and survivability, but also deep electronic support which is being offered by modified long-range business jets equipped with sophisticated surveillance and electronic warfare (EW) suites.

In recent years, these ISR platforms have enlarged their customers' fleets and the market for them is significantly growing, notwithstanding the diffusion of unmanned aerial systems. In large part this is due to their long range, large cabin, electrical power and ready availability of commercial off-the-shelf spares, sustainment support and different operating schemes, including direct or contractor management and ownership. Key characteristics to accomplish ISR missions include the capability to fly at altitudes of 15.24 km (50,000 ft) at high speeds, above commercial air traffic, and providing reduced transit time to the area of operations (AO). A further benefit of flying at higher altitudes is that doing so lowers the radar/optical horizon and provides a greater field of regard for the aircraft's electronic, radar and optical sensors, allowing a larger area to be surveyed in a single mission.

In terms of the manufacturers for the host platforms, some of the main contenders in the field include Gulfstream Aerospace, Bombardier Defense, and Dassault Aviation. Gulfstream Aerospace is a wholly-owned subsidiary of General Dynamics, and has delivered more than 200 special mission aircraft to support government and militaries in over 40 countries. Most notable in this category was the G550 platform, which found use in a varied range of missions. However, after nearly two decades in service, production of the G550 has now been completed, following final deliveries in 2021. Despite this, numerous examples remain in service, and Gulfstream is in the process of deciding a successor among its available platforms. Bombardier Defense has already delivered over 550 aircraft for specialised missions, and is presently offering its families of Challenger and Global aircraft. Dassault Aviation has delivered 250 Falcon multi-role aircraft worldwide, and is presently promoting the Falcon 2000 and 900 series platforms, the latest addition being the Falcon 8X.

USA

In October 2021, L3Harris Technologies (L3Harris), the platform integrator and prime contractor for the US Air Force's next generation EC-37B Compass Call EW platform, announced the completion of the first flight of the aircraft's first flight. Under this programme, L3Harris is migrating the Compass Call EW suite from the legacy EC-130Hs into the newer Gulfstream G550 business jets. BAE Systems is the mission systems integrator and provider of the redesigned and enhanced mission suite, making it the US DoD's only long-range, full-spectrum stand-off EW jamming platform. With increased speed, endurance, and extended stand-off range over the legacy EC-130H, the hardware migration programme envisions a fleet of 10 EC-37B aircraft providing the equivalent EW capacity as the original high-demand 14 EC-130H original fleet.

The EC-37B exploits the modification work initially applied to the Conformal Airborne Early Warning (CAEW) G550-based platform in service with Israel, Singapore, and Italy's air forces, as well as the US Navy in the form of the NC-37B missile range support platform, which is intended to perform surveillance and monitoring of missile tests. In September 2022, BAE Systems announced that they had delivered key components for the first aircraft, paving the way for developmental and operational flight testing of the Baseline 3 configuration (for the first five aircraft) of the Compass Call from early 2023. Interim fielding is expected to follow the completion of testing by mid-2024.

Under a contract signed in June 2021 for the US Air Force (USAF) Battlefield Airborne Communications Node (BACN) programme, Bombardier Defense delivered the first of up to six additional modified Global 6000 aircraft in the E-11A configuration in September 2022. These will be added to the four already in service, which have been delivered by

Photo: USAF

Under the Compass Call rehost programme, L3 Harris as prime contract and platform integrator, is migrating the electronic warfare suite provided by BAE Systems from the legacy EC-130Hs into the Gulfstream Aerospace G550 business jets.

Bombardier under previous agreements since 2007. The E-11A is equipped with the BACN mission suite provided by Northrop Grumman to act as airborne relay that extends communications ranges, bridges between radio frequencies and 'translates' among incompatible communications systems, enhancing tactical and situational awareness, as well as communications and coordination for joint and coalition forces.

In September 2022, the US Army awarded L3Harris and Raytheon Applied Signal Technology the phase 2 contracts for the Multi-Domain Sensing System (MDSS) programme. This aims to demonstrate, develop, build, and integrate prototype ELINT and COMINT sensors onto the High Accuracy Detection and Exploitation System (HADES), the service's next-generation airborne ISR system. The US Army is pursuing HADES to address the demands of future Multi-Domain Operations (MDO) against peer- and near-peer adversaries. HADES will be globally deployable and provide a multi-faceted sensing capability at higher altitudes and longer ranges, and with longer endurance than is currently available from the Army's RC-12 Guardrail, MC-12 EMARSS and EO-6C ARL aircraft.

The goal is to provide deep-sensing intelligence collection of indicators and warnings, electronic order of battle, and patterns of life for targeting. Thanks to the contract, the two companies will further develop and build their sensors, which will be flight tested during Phase 3 and then procured and installed on a long-range high-altitude business jet. Until it is delivered, the US Army is collecting feedback and bridging aerial surveillance needs with three technology demonstrator programmes:

1. The Airborne Reconnaissance and Targeting Multi-Mission System (ARTEMIS)
2. The Airborne Reconnaissance Warfare System (ARES).
3. The Army Theater Level High-Altitude Expeditionary Next Airborne ISR Radar (ATHENA-R).

ARTEMIS and ARES are respectively based on the Leidos-owned and operated Bombardier Challenger 650 with a mission suite currently flying in Europe, and a Bombardier Global Express 6500 jet equipped with an L3Harris suite deployed to the Pacific. The soon to-be tendered ATHENA-R programme for the supply of a batch of contractor-owned, contractor-operated business jet equipped with an ISR suite is attracting several bidders. L3Harris and MAG Aerospace announced a teaming agreement based on a Global 6500, Sierra Nevada unveiled the rapidly configurable RAPCON-X platform in August 2022, also based on a Global 6500, while Leidos could offer a further development of its Bombardier Challenger 650-based ARTEMIS II solution on the more capable Global 6500 platform.

Australia

In 2019, the Australian Ministry of Defence announced that the Department was buying four modified Gulfstream G-550 business aircraft under the Project Air 555 programme. Designated the MC-55A 'Peregrine', it has been described as a highly capable, full-spectrum intelligence, surveillance, reconnaissance, and electronic warfare (ISREW) platform. The aircraft is intended to provide a critical link between platforms, including the F-35A Joint Strike Fighter, E-7A Wedgetail, EA-18G Growler, the Navy's surface combatants, amphibious assault ships and ground assets. At present, all four aircraft are being converted and subjected to a flight-test programme scheduled to be completed in mid-2023. The first aircraft is expected to be delivered to the Royal Australian Air Force in late 2023.

These platforms are being modified and equipped with ISREW equipment by L3Harris under contract from the USAF's 645th Aeronautical Systems Group, also known as 'Big Safari'. The latter has extensive knowledge in the design and development of airborne electronic intelligence platforms in a classified environment. Although few details were provided on the mission suite, based on the external modifications from previous programmes (namely the CAEW G550, the US Navy NC-37B and USAF EC-37B Compass Call), the MC-55A 'Peregrine' is reported to be equipped with a SIGINT package, alongside a Leonardo Osprey 50 AESA radar suite with distributed arrays, an optronic infra-red (IR) gimballed sight in a dome-shaped housing (located under the aircraft's bulbous rear tail cone fairing), wideband secure SATCOM data link and radio communications, in addition to a self-protection suite. The platform is reported to have EW capability, including electronic attack, in order to support Royal Australian Air Force (RAAF) offensive and deep-strike missions. Deliveries are slated for completion in 2025.

Israel

Among the most prolific worldwide developers of special mission aircraft (SMA) from business jets and military aircraft conversion, Israel Aerospace Industries' (IAI) Elta Systems division together with national industry is proposing a range of solutions including the ELW-2085 CAEW, ELW-2090 AWACS, P-600 AEW, ELI-3001 SIGINT, ELI-3150 Multi-Mission Airborne Reconnaissance & Surveillance System (MARS2), ELI-3150 ISTAR and ELI-350 CL650 aerial ground surveillance (AGS) multi-mission aircraft.

The ELW-2085 CAEW is based on Gulfstream G550, and is in service with Israeli, Italian and Singaporean air forces. It is characterized by low-drag conformal radomes accommodating the latest

Photo: L3Harris

Under the Project Air 555 programme, the Australian DoD is working to put into service four modified Gulfstream G-550 business aircraft, designated the MC-55A 'Peregrine', which has been described as a highly capable, full-spectrum intelligence, surveillance, reconnaissance, and electronic warfare (ISREW) platform.

Photo: Israeli Air Force

Unveiled by the Israeli Air Force officially in April 2021, the multi-mission Nachshon Oron G-550 based platform is reported to be capable to conduct surveillance and intelligence operations in support of ground and naval forces and act as flying relay platform.

generation AESA dual-band (L/S band) radar, ESM/ELINT, communications with wideband secure SATCOM and data link, in addition to a self-protection suite. Elta also developed the ELI-3001 SIGINT, which is also based on the Gulfstream G550 platform. It includes Elta's latest ELINT and COMINT sensors and 10 multi-mission operator stations which manage radio, satellite communications and data links, and a self-protection suite. The ELI-3150 MARS2 is another G550-based platform, equipped with a sophisticated AESA multi-mode radar suite with air-to-ground, air-to-sea and air-to-air capabilities, an integrated SIGINT suite with ELINT/COMINT systems, all managed by a C2 suite based on 4-to-6 operator workstations, in addition to a communications suite including SATCOM data links. This platform is capable of carrying two ISR pods under its wings. Elta also offers the ELI-3150 ISTAR model, which can be based on either the Bombardier Global 6500 or Challenger 650 platform, and is equipped with Elta's sensors and systems including multi-mode AESA radar, SIGINT and long-range multispectral optronic IR system, and self-protection suites, all managed by 4-6 operator workstations.

In addition to the Nachshon Eitam ELW-2085 CAEW G550s and the Nachshon Shavit SIGINT platforms based on Gulfstream V, the Israeli Air Force officially introduced the Nachshon Oron G550 based platform in April 2021. A joint development by the Israeli MoD, Armed Forces and industry, the Nachshon Oron will reportedly perform different missions, and is equipped with a latest-generation AESA radar suite incorporating air-to-ground and air-to-sea modes, SIGINT sensors and self-protection systems. The aircraft also possesses a communication suite which includes flying relay station capabilities to support joint operations. Capable of accommodating a large team of operators, it is also reported to be capable of providing targeting in support of ground operations, as well as EW capabilities. Since its arrival in Israel, the first of an undisclosed number of aircraft began the mission system installation, integration and qualification process, which understood to require two years before the aircraft is ready for operations.

Italy

In February 2021, the Italian Parliament approved the JMMS (joint airborne multi-sensor multi-mission system) multi-phase programme for eight platforms to undertake a wide range of missions including ISREW, AEW&C and EW. According to available information, the Italian MoD has selected the Gulfstream G550 platform, which is already in service with the Italian Air Force in the CAEW variant, with two aircraft delivered respectively in 2016 and 2018 by IAI/Elta Systems. The EUR 1.2 Bn multi-year programme covers the procurement of the first two aircraft as dedicated platforms, as well as an additional six 'green' airframes to be later converted to JMMS platforms.

n March 2022, the Italian MoD awarded Elta Systems a EUR 209 M contract for the procurement of two additional G550 CAEW to cover multiple theatres of operations. The follow-on programme phase regarding the procurement of mission suites for the four previously acquired JMMS airframes was approved by Italian Parliament in late 2021. No contract details were released but in December 2020 the US State Department approved a potential Foreign Military Sale (FMS) to

Photo: Italian Air Force

The first of the two G550 aircraft to be converted into an AISREW platform arrived in Italy in March 2022, to be used for training until the modification activities will commence. In 2022, the Italian MoD has already acquired two CAEW in addition to the two already in service while four more ISR and attack platform are in the pipeline.

Italy for airborne ISREW (AISREW) mission systems to be installed on two G550 aircraft provided by Italian MoD for an estimated cost of USD 500 M, with L3Harris Technologies listed as prime contractor. According to US documentation, the mission suite is centred on L-3 Rio COMINT suite (two installed, two spares), Leonardo Osprey 50 AESA radar and L3 Harris MX-20HD multispectral optronic sight, additional unspecified ISR equipment and Link 16 MIDS, alongside other communications, Identification Friend or Foe (IFF) systems, and a self-protection suite. The first of two aircraft to be converted to the AISREW configuration arrived in Italy in March 2022, and are to be used for training until the modification works begin. More recently, the Italian Air Force's Chief of Staff declared that an unspecified number of the remaining 'green' airframes will be converted to an electronic-attack-capable model such as the EC-37B Compass Call for the US Air Force. Should Italy decide to go for this configuration, it would need US approval to obtain them.

Photo: Dassault Aviation

Under the ARCHANGE programme, the French MoD is acquiring three SIGINT platforms based on Dassault Aviation Falcon 8X business jet equipped with the CUGE (Capacité Universelle de Guerre Electronique or Universal Electronic Warfare Capability) suite under development by Thales.

France

On December 2019, the French Armament General Directorate awarded Dassault Aviation and Thales the contract for the ARCHANGE (Avion de Renseignement à CHArge utile de Nouvelle Genération; ENG: Intelligence Aircraft with New-Generation Payload) programme. Launched in November 2019, it concerns the development and delivery of a new airborne SIGINT capability to replace the two then-in service Transall C-160 Gabriel dedicated platforms. Dassault Aviation is modifying and equipping the Dassault's Falcon 8X aircraft with the CUGE (Capacité Universelle de Guerre Electronique; ENG: Universal Electronic Warfare Capability) SIGINT suite under development by Thales. The initial contract is for two modified aircraft, but the programme also calls for an additional platform plus a ground training system.

According to French MoD documentation, the ultra-long range Falcon 8X tri-engine platform will offer two-to-three times the endurance of the C-160 Gabriel in the area of operations, in addition to extended range. The three new aircraft will allow the French MoD to regain the strategic SIGINT capability offered by the C-160 Gabriel plus the DC-8 Sarigue platforms, the latter retired in 2004. Although few details were disclosed, being capable of concurrent ELINT and COMINT missions, the integrated CUGE suite features sophisticated digital technologies and long-range, highly sensitive sensors capable of detecting modern low probability of intercept signals, namely through Thales' multi-polarisation antennas. In future, it will use artificial intelligence to automate large amount of data processing. The integrated data processing and distribution suite will allow almost real-time information processing and sharing. Due to high operating costs and low availability of remaining C-160 fleet, the French MoD decided to retire their C-160 Gabriel aircraft in May 2022, along with the rest of the fleet. The country's first new SIGINT platform will be commissioned in 2026, a year later than initially planned. To fill the gap, the French MoD launched a tender to loan a Saab 340 twin-engine turboprop platform, capable of carrying out missions lasting seven to eight hours, equipped with a modern SIGINT suite. This platform will work alongside the country's Beechcraft Super King Air-350 VADR ISR aircraft, Rafale fighters equipped with the ASTAC pod, MQ-9 Reaper UAVs, and the CERES satellites until the ARCHANGEs arrive.

Germany

A new milestone in the PEGASUS (Persistent German Airborne Surveillance System) programme led by Hensoldt was reached in November 2022, when the first of three Global 6000 aircraft arrived at Bombardier's Wichita facility in Kansas, USA, on 28 November to perform structural modifications to accommodate Hensoldt's SIGINT suite. In June 2021, the Hensoldt received a contract from Germany's BAAINBw defence procurement agency, for the development and delivery of three SIGINT platforms centred on the Global 6000 platform, equipped with the Hensoldt 'Kalætron Integral' suite. German company Lufthansa Technick, along with Hensoldt, is responsible for the integration of the SIGINT suite on board the three aircraft in Germany. Modifications are due to take place once Bombardier Defence completes their structural modifications, testing and certification in the US.

Presented for the first time at Paris air show 2019, according to the few details provided by Hensoldt, the Kalætron Integral suite can conduct both ELINT and COMINT operations simultaneously using a single system. Kalætron Integral detects emissions over an extremely wide frequency range and thanks to automated resource allocation and software-defined tasks, it can detect, analyse, monitor, and evaluate interaction between radio emissions. It can also use intelligence (AI) algorithms to identify new threat patterns from collected raw data, depicting the enemy electronic order of battle during the mission. According to the latest German MoD documentation, the PEGASUS will reach initial operational capability in 2025 while the full operational capabil-

Photo: Hensoldt

In June 2021, Hensoldt received a contract by German defence procurement agency for the development and delivery of three SIGINT platforms centred on the Global 6000 platform and equipped with the Kalætron Integral suite, in addition to an evaluation system, a reference system and training package.

ity is planned for mid-2027. Thanks to this programme, the German MoD will regain a strategic capability which was lost in 2010 with the retirement of the Breguet Atlantic SIGINT platforms. Previously the German MoD has been working on the Global Hawk unmanned platform, but concerns about full European Union Aviation Safety Agency certification achievement in the required timescale, higher costs, operational analysis together with parts commonality with in-service VIP transport aircraft, pushed the MoD toward a manned solution.

Other Programmes Worldwide

In Europe, the Swedish Air Force is using two Gulfstream S102B Korpen SIGINT platforms based on the Gulfstream IVSP aircraft to monitor the War in Ukraine. In June 2022, The Swedish Defence Materiel Administration (FMV) contracted Saab to deliver two customised GlobalEye Airborne Early Warning Control (AEW&C) aircraft based on the Bombardier Global 6000, with deliveries planned for 2027, and an option for additional two platforms.

On March 2019, the Turkish Presidency of Defence Industries (SSM; now Defence Industry Agency (SSB)) announced that two green Bombardier Global 6000 airframes were delivered to Turkish Aerospace (TAI) to undergo modification to the Hava SOJ (Air Stand-off Jammer) configuration developed by Aselsan, the prime contractor. Deliveries of the first two platforms are expected in 2023.

Italian company Elettronica is offering the ELT/819 ELINT suite, whose modular architecture allows to be configured for various requirements. In addition to tactical intelligence with warning and self-protection capability and accurate data analysis for intelligence-gathering, it can also accommodate COMINT/CESM capabilities. According to Elettronica, the ELT/819 is part of an unspecified likely multi-sensor suite installed on Bombardier Global Express platforms for an undisclosed customer in the Middle East region.

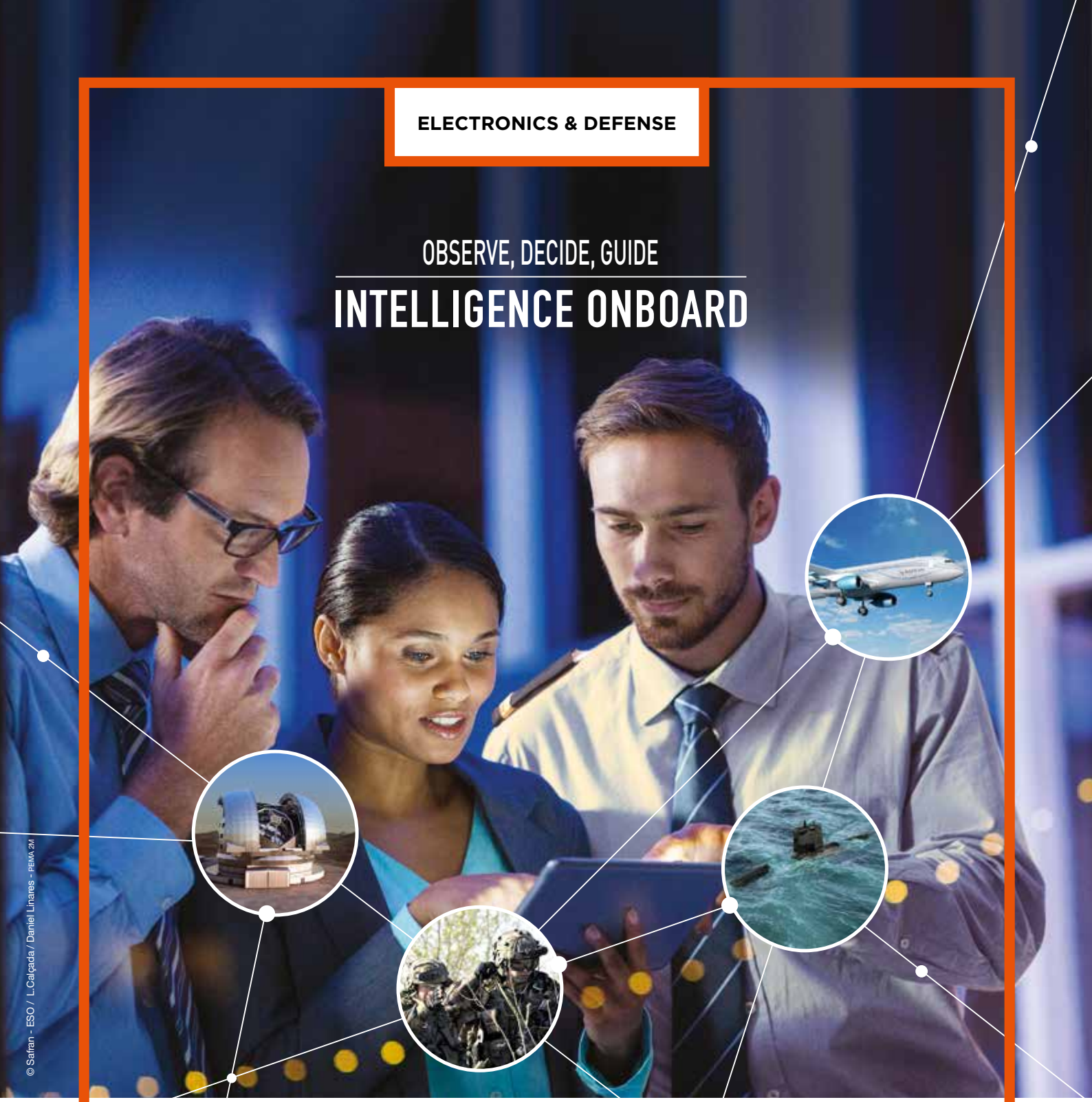
Saudi Arabia has a small fleet of RE-3A/B Tactical Airborne Surveillance System (TASS) platforms based on the modification of up to three Boeing KE-3A tanker/cargo aircraft in service with the Royal Saudi Air Force. Externally resembling the RC-135 Rivet Joint and equipped to conduct SIGINT operations, these platforms are aging, and US companies L3 Harris and BAE Systems reportedly offered a replacement based on the Gulfstream G550 in an unspecified AISREW configuration.

Under the Project Dolphin, the UAE Armed Forces acquired and put into service two Bombardier Express platforms which were modified by Marshall Aerospace and Defence Group. Their configuration reportedly included ELINT/COMINT capabilities and a long-range oblique photography camera in addition to a self-protection suite. They join the five Saab GlobalEye AEW&C Global 6000-based platforms due for delivery.

In the Asia-Pacific region, India's foreign intelligence agency, the 'Research and Analysis Wing' (R&AW) operates two Bombardier Global 5000 which were converted in Israel and equipped with a mission suite reportedly including an Elta ELI-3001 Airborne Integrated Signal Intelligence System (AISIS), together with radar, optronic IR sight, and self-protection suite, making the aircraft a multi-purpose intelligence-gathering platform. ■

Photo: Saab

In June 2022, the Swedish Defence Materiel Administration (FMV) ordered Saab two customized GlobalEye AEW&C aircraft based on the Bombardier Global 6000 with deliveries planned for 2027, and option for additional two platforms.



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Airborne ASW – Past and Future

Sidharth Kaushal

Airborne assets have long been a critical component of Anti-Submarine warfare. Capabilities such as maritime patrol aircraft have had a central role in hunting subsurface threats since the second world war, when units such as the RAF's 461 squadron worked to contain U-Boats in the Bay of Biscay. During the Cold War, NATO campaign plans to contain Soviet submarines at chokepoints such as the GIUK gap involved the coordinated use of air and sea based assets. The airborne component of this effort included maritime patrol aircraft laying sonobuoy fields and shipborne helicopters equipped with dipping sonar.

The centrality of air-based assets to anti-submarine warfare (ASW) remains, but a number of factors may change its modalities. This will be of particular salience to Western navies, which lack the mass to operate the numbers of ASW barriers that they envisioned during the Cold War. However, it will also be driven by other factors. The nature of the challenge faced by ASW forces will also evolve in important ways. A tendency towards equipping submarines with long range precision strike capabilities- with examples including the Russian Yasen class SSGN and the Chinese Type 093- means that to perform certain missions submarines may not need to transit chokepoints. The use of Unmanned Underwater Vehicles (UUVs) – which will pose a challenge for both acoustic and non-acoustic detection – may also challenge existing approaches to airborne ASW. Finally, we might consider climate change, for example the heating of the world's oceans and changes to salinity, both of which impact the passage of sound through water.

Equally, technological change – both in areas such as the application of autonomous capabilities to war and emerging capabilities such as quantum magnetometry, but also more evolutionary developments in multi-static sonar – will also have a substantial impact on how airborne ASW is conducted. The net effect of adaptations that may emerge in the area of airborne ASW, as well as ASW more broadly, may be to shift countries' focus from the control of areas such as chokepoints, to forward defence.

Photo: US Navy/Spc. Seaman Bryan Reckard

Airborne ASW assets are cued in by hydrophone arrays and vessels such as the U.S Navy's TAGOS ships, which are equipped with low-frequency active sonar.

The Current State of Play

Presently, airborne ASW is based around three layers which developed during the Cold War. First, air and space based capabilities including Electronic Intelligence (ELINT) satellites and aircraft provide early warning regarding submarines' movements. Other sources of data include tripwire networks of hydrophones such as the US SOSUS, as well as ships equipped with long-range, low-frequency active sonar such as the US Navy's T-AGOS ships.

Based on early warning regarding a submarine's potential routes of transit, maritime patrol aircraft such as the P-8A Poseidon are tasked to form a second layer of defence. These aircraft can lay sonobuoy fields across a submarine's likely route of travel. In the 1970s and 1980s, the US navy innovated the use of the AN/SSQ-77 directional frequency analysis and recording (DIFAR) sonobuoys, alongside the AN/SSQ-62 directional command activated sonobuoy system (DICASS). The former, a passive system, shaded its array to form beams in the horizontal direction and thus increase transmission gains. DICASS systems such as the AN/SSQ-62 are active systems, which emit omnidirectionally in azimuth and directionally in elevation. The purpose of directionality was to reduce the effects of ambient noise, an adaptation needed to cope with increasingly quiet Soviet submarines. Today, both DIFAR and DICASS sonobuoys such as the AN/SSQ-62 are still operated by both the US and allied forces such as Australia's RAAF. Other nations such as Russia operate a similar mix of sonobuoys on their maritime patrol aircraft such as the Il-38N and the Tu-142. Russian MPAs carry the

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Photo: RAF

Maritime patrol aircraft such as the P-8 Poseidon are critical to airborne ASW

RGB-57, RGB-75, RGB-15 and RGB-55 sonobuoys which are, respectively, passive omnidirectional sonobuoys, a Low-Frequency Array (LOFAR) sonobuoy, and a directional active sonobuoy. This is likely to change, however, in part due to the systems' limited range of 5.55 km (3 NM), and the fact that their sensitivity is impacted by factors such as reverberation, which will be a particular challenge in littoral spaces and when dealing with increasingly quiet submarines more broadly. As a result, we should expect to see a growing emphasis on multistatic sonobuoys, a subject that will be discussed in more depth in subsequent sections.

Maritime patrol aircraft (MPA) can also use other sensors to track targets. Modern MPA such as the P-8 are typically equipped with Magnetic Anomaly Detectors (MADs), which use magnetometers to detect distortions in the Earth's magnetic fields caused by the presence of a submarine. As large ferromagnetic objects (such as submarines) pass through the Earth's magnetic field, they cause distortions in these fields around them, producing anomalies. Other sensors include radar, such as the AN/APS-154, and forward located infrared (IR) sensors which can detect features such as periscopes and masts. MPA are typically armed with both torpedoes and depth charges to engage targets.

Beyond MPA, the other major component of airborne ASW consists of helicopters. ASW helicopters are typically equipped with a dipping sonar, and helicopters such as the Royal Navy's Merlin MK II can carry up to 30 sonobuoys as well. They can engage targets directly using torpedoes, such as the Sting Ray torpedo carried on the Merlin. The major limitations of helicopters are their endurance and their capacity to coordinate large numbers of offboard data sources. They are thus typically used as a point defence asset around critical platforms such as aircraft carriers, or as a final means of prosecuting ASW against targets cued by an external source such as an MPA.

Photo: UK MoD

Helicopters such as the Merlin Mk.2 are crucial for close-in force protection.

The Evolution of Airborne ASW: Beyond Barriers

A number of factors are likely to combine to incentivise the evolution of airborne ASW. Key drivers are likely to be (among others) resource tradeoffs, evolutions to both the capabilities and Concept of Operations (CONOPS) of submarines being hunted, and technological shifts in areas such as non-acoustic submarine detection and the use of autonomous capabilities. Cumulatively, these shifts will incentivise a more forward-leaning approach to ASW than has previously been the case, and one that relies more heavily on surface and subsurface platforms. In this context, one might expect the role of manned airborne ASW assets to evolve into one that emphasises command and control rather than the laying of sensor fields or direct target engagement.

First, the subsurface threat is likely to evolve in a number of ways. Long range prompt strike capabilities are increasingly ubiquitous on modern SSNs. The US Virginia class Block V will carry a payload module that will enable it to launch, among other things, the US Navy's Conventional Prompt Strike missile, which has a range of approximately 2,736 km (1700 miles). Similarly, the Russian Yasen class submarine can carry a range of missiles, from the Kalibr to the 3M22 Zircon. To be sure, there is nothing new about SSGNs, which have existed for some time. What is new is that the distinction between attack submarines and SSGNs is increasingly blurred, with most nuclear powered boats and many diesel electric boats such as the Chinese Yuan class also having an ASCM launch capability. What this means is that submarines may in many instances need not transit chokepoints in order to prosecute strike missions against targets both at sea and ashore. Moreover, both deep water threats and those found in littoral spaces are becoming increasingly quiet, which poses a challenge for passive detection. In littoral spaces this will be driven by the emergence of relatively quiet long endurance diesel electric submarines such as the Chinese Yuan class, which is equipped with air-independent propulsion. The environment within which submarines are likely to operate will also change in coming years. For example, in the high North, melting permafrost will impact both the temperature and salinity of water, thereby impacting sound transmission.

This poses a major challenge to airborne ASW. Maintaining barriers on station may not be viable, while operating assets such as maritime patrol aircraft close to the well-protected bastions from which submarines launch precision strike capabilities will expose them to both ground and sea based surface to air missile (SAM) systems. There is an additional challenge, maintaining and reseeding sonobuoy fields represents a capacity challenge, especially when tracking submarines at scale. During the Cold War, large numbers of SSNs and maritime patrol aircraft were needed to maintain multiple barriers across the likely routes of egress that submarines might take. Tasking MPA to track individual SSNs to cue assets such as a friendly SSN to trail a target involves multiple assets being engaged to provide information on any likely object of interest. This requires a resource commitment that is feasible in peacetime but may strain states' wartime capacity. This is not an exclusively Western conundrum, with opponents such as Russia facing significant shortfalls in MPA capacity.

One way in which ASW forces might seek to shift the balance of cost in their favour is through the use of unmanned platforms. Unmanned Surface Vehicles (USVs) equipped with active and passive sensor payloads could, in principle, offer more enduring coverage of an area than a sonobuoy. Experimentation with the control of USVs using helicopters has been conducted using US Navy T24 and T38 USVs being tasked using Seahawk helicopters. In a similar vein, aircraft like the P-8 could be leveraged as control platforms for USVs and UUVs (the latter likely needing to communicate by coming close to the surface intermittently). Secondly, Unmanned Aerial Vehicles (UAVs) – which are currently being experimented with for ASW roles – could be used to expand the endurance of fixed wing ASW assets, thereby reducing the burden on manned MPA. Unmanned assets, if sufficiently cheap, could also be used to harry submarines in highly contested areas. Aerial platforms, which can communicate over the horizon more easily than surface assets, might make logical command platforms for these assets. The premise behind the proposal to use UAVs or USVs is that advances in areas such as machine learning will make it viable to layer historical data with sensor input to detect submarine tonals on the basis of limited acoustic data. Other suggestions include the use of UAVs and USVs in a multistatic array, with expendable assets being used as active emitters and more expensive ones acting as passive receivers. While promising, such forward-looking CONOPS are still nascent.

Secondly, new non-acoustic methods of detection can help offset the impact of quieting submarines. For example, the Peoples Liberation Army Navy (PLAN) has trialled the use of a Superconducting Quantum Interference Device (SQUID), capable of measuring extremely subtle changes in magnetic

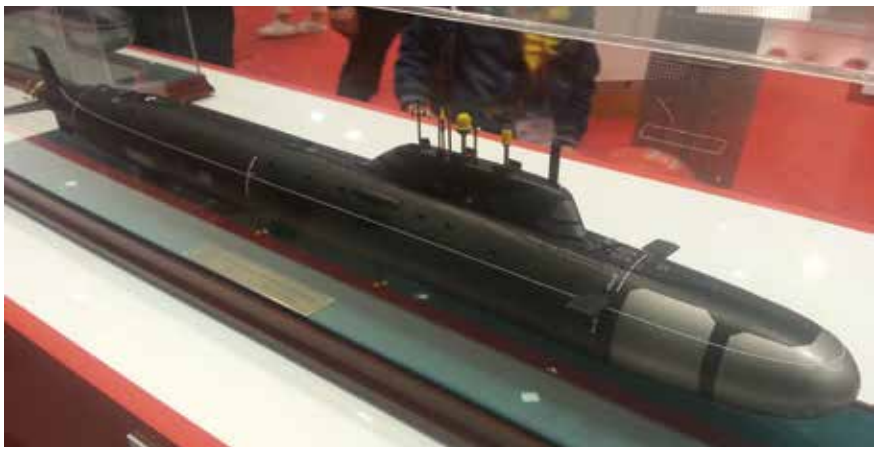


Photo: LeAZ-1977, via Wikimedia Commons

SSGNs like the Russian Yasen Class will alter the ASW challenge both due to their quietness and the range of their weapons.

fields. The capability, if realised, would lead to a step change in the range of magnetic anomaly detectors, with a SQUID having ranges of up to 8 km – well in excess of what a contemporary MAD can accomplish. Thirdly, we might expect to see more evolutionary changes, many of which are already occurring. For example, the US Navy is shifting from DIFAR and DICASS sonobuoys to the use of the AN/SSQ-125 and the AN/SSQ-101 sonobuoys which form the active and passive components of a multistatic sonobuoy system. Multistatic sonobuoys mitigate some of the effects of sound reverberation, and thus extend the range of a given sonobuoy to approximately 8 km, up from the 2-3 km that might be expected using existing bistatic and monostatic systems. Finally, remotely activated mines such as the US Navy's Hammerhead can be deployed from the air to act as active components of an anti-submarine barrier.

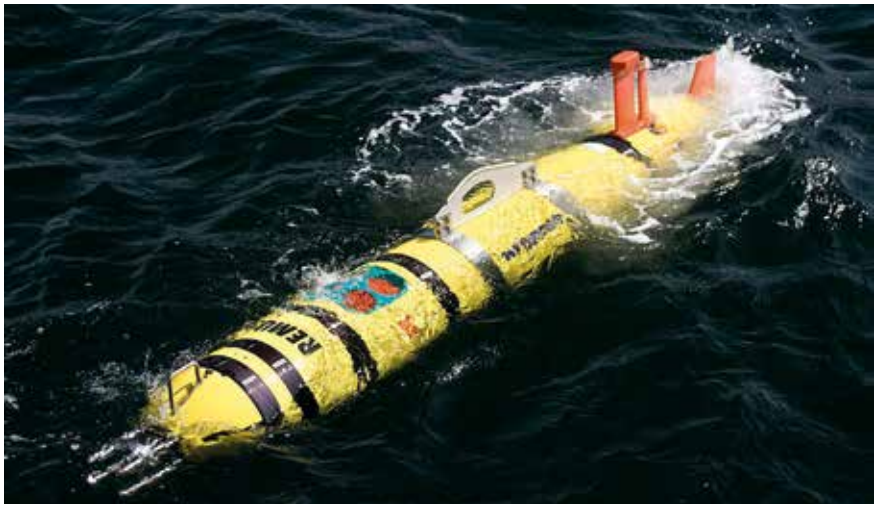


Photo: Royal Navy

One way in which the role of airborne systems could evolve is for them to become battle management platforms for unmanned capabilities such as USVs and UUVs.

Looking Ahead

Ultimately, the future of airborne ASW holds out both challenges and opportunities for its practitioners. A combination of increasingly quiet and long endurance threats and the fact that many threats will operate within contested bastions may pose a challenge to existing approaches. This will be compounded by the issue of diminishing mass, which means that even as capabilities of platforms increase, the capacity available to Western navies may diminish. In this context, purely reactive approaches to ASW will become ever more difficult. A number of evolutions in the area of ASW, particularly those leveraging unmanned assets and longer-range modes of non-acoustic detection, could lead to a renaissance of more forward-leaning approaches to ASW. In this context, airborne ASW assets would retain many of their core functions, but would increasingly act as controllers for other assets, including surface- and subsurface-based unmanned vessels.

Instant Bombers: Rapid Dragon Lends Teeth to Transport Aircraft

Sidney E. Dean

The US Air Force (USAF) is developing the capability to launch cruise missiles and other air-to-ground weapons from cargo aircraft. Experiments deploying palletized munitions are currently being conducted as part of the 'Rapid Dragon' programme. The new operational concept is also being recommended to allies as a rapid force multiplier.

The term 'Rapid Dragon' is derived from a medieval Chinese weapon – 'Ji Long Che' (ENG: 'Rapid Dragon Chariots') referred to ballista-like siege weapons that could fire twelve projectiles at once. According to a 2021 USAF press release, the service chose the name for the new weapon concept because the palletised ammunition similarly promises to launch massed effectors in a single salvo. Its implementation requires no special infrastructure on the ground, no modification of the aircraft, and no special training of the flight or ground crew – any aircraft and crew qualified to execute heavy equipment airdrop would be capable of executing this mission. At the heart of the Rapid Dragon Palletized Effects System lies the standard roll-on/roll-off cargo pallet routinely used for dropping equipment from transport aircraft. A modular carrier frame or "deployment box" with four, six or nine payload cells is mounted on this pallet (respectively known as 'four-pack', 'six-pack' or 'nine-pack' configurations). Each payload cell holds a single munition, and presently the system is compatible with Lockheed Martin's AGM-158 Joint Air-to-Surface Standoff Missile (JASSM) cruise missile family but efforts are ongoing to integrate other munitions, including bombs fitted with Boeing's Joint Direct Attack Munition – Extended Range (JDAM-ER) guidance kits and Raytheon's ADM-160B Miniature Air-Launched Decoy (MALD). Up to two 'six-pack' pallets (for a total of 12 cruise missiles) can be carried on a C-130 Hercules, while the C-17 Globemaster III can accommodate up to four 'nine-pack' pallets (totalling 36 missiles).

Each deployment box is equipped with a cargo parachute to pull the cargo out of the aircraft, and a drogue parachute to slow the box's fall, as well as an electronic control module. The control module serves as an interface to the individual cruise missiles and is used, among other things, for entering target coordinates into the weapons' navigation system. As a rule, the targets are set before the carrier aircraft takes off, but it is possible to change or update the target coordinates at any time before triggering the weapons.

When the launch zone is reached, the pallets are jettisoned via the cargo ramp. The parachutes open and the pallets assume a stable vertical descent. The electronic control module of each deployment box expels the individual cruise missiles one after the other at safe intervals. After expulsion, each cruise missile unfolds its wings and tail fins and achieves aerodynamic control, the air inlet opens, and the engine ignites. After engine ignition is achieved, the weapon performs a powered pull-up manoeuvre to transition from vertical to horizontal flight mode, and sets its course for the predetermined target coordinates.

Photo: Lockheed Martin

CG concept image of a flight of C-17s equipped with Rapid Dragon, deploying up to 36 cruise missiles each.

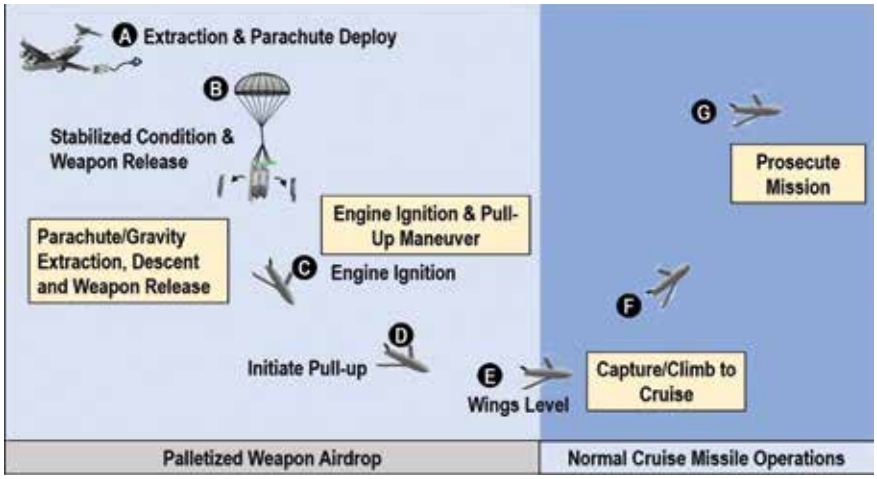
Operational Advantages

USAF describes the Rapid Dragon Palletized Effects System as a force multiplier with several operational advantages:

- The new capability permits a rapid and flexible ramping up of offensive capacity whenever and wherever the tactical situation dictates. The US Air Force alone has more than 650 C-130, MC-130 and C-17 transport aircraft, but only 140 long-range bombers. Even more important than the absolute figures is the fact that transport aircraft are forward deployed in many parts of the world, while long-range bombers must first be dispatched from the Continental United States (CONUS). The Rapid Dragon concept therefore enables an early counter-offensive, buying time for deployment of forces from CONUS.
- Even when a sufficient number of bombers is available in-theatre, Rapid Dragon-equipped aircraft can relieve

a portion of their operational burden and allow theatre commanders to dedicate the bombers to the most demanding missions. As Lt. Gen. Clinton Hinote, USAF Deputy Chief of Staff for Strategy, Integration, and Requirements, expressed in 2020: "What we see is that no matter how big our bomber force is, the capacity that the joint force needs is always more and more."

- Transport aircraft deployed in the Rapid Dragon role can match or even exceed the payload capacity of dedicated long-range bombers – for comparison, a B-52 can carry 20 cruise missiles, and the B-1 can take 24. Deployment of palletised munitions could increase the "on demand" availability of large-capacity, cruise-missile capable aircraft significantly, without the need to invest in highly specialised and expensive bombers which will only be needed infrequently. Following weapons deployment, the aircraft can immediately resume their primary transport function, or conduct additional offensive operations as needed.
- Long-range bombers have special infrastructure requirements and can only operate from a comparatively small number of airfields in most operational theatres. This leads to concerns that an adversary such as China or Russia could pre-emptively target suitable installations with ballistic and cruise missiles to deny their use by USAF bombers. The ability of tactical transport aircraft to take off from any number of airfields, including austere landing zones, forces the adversary to recalculate its strategy, said Lt. General Jim Slife, commander of USAF Special Operations Command (AFSOC). "It's not hard to figure out where all the 10,000-feet concrete runways in the Pacific are, but when you're trying to figure out where the 3,000-feet straight stretches of road and grass strips are, that's a different targeting problem for your adversaries," Slife said at an Air & Space Forces Association (ASFA) event on 7 September 2022.
- This unrestricted choice of starting location means that a larger number of transport aircraft can perform attack flights simultaneously from a variety of directions, putting a strain on enemy defences. The fact that the large transport aircraft have no stealth properties is considered inconsequential, as they are intended to deploy long-range cruise missiles from outside the protected area of enemy air defences. The low-observable AGM-158 JASSM-ER being used in the Rapid Dragon test series has a range of more than 800 km, while the extended range JASSM-XR variant due to be introduced in 2024, will be capable of reaching targets as far away as 1,900 km.



Graphic: AFRL

Representation of Palletized Munitions CONOPS.

Programme Phase 1

The Rapid Dragon programme was launched in December 2019. The US Air Force Strategic Development Planning and Experimentation (SDPE) Office, a division of the Air Force Research Laboratory (AFRL), acts as project lead, with substantial participation of AFSOC, Air Mobility Command (AMC), and industry partners Lockheed Martin Missiles and Fire Control, Safran Electronics and Defense, and Systema Technologies. The programme is divided into two phases: a two-year proof-of-concept phase (2020-2021), and a follow on phase to refine technology and operating procedures (2022-2023).

During the proof-of-concept phase, the programme progressed from a concept design to an initial system flight test within 10 months, followed five months later by the first live-fire flight test. A total of five system level test flights were conducted between August and December 2021, each with increasing difficulty. Three different aircraft – the MC-130J, the EC-130SJ, and the C-17A – were involved. The test missions, some of them utilising mass simulants and surrogate cruise missile payloads, confirmed the procedures for launching and stabilising the carrier pallets, as well as for releasing the missiles. On 16 December 2021, AFSOC conducted a test using a production model AGM–158 JASSM-ER cruise missile with a live warhead. As part of that test mission, new targeting data was transmitted from a ground control centre to an MC-130J aircraft flying over the Gulf of Mexico. The MC-130J's battle management system (BMS) relayed the data to the Rapid Dragon control module mounted on the four-pack deployment box. The module transferred the target coordinates into the cruise missile, overriding the initial set of coordinates. The pallet was subsequently jettisoned,

Photo: Lockheed Martin

Concept image of a cruise missile transitioning to powered flight mode after release from the deployment box.

Photo: SOCEUR

Members of the Polish Air Force help load the palletized precision effects on 8 November 2022, in Powidz, Poland. This training is a c ontinuation from previous iterations with US Special Operations Command Europe (SOCEUR).

releasing the JASSM-ER and three mass simulants. The weapon successfully located and destroyed the intended target within the Eglin AFB Overwater Test Range off the Florida coast.

This test flight marked the conclusion of the first Rapid Dragon test series. It set several milestones, including completion of a mission-relevant test flight within two years of programme inception. The successful transfer of targeting data via the MC-130's aircraft-agnostic BMS also confirmed that missions using transport aircraft can still allow last-minute adjustments to mission parameters. This new retargeting methodology was first developed by the Rapid Dragon team, and now the Air Force plans to apply it to other strike and cargo platforms in the future.

Programme Phase 2

The follow-up developmental prototype phase, also scheduled to run for two years, is presently underway. It aims to refine and optimise the technology and operational concepts. It will also expand the Rapid Dragon carriage portfolio by testing the use of additional weapon systems beyond cruise missiles. This includes developing the ability to load multiple munition types into a single deployment box, enabling a single transport platform to attack multiple target categories on a single pass. Among the primary candidates for expanded ordnance options are AGM-158C Long Range Anti-Ship Missiles (LRASM), which is the maritime variant of the JASSM, and sea mines. These payloads would be especially critical in the early days of a war with China, to prevent the People's Liberation Army Navy (PLAN) from gaining dominance in the East and South China Sea area. Here again, the flexibility and availability of tactical transport aircraft carrying the Rapid Dragon Palletized Effects System could prove a game-changer, buying time for US and allied air and naval assets to deploy.

According to a 9 November 2022 AFRL press release, the Rapid Dragon Experimentation Program has also begun to look beyond kinetic munitions, expanding its focus "from Palletized Munitions to Palletized Effects, which include kinetic and non-kinetic munitions; intelligence, surveillance, and reconnaissance, or ISR, platforms; cargo resupply; and humanitarian aid delivery." Lt. Col. Lawrence Melnicoff, a staff officer with US Special Operations Command – Europe (SOCEUR) added that the system could potentially be paired with hypersonic weapons and swarming Unmanned Aerial Vehicles (UAVs).

(Joint) Force Multiplier

From the beginning the Pentagon has proposed that allied forces adopt the Rapid Dragon concept, which would enable large-scale airborne cruise missile deployment by allies and partners who do not operate heavy bombers. This would significantly increase the force multiplier effect, providing massive firepower against a strong or geographically widespread opponent.

The fact that more than 60 countries worldwide use the C-130 and seven allies have the C-17 in their inventory means that US experience and lessons learned can be seamlessly transferred. Moreover, the concept is not restricted to US-designed airframes. Any other medium-sized to larger class of transport aircraft capable of airdropping supplies and equipment is also suited for the use of the Palletized Effects System.

At the September 2022 ASFA symposium Gen. Slife revealed that several partners

Photo: USAF

A Rapid Dragon Palletized Effects System falls from the cargo hold of a 352nd Special Operations Wing MC-130J Commando II during a live-fire demonstration for ATREUS 22-4 at Andøya Space Defense Range, Norway, 9 November 2022.

from different regions of the world had already asked USAF for help integrating palletised munitions on their transport planes. "We demonstrated this capability [to our allies] in the spring of 2022, and plan to repeat it in the fall of 2022," Slife said.

This second demonstration took place on 9 November 2022 during the Atreus 22-4 NATO exercise conducted at Norway's Andøya Space Defence Range, some 300 km north of the Arctic Circle. A US Air Force MC-130J assigned to the 352nd Special Operations Wing stationed at RAF Mildenhall (UK) jettisoned the deployment box over the Norwegian Sea. As the container descended, it sequentially launched a live JASSM-ER and three mass simulants. The live cruise missile manoeuvred to intercept an ocean surface target, detonating on impact. Allied personnel from Norway, Poland, Romania and the UK witnessed the demonstration. One day prior to this event, US special operations airmen briefed allies on operational procedures, and assisted Polish personnel with loading a Palletized Effects System onto a Polish Air Force C-130 in Powditz, Poland, though no attempt was made to launch that system.

The 9 November demonstration was the first of its kind to be conducted in Europe, and underscored Rapid Dragon's potential for deployment on Russia's flanks as well as in a sea-control mission over Arctic waters, enhancing allied capabilities. "It puts this thing within range of Russia," said Lt. Col. Melnicoff, lead officer for the Atreus 22-4 exercise. "We are intentionally trying to be provocative without being escalatory. We're trying to deter Russian aggression, expansionist behaviour, by showing [the] enhanced capabilities of the allies."

Aiming for Rapid Fielding

At the end of Phase 2, the USAF hopes to have an operational prototype which will lead to serial deployment of the Palletized Effects System. If successful, the effort will represent another victory for advocates of re-tasking systems already in the military's inventory in order to quickly gain new operational capabilities. The Pentagon attributes the program's rapid progress, at least in part, to early inclusion of not only the developmental and operational test community, but also the relevant major commands, mission planners, and aircraft and weapon programme offices. "Rapid Dragon is a prime example of a government/industry partnership that embraces this acceleration mindset, building a community of subject matter experts and executing an aggressive, but well-thought-out, experimentation campaign," said Dr. Dean Evans, SDPE's Rapid Dragon programme manager.

"This type of experimentation campaign, that address capability gaps and demonstrates transformative efforts, helps us shape future requirements and reduces timeline to fielding," said Maj. Gen. Heather Pringle, Air Force Research Laboratory commander, following the December 2021 experiment. "This approach ultimately enables a rapid fielding alternative to traditional lengthy acquisition timelines."

Watching from Above – NATO Airborne Sensing

Tim Guest

Effective and highly sophisticated, NATO has airborne platforms to keep watch on air and surface activities and ensure the Alliance's and friendly tri-service forces are fed with the best possible, real-time information to gain and maintain advantage in any complex battlespace.

NATO has several technological heavyweights in its arsenal of airborne sensing capabilities, which, together, support a wide-range of peacetime and wartime activities conducted by the Alliance. This article takes a brief look at some of NATO's airborne sensing capabilities and force structure, then focuses on two of its key assets: the E3A Sentry AWACS and the RQ-4D Unmanned Aerial Vehicle (UAV) platform.

Overview

Under Allied Air Command's operational control, the NATO Airborne Early Warning and Control Force (NAEW&C Force), the Alliance's largest multi-national collaborative venture, has its HQ located at NATO Air Base (NAB) Geilenkirchen in Germany. It was here, in 1982, that the first NATO Boeing E-3A Sentry Airborne Warning and Control System (AWACS) aircraft arrived to become the Alliance's key 'eye-in-the-sky' component, providing airspace surveillance, battlespace management, as well as command, control and communications (C3) capabilities to NATO.

These airborne sensing platforms have supported such activities as peacetime air policing, counter-terrorism, evacuation, humanitarian and crisis-response operations, as well as the full spectrum of wartime missions. Today, the AWACS fleet at Geilenkirchen comprises 14 Boeing E-3A Sentry aircraft capable of detecting air and surface contacts over large distances, though as part of a larger AEW and airborne reconnaissance entity. The NAEW&C Force currently comprises two operational units, the first consisting of the 14 NATO-owned E-3A aircraft, manned by international crews from 19 NATO member countries. The other unit is the force's E-3D component based at RAF Waddington in the UK, currently operating three, RAF-manned, Boeing E-3D aircraft; these are set to be replaced by E-7 Wedgetail AEW&C aircraft in 2024. France, with an NAEW&C Force observer role, participates in joint exercises and ensures its E-3F planes remain interoperable

Author

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Photo: NATO

NATO's E-3A AWACS aircraft is a modified Boeing 707/320 commercial airframe with a distinctive rotating radome equipped with long-range radar and passive sensors capable of detecting air and surface contacts at long range.

Photo: NATO

NATO's fleet of AWACS aircraft provide the alliance surveillance, as well as airborne C3 and air battle management capabilities.

with other E-3 fleets. The NAEW&C Force also maintains three forward-operating bases (FOBs) at Konya in Turkey, Aktion in Greece, and Trapani in Italy, as well as a forward-operating location (FOL) at Ørland, Norway.

Also owned and operated by NATO is the Alliance Ground Surveillance (AGS) Force, comprising five NATO RQ-4D unmanned aerial vehicles (UAVs) and associated European-sourced ground command and control stations. The UAVs provide Allied forces with near real-time terrestrial and maritime situational awareness in support of a full range of NATO military, as well as civil-military missions and use advanced radar sensors to continuously detect and track moving objects throughout observed areas, providing radar imagery of areas of interest and stationary objects. Based on the USAF Block 40 Northrop Grumman Global Hawk, the RQ-4D system has been adapted to meet NATO's specific intelligence-gathering, surveillance and reconnaissance requirements.

The AGS also comes under operational control of Allied Air Command and enables persistent surveillance to be carried out over wide areas from high-altitude, with these long-endurance aircraft capable of operating at considerable stand-off distances in any weather or visibility. The AGS has its main base at the Sigonella Air Base in Italy, which serves as a NATO Joint Intelligence, Surveillance and Reconnaissance deployment base and from where all five RQ-4D aircraft operate. While the majority of the AGS personnel are in Italy, some are based at Allied Command Operations in Mons, Belgium and at HQ Allied Air Command in Ramstein, Germany.

Photo: NATO

The 14 NATO-owned E-3A aircraft at NAB Geilenkirchen are manned by international crews from 19 member states.

AWACS in Focus

NATO's fleet of AWACS aircraft provide the Alliance with surveillance, as well as airborne C3 and air battle management capabilities that are immediately available in the skies over Europe. The planes in their Airborne Early Warning and Control role can provide airspace surveillance and early detection of airborne threats, such as enemy aircraft and missiles. Support to maritime operations can also be provided, using its maritime surveillance radar to pro-

vide a picture of real-time activities at sea. AWACS aircraft also provide control and management of friendly airspace and aircraft, including the coordination of search and rescue (SAR) operations. Since the E-3A component of the NAEW&C Force was established, it has undergone various modernisation programmes, (more of which later), to upgrade such things as communications, navigation and radar equipment.

Photo: Boeing

Boeing's 2018 cockpit and avionics upgrades of NATO's AWACS aircraft, included five full-colour displays providing crew with customisable engine, navigation and weather data.

Specs and Capabilities

NATO's E-3A AWACS aircraft is a modified Boeing 707/320 commercial airframe, 46.6 m long, 4.5 m wide, and with a 44.43 m wingspan. They are powered by four TF-33-PW110A turbojet engines and the distinctive rotating radome, (also known as a rotodome), which has a diameter of 9.1 m. The rotodome is 1.8 m thick and is held 3.33 m above the fuselage by two struts. Equipped with long-range radar and passive sensors, AWACS is capable of detecting air and surface contacts at long range; combined with an identification friend or foe (IFF) sub-system, the radar can detect, identify and track enemy and friendly low-flying aircraft by eliminating ground clutter returns.

Information collected by AWACS can be transmitted directly from the aircraft to other users on land, at sea or in the air in near real time. The aircraft typically operate at altitudes of around 10 km (32,808 ft) from which a single E-3A can constantly monitor the airspace within a radius of over 400 km, exchanging information with ground-based, sea-based and airborne commanders via digital data links; three E-3As with overlapping orbits can cover the entire area of Central Europe. Using pulse Doppler radar, and flying within NATO airspace, NATO's AWACS planes can distinguish between targets and ground reflections to give early warning to friendly land, sea and air forces of low or high-flying aircraft or aerial threats operating from, or over, the territory of a potential, or active, aggressor. Though capable of flying longer operations with in-flight refuelling, AWACS aircraft typically operate for about eight and a half hours and cover surveillance areas of more than 310,798 km², its maximum range under normal circumstances is 9,250 km. The system's active surveillance radar subsystem is located in the rotodome, which rotates once every 10 seconds and provides 360° radar coverage and surveillance from the Earth's surface up into the stratosphere, over land or water; it can, for example, detect aircraft at ranges of over 400 km. The aircraft has an integrated command and control battle management, or C2BM, surveillance, target detection, and tracking platform that provides an accurate, real-time picture of the battlespace to the Joint Air Operations Centre.

The E-3A's major sub-systems include its avionics, navigation, communications, sensors (radar and passive detection) and identification tools (IFF/SIF – selective identification feature). The mission suite includes consoles that display computer-processed data in graphic and tabular format on video screens. Each aircraft is manned by a flight crew of three and mission crew of 12, the latter tailored for each flight to meet the requirements of each assigned mission and performing all surveillance, identification, weapons control, battle management and communications functions.

Radar and computer subsystems on the E-3A Sentry can gather and present a range of battlefield information, such as position and tracking information of enemy aircraft and ships, and location and status of friendly platforms, all to be sent to major command and control centres in rear areas or aboard ships, including real-time information needed for interdiction, reconnaissance, airlift/SAR and close-air support for friendly ground forces. It can also provide information for commanders of air operations to gain and maintain control of the air battle and can direct fighter-interceptor aircraft towards enemy targets detected approaching NATO member country borders.

Photo: NATO

WACS aircraft have been flying many missions over the years, including operations against ISIS. Pictured – crew conducting anti-ISIL ops.

During hostilities, AWACS intel can also be shared in real time at the highest governmental levels of NATO member countries.

AWACS – Revolving and Evolving

All AWACS aircraft undergo continuous modifications and modernisation. In 2018/2019, for example, major upgrades took place in which a digital, or glass, cockpit and other modifications were completed by Boeing, in part to meet changing European air traffic management requirements. Upgrades included five full-colour digital displays in each aircraft, replacing 1970's-era dials and providing the crew with customisable engine, navigation and radar data. These digital capabilities have also allowed NATO to consolidate crew responsibilities.

The latest upgrades currently underway are large-scale mission and audio system modernisation efforts, designated the Final Lifetime Extension Programme (FLEP), and intended to ensure the aircraft remain operationally effective through 2035.

The FLEP is valued at USD 1 Bn, (Boeing is prime contractor with several subcontractors from NATO member defence industries), and will provide AWACS with sophisticated new communications and networking capabilities, including upgrades to data link and voice communications capabilities, and with an enhanced wide-band, beyond-line-of-sight, airborne networking capability. The first AWACS entered the FLEP in April 2022 to provide what Boeing states as 'critical modifications to improve the system capability, interoperability and availability' of the aircraft, which Kim Stollar, Boeing MD for Europe & NATO Government Affairs said would support the Alliance's smooth transition from the AWACS into the Alliance Future Surveillance and Control (AFSC) capability.

The Alliance already raised the subject of an AWACS successor at NATO's Warsaw conference in 2016 when it was agreed that, "by 2035, the Alliance needs to have a follow-on capability to the E-3 AWACS. Based on high-level military requirements, we have decided to collectively start the process of defining options for future NATO surveillance and control capabilities." This effort has since been carried forward as the AFSC initiative involving all NATO members. It is evaluating new technologies and a 'system-of-systems' approach, that will potentially combine air, ground, space and unmanned systems, networked together, to collect and share battlespace information. A 2018 AFSC first phase led to six concept proposals from trans-Atlantic industry consortia delivered in 2020, with the best innovative ideas selected by NATO for further development. A second phase competition involving those ideas was launched in 2021. Then, in March 2022, a Boeing-led industry team won a NATO E-3 replacement contract from the NATO Support and Procurement Agency (NSPA) to conduct a risk reduction and feasibility study of future air surveillance, command, and control concepts to help NATO refine concepts to replace the capabilities currently provided by its AWACS fleet. The Boeing-led team – the Abiliti partnership – comprises: Indra, Spain; Leonardo, Italy; Thales, France; ESG Elektroniksystem und Logistik, Germany; Lufthansa Technik, Germany; and Mott MacDonald, UK.

AWACS – Latest and Urgent Operations

AWACS aircraft have flown multiple missions over the years, from its 'Assurance Measures' missions since 2014 to its eastern allies, following Russia's illegal annexation of Crimea, to tailored Assurance Measures missions over Turkey, following the crisis in Syria, and operations against ISIS.

The aim of the missions following the Crimea annexation was to demonstrate NATO's collective resolve, its defensive nature, and to deter Russia from further aggression or the threat of aggression against NATO members! That worked well. It begs the question, what have AWACS been doing since Russia's 24 February 2022 invasion of Ukraine? Well, in reaction to the build-up of Russian troops at Ukraine's borders prior to the invasion, the NAEW&C Force began preparations for additional intensive air operations and enhanced vigilance activities to substantially increase Allied readiness. All aircraft were prepared to be ready continuously and since the invasion, flying hours have significantly increased, ensuring the comprehensive monitoring of the evolving situation on NATO's Eastern flank. Unsurprisingly, NATO has also considerably increased the number of fighter jets on alert across Eastern Europe in response to Russia's war against Ukraine. Major General Jörg Lebert, Allied Air Command HQ Chief of Staff, said, "NATO air forces have bolstered their presence in the eastern part of the Alliance helping to shield NATO against any aggression. Several dozen fighter jets are on alert at any time to respond to possible airspace violations and to deter aggression. Allied Air Command integrates the Allied air forces' fighters, air-to-air refuelling and transport aircraft, as well as Allied and NATO AWACS platforms into standing arrangements to safeguard allied skies. These assets enable NATO to patrol Allied airspace and have 24/7 situational awareness above NATO and adjacent territory." A

Photo: NATO

The first of five AGS NATO RQ-4D aircraft landed at Sigonella in November 2019.

Joint Force Air Component (JFAC) has been stood up at Allied Air Command to plan, task and control Allied aircraft flying these latest Enhanced Vigilance Activities.

Alliance Ground Surveillance

Complementing NATO's AWACS eyes in the sky is NATO's Alliance Ground Surveillance (AGS) system, based at the AGS main operating base in Sigonella, Italy, and comprising five NATO RQ-4D Phoenix (Global Hawk) UAV and a series of associated ground command and control stations. The airborne system provides a near-real-time terrestrial and maritime Intelligence, Surveillance and Reconnaissance (ISR) capability for NATO forces and Allies, delivering in-theatre situational awareness to commanders of units on the battlefield. The system's role extends from the support and protection of Allied ground troops and civilian populations, to border control and maritime safety, counter terrorism activities, crisis management and humanitarian assistance in natural disasters. Like AWACS, AGS assets are NATO-owned and operated and enable the Alliance to perform persistent surveillance over wide areas.

The RQ-4D platform is a high-altitude, long-endurance (HALE) ISR aircraft, which can operate at considerable stand-off distances in all weather and visibility. Its advanced radar sensors continuously detect and track surface moving objects, as well as highlighting

Photo: INATO

NATO RQ-4D at Sigonella on the occasion of full handover.

stationary targets throughout an observed area of interest. The platform has a wingspan of 39.8 m, is 14.5 m long, and stands 4.7 m high. Weighing 6,781 kg, the Phoenix is powered by a Rolls Royce-North American AE 3007H turbofan engine delivering 33,800 N of thrust. It has a maximum take-off weight of 14,628 kg and a typical 1,360 kg payload. With a fuel capacity of 7,847 kg and flying at operational speeds around 575 kph and maximum altitudes around 18.28 km (60,000 ft), the AGS Phoenix UAV can achieve a range of some 16,113 km (8,700 NM).

Origins

The AGS programme emerged in the 1990s, aimed at providing NATO with a complete and integrated ground surveillance capability giving Alliance members unrestricted and unfiltered access to ground surveillance data in near real-time, and in an interoperable manner. Its air segment was set to comprise airborne radar sensors, and its ground segment fixed, transportable and mobile ground stations for data exploitation and dissemination, all seamlessly interconnected through high-performance data links. While a mixed fleet approach for the air segment was initially set in motion in 2004 with Airbus A321 manned aircraft and Global Hawk UAVs, both carrying versions of the TCAR radar, a NATO decision was taken to discontinue the mixed-fleet approach in 2007 due to declining European defence budgets. Instead, a simplified AGS system was agreed, with the air segment based on the off-the-shelf Northrop Grumman Global Hawk Block 40 UAV and its associated MP-RTIP sensor. In 2012, it was agreed that instead of financial input to the programme, the UK would instead make its Sentinel manned system available, and the French their then future Heron TP UAV system available to NATO's emerging AGS capability.

That same year, a procurement contract for the AGS system was signed with prime contractor, Northrop Grumman, on behalf of the 15 NATO countries contributing to the purchase: Bulgaria, Czech Republic, Denmark, Estonia, Germany, Italy, Latvia, Lithuania, Luxembourg, Norway, Poland, Romania, Slovakia, Slovenia and the US. Northrop Grumman's AGS industrial team includes Airbus Defence and Space, Leonardo, and Kongsberg, together with companies from all acquiring nations.

In 2015, the NATO AGS force determined the configuration of its AGS NATO RQ-4D unit in terms of staffing levels and unit structure, and that the UAVs would operate from Sigonella Air Base. In the same year, Mobile General Ground Station (MGGS) and Transportable General Ground Station (TGGS) rollouts took place, together with the first test flight of a NATO-configured RQ-4D in the US. The first remotely-controlled test flight from Sigonella took place at the end of 2017, with temporary AGS infrastructure in place throughout the following few years, though with the construction of permanent AGS facilities scheduled to have been completed by end 2022.

The first of five permanent AGS NATO RQ-4D aircraft landed at Sigonella in November 2019; the fifth aircraft arrived one year later in November 2020, at which time formal handover of the entire AGS system to the NATO AGS Force commenced, with a first operational mission flown in November 2021. This mission saw one of the RQ-4D Phoenix aircraft take off towards the Black Sea and return 24 hours later to Sigonella proving its full operational capabilities. The challenge of this long mission focused on the airmen and soldiers operating the system, in particular their ability to hand over smoothly between shifts, including sensor operators, responsible for controlling the system's synthetic aperture radar, who also changed over at the same time as the pilots. An initial full operational capability was achieved in February of 2022, with full and final handover completed in March.

AGS Today

Today, the NATO AGS Force at Sigonella serves as a NATO JISR deployment base and as a data exploitation and training centre. It comprises some 400 AGS personnel, though some AGS staff elements are based at Allied Command Operations in Mons, Belgium and at Allied Air Command in Ramstein. Like AWACS, AGS monitors Alliance territory, though solely to determine what is happening on the ground in relation to NATO operations.

It is an integrated system consisting of the air segment, a ground segment and a support segment. The air segment comprises the five NATO RQ-4D aircraft, which are equipped with a multi-platform radar technology insertion programme (MP-RTIP) and ground surveillance synthetic aperture radar (SAR) sensors, as well as an extensive suite of line-of-sight and beyond-line-of-sight, long-range, wideband data links.

Consisting of a number of ground stations in fixed, mobile and transportable configurations, the AGS ground segment provides high-speed data-link connectivity, data-processing, exploitation capabilities and interoperability interfaces to the system network and interfaces the AGS core system with a wide range of command, control, intelligence, surveillance and reconnaissance (C2ISR) systems. It interconnects with multiple deployed and non-deployed operational users, and reach-back facilities away from the surveillance area.

In December 2022, sustained surge operations were conducted from Sigonella, which is now known as NATO's Alliance Ground Surveillance Force (NAGSF), during which the multinational ISR collection force flew RQ-4Ds on four 24-hour missions on the Alliance's eastern flank. Pilots, sensor operators, and intelligence analysts all controlled collection activities from Sigonella's mission operation support centre.

Commander of the NAGSF Flying Squadron, USAF Lieutenant Colonel Douglas Pruitt, said the surge missions required that five different crew positions be manned continuously while the UAVs were in flight. He said that as with any operational air missions, pre-mission planning and post-mission debriefs were also required, adding, importantly, "NAGSF's multi-national, professional aircrew are providing vital, near-real-time intelligence that is enhancing situational awareness on NATO's eastern flank following Russia's invasion of Ukraine."

The NAGSF base commander at Sigonella, USAF Brigadier General Andrew Clark, said, "After declaring our initial operating capability, we increased our operational tempo faster than anticipated, with Russia's invasion of Ukraine being the primary factor." He added that well over 100 sorties had been flown by end 2022 and more than '11,000 intelligence products disseminated'. Clark said that NAGSF not only collects and distributes intelligence from its RQ-4D missions, but also – and more importantly – processes and shares so-called 'federated intelligence products' received from other sources, and it is this integration of these two processes that makes NAGSF a crucial specialised unit within NATO's ISR community. ■

Chinese Strategic Airlift – The Dragon's Talons Extend

Ian Frain

In the second week of April 2022, six of the latest X'ian Aircraft Industrial Corporation Y-20A transport aircraft of the People's Liberation Army Air Force (PLAAF) appeared at Nikola Tesla International Airport in Belgrade, much to the surprise of many Western observers.

The appearance of the six Y-20A transport aircraft, apparently delivering an unspecified cargo, was part of the ongoing cooperation between Belgrade and Beijing according to Chinese Foreign Ministry spokesperson, Zhao Lijian. In the meantime, Serbian President, Aleksandar Vučić, announced that the Chinese were delivering FK-3 surface-to-air missiles (SAM), the export variant of the HQ-22 SAM system, as part of Serbia's re-armament programme.

The arrival of the Chinese transport aircraft in Europe attracted the attention of aviation enthusiasts watching the Flightradar24 App, and shared through the ADSB global exchange website, as they transited through Baku International Airport in Azerbaijan, before crossing Turkish airspace and landing in Belgrade, though they were unlikely to be aware of the significance of their appearance.

At the AIRPOWER22 air show, held on 2-3 September 2022 at Zeltweg Air Base in the Austrian state of Styria, one PLAAF Y-20A appeared as the star attraction, along with the last public appearance of the Austrian Armed Forces (Bundesheer) Aerospatiale Alouette III legacy helicopter.

The Y-20 has a deceptive appearance. At a distance, it resembles the United States Air Force (USAF) Boeing C-17A Globemaster III, but on closer inspection, it is in fact not only different, but also smaller.

Author

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Photo: Ian V Frain

Front side view of the X'ian Y-20A, during the AIRPOWER22 air show in Austria, September 2022.

The Y-20A has been under development for over a decade, and there are elements in its design that have come about with Russian help, such as the Antonov Aircraft Design Bureau with the Y-20A's nose resembling that of the Antonov An-178.

The Millennium Airlifter

The development of the Y-20 was accelerated following the 2008 earthquake in China's Sichuan Province, a tragic natural disaster that demonstrated the urgent need for an airlifter in that class.

The PLAAF has been using the smaller Shaanxi Y-9 'Mist' aircraft powered by four turboprop engines and the legacy Xi'an Y-7G. The latter was based on the design of the Russian Antonov An-24 transport aircraft. The Chinese derivative of the An-24 first flew as far back as 1970, and since then there have been no less than 14 variants including one Airborne Early Warning (AEW) variant, the Xian JZY-01/Y-7 AWACS. More recently, this particular variant has been used as a testbed for the new carrier-based Xi'an KJ-600 for China's new aircraft carriers.

The Y-20 combines the latest manufacturing technology and composite materials in the aircraft construction, which leads to a reduction both in its overall weight and in fuel consumption. The Y-20 has numerous unique features, such as the airframe, which includes high-lifting devices along the wings' leading and trailing edges, which is aerodynamically advantageous. The aircraft has a supercritical wing design which provides increased lift, reduced drag, and the airflow over the wing can almost be supersonic. The Y-20 was designed to operate closer to the edge of battle with short (unprepared) runways and has an undercarriage with six pairs of main landing wheels.

Photo: Japanese MoD

The PLAAF H-6K bomber in flight, from the same family as the H-6U variant developed as to undertake AAR missions.

The first Y-20 prototypes were powered by Russian 12-tonne thrust Soloviev D-30-KP-2 engines, which thereafter became the standard for those coming off the production line. However, the PLAAF's longer-term plans include the latest versions, the Y-20B, due to be powered by an indigenous power plant, following a considerable amount of research and development. The result is the Shenyang WS-20 high bypass turbofan aircraft. A Y-20B prototype fitted with the WS-20 flew for the first time at the end of 2020.

As with the latest western transport aircraft of the Airbus A400M Atlas or Boeing C-17A Globemaster III class, the Y-20 has a modern digitised avionics suite and is also equipped with Fly-By-Wire (FBW) technology. The Y-20 boasts a four-crew glass cockpit with two Heads Up Display (HUD) units, and five large Multi-Function Displays (MFD) to ease pilot workload. The aircraft has an Enhanced Vision System (EVS) installed below the forward windshield to assist in taking off and landing under adverse weather conditions.

A Candid Move

Around two decades ago, the Chinese military ordered about a dozen Russian United Aircraft Corporation (formerly known as Ilyushin) Il-76MD/TD aircraft (NATO reporting name: Candid), and during the course of 2005, they ordered an additional 34 airframes. However, the order and subsequent deliveries were hampered by the collapse of Ilyushin itself. Finally, in 2012, all Il-76 deliveries were completed, including an additional three second-hand Il-76MD/TD aircraft ordered the previous year. The Il-76 has been in the Russian Air Force's service since the late 1960s, forming the backbone of their strategic airlift before the introduction of the heavier Antonov An-124 (NATO reporting name: Condor). It is understood that the Il-76 will be replaced by the Y-20 in the future.

Fuelling the Flight

The PLAAF has amassed a large amount of fourth and fifth generation combat aircraft over the last two decades. It has done so through purchasing, as well as manufacturing under licence, as with the case of the Russian Sukhoi Su-27 becoming the J-11 in PLAAF service and J-15 in the inventory of the People's Liberation Army Navy (PLAN) aviation. There are also numerous variants of the indigenously produced J-10 fast jet, the JF-17 single-engine, single-seat fighter, and the latest fifth generation J-20 Mighty Dragon and JF-35 Blue Shark. Expanding into the Indo-Pacific region with this larger fleet has necessitated the creation of a greater Air-to-Air Refuelling (AAR) capability. For three decades, the PLAAF used a derivative of the legacy Russian Tupolev Tu-16 strategic bomber (NATO reporting name: Badger), known as H-6U, built by X'ian. There are versions of the H-6U used for the AAR role, after being equipped with a pair of underwing hose-and-drogue RDC1 refuelling pods.

The majority of the H-6U tanker fleet is based in the east and south-east of the country, as Taiwan is currently the focus of Chinese strategic policy. The small island, formerly known as Formosa, has experienced aggressive moves from China for several decades, from naval manoeuvres to near incursions by PLAAF aircraft. The design may be six decades and over, but the PLAAF fleet underwent a number of improvements with regard to avionics, such as the new navigational equipment, including an Inertial Navigation System (INS) and Global Positioning System (GPS), which were installed along with an improved flight control system. One drawback of the H-6U is its inability to conduct AAR operations at night following a number of trials, which resulted in the decision that this aircraft would not conduct routine night operations.

The PLAAF also operates the tanker version of the Ilyushin Il-76, known as the Il-78 (NATO codename Midas). The Il-78's configuration includes two large fuselage tanks that carry 80,000 lb of auxiliary fuel. Both of these tanks are mounted on fixed pallets which are carried on the main freight deck. The original Il-78 tankers initially served in a dual role, tasked with both transport and AAR, but more recently, the PLAAF Il-78 aircraft have been employed as dedicated tankers, with a single large fuselage tank fitted for auxiliary fuel.

With the modernisation of the PLAAF fast jet fleet, plans are afoot to replace the H-6U with a tanker version of the Xi'an Y-20, known as the YY-20. The YY-20 is equipped with the newer RDC3 refuelling pods, with one each located on the wing stations and one on the centreline of the aircraft. As with other AAR tankers in the global marketplace, such as the twin-engine Airbus A330 MRTT (Multi Role Tanker Transport) and Boeing's KC-46A Pegasus, the YY-20 is

Photo: Taiwanese MoND

The Y-9 is available in multiple configurations. The pictured Y-9Q variant in service with the PLAN is configured for anti-submarine warfare, with a notably long tail boom housing a magnetic anomaly detector.

equipped with infrared (IR) and television cameras mounted on the fuselage to assist the aircrew (especially the air refuelling airman) when conducting refuelling operations safely, day or night. As with the Y-20A/B transport, the YY-20 is in the process of replacing the Il-78 in the AAR role for the PLAAF.

Turbo Transports

The PLAAF may have the latest heavy jet powered strategic transports and AAR platforms, but they also hold a substantial number of turboprop airframes. In 2005, at the 11th Beijing Air Show, the new four-engine turboprop Shaanxi Aircraft Company Y-9 was unveiled, with the first prototype then flown in 2010 and deliveries commencing in 2012. Powered by four WJ-6C engines, the Y-9 was intended to replace the older legacy Y-8 (Antonov An-12). The engines themselves provide 5,100 shaft horsepower (SHP) and are fitted with composite blades for increased performance at high altitude. Interestingly, the tail has additional vertical stabilisers to assist the aircraft with maintaining stability at very low speeds. As with other modern airlifters in its class, the aircraft has an all-glass cockpit consisting of Multi-Function Displays (MFD), and Electronic Flight Information Systems (EFIS) to ease pilot workload. It is also equipped with an optronic Forward Looking Infrared (FLIR) sensor to aid with low-level flights or in adverse conditions, as well as in possible special operations. In terms of capacity, the Y-9 can carry just under 100 paratroopers or between 13—15 tonnes of cargo. The PLAAF is not the only operator of the Y-9, as two examples were briefly in China's Army Aviation Corps before being returned to the PLAAF, while the People's Liberation Army Navy (PLAN) acquired the Y-9 about three years ago in 2020.

Another modern PLAAF turboprop is the Short Take Off and Landing (STOL) twin-engine Harbin Y-12D, which entered service in 2015 in the light transport and paratrooping role. The Y-12D evolved from a 40-year old design, which began life as the Y-11 in the early 1980s. The early versions of the Y-12 were unique in that they were powered by western engines, in this case the Canadian Pratt & Whitney, Canada (PW & C) PT6A-11, and now have the newer four-blade locally-produced WJ-9 engines. With regard to the use of the PT6A-11, the Y-12 civilian version was actually certified by the United States Federal Aviation Administration (FAA) in 1995.

The Y-12D is more of an army aviation asset as it serves in the Peoples Liberation Army Airborne Corps, which replaced the Russian Antonov An-2 biplane (NATO reporting name: Colt), Y-5 in the paratrooper drop role.

Photo: Ian V Frain

Three-quarter rear view of the X'ian Y-20A, during the AIRPOWER22 air show in Austria, September 2022.

Distinguished Flying

As with many air arms around the globe, the PLAAF has a small fleet of Distinguished Visitor (DV)/Very Important Person (VIP) aircraft to transport the president/prime minister, and other dignitaries around the country, and also globally. These aircraft have also served in a secondary role as an airborne command post, such as one two-engine Boeing 737-3Q8 in their fleet. This particular airframe is based on the 737CL (Classic), and was converted from an airline configuration (operated previously by China United Airline) into an airborne command post by Xi'an.

The PLAAF also operates a small number of the Boeing 737NG (New Generation) in the DV/VIP role. These were initially painted with civilian markings and registrations, but now have PLAAF symbology and military markings. Additionally, the PLAAF operates the more modern Airbus Corporate Jets (ACJ) A319, with three currently in service.

The Dragon's Global Presence

In 2022, from the escalating tensions in the South China Sea and Taiwan Strait, to the surprise presence of the Y-20 in the Balkans and the international air show in Austria, the PLAAF has demonstrated a global reach capability beyond the Indo-Pacific region. Over the past decade, PLAN units have deployed to the Horn of Africa as part of the international effort to combat piracy against international shipping. A small aviation element of the Chinese military is seen with the ship-borne Harbin Z-9 Dauphin, which is a licence-built version of the Aerospatiale (then Eurocopter, and now Airbus Helicopters) AS365N/AS565F Panther multi-role helicopter. The PLAN has established a naval base in Djibouti to support these activities in the region over the last six years. There is also a proposal to establish another naval base in Equatorial Guinea, covering the Atlantic.

PLAAF air transport capabilities are also expanding with the introduction of the Y-20 and YY-20. In the West, the new airframes match the capabilities of the American Boeing C-17A and European Airbus A400M, as well as the Airbus A339 MRTT (Multi Role Tanker Transport). However, it does not stop there, as it is rumoured that the PLAAF (as of 2022), is developing a heavier strategic transport aircraft, thought to be around the Lockheed C-5M Super Galaxy and Antonov An-124 four-engine class. With 2023 being the Chinese Year of the Rabbit, it seems the PLAAF and China's air industry are in a good place to continue upwards and outwards. ■

The Indian Air Force's Falling Squadron Strength

Suman Sharma

As the Indian Air Force (IAF) enters its 91st year, an apparent 'code-red' seems to have been sounded by its top leadership over the declining fighter squadron strength, raising the questions around how many combat jets India has available and how many it needs to fight a war. To deal with this historic drop in its air power, the IAF is scouting for foreign fighters, while also looking at indigenous options, thereby expediting the large multi-role fighter aircraft (MRFA) programme for 114 fighter jets.

The IAF's Air Chief Marshal VR Chaudhari reiterated the grim picture over the plummeting squadron numbers in October 2022: "With the given numbers it may not be possible to maintain a 24/7 combat air patrol or an air defence watch from Sir Creek to Siachen and further to the East. So, the numbers definitely are essential, 42 will remain, though it's a difficult goal to achieve in the next decade or so, we will review it only based on the situation arising in the neighbourhood. Based on the current situation, as per the mandate given to the IAF, it is essential that we build up the numbers."

Currently down to just 31 fighter squadrons, making it roughly 18 fighters per squadron, the IAF's predicament increases each year as combat aircraft retire. The fighter squadron strength of the IAF fell to 31 recently with the phasing out of the Srinagar-based MiG-21 Bison squadron. The force finds itself in desperate need of fighters, as its falling numbers are expected to present a challenge in the coming decades. The IAF's requisite authorised strength is 42 squadrons, and squadron numbers are only expected to rise to 35-36 by the middle of the 2030s. Owing to the ongoing Ukraine-Russia conflict, the IAF has deferred its orders for 21 more MiG-29s and 12 more Sukhoi Su-30MKIs from Russia.

Dwindling Numbers

The IAF Chief's statement echoes what experts have been opining in the context of several units either getting 'number-plated' (wherein the unit is kept in service on paper, but its personnel are in fact sent out to other units) or are in the process of being so, in a process expected to last until the mid-2030s. For instance, the IAF's twin-engine Jaguars are likely to be phased out by 2032-33, while the upgraded MiG-29s and the Mirage-2000 fleet will complete their shelf life and total technical life approximately by the same time. Adding to the IAF's woes is the fact that in the next 15 years, multiple squadrons are due to be decommissioned, beginning with the three remaining MiG-21 Bison squadrons to be out of service by 2025.

In November 2022, on the sidelines of the Indo-French joint exercise Garuda VII in Jodhpur, IAF Chief Chaudhari had said that India will need about five-six squadrons of '4.5 generation' fighter aircraft to accomplish the IAF's immediate commitments. Some progress has been made on the domestic development front, with India recently including its home-grown Light Combat Aircraft (LCA) Tejas and the recently inducted light combat helicopter (LCH) 'Prachand' in the Indo-French exercise 'Garuda VII'. This was the first time these aircraft have participated in an international exercise. While this shows some promise, India will need much more to plug its capability gaps.

Photo: US Navy

Aircraft assigned to the US Navy's USS Ronald Reagan (CVN 76) Carrier Air Wing (CVW) 5 and the Indian Air Force aircraft fly in formation over the Indian Ocean.

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With most fighter squadrons set to be phased out over the next decade and a half, the IAF has made it clear that there's no question of reviewing its sanctioned strength of 42 fighter squadrons. However, the gap between the current strength and the target strength is somewhat greater than it appears. This is because despite the IAF maintaining a fleet strength of 31 squadrons on paper, the number is lower in reality, since the availability of some of the fighter types is less than 50%, due to serviceability issues and non-availability of spare parts.

Air Chief Chaudhari has clarified that despite the service looking at technology and quality of the fighter aircraft, raw numbers still matter. The IAF's Air Vice Marshal Suresh Singh (retd) added, "If India must fight a war with China and Pakistan, then the numerical superiority is not in our favour. Although the man behind the machine is most important, but notwithstanding, we need to increase our combat aircraft on topmost priority."

The Threat Perception

The IAF's present leadership has reiterated the importance of numbers in the wake of the burgeoning Chinese and Pakistani assets, stating that it is imperative to augment fleet strength to operate over a large region while facing adversaries possessing greater combined numbers.

Pakistan

There are reportedly 20 squadrons with 400 fighter jets in the Pakistan Air Force (PAF), with prospects of the number going up to 24-25 squadrons with vintage fighters being replaced by J-10C and JF-17 Block III, which are being inducted.

Recently US Congress' clearance to supply a spares and maintenance package for F-16s is bound to lengthen the life of the PAF fighters, thereby augmenting the inventory with 75 F-16s, 50 J-10 C (two squadrons) and 250 JF-17s.

China

A rapidly rising China's People's Liberation Army Air Force (PLAAF) boasts a modern combat aircraft fleet, supplemented by capable ground-based air defence (GBAD) systems. The PLAAF's present inventory comprises approximately 1,700 fighters, including 150 fifth-generation J-20s, and a second fifth-generation fighter FC-31/J-31 due to enter service over the short term. China has also made capital available for further modernisation of the Chinese armed forces.

While India does not regard the PAF as its primary threat, due to regarding it as air-defence oriented, nonetheless its close wargames with PLAAF have demonstrated interoperability, and present the possibility that the PLAAF could operate from Pakistani bases. This presents the IAF with the threat of a two-front conflict, complicating India's defence in such a scenario.

IAF's former Assistant chief of air Staff, Air Vice Marshal Manmohan Bahadur (retd) says, "Though numbers have their own value, the accretion of modern multi-role aircraft in the inventory offsets that to a great extent. The Air Chiefs have been quite clear in their statements that the threats have been catered-for in the IAF's plans with the inventory at hand."

According to security experts, the Indian armed forces are presently equipped to go to war simultaneously on both fronts, at 30 days (intense) and 60 days (normal) rates.

The IAF's Current Combat Assets

The IAF operates an assorted fleet which is an aviation aficionado's delight, drawn over the years from different parts of the world, from the MiG-21 'Bison' fighter, to the 4.5 generation French Rafales. Faced with a shortfall of 11 squadrons and 200 fighters, the IAF currently operates 12 Sukhoi Su-30MKI, five Jaguar, three Mirage-2000, three MiG-29, two Rafale and two LCA squadrons, spread all over India.

Dominant among IAF's fleet is the Russian twin-engine Sukhoi Su-30MKI, of which around 270 are in service. These are license-produced by the state-owned Hindustan Aeronautics Limited (HAL), and were planned to undergo a major upgrade in electronics and weapons until the outbreak of the War in Ukraine. Indian Parliament was informed by a Standing Committee on Defence that an increase in availability rates of Su-30MKI and other fighters in service could counter some of the aircraft shortages in the interim.

Close on the heels of the Sukhoi Su-30MKI, in terms of numbers, are the vintage, twin-engine Anglo-French SEPECAT Jaguar strike aircraft, also built by HAL under license. About 130 Jaguars are currently in service in the IAF, with some of them configured for anti-ship operations. The six squadrons of the aging Jaguars are expected to be phased out by 2031-32.

The Russian MiG-29 twin-engine, multi-role fighter comes in third place, with 65 in service currently. The IAF Fulcrum fleet is due an upgrade to their weapons and sensors, thereby transforming them into modern combat platforms. The MiG-29 fleet is likely to be decommissioned by 2035.

At number four is the Soviet-era MiG-21 Bison, which is well past its prime. The last 54 of these MiG-21 vintage jets are due to be phased out of service by 2025. The French Mirage-2000 are India's most trusted combat aircraft, as their reliability was proven during the Indo-Pakistani

Photo: US Air Force/Tech. Sgt. Nathan Lipscomb

Two French F-2 Rafales fly over Iraq in support of Operation Inherent Resolve, 8 January 2016. The Rafale is the Indian Air Force's most capable Western-developed combat aircraft.

Kargil conflict in 1999 and the more recent Balakot air strikes in 2019. A robust upgrade programme has helped them to keep pace with the modern battlefield. India's Mirage-2000s are likely to retire from the IAF by 2035.

The IAF's latest acquisition is the French Rafale twin-engine multi-role fighter, currently making up just two squadrons, one in the north and the other in the east, with 36 fighters bought under a fast-tracked contract in 2020. The Rafales have been used for combat air patrols in eastern Ladakh, where they played a key role in containing the situation at the Indo-China border, during the ongoing standoff, as they were operationalised within a few weeks of their arrival and induction.

The home-grown LCA Tejas single-engine fighter has been used to equip two squadrons based in the South of the country, with 30 aircraft currently in service, with an order of 83 more LCA Mk-1 in the pipeline. The IAF is also considering further orders for an improved LCA Tejas Mk-2 model.

MRFA: Will Foreign Fighters Dominate Indian Skies?

The multi-role fighter aircraft (MRFA) programme is India's most ambitious 'mother of all deals', intended to reverse the decline in squadron strength. Under the international tender, India plans to acquire 114 multi-role fighters, equating to six squadrons, and valued at USD 20 Bn. The IAF is in the process of firming up MRFA's technical and air staff qualitative requirements (ASQRs), after a Request for Information (RfI) was sent out to eight contenders, following which a Request for Proposal (RFP) is due to be issued soon.

This tender has been pending for a long time, as the Indian Government is said to be in talks with the original equipment manufacturers (OEMs) to boost indigenisation in combat jets towards a greater 'Buy Global Make in India' commitment. Under these plans, a portion of the fighters will be bought directly, while the remaining will be built in India under a joint venture with an Indian strategic production partner. The Indian government has clearly stated that the selected aircraft manufacturer will have to favour its 'Buy Global Make in India' initiative over the strategic partnership policy model to produce the fighters within the country.

The MRFA programme kicked off in 2018, with the following eight contenders responding to one of the biggest fighter purchases in the world.

Photo: Saab

Sweden's Saab is pitching the Gripen E as the most cost-effective option for India.

Who Are the Contenders for the Big Prize?

1. Rafale from Dassault Aviation France – considered to have an edge by virtue of being in service already, this twin-engine fighter stands a good chance of winning as India has invested a large amount over infrastructure support for its present Rafale fleet. However, following the 2015 order for 36 jets, its chances have been negatively impacted in the wake of controversy surrounding the original deal. Despite this, other factors may play a greater role. For instance, the navalised Rafale-M has also been shortlisted for the Indian Navy's carrier aircraft requirement, taking Rafale for both programmes would offer benefits to training, equipping, and maintenance through high commonality between the two fleets.

2. F-15 Eagle II from America's Boeing Defence – this twin-engine aircraft is a surprise entrant in the competition. With an impressive combat track record, the F-15 is considered a formidable contender in the contest.

Photo: Lockheed Martin

The most modern variant of the legacy F-16 design, this single-engine jet is being pitched as a brand new fighter.

3. JAS 39 E/F Gripen from Sweden's Saab – seen as an underdog, the single-engine Gripen is being pitched as the most cost-effective package. It remains to be seen whether this cost-friendly offering will make it to the next round.
4. Sukhoi Su-35 from Russia's UAC – this twin-engine fighter is the latest from Sukhoi's 'Flanker' family. Marketed as the logical next step for the IAF as it already operates a huge fleet of the Su-30MKIs, with benefits brought through commonality being a strong selling point. However, with Russia's present diplomatic isolation, this would be less politically straightforward than the alternatives.
5. F-21 from the America's Lockheed Martin – the single-engine F-21 is the latest and the most advanced version of the legacy F-16, with a proven active electronically scanned array (AESA) radar. Following rounds of twists and turns in the IAF's earlier medium multi-role combat aircraft (MMRCA) contest, Lockheed rebranded the F-16 as 'F-21'. The legacy F-16's association with Pakistan has often created roadblocks for Lockheed's sales pitch to India, who now believes it has a fair chance in the contest owing to the present US Government's backing.
6. Eurofighter Typhoon from European Consortium Eurofighter GmbH – this twin-engine jet built by a four-nation consortium led by Airbus, was a co-frontrunner in the earlier MMRCA contest, but lost out to the Rafale in the final down-select, and led the Typhoon manufacturers to claim that their rejection was on unfair grounds.
7. F/A-18E/F Super Hornet from Boeing Defence – this twin-engine fighter, with an AESA radar, represents a capable aircraft which is also a contender in the Indian Navy's carrier-based order contest along with the Rafale-M. The Super Hornet has been in the running for the IAF's contract for a decade and a half.
8. MiG-35 from Russia's UAC – this twin-engine multirole fighter is considered as having the least chance of success. It is a heavily-modernised version of the legacy MiG-29 fighter, which is already in service in the IAF, but the IAF has made it clear to the Government that its future fighter is unlikely to be MiG.

Photo: DRDO

India's domestic fighter was developed by the DRDO, and is intended to replace the IAF's MiG series aircraft.

India's Indigenous Programmes

India's thrust towards its 'Make in India' initiative aimed at 'ÁtmaNirbhar Bharat' (ENG: Self-Reliant India), is driven by two programmes: the LCA Tejas single-engine indigenous fighter and the Advanced Medium Combat Aircraft (AMCA) twin-engine, fifth-generation multi-role aircraft.

LCA Tejas

At present, 30 LCA Tejas jets are in service with two squadrons in southern India, with 16 Tejas fighters inducted in their initial operational clearance (IOC) version, and 14 in the final operational clearance (FOC) version. The IAF is also expected to get the remaining 10 LCA jets of the first lot of 40 delivered in 2023.
IAF's latest order with HAL for 83 LCA Tejas Mk-1s is due to start deliveries in the next two years, while IAF has plans to order more of the advanced LCA Tejas Mk-2 aircraft, in the near future. The 83 LCA Mk-1 would help replace the MiG series of fighters such as the MiG-23, MiG-27 and MiG-21s. The LCA Tejas Mk-2 is under development by the state-owned Defence Research and Development Organisation (DRDO), and is expected to complete development and flight testing by 2027.

AMCA

The AMCA is being developed indigenously by DRDO and due to be produced by HAL. The aircraft is expected to roll out for trials by 2030. This fifth-generation, twin-engine, multirole, low-observable fighter is due to have a maximum take-off weight in the 25 tonne category, and includes a number of fifth-generation features including Diverterless Supersonic Inlets (DSIs), serpentine intakes an internal weapons bay, and thrust vectoring engines. At present, the AMCA still in the design phase.

The Way Forward

Regarding the IAF's future, Air Marshal Anil Chopra (retd.), Director-General, Centre for Air Power Studies (CAPS), New Delhi, sounded optimistic, stating: *"I assess that the IAF could reach 42 squadrons by 2038 only if the nation takes a resolution and all actions go by plan. The end state could be 14 squadrons of Su-30 MKI, two each of Mirage 2000 and MiG 29, 12 squadrons of LCA variants, two of Rafale, six of the new fighters, and four of Advanced Medium Combat Aircraft (AMCA). This would make it 42."*
According to the IAF's claims, so far there has been no shortage of spares due to the ongoing Russia-Ukraine war. IAF Chief Chaudhari has tried to put fears over readiness to rest by going on record to state: *"We have domestically procured 62,000 spares and components in the last few years. Our dependence on Ukraine and Russia is reducing. We are confident with domestic industry stepping up, we will be able to overcome any shortfall in spares that we have been traditionally getting from Russia and Ukraine."*
Approximately 24,000 medium, small and micro enterprises (MSMEs) are presently engaged with the defence sector in India, with more than 500 licenses issued to private defence manufacturers and the numbers are rapidly increasing. Aiming at reducing defence imports from 70 percent to 40 percent, the 'Defence Production and Export Promotion Policy 2020' was formulated to boost self-reliance in India's defence production. While such signs are broadly positive, only time will tell if these will be sufficient to meet India's growing domestic demands as well as its ambitions on the export market. ■

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Keeping the Beam Alive

Thomas Withington

Almost 30 years ago, something happened that would change radar forever. The first military Active Electronically Scanned Array (AESA) radar entered service. Where is this technology heading in the future?

The system in question was Mitsubishi Electric's J/FPS-3 S-band (2.3 GHz to 2.5 GHz/2.7GHz to 3.7 GHz) ground-based air surveillance radar. It was deployed with the Japan Air Self-Defence Force's 45th Aircraft Control and Warning Group to help protect the skies over the archipelago and its air approaches. The J/FPS-3 remains in production. In October 2022 the Philippines announced it would procure three systems for USD 103.5 M which will contain improvements to the existing design. The advent of AESA technology was the culmination of years of research kick-started by the Second World War and accelerated during the Cold War. East and West raced to win the technological upper hand with this competition manifesting in part through radar design.

Graphic: Mitsubishi Electric

Where it all began. Mitsubishi Electric's J/FPS-3 was the world's first deployed military AESA radar. Almost 30 years later, the design is still going strong with recent orders from the Philippines.

The Basics

Radar employs an elegantly simple principle. Radio waves, a form of electromagnetic (EM) waves, known as RF (Radio Frequency) energy to engineers, are generated in a radar's back end and sent to its antenna. The antenna is pointed towards the area of sky, land, sea or space the operator wants to look at and the waves are transmitted from the antenna. The RF energy leaves the antenna at a particular frequency, for example, at 5.25 GHz. These waves zoom out of the antenna at the speed of light (299,274 km/s). The RF energy moves through the ether until it hits a solid object like an aircraft or ship. This collision causes some of the RF energy to bounce back to the antenna as an echo. The radar compares the time it received the echo with the time of transmission. By dividing this time in two (to remove the time required for the return trip) the radar determines the distance to the target. Suppose the round trip of the signal is one second it will have travelled 153.9 km (83.1 NM), meaning the target is 76.95 km (41.5 NM) away.

Radars do not just calculate range, they also determine the direction a target is moving in by exploiting the Doppler Effect. We observe the Doppler Effect every day without even realising it. You may be standing by the kerbside hearing an emergency vehicle such as an ambulance coming towards you. Your ears will perceive the pitch of the siren rising as the vehicle approaches, and conversely, the pitch seems to lower as the vehicle drives away. The pitch is unchanged in reality, as the vehicle's occupants would attest. Instead, the frequency of the sound waves increases as the vehicle approaches you and vice versa. Why does this happen? Sound waves have a similar shape to radio waves, with peaks and troughs. Frequency is a measurement of how many peaks and troughs a wave moves through each second. As the target approaches a radar's antenna the echoes take progressively less time to arrive. This causes the frequency of the echo to increase as the target approaches and decrease as it moves away. By exploiting this effect, the radar can determine that the target is in motion and its direction. The Doppler Effect, known as Doppler Shift to radar engineers, also allows the radar to calculate a target's speed.

The last element is elevation. A ground-based, naval or airborne radar may need to determine target elevation and hence the target's altitude, particularly if tracking airborne targets. The radar's software will determine the position of the horizontal relative to the antenna's angle. It will also account for the curvature of the Earth if the target is beyond the horizon at surface level. This creates a right-angled triangle. A bit of high-school trigonometry tells us the adjacent angle is the horizontal line from the radar to the horizon. Suppose the antenna is pointed towards the sky at an angle of 17°. The invisible line drawn from the tilted antenna into the sky between the radar and the target is the hypotenuse. Finding the length of the opposite side of this right-angle triangle determines the target's altitude. The distance between the target and the antenna along this hypotenuse is 185 km (100 NM). The sine of 17° is 0.29 giving our target an altitude of 54 km (29.2 NM).

Arrays

These basic principles at the heart of how radars work have evolved significantly since the technology was first used en masse during the Second World War. Two historical developments were important in the de-

Author

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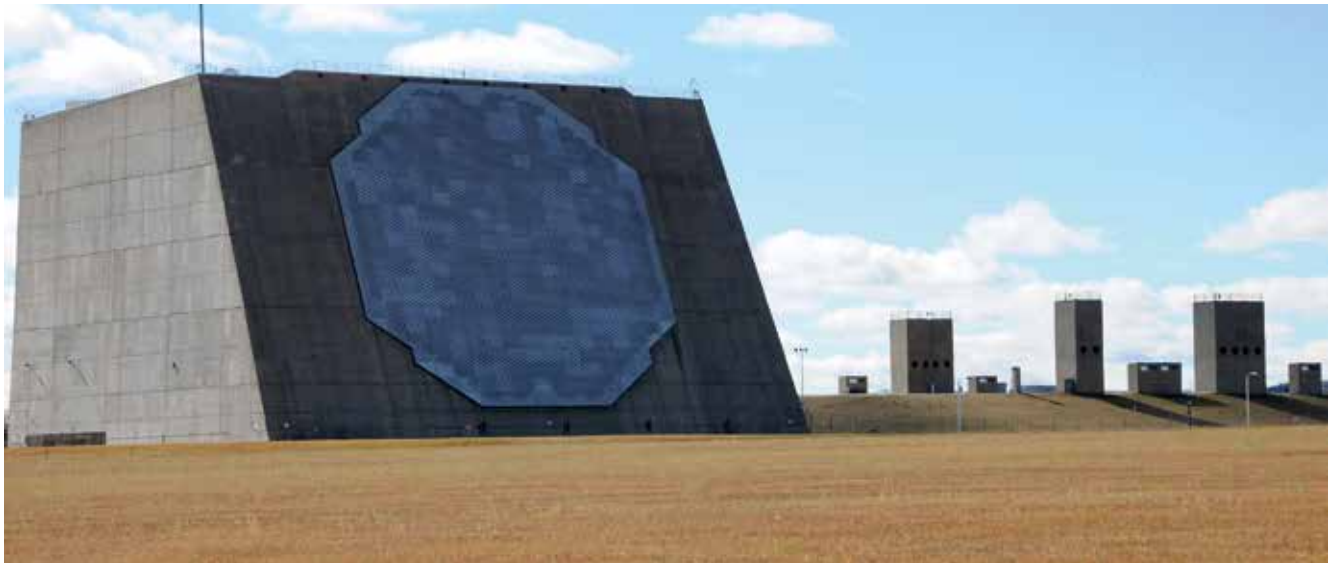


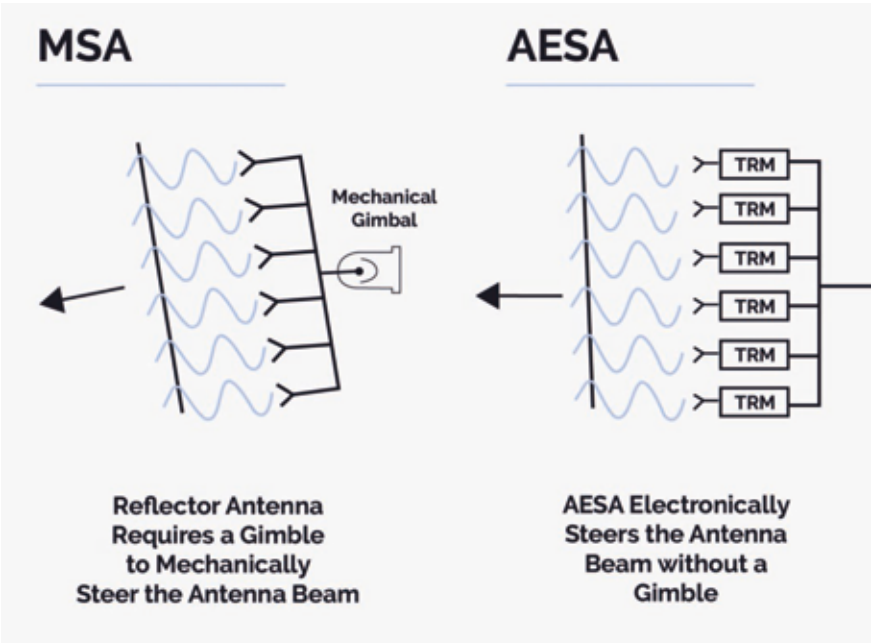
Photo: USAF

The US Army's AN/FPQ-16 Perimeter Acquisition Radar Attack Characterisation System uses a phased array architecture. Phased array radars are increasingly supplanted by active electronically scanned array systems.

velopment of radar technology. The first was the phased array radar which began to appear during that conflict. A phased array radar moves its beam electronically in contrast to a conventional radar which does this mechanically. The radar's transmitter sends its RF energy to an array of elements mounted on the antenna. Each element has a phase shifter which can change the angle at which the radar beam leaves the antenna. An analogy would be the eyes in a person's head. Imagine that you could not move your eyes, but you could move your head up and down and side to side. You could still see around you but will have to move your head to do this. Now imagine your head is fixed, but you can move your eyes up and down and from side to side. This is akin to how a phased array radar works.

A phased array radar beam is electronically scanned from side to side and/or up and down without the antenna having to move (though the antenna can be moved to get additional coverage beyond the default field of regard). Some radars have this arrangement because they are physically very large and impractical to outfit with a mechanically-scanned antenna. An example would be the General Electric AN/FPQ-16 Perimeter Acquisition Radar Attack Characterisation System. The radar was activated in 1975 as part of the US Army's Safeguard anti-ballistic missile system. It remains in service at Cavalier Space Force Station, North Dakota. The radar is housed in a multi-story building. It needs only to point in the general direction where a ballistic missile threat is likely to come from. In this case, the radar's antenna is permanently pointed north to provide ballistic missile surveillance of the Arctic approaches to the continental United States. The radar's mission and size make it unnecessary and impractical to use a mechanically scanned antenna. Nonetheless, phased array radars do often use mechanically-scanned antennas. By combining the two technologies, the user gets the best of both worlds; a radar which can scan in a conventional pattern, or which can remain stationary to scan in a specific area. This is particularly important regarding missile defence applications. Let us assume that a conventional radar scanned through 360° once per second. An intercontinental ballistic missile (ICBM) re-entry vehicle can re-enter the atmosphere at speeds of 6-8 km/s (15,551 knots). In the time it takes the antenna to perform a full revolution, the missile will have travelled 6-8 km (3.2-4.31 NM). This can be problematic if the radar is guiding a surface-to-air missile to intercept the ballistic missile, or an accurate assessment of the missile's point of impact is required.

The advent of AESA technology was an outgrowth of phased array radar innovation. The latter used several elements mounted on its antenna, fed by a single transmitter. AESAs use a multitude of Transmit/Receive Modules (TRMs). Each TRM is like a miniature radar. It produces the RF energy, transmits it and processes the echo. Like a phased array radar, radar beams can be electronically scanned.



Graphic: RADA

This graphic summarises the difference between a mechanically and electronically steered array. The former requires a mechanical gimbal to physically move the antenna. The latter does not.

Photo: Thales

The multitude of individual transmit/receive modules are clearly seen on the antenna of this Thales RBE2 AESA radar equipping a Dassault Rafale combat aircraft.

However, unlike a phased array radar, the antenna can perform several tasks simultaneously, as each TRM is generating its own beam. For example, perhaps a radar must detect and track hostile aircraft approaching from the northeast, but the radar also needs to detect and track hostile surface-to-surface missiles approaching from the North. The antenna is kept stationary, and assuming both sets of targets are within the antenna's field of regard, some TRMs can be tasked with monitoring the northeast, while another set monitor the missiles to the North.

The radar is configured to perform in a particular way by instructional software. The resulting transmitted radar signal intended to perform a specific task is known as a waveform. This waveform can be adapted to achieve the best possible RF energy return from a particular type of target. AESAs allow each set of TRMs to optimise for a given target type. Using the above example, the TRMs monitoring the northeast can tune their transmissions to optimise conventional aircraft detection, while those monitoring the North can tune theirs to achieve the best return from missiles.

AESAs offer several other key benefits compared to conventional radars such as generally better signal-to-noise ratio, improved clutter rejection, and graceful degradation. This latter advantage can be explained through an example. Some AESA radars have hundreds, if not thousands, of individual TRMs in their antennas, for instance, Thales' RBE2 AESA radar equipping the Dassault Rafale family of combat aircraft has circa 800. If a few of the TRMs fail, the radar will still function but with only a marginal loss of performance. By comparison, if a phased array radar fails, the loss in performance can be total. Added to this, AESAs are often relatively easy to repair, with new TRMs modules slotted into the antenna to replace broken ones. Fixed AESA antennas typically also have fewer moving parts (and hence fewer points of failure) than mechanically scanned radars, although this does not apply to AESA radars which can be physically moved. For instance, the Euroradar Captor-E AESA system for the Eurofighter Typhoon combat aircraft is mounted on a mechanical re-positioner to further increase the radar's field-of-view beyond what is possible with purely electronically scanned systems.

An AESA often performs what is known as a raster scan. A beam moves very quickly in a rectangular pattern, from right to left downwards in a saw tooth pattern. The radar beam itself is very narrow meaning it can depict a target in detail. This helps the radar to identify its target as a conventional aircraft or a vehicle on the ground for instance. As an AESA can generate several beams because it has multiple TRMs, it can continue scanning for targets while one, or several, beams continue to track a specific target. This saves the radar having to return to that target anew each time the raster scan starts. The process also makes the radar's transmission behaviour less predictable. Hostile Electronic Support Measures (ESMs) detect, identify and locate radar transmissions. Once the ESM detects a radar, identifies it as hostile, and determines its location, it can be attacked with jamming. ESMs use specific software which interpret incoming radar signals, a well-programmed ESM can even identify a particular radar equipping a specific aircraft. This is done by associating particular waveforms with particular radars. An AESA transmitting with multiple beams can act in a seemingly random way which makes it harder for the ESM to correlate a series of radar signals with a particular radar, thereby helping the latter avoid identification. Moreover, the TRMs can even make each pulse different in terms of frequency. This further frustrates the ESM's ability to associate a collection of seemingly random signals with a specific radar.

The Future

Where do AESAs go from here and what technologies will they incorporate? Radar manufacturers are understandably coy about sharing their future innovations. Nonetheless, some indication of the direction of travel can be gleaned from information in the public domain. Four key areas are cognitive techniques, materials, architectures and cost-effectiveness.

The application of cognitive techniques to radar focuses on the adoption of Artificial Intelligence (AI) and Machine Learning (ML) techniques. In 2018, Dr. Nathan Goodman of the University of Oklahoma published a paper entitled 'Foundations of Cognitive Radar for Next-Generation Radar Systems'. He noted that "all radar systems constantly observe the surrounding environment, inferring properties about the environment … and modifying their observation … through changing waveforms and antenna pointing directions." Dr. Goodman argued that cognitive radar takes this further. Tomorrow's radars will "(maintain) real-time hypotheses about the environment in order to adaptively control the form and parameters of the actual sensing procedure."

A cognitive radar could understand what it is seeing and adapt its behaviour therein. For example, a radar could detect several vehicles are moving together. Is this an advancing column of armour? Nothing much else is happening in the rest of the radar's field-of-view. A cognitive radar would immediately recognise the column and deprioritise what is happening elsewhere. The radar will have learned to recognise the column of armour as distinct from a traffic jam of stationary cars. Its software will have been 'trained' to recognise armoured vehicles by determining their speed, disposition and behaviour. In

Photo: BAE Systems

AESA radars equipping sixth-generation combat aircraft like the BAE Systems Tempest, a rendering of which is shown here, will doubtless feature several innovations like cognitive radar functions and distributed arrays.

fact, a cognitive radar's software could be trained with numerous data to recognise certain targets or situations and to change its behaviour as appropriate. Likewise, perhaps the radar has been trained to recognise when it is being jammed. It will automatically modify its waveforms and transmission power, etc. to ameliorate the worst effects. The rationale behind adopting AI and ML techniques in radar is to reduce operator workload and improve radar efficiency. However, a note of caution should be sounded – a cognitive radar will only ever work as well as the learning data it receives. Incorrect, incomplete or corrupted data will significantly degrade performance.

Beyond cognition, we can expect improvements in the materials which radars depend on. AESAs rely on two vital materials, Gallium Arsenide (GaAS) and Gallium Nitride (GaN). The latter is progressively replacing the former, although both are routinely used in AESA TRMs. GaAS and GaN are favoured as tough materials which can handle the significant heat produced by a radar. Although GaN is in vogue for AESAs it could be progressively replaced in the coming years by diamonds, which can be grown in a laboratory, and provide excellent thermal conductivity. TRMs constructed thus could tolerate even higher operating temperatures compared to today's AESAs, translating into improvements in radar performance and longevity. The US Defence Advanced Research Projects Agency (DARPA) has embarked on research into employing diamonds, with DARPA's Near Junction Thermal Transport (NJTT) project having demonstrated combining GaN and diamonds in transistor design.

Using diamonds will also help make AESA radars smaller, assisting miniaturisation. All military radars must be designed with the size, weight and power constraints inherent in the platform or capability they equip. Electronics, and hence radars, are getting smaller. This is thanks to the oft-quoted dictum of Moore's Law. Dr. Gordon Moore, co-founder of the Intel Corporation, made a prescient prediction in 1965. He forecast that the number of transistors that could be housed on a single microchip will double every two years. This broadly held true for a number of years, which is why today's smartphones are smaller, and do more than 1980s era cellphones, however more recently such progress has declined, owing to difficulties making smaller and smaller transistors, and practical challenges such as power and thermal management.

Nonetheless, smaller radars will have two consequences. Firstly, more platforms and smaller platforms can be outfitted with high-performance AESA radars. This will enrich situational awareness to previously-unseen levels. Secondly, more radars will be able to outfit a single platform. Traditionally a combat this has one radar mounted in the nose providing a 90° to 120° degree field-of-view in front of the plane. Smaller radars could enable the jet to be covered with AESAs along the wings, on dorsal and ventral fuselages and behind the aircraft. The pilot will now be able to see what is happening through 360° around their plane, and cognitive techniques will ensure they are not deluged with data, as the radar's software continually prioritises what they need to see.

Last, but not least, we must talk about money. Many of the innovations discussed above risk increasing radar development and procurement prices further. That said, the adoption of materials like diamonds could paradoxically probably reduce radar operating costs by reducing maintenance, repair and overhaul expenses. The radar world will benefit from innovations like digital twin technology. A digital twin is a virtual model of a real-world system under development. All aspects of the system's design and performance are programmed into the digital twin. This reduces research and development costs by eliminating the need to produce so many prototypes to evaluate numerous aspects of the design.

The first thirty years of AESA radar has been exciting. These systems are now in routine military use globally across sea, land, air and space domains. As the cost of AESAs reduce we could see this technology increasingly migrating to the private sector. The innovations discussed in this article are very much on the horizon and could become routine in tomorrow's radars. The next three decades should be even more exciting. ■

Getting The Picture – Battle Rifle Optics

David Saw

As far as the infantry is concerned, it would appear obvious that it is in everybody's interest that they achieve the maximum performance from their primary instrument, the rifle. What is required here is the ability to accurately engage and neutralise targets both in close quarter battle environments and in long-range engagements. To achieve this objective the optimum combination of rifle and ammunition is required, but beyond that the maximum utility of an individual weapon can be obtained with the installation of an optic, otherwise known as an optical sight.

An optic provides the ability to identify and accurately engage targets at all desired battle ranges. What is perplexing is that there was so much resistance, even in the most advanced forces, to equipping the infantry rifle with an optic. Even today you can see the infantry of major European militaries operating with modern rifles, which even have Picatinny (MIL-STD-1913) rail or equivalent rail systems fitted, with absolutely no optics. Now, it might be that standard practice in a particular military to not install an optic during training, more likely it could be that either there are no optics to install at that point in time and they will arrive at a later date, or there are just no optics available to install. Fundamentally, the enemy of optics installation on rifles still remains conservatism and/or cost.

Photo: US Marine Corps

US Marine Corps patrol activity in Helmand Province, Afghanistan. Note the Rifle Combat Optic (RCO) sight, this is the Trijicon Advanced Combat Optical Gunsight (ACOG), which was adopted in 2004. The RCO is being replaced by the Squad Common Optic (SCO), which is the Trijicon Variable Combat Optic Gunsight (VCOG), a 1-8×28 optic.

Starting Points

In many respects, the small arms landscape of today is the result of decisions made in the post-1945 era. At that time, the standard rifle calibres of the primary combatants were 7.62 × 63 mm (.30-06) for the US, 7.92 × 57 mm for Germany, 7.62 × 54 mmR for Russia and 7.7 × 56 mmR (.303) for Britain. These were proven, powerful rounds, but it became increasingly obvious that these rounds were, perhaps, too powerful and that what was needed was an intermediate round. In response, Germany developed the 7.92 × 33 mm Kurz round, the round that was used in the StG 44, and Russia came up with the 7.62 × 39 mm M43 round, this was the AK-47 round. Following this trend line, Britain came up with its own intermediate round in the 7 × 43 mm calibre. The British had developed a new rifle to utilise this new intermediate round in the form of the EM-2, certainly a unique and innovative weapon, and one with an integrated optic.

Others were not convinced by intermediate rounds, starting in 1949 there was an effort to achieve ammunition standardisation between the US, Britain and allied powers. Inevitably, the wishes of US were paramount, and they pushed for a full-power round that would be suitable for extended range engagements for rifles and machine guns, resulting in the adoption of the 7.62 × 51 mm as the standard NATO round. The EM-2 and its integrated optic could not accommodate the power of the 7.62 × 51 mm round and was therefore consigned to oblivion. On the other hand, the FN FAL, a rifle that had started off using intermediate calibres, did have the growth potential to handle the NATO round. Canada was an early adopter of the FAL and initially they equipped the weapon with an optic, but when the rifle was fully rolled out across the Canadian military, the optic was jettisoned.

It was to take until the 1970s for the optic to emerge as a serious proposition, the starting point for this was the Steyr Armee Universal Gewehr (AUG) in 5.56 × 45 mm, adopted by the Austrian Army as the Sturmgewehr 77 to replace the FAL. The AUG featured an integrated Swarovski 1.5× optic. Elsewhere the British army were starting to get back into the rifle optic game, with the L2A2 Sight Unit Infantry Trilux (SUIT), a 4× optic for day and low-light conditions, attached to the Self-Loading Rifle (SLR), the British version of the FAL, and the GPMG machine gun. However, this optic was never widely issued. Both Britain and Canada were to achieve the full adoption of rifle optics when they adopted their replacement for the FAL. In Britain, the mid-1980s saw the arrival of the L85 rifle in 5.56 × 45 mm as the SLR replacement, while the rifle might have been dire, it was to take many years and a lot of effort by Heckler & Koch to fix all of its problems, the optic teamed with the L85, the L9A1 Sight Unit Small Arms Trilux (SUSAT), a 4× optic, was actually rather good!

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Photo: Raytheon ELCAN

The German Army HKV Main Combat Sight programme was won by Raytheon ELCAN and Leonardo Germany. The HKV sight is based on the ELCAN SPECTER DR 1-4× (shown here), with a bullet drop compensator, etched reticle, Picatinny/STANAG rail integrated into the housing and an ambidextrous throw lever to switch between magnifications.

In Canada, the Canadian Armed Forces (CAF) chose a successor to their C1/C1A1 (FAL) rifles in the form of the Colt Model 715 in 5.56 × 45 mm, entering Canadian service as the C7 and the C8 carbine variant. The CAF wanted to equip these weapons with a new optic of Canadian design, to that end ELCAN were selected to design, develop and deliver a new optic, with the Canadian government providing funding support for this process. This resulted in the SPECTER OS, a 3.4× optic, being adopted by Canada as the C79. Since the SPECTER OS arrived at the end of the 1980s, Raytheon ELCAN have delivered 475,000 sights to more than 40 countries. On top of that, as we shall see, they have added a major order that will significantly boost their optics deliveries.

The Optic Era

If anybody was to bring optics into the military mainstream it was inevitably going to be the US military. Trijicon was a small US company, but in 1987 it came up with a product that would change small arms optics in the shape of the TA01 4x32 Advanced Combat Optical Gunsight (ACOG). In 1995, United States Special Operations Command (USSOCOM) ordered 12,000 ACOG sights, while the next year saw Israeli special forces order 5,000 ACOGs for designated marksman applications.

Between 1987 and 2005 Trijicon built 100,000 ACOGs, then the US Marine Corps selected the ACOG for their Rifle Combat Optic (RCO) requirement and within 18 months Trijicon had built 100,000 units for the Marine Corps. Orders kept on coming for the ACOG and by 2017, one million systems had been built! The next major military order came with another US Marine Corps procurement, in the form of the Variable Combat Optic Gunsight (VCOG), 1-8×28 optic, which was selected to meet the requirements of the Squad Common Optic (SCO) programme.

USSOCOM was to have a major influence on small arms optic acquisition, for example in 2001 they acquired the EOTECH Holographic Weapon Sight (HWS). EOTECH continues to be an important player in terms of small arms optics. In January 2023 the company announced an order from Kopassus, Special Forces Command of the Indonesian Army (TNI-AD) for 1,000 HWS and magnifiers. Other USSOCOM acquisitions would include sights from Aimpoint and ELCAN.

Earlier in this article we mentioned the Steyr AUG and its integrated 1.5× Swarowski optic as being the starting point for the modern optic, this weapon also provides an excellent example of how small arms optics have developed and the enhanced performance that they can offer. The Australian Army had adopted the AUG (known as F88 in Australian service) as the replacement for the SLR and the M16A1 in the late 1980s, the AUG and its optic were more than adequate to support envisaged engagements out to a range of 300 m.

By 2015 the Australian Army was replacing the F88 with the more modern EF88 variant, this used the AUG as its starting point, but is a significant enhancement on the original rifle. The integrated optic was replaced by a rail system and a new optic in the form of the ELCAN SPECTER DR, a 1-4× optic, optimised for close quarter and extended range engagements. Did the new optic make a difference to the rifle? The answer to that is a clear yes, as the Australian Army had to change its marksmanship qualification standards to accommodate engagements out to 600 m.

One of the most significant European optic acquisitions of recent times occurred in Germany in late 2021 with the announcement that the Germany Army HKV Main Combat Sight programme was won by Raytheon ELCAN and Leonardo Germany. In total 107,929 HKV sights are to be acquired, these are based on the Raytheon ELCAN SPECTER DR 1-4× optic, featuring customer specific requirements including a bullet drop compensator, etched reticle, Picatinny rail integrated into the housing, anti-reflective device and an ambidextrous throw lever to switch between magnification levels. Germany also has a contract option to increase its order of HKV sights by 50%. More sights will certainly be needed, as the new German assault rifle, the System Sturmgewehr Bundeswehr, will see some 118,718 G95A1 and G95KA1 rifles acquired.

Possession of an effective optic can significantly enhance the combat capabilities of a modern rifle, it can also increase soldier effectiveness by enhancing situational awareness. On the other hand, all optics are not equal. Attaching an optic to a rail which is in turn attached to a rifle is not the end of the story, the optic will be expected to operate in a challenging environment, at different temperatures and in different climatic conditions. To be a viable solution, an optic must be able to cope with everything the rifle has to cope with and continue to deliver specified performance throughout its extended service life. ■

Photo: French Army

Gunners of the 40e régiment d'artillerie on an urban warfare exercise with their Heckler & Koch HK416F rifles. The rifle is fitted with the appropriate rails, but no optic at this point. Back in July 2018 it was announced that France would be purchasing up to 120,000 Aimpoint CompM5 sights for the HK416F.

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Combat Shotguns for Military and Police Applications

Sidney E. Dean

While automatic rifles and machine guns form the backbone of modern infantry firepower, shotguns retain a niche role for combat operations. They also provide civilian police forces with a vital boost to their firepower without the need for escalation to automatic weapons, with the exception of special units and missions.

Like any weapon, shotguns possess certain strengths and weaknesses which dictate their optimal deployment. The primary strength is their very high stopping power or anti-materiel effect. The combination of large bore-size or gauge and the employment of either a single heavy projectile (slug) or numerous buckshot projectiles per round determines the above-average kinetic power of the combat shotgun. Military and police generally procure 12 gauge shotguns (with a bore diameter of 18.5 mm); standard ammunition is the 70-cm long 12/70 shell.

The weapon's primary limitation is range. Given the lack of barrel rifling in most (but not all) shotguns, and the natural tendency of buckshot to spread out, shotguns have a significantly lower effective range than rifles. The combination of pellet spread and waning velocity will limit a 12 gauge weapon on firing 00 buckshot to an effective range of about 30 m. A slug, especially when fired from a shotgun with a rifled barrel, can engage targets up to approximately 100 m, still well below a carbine's range.

These characteristics make the shotgun most suitable for military and police close-quarters scenarios in both urban and field settings. This includes house-to-house search and clearing missions, trench clearing, maritime boarding (and counter-boarding) operations, or point defence. Shotguns have also been extensively employed for jungle warfare. The ammunition's tendency to spread, and the shotgun's ability to deploy less-than-lethal munitions, also make the weapon suitable for riot control or similar scenarios.

Photo: USAF

A shotgun-armed sergeant leads his team during a force protection exercise at Eglin Air Force Base, Florida.

Shotgun Ammunition

The wide variety of available munitions adds to the shotgun's versatility. For close-range anti-personnel engagements, 12/70 shells loaded with 00 buckshot provide optimal stopping power at short range. A single 00 buckshot ball projectile has approximately the diameter of a .32 calibre bullet. The individual buckshot ball is somewhat lighter than the bullet, but a typical 12/70 gauge shell will be packed with between eight and 12 balls of lead or steel shot, fired at a muzzle velocity of 1,300 feet per second; larger 12/76 Magnum shells hold up to 15 balls. At typical engagement range, multiple balls will strike a person-sized target simultaneously, inflicting heavy damage to unarmoured personnel. A joint service study carried out in the 1990s by the US Armed Forces, (which incorporated the experience of British forces during Operation Claret in Borneo in the 1960s), determined that the likelihood of hitting person-sized targets with a shotgun was considerably higher than with any other firearm type, and twice as high as the odds of hitting an enemy with an assault rifle burst.

Shotgun slugs are aerodynamically more stable than balls. This is especially true for rifled slugs which are endowed with ribbing, inducing spin while the projectile is fired through a smooth barrel, and for sabotoed slugs, which are fired from rifled barrels. Full-bore lead or copper slugs' typical weight range runs between approximately 25 to 32 g (383-492 grains), approximately three times as much as a NATO 7.62 × 51 mm rifle round. Slugs can also be used in situations where the spread of shot entails too much risk of collateral casualties. Their mass and velocity also make them suitable for attacking armoured adversaries and in the anti-materiel role, including penetration of vehicle engine blocks.

A major use for police and military shotguns is fast forcible entry into rooms or buildings. Breaching rounds are specialised slugs designed to forcibly open doors with minimal risk to humans. These frangible rounds are composed of loose materials such as metal powder tightly packed into a wax casing. They can be fired at hinges or locks (including padlocks) on doors and gates, at steel bars securing windows, or at plate glass windows. The frangible slug disperses into its components immediately after impact to prevent ricochet and injury to either the breaching team or non-combatants inside the room. Other non-lethal munitions (or munitions with a significantly reduced risk of death) include rubber slugs, rubber buckshot, beanbag rounds and teargas rounds.

Pump-Action

Military and police shotguns normally fall within one of two categories: pump-action guns or semi-automatic shotguns. The pump-action gun represents older technology and has a somewhat slower rate of fire. On the other hand, the mechanism is

less complex and therefore less prone to jam or foul. Both categories are equipped with gun safeties to prevent accidental discharge. Pump-action shotguns frequently feature a ventilated hand guard on the barrel to avoid burns to the user's support hand.

The Mossberg 500 series, produced by O.F. Mossberg and Sons, remains very popular with police and military forces around the world. The most popular iteration is the Model 590. It was designed for combat operations, and is the only shotgun to meet the US Army's MIL-S-3443E specification defining standards for accuracy, endurance and ruggedness. It features a heavy-walled barrel, a clean-out magazine tube, a top-mounted ambidextrous safety, and an anti-jam elevator. The weapon can be customised with various stocks, a pistol grip, optional ghost ring or reflex sights, and front-end configurations including a bayonet lug. The shotgun comes with either a 47 cm or a 51 cm barrel. The tubular magazine's capacity ranges from six rounds for the shorter barrel, to eight or nine for the longer configuration.

In 2018, Mossberg introduced the 590M variant which accommodates detachable magazines with 5, 10, 15 or 20-round capacity. The larger capacity, plus ease of reloading, provides a considerable advantage over most shotguns during intense firefights. Mossberg 500 series shotguns are in service with the police and military of more than 20 nations.

The Remington Arms Company has designed 16 variants of its 870 series pump-action shotgun. Four of these are specifically targeted to police and military users. The Model 870 is known as an extremely robust gun with smooth cycling. Depending on configuration, barrel length ranges from 28 to 76 cm. Shorter barrels are preferable for police and breaching operations, while longer barrels provide enhanced accuracy and effective range for combat.

The 870 MCS (Modular Combat Shotgun) variant was introduced in 2004. The core of the MCS is formed by the common receiver consisting of the trigger group, bolt, pump-action, a three-round magazine tube, and a Picatinny rail for mounting a selection of optics including laser sights. The receiver is customised with additional components according to mission requirements, and can be reconfigured at any time. Three stock/grip options are available, including a pistol grip with fixed stock, a grip with collapsible stock, or a pistol-grip-only configuration. Barrels are available in 25, 35.5, and 46 cm lengths. The short barrel paired with only the pistol grip is known as the Breacher configuration, and can be carried in a holster. The longer barrels can accommodate various sight options, a flash suppressor, and magazine extensions increasing internal capacity up to six rounds. The various iterations of the Remington 870 serve worldwide with police and armed forces of 30 nations.

Photo: US DoD

A US Air Force security forces member takes cover with his Remington 870.

Semi-Automatic

Beretta produces the 1301 family of semi-automatic shotguns specifically for the law enforcement and home defence market. The latest iteration is the 1310 tactical which features enlarged, shooter-friendly safety and bolt-release buttons and charging handle, and an oversized loading port. According to Beretta, the firm's proprietary BLINK gas operating system, coupled with a cross-tube gas piston, cycles rounds 36% faster than competing firearms. The back-bored barrel is designed to dissipate recoil and reduce muzzle flip. The adjustable stock and optional pistol grip, interchangeable front sights, and a Picatinny rail allow for significant customisation by the operator.

Italy's Benelli Armi SpA (a subsidiary of Beretta) produces two popular semi-automatic shotguns. The M2 Tactical comes with a five-round internal magazine, a standard 47 cm barrel, a pistol grip for greater control, and a selection of sights including specialised optics attached to an optional Picatinny rail. Benelli claims that the M2 has up to 48% less

Photo: New Zealand Defence Force

New Zealand army soldier with the Benelli M3 hybrid shotgun.

Photo: USMC

In 2004 the US Marine Corps tested the AA-12 full-automatic shotgun, firing both conventional munitions as well as 12/76 anti-personnel and armour-piercing explosive rounds. Ultimately the service found little requirement for either the weapon or the FRAG-12 explosive munitions.

recoil than competing weapons, enhancing both comfort and accuracy. The firm also produces the M1014 or M4 semi-automatic shotgun. It was designed in the 1990s to meet specific requirements of the US Marine Corps (USMC), but has since entered service with numerous armed forces including the Italian Army. It can be modified with various sight optics and other attachments.

Photo: US Army

A soldier from the US Army's 101st Airborne Division (Air Assault) fires the M26 Modular Accessory Shotgun System.

The particular advantage of semi-automatic shotguns' enhanced rate of fire was illustrated by a British Special Air Service (SAS) member in Iraq. As reported in 2019, the soldier breached an ISIS bomb factory, and was immediately confronted by five hostiles, two of whom wore suicide vests. With his M1014, he killed all five within seven seconds, effectively decapitating the two suicide bombers and saving the lives of his entire team.

Hybrid Shotguns

One notable disadvantage of semi-automatic shotguns' gas-operated cycling system is reduced reliability when firing lower-powered loads including non-lethal munitions and breaching rounds. Hybrid shotguns such as the Benelli M3 and the Franchi SPAS family of weapons allow the user to switch between modes depending on the munition load and the operational scenario.

The Benelli M3 is offered in several variants including the standard M3 Super 90. Switching firing modes is accomplished within a second by turning the selector lever. The Super 90 is available with a fixed or a collapsible stock and an optional pistol grip. The optional Benelli Super Nova Tactical Collapsible Stock can be locked into five different positions allowing the user to optimise the seat of the weapon to accommodate body armour. The weapon has an overall length of 104 cm. The more compact M3T variant is similar to the Super 90, but comes standard with a pistol grip and tubular metal folding stock. Both variants' tubular magazine fits seven 12/70 rounds. The most compact variant is the M3T Short, with an overall length of 63.5 cm (with folded stock) and a five-round magazine. The M3 family is used primarily by military and police special operations units in 14 nations, mostly in Europe and Asia.

The SPAS-15 and its predecessor the SPAS-12, both produced by Luigi Franchi SpA., stand out visually. The SPAS-12, developed in the 1970s specifically for military applications, is an extremely rugged weapon available with four different barrel lengths ranging from 46 to 61 cm. The shorter barrel version was a later design optimised for law enforcement use. Internal magazine capacity ranges from five to eight rounds, with longer barrel variants being able to accommodate larger tubular magazines. Both fixed and folding-stock versions are available. An interesting enhancement is the optional hook-shaped folding stock. It can be rotated 90 degrees to fit under the shooter's forearm, permitting stable one-handed operation in semi-auto mode. Primary users are currently police and special operations units. The SPAS-15's form, featuring a Picatinny rail, pistol grip, box magazine (three or six rounds), and tapered barrel resembles an assault rifle. It is used by the Italian Army and Carabinieri, and by various police and military special operations units globally.

Full-Automatic Fire

A small number of fully-automatic shotguns have been developed over the decades, but most programmes were terminated due to an overall lack of interest by armed forces. The AA-12 Atchisson Assault shotgun, originally developed by Maxwell Atchisson in 1972 and sold to Military Police Systems Inc. (MPS) in 1987, boasts a theoretical 300 rounds-per-minute firing rate. According to the manufacturer, 80% of recoil is absorbed by the proprietary gas system, making it possible to remain trained on target while firing in full auto mode. The AA-12 was tested by multiple services, including the USMC, but was never acquired by any force. Korea's SNT Motiv Co., Ltd. (Formerly Daewoo Precision Industries) currently markets the automatic USAS-12 (Universal Sporting Automatic Shotgun 12 gauge) which is derived from the original AA-12. The USAS-12 comes in a semi-automatic variant for the civilian market, and a military/police variant which can be set for full- or semi-automatic fire. The gas-operated weapon has a 400

rounds-per-minute rate of fire, and an effective range of 40 m. Magazine options include a 10-round box and a 20-round drum; fully loaded, the weapon weighs in at 6.8 kg. The automatic variant is operated by various military and police special operations units in Asia and Latin America.

New Configurations and New Missions

In 2012, following years of operational testing in Iraq and Afghanistan, the US Army commenced serial fielding of the M26 Modular Accessory Shotgun System (MASS). It is designed as an add-on to be mounted below the barrel of a standard M4 or M16 assault rifle, providing the soldier two weapon options in one unit and obviating the need to carry two separate firearms. Alternately, MASS can be equipped with a stock and be deployed as a stand-alone weapon. Either way, MASS is lighter than the Mossberg 590; depending on configuration, the unit weighs up to 2.25 kg and has a 19-cm barrel. It fires 12/70 shells and can accept a three or five-round box magazine.

The US Army currently has 9,000 units in its inventory, with most weapons issued to specialised units such as the military police and engineers. In the long run, it is expected to completely replace the Mossberg in the US Army inventory.

Looking forward, Counter-Unmanned Aerial Vehicle (C-UAV) is becoming something of a new mission for combat shotguns. Quadcopters and other tactical UAVs deployed either as reconnaissance and targeting systems, or as armed assault drones, have become an increasing menace for frontline troops. Buckshot's natural spread makes shotguns especially suited for targeting small to medium UAVs, which approach within effective range, while well-aimed slugs can disable heavier UAVs at even greater distances. Special munitions, including shells that deploy nets to ensnare UAVs or that release viscous substances designed to immobilise rotors, are also being developed. All other applications aside, the UAS threat will ensure that the venerable shotgun, which has been systematically used by the military since the American Civil War, will remain relevant well into the 21st century. ■

Photo: Pacem Defense

The ALS12SKY-Mi5 is a 12 gauge anti-drone round designed to be rapidly deployed against commercially available drones. Upon firing, the five tethered segments separate with centrifugal force and create a 1.5 m wide 'capture net' to effectively trap the drone's propellers causing it to fail.

Product Feature: EVPÚ Defence

Czech Optronic System Producer Reinforces its Ties to the Defence Sector

Security and defence applications are two sides of the same coin for EVPÚ Defence a.s., whose unique level of expertise in the design of electro-optical systems has led the company to develop interesting products and solutions for both sectors. In anticipation of IDEX 2023, their project manager Jiri Zemcik talks about the military side of the Czech manufacturer's production.

EVPÚ Defence is a regular exhibitor at IDEX. How would you like the visitors to perceive the company in 2023?

I'm very pleased to say that we have come a long way in confirming our position as a reliable partner for the Central European armed forces as well as for the system integrators participating in the local army modernisation programmes. To name a few examples, our CMS-1 commander sight is being successfully tested on BAE Systems' CV90 vehicle, the LAWAREC laser and radar warning receiver is being produced for Rheinmetall's LYNX vehicles destined for Hungary and our 12.7 mm remote weapon stations have recently been supplied to the Czech Army. While there is a good general awareness of our defence products on the European market, we believe that IDEX will enable us to show the breadth and quality of our portfolio also to visitors and potential partners from outside Europe.

What kind of defensive systems does EVPÚ Defence currently offer?

We specialise in systems designed for tracked or wheeled armored vehicles, such as gunner and commander sights, remote controlled weapon stations for light-to-medium and medium-to-heavy machine guns, modular awareness systems, and laser and radar warning receivers.

What is special about your systems?

With more than a quarter of our team being directly involved in design and R&D, our products are built as a result of close cooperation with the customer whose requirements for technical modifications are always carefully considered.

Where can visitors find you at IDEX?

Our team and I are looking forward to welcome the visitors at booth no. 10-B20.

Photo: : EVPÚ

European Military Pistol Programmes – Navigating the Choices

David Saw

In principle designing a modern military pistol ought not to be that challenging, after all, you are not inhabiting an area that might be described as the high end of high technology! All of the basic principles of effective pistol design are well understood, advances in materials technology offer all sorts of interesting possibilities in terms of frames and moving parts, while computer-aided design and manufacture ought to simplify the task of delivering the 'ideal' military pistol. Yet despite considerably more than one hundred years of designing, developing and producing 'modern-style' military pistols, there have been some surprisingly bad designs which have entered the marketplace.

Photo: US Army

A soldier from the 3rd Brigade Combat Team, 1st Armored Division, US Army, qualifies on the M9 pistol at a range in New Mexico. The M9 is the US version of the Beretta 92SB-F pistol, developed during the 1970s, and selected by the US Army to replace M1911A1 pistol in the mid-1980s.

Pistols are an area in which simple has become very difficult to get right for many users and manufacturers! On the other hand, military customers can benefit from the fact that there are a vast number of pistols out there that could meet all sorts of proposed requirements and within that 'vast number' of pistol designs there are some seriously high quality pistols that can really deliver the desired performance in all of the standard military pistol scenarios. Then there are the other factors, many of them subjective, that influence perceptions of how good a particular pistol is. In that context one would do well to remember the US love affair with the .45 calibre pistol cartridge (11.43×23 mm) and the Colt M1911 pistol, a combination that has remained in service with the US military for more than seventy years.

Another pistol that earned itself a place in the pantheon of classic pistol designs is the Luger, designed by Georg Luger (1849-1923). For all of his contributions to German small arms design, Luger was actually an Austrian, born in the Tyrol region. Hugo Borchardt designed the C-93 semi-automatic pistol in 1893 in a new 7.65×25 mm Borchardt cartridge loading, Luger became involved in the marketing of this pistol and then his involvement grew to work on modifications and enhancements to the pistol. The saw the development of a new cartridge 7.65×21 mm, later known as 7.65 mm Luger, and eventually a whole series of other evolutionary developments that the resulted in what we know today as the Luger pistol.

The first customer for the Luger pistol was Switzerland who adopted the weapon in 7.65 mm Luger as the Pistole 1900, a second variant was the Pistole 1900/06, initially manufactured by DWM in Germany and later by Waffenfabrik Bern (W+F Bern). A further improved variant was the 06/29 and this was manufactured by W+F Bern from 1929 onwards. The Luger remained the frontline Swiss military pistol until replaced by the SIG P210 at the end of the 1940s, but the Luger remained in Swiss second-line service as late as the 1960s.

The enduring legacy of Georg Luger surprisingly was not his eponymous pistol, but rather ammunition. The Imperial German Navy liked the Luger pistol, but was not too keen on the 7.65 mm round. Consequently, Luger designed a new round based on the 7.65×21 mm cartridge, which resulted in the 9×19 mm Parabellum, also called 9 mm Luger, which arrived in 1902. The Navy adopted the 9 mm pistol in 1904, with the German Army adopting the pistol in 1908. What is really significant today, is that the Luger 9×19 mm round is a standard NATO round and remains the dominant military pistol calibre. As an aside, the Luger took part in the US Army pistol trials that led to the selection of the Colt M1911, initially in 7.65 mm Luger and then in .45 calibre, using US-supplied ammunition, most of which was faulty, forcing the German manufacturer DWM to configure its own .45 rounds for the US trials.

The legacy of Georg Luger in pistol design lives on through 9x19 mm ammunition. However, it is worth remembering that another major figure in small arms development in the form of John Moses Browning (1855-1926), who was responsible for the design of the Colt 1911. Outside of his work in the US, Browning had a major relationship with FN in Herstal, Belgium, and FN Browning pistol designs included the M1900, the M1903, and the M1910/M1922 as well as the design for the Hi-Power pistol, which has been incredibly significant in terms of military pistols. Indeed, Browning was with FN Herstal when he died in November 1926.

Industrial Background

Over the years Europe has found itself blessed with what might be described as an overabundance of pistol manufacturers seeking to access military, paramilitary and law enforcement markets. Initially this large industrial base grew for a requirement to replace or perhaps look beyond the revolvers that had been dominant in the pistol market. In the early years of the modern pistol, the basic principles of design and engineering were relatively easy to master, resulting in a profusion of designs. Many of these had merit, others were less than satisfactory.

At the beginning of the twentieth century, advances in materials, ammunition design, chemistry and related disciplines provided the basis for successful pistols. Added to which, there was a more laissez-faire attitude to gun ownership for private citizens, creating a significant domestic pistol market. Even today, the significance of private gun ownership in providing a major market for pistol manufacturers cannot be underestimated. While such a market does not exist in Europe, access to the US market has proven essential for European manufacturers.

Inevitably, industrial consolidation has reduced the number of European pistol manufacturers, but there is still a very strong European industrial base in this sector. There are the traditional names such as Beretta, FN, Steyr, Walther, as well as names of more recent provenance such as the CZ Group, Radom in Poland (currently operating as FB Łucznik Radom), Heckler & Koch, SIG and, of course, Glock. On top of that, pistol designs have emerged in numerous Eastern European countries such as Bulgaria, Croatia, Montenegro, Serbia and the Ukraine amongst others. If your horizons were broadened to include US-manufacturers, then it is fair to say that any reasonable pistol requirement could be met with little difficulty. Look elsewhere and modern pistols can also be acquired from Israel, Brazil, the Republic of Korea, China, Russia, Turkey and quite a few others.

Photo: UK MoD

Past and present in British Army pistols. On top is the Glock 17 in 9×19 mm adopted as their standard pistol in 2013, with the acquisition of 25,000 weapons and designated as the L131A1. On the bottom is the L9A1, the FN Browning Hi-Power, the standard pistol from the 1960s onwards.

The Process of Change

The British Army provides an excellent example of how pistol requirements have evolved over the years, moving from the revolver era to the automatic pistol and then through different types of automatic pistol. In 1887, the British Army adopted the Webley Mk I revolver in .455 British (11.55×21.7R mmR), later models used an 11.55×19.3 mmR round. The final Mk VI model of the Webley was introduced in 1939, by which time the British Army had another revolver in service in the form of the Enfield No 2 Mk 1, that arrived in 1932 and was in .38 (9×20 mm) calibre. The Enfield was essentially based on the Webley Mk VI, in a more ergonomic format. These British revolvers would remain in military and law enforcement use through the 1950s, but as far as the British Army was concerned, the future was with the automatic pistol. They had flirted with automatic pistols previously, but the solution that they opted for came about by a somewhat fortuitous route. Prior to the occupation of the FN Herstal facility in 1940, FN staff members has been able to evade capture and eventually managed to escape to England. Amongst them was Dieudonné Saive, he had initially been John Browning's assistant at FN, but after the death of Browning, it was Saive who proceeded to make the Browning Hi-Power pistol a reality. One of the things that Saive did when he arrived in England was to prepare a complete set of technical drawings of the Hi-Power. These were then used to create a version of the pistol using British standards, with the resulting Mk 1 Browning pistol being produced by Inglis in Canada and used to equip British and Commonwealth armies as well as numerous other countries.

Come the 1960s and the British Army are looking for a new pistol. This culminated with the selection of the L9A1 pistol which once more is the Hi-Power as produced by FN. Later still the British Army is once again in the market for a new pistol, this time as a supplement to the Hi-Power, with Special Forces making some acquisitions and other pistols acquired as Urgent Operational Requirements (UORs) with regard to Iraq and Afghanistan. The calibre is still 9×19 mm, with the selected pistol being the SIG P226, which is acquired in two variants as the L105A1 and the L106A1, and later A2 versions of the weapon entered service. Then came the adoption of the P228 pistol, essentially a compact P226, as the L107A1, after which the L117A1/A2 pistol, the SIG P229, arrived. British Special Forces also acquired the SIG P230 pistol as the L109A1, with the Walther P5 Compact being acquired as the L102A1.

Time passed and once again the British Army was in the market for a new pistol, with the objective being the replacement of the L9A1 and eventual replacement of the various versions of the SIG P226 once they reached their end of life. Over a period of 18 months, eight different pistol types were trialled, and some 250,000 rounds were fired in various different operational environments as a part of the evaluation process. Eventually, in January 2013, it was announced that the Glock 17 Gen4 in 9×19 mm had been selected and that some 25,000 pistols would be acquired and given the L131A1 designator. Subsequently, the Glock 19, essentially a compact format Glock 17, was purchased and given the L137A1 designator.

Glock is an Austrian company, its founder Gaston Glock had no experience of firearms design, but he was an engineer and

Photo: UK MoD

Using their L131A1 9×19 mm pistols (Glock 17), British troops participate in tunnel search drills using the Urban Subterranean Trainer (UST) during the Army Warfighting Experiment 2021. The UST can be customised to meet multiple urban training requirements.

had some contact with the Austrian military supplying them with field knives. When the Austrian Army issued a requirement for a new pistol to be called the P80, Glock decided to compete for the programme and after looking at the state of the art, he sought to apply new materials and new techniques to pistol design. In March 1982, Glock provided the prototypes of his unique polymer-framed pistol in 9x19 mm, with its 17-round magazine, the weapon later received the Glock 17 designation, with the Austrian Army selecting it following evaluation. The Glock company state that they delivered 25,000 P80 pistols to the Austrian military between 1982 and 1984. By 2020, Glock had sold 20 million pistols, and today their pistol product range covers multiple formats and calibres. All told, the success of the Glock pistol is one of the most significant small arms stories of the modern era.

Other Paths

The British Army decision to find a successor to the Browning Hi-Power, was a challenge that was recently encountered by two Commonwealth militaries in the form of Canada and Australia. In October 2022, the Canadian Minister of National Defence announced a USD 3.2 M contract to provide the Canadian Army with 7,000 pistols and holster systems. The selected pistol is the SIG Sauer P320 in 9×19 mm, which will be given the C22 designator in Canada, with first deliveries due in the middle of this year. The contract has options for up to 9,500 additional pistols to cover the needs of the Canadian Army, Royal Canadian Air Force, Royal Canadian Navy and Military Police. If these options are exercised, the contract value will rise to USD 7.6 M. Elsewhere, as a part of its LAND 159 Tranche 1 Sidearm Weapon System replacement for the Hi-Power, Australia announced late in 2022 that it had selected the SIG Sauer P320 XCarry Pro as its future pistol.

The Direction Générale de l'Armement (DGA), responsible for defence acquisition in France, was tasked with the acquisition of a new semi-automatic pistol or pistolet semi-automatique (PSA) to replace the existing the MAC 50 and the PAMAS G1 (Beretta 92 license produced in France) both in 9×19 mm calibre. At the end of 2019 the DGA announced that the Glock 17 Gen5, known as the Glock 17FR, had been selected for a EUR 44 M contract covering the supply of 74,596 pistols, the last of which were delivered in October 2022. In total 80% of the pistols were destined for the French Army, with the remaining 20% for the French Air and Space Force, the French Navy and other services.

In December 2022, Colt CZ Group of the Czech Republic announced that it had signed a joint venture agreement with N7 Holding, a Hungarian-government owned company. A joint venture company, in which Colt CZ Group will have a 51% stake and the Hungarian government 49%, will be formed to establish a small arms production facility in Hungary to provide equipment for the Hungarian military. The new joint venture agreement builds on a successful technology transfer and license production agreement signed in 2018, under which the state-owned M.o.D. ARZENÁL plant in Kiskunfélegyháza is manufacturing four Colt CZ Group products for Hungary in the form of the P-07 and P-09 pistols in 9×19 mm, the Scorpion EVO 3 carbine in 9×19 mm and the BREN 2 rifle in 5.56×45 mm. The P-07 and P-09 are the standard service pistols of the Hungarian military.

Outside of Europe the most significant pistol order of recent years was the M17/M18 US Army Modular Handgun System (MHS), won by the SIG Sauer P320 in 2017, obviously providing that weapon with major market momentum. At the same time, Glock continues its success, with constant product evolution. Beyond that, famous names such Beretta, FN and Steyr, all have highly capable pistol products on offer. European military pistol requirements will continue to attract a profusion of viable pistol designs, representing a challenging selection process for any potential purchaser. ■

Photo: US Army

The SIG Sauer P320 9x19 mm pistol provided the basis for the solution to the US Army M17/M18 Modular Handgun System (MHS) requirement, replacing the M9 (Beretta 92) as the standard US military pistol, in 2017. The weapon shown here is the M17, the M18 is the 'compact' variant of the system.

Ammunition in the Post-Nuclear Age

Scott E. Willason and Thomas L. Nielsen

The consequences of the 'special military operation' in Ukraine, launched by Russia on 24 February 2022, are being felt globally, and are now forcing nations to rethink their strategic relationships and their security strategies on several levels. Ammunition production and sourcing form a significant part of the defence procurement policies that both support and result from these relationships and strategies which are now being questioned. In order to properly understand these questions, we must first understand how we got here.

Much of our collective defence preparedness has continued to rely on the Cold War strategy of nuclear deterrence. One concern of this strategy was the European belief that minor aggressions, such as those perpetrated by Russia, would go unpunished, should such aggressions require a softer response than nuclear confrontation and a determined NATO, uncluttered by political inaction. By contrast, the American concern was to avoid the risk of entanglement in political matters perceived as largely relating to uniquely European interests. The logically, these opposing concerns should have logically resulted in increased national defence postures for European nations, or a European resolve to form a body capable of acting independently from NATO, but neither of these really seems to have occurred.

The special military operation in Ukraine undoubtedly sought to exploit the perceived Allied and European lack of resolve. Instead of this expected outcome however, the strength of Ukrainian resistance, and the coherence of Western responses prevented a rapid conclusion to the war, creating a subsequent unintended consequence: the heightened risk of inadvertent and uncontrolled escalation, due to the prolonged conflict.

Ammunition Logistics, Heavily Abridged

The concept of military logistics, keeping an armed force supplied with everything it needs, "from beans to bullets", of course predates Gen. Bradley, let alone NATO, by more than two millennia. The earliest known standing army, and with it, the earliest known military logistics system, was that of the Assyrians (circa 700 BCE). Then as now, when properly executed, the art of logistics provides for the planning and implementation of those actions necessary to achieve military and, by extension, political objectives. These actions, and their basic objective of supporting the troops, form the foundation of any victory, as military professionals well understand. While a part of the military complex since the Assyrians, logistics only relatively recently achieved a degree of autonomy from other military disciplines.

The basic realities of logistics are well illustrated by the apocryphal quote from Napoleon Bonaparte that "an army marches on its stomach". While the objective toward which Napoleon was marching is left unsaid, there is no doubt that his desired political objective was victory over the 'enemy du jour'. Achieving such an outcome required proper planning and equally proper implementation, both of which required 'time consistency', in effect determining which capabilities and resources were

Photo: NATO/Pall Hall

With the replacement of musket balls and round shot with metal cartridges, arming and managing the new products in the changing marketplace required different techniques and operations.

Authors

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needed, at which point in time, and at which place.
The answers to such questions formed the basis for logistics policies whose implementation required support from experts and dedicated entities (later evolving into supporting institutions). In the case of La Grande Armée, Napoleon's logistics policy was organised according to a direct and an indirect manner of supplying his troops. Direct supply is that provided by the military logistics organisation, from central supply points, while indirect supply requires obtaining supplies locally. Napoleon's over-reliance on indirect supply, which required foraging for food and other supplies from the surrounding environment, would nearly decimate his army during the Russian Campaign.
As advanced as La Grande Armée was for its day, their logistics system showed strong parallels with the Assyrian army mentioned above, which similarly relied on local foraging to supply their forces. Proper planning meant the Assyrians couldn't stay in foreign or neutral locations for extended periods, since their armies then risked exhausting both local supply capacities and/or goodwill. Military actions thus often depended upon seasonality and the perceived availability of food or harvests in the area of operation.
As the ages and technology progressed, reliance on indirect methods of logistics support declined in practicality, and formal direct support structures prevailed, leading to updated logistics policies. These policies naturally mirrored the social, political, and economic trends of the time, seeking to benefit from increased specialisation arising from new organisations and divisions of labour, themselves in turn partially necessitated by the increasing complexity of weapons systems and other technologies.
Two of the oldest such structures, that can still trace their history to the present day, are the British Board of Ordnance and the Danish Tøjhuskomplekset. The former was established circa 1460 in the tower of London, and itself predated by earlier specialist logistical positions. Its purpose was "to act as custodian of the lands, depots and forts required for the defence of the realm and its overseas possessions, and as the supplier of munitions and equipment to both the Army and the Navy", according to the History of the Ordnance Survey, citing older sources. The Tøjhuskomplekset was created in Copenhagen in 1602 by order of King Christian IV of Denmark, and its name can be roughly translated to 'War Goods Complex' or simply the Danish Armoury. This institution was populated by specialists and tasked with supplying the Danish Navy with cannon, shot, gunpowder, rope, sails, timber, tar and all the other elements required for a Navy to operate successfully. The descendants of both these organisations survive to this day.
Institutions such as the Board of Ordnance and the Danish Armoury were instrumental in supporting further technological change in military ordnance, which through specialisation discovered better production methods, enhanced skills, and various means to improve efficiency. One of these technological changes concerned small arms, specifically the migration from muzzle-loaded smoothbore muskets to breech-loaded rifles firing self-contained, metallic cartridges. This technological change, and the military advantages it provided, necessitated increased standardisation, which was better supported by specialist entities. When firearms were muzzle-loading, smoothbore muskets firing paper- or cloth-wrapped lead balls, local armourers could be relied upon to produce their own ammunition, which involved casting the projectiles and locally sourcing the gunpowder. Yet as ammunition changed from musket balls and round shot, managing the new products in the changing market space required different techniques to cope with the introduction of metallic cartridges. Direct logistics support methods were required to ensure the fit between the weapons and the cartridges. Lack of proper fit could limit the functioning of the weapon, injure the operator(s), or could render the weapon nearly useless. None of these outcomes would be desirable. Improved production techniques and management permitted series production of a consistent cartridge, increasing the soldier's probability of a kill by improving the major variables. Peter Courtney-Green wrote in Brassey's 'Ammunition for the Land Battle' that "The probability of achieving a kill is a simple probability product: that is, the probability of a kill is equal to the probability of hitting the target multiplied by the probability that the ammunition will have the required degree of lethality multiplied by the probability that the weapon will perform reliably."
For smaller nations like Denmark, centralising and nationalising the production and distribution of small arms ammunition gained in importance as a way of ensuring the supply and quality, creating the pretext for a well-controlled state-supported natural monopoly. However, unlike in larger European countries, these capacities were not expanded beyond the need for internal defence. Starting in 1914, World War 1 (WW1) was the first modern, global, industrial war and marked a change from the limited wars of feudal Europe, to total war. During WW1, several nations managed to remain neutral. Danish neutrality allowed the nation to escape the devastating effects war and even allowed export trade to continue to both belligerents on both sides of the conflict. A similar policy of realpolitik in WWII failed to discourage invasion and occupation.
During the interwar period, Europe's shifting political landscape refocused trade on the UK as Europe's major trading partner, encouraging shifts away from agriculture towards manufacturing and motivating changes to national monetary policies, however capital controls and reduced capital mobility meant that nations with difficulties were unlikely to recover. Robust,

Photo: US Navy/Jan David De Luna Mercado

During the Cold War, handgun ammunition factories were in many cases able to make a living from orders placed by their national armed forces.

A number of European countries, such as France, the Netherlands, Spain, Portugal and Denmark, have completely abandoned national production of small arms ammunition.

pre-war integrated financial markets may even have obscured the looming war by convincing leaders that economic success was meant security, according to historian Niall Ferguson. As the 1930s spun to a close, the renewed demand ammunition and equipment would see countries becoming dependent on American innovations in mass production to meet their needs.

The European Ammunition Scene since WW2

At the end of World War 2 (WW2), much of Europe's industry lay in ruins, though levels of destruction varied between countries. Germany, for example, had very little surviving industrial infrastructure. In contrast, a nation like Denmark had survived almost intact. Economist Ingrid Henriksen wrote that "Economic reconstruction after World War II was swift, as again Denmark had been spared the worst consequences of a major war. In 1946 GDP recovered its highest pre-war level. In spite of this, Denmark received relatively generous support through the Marshall Plan of 1948-52, when measured in dollars per capita."

The market advances and adapted lessons of mass production from the US supported the bloated production required for the war but which was unnecessary afterwards. Public sentiment, positive in support of the war effort, felt the effects of increased public spending on defence that could not be maintained in the post war era. Political leaders had little choice but to cut production and seek opportunities for privatisation. Considerable demobilisation programs occurred. For comparison, by 1947, the US Army force strength was reduced to less than 10% of its size in WWII. Almost as a corollary to the Marshall Plan, the US came to regard post-war Western Europe as a potential market for surplus US military equipment and consequently, many western-European nations benefited from low-cost supplies and ammunition from the US. During this period, the US was faced with extremely large, unprofitable factories requiring considerable management to control them. Confronted with this challenge, the US began shifting policy toward decentralised, smaller manufacturing sites for military requirements, according to historian Joshua B Freeman. This was as much a question of management as a question of avoiding public outrage over high military spending in an era rapidly turning toward optimism and peace.

One of the mechanisms thought to support that peace was the North Atlantic Treaty Organization (NATO). NATO, an international organisation established to maintain political order with particular focus on collective security, was created in 1949 as a way to safeguard western ideologies and Western Europe from perceived threats to those ideologies and the post-war order. In typical political reciprocity the Eastern Bloc formed its own equivalent, the Warsaw Pact, though these were not the only political institutions created to maintain political order. Niall Ferguson wrote: "Over time, American aid in particular became hedged around with political and military conditions that were not always in the best interest of the recipients…to some critics, however, the World Bank and the IMF were no better than agents of the same old Yankee imperialism. Any loans from the IMF or World Bank, it was claimed, would simply be used to buy American goods from American firms – often arms to keep ruthless dictators or corrupt oligarchies in power…". In safeguarding security, NATO also provided one potential platform for the future export market for weapon systems and ammunition.

For Europe, the 1950 Schuman Plan called for the development of independent European political, economic, and military institutions. While the political and economic aspects were supported (such as the European Coal and Steel Community), hopes for an independent defence force were left unsupported in the 1955 Messina Conference.

At this point in time a third World War, whether conventional or nuclear, was seen as probable or even, inevitable to some, due to the ideological and existential differences between NATO and the Warsaw Pact. This encouraged countries to maintain national production of ammunition, and the formation of NATO also obligated nations to maintain a certain level of defensive capability, including stockpiles of weapons and ammunition. A significant consequence of this was that, in many cases, the national small arms

Photo: US Army/Alex Manne

Sustained high-intensity warfare operations quickly push ammunition production, currently set for peacetime operations, to its limits.

ammunition factories de facto came to 'live off' orders from their national armed forces who, in many cases, owned the factories. Additionally, the ammunition they were producing was made according to their armed forces' requirements and standards, not just with regards to the ammunition itself, but also with regards to testing, packaging and marking.

Consequently, many of the state-owned factories over the years got used to operating in a non-competitive environment, where they effectively had a monopoly on ammunition supply to 'their' armed forces, as well as renovation and disposal of expired stockpiles. From around 1970, and over approximately the next three decades, several factors conspired to negatively influence the European ammunition production scene:

Firstly, the 1970s saw the rise of a peace movement in many Western countries. Due to the risk of a conventional conflict directly between NATO and the Warsaw Pact going nuclear, and resulting in global destruction, both sides of the Cold War instead involved themselves in a series of proxy wars around the world, mainly in the Middle East, the Far East and Africa. This allowed the Western powers (primarily the US) to engage in ideological battle with their Eastern counterparts (primarily the Soviet Union), with little risk of a major, direct conflict. The appearance and rise of the peace movement can be tied to the fact that many of these proxy wars were regularly broadcast to the public, giving a front-seat view of the realities of these wars. Unlike WWII, the many proxy wars proved increasingly difficult to justify, politically or militarily. Peace movements increased pressure on Western governments to transfer defence spending to other areas that were seen as more valuable to society. Essentially, public demand for national defence markedly declined. At the same time, lower levels of investment from individual non-US NATO nations were enabled by free rider behaviour. Lower defence investment in turn meant less than efficient levels of NATO output.

Secondly, less than a couple of decades later, the dissolution of the Warsaw Pact and the Soviet Union in 1991, and the end of the Cold War, saw the (perceived) end of the threat of a conventional war in Europe. This provided further impetus for drawdowns of national forces in Europe, including the large, cold-war stockpiles of weapons and ammunition, and for a reduction in the continuous need for ammunition for training. The absence of a clear threat in the aftermath of the Cold War found allied nations confused about the New World Order. Defence budgets lacked justification with their apparent ideological foe vanquished. Nations searching for meaning, unity, and direction found none resulting from the experience of Operation Desert Storm. Their continued lack of focus and desire was evidenced by their failure to act decisively in the early days of the Bosnian War.

Thirdly, the creation, of the European Union in 1992 with the Maastricht Treaty, obliged member states to conduct as much as possible of their government procurement via open, international bidding which marked a policy shift by multiple nations toward international tenders in supporting their ammunition requirements.

Lastly, with military budgets increasingly constrained, defence managers implemented modern business methods and strategies for procurement and production. While lean strategies may improve efficiency for some organisations, they do not necessarily provide for effective competitive strategy, nor do they replace budgetary oversight. With improvements in technology, weapon systems and defence platforms increased in complexity, requiring more non-operational activities such as training. Consequently, non-operational time may be more important to battlefield outcome than operational time. Such investments in personnel complemented the weapon systems and were seen as an incentive for positive long-term consequences.

Did the above points create a perfect storm which reduced European defence posture and preparedness? For small arms factories in Europe, the consequence was that their previous main customers, their national armed forces, severely reduced their procurement volumes, often to levels that were too low to ensure the survival of the factory and, at the same time, often started procuring ammunition through open, international tenders.

For many smaller countries such as Spain, Portugal, Denmark, and The Netherlands, which had relatively limited ammunition requirements, the transition to Just-In-Time production and international tenders meant that the ammunition requirements coming from the national MODs were now insufficient to keep the national ammunition factories in business. Added to this, competing on the international military and civilian markets was often fraught with difficulties, especially for factories that had previously operated in a 'safe', non-competitive environment. On the military markets, a producer was either competing in an international tender against several other producers, or the potential customers were trying to support their own national industry and, as such, were disinclined to buy from abroad. On the civilian markets, requirements in terms of performance and testing were different from the military, making transition difficult for many factories, unless they were already used to producing ammunition for the civilian market. Additionally, for some countries, the potential negative publicity implications of having ammunition produced in a national factory, appearing in criminal investigations elsewhere were considerable.

The peacekeeping and peace support operations in the Balkans, that started in the early 1990's, were insufficient to boost procurement and production numbers for small arms ammunition, and the concurrent Operation Desert Shield and Desert Storm in the Middle East were also quickly replaced by similar peace support efforts.

The result was that a number of European countries, such as France, The Netherlands, Spain, Portugal and Denmark, completely abandoned national production of small

arms ammunition. In some cases, attempts were made to privatise the production facilities but, for the reasons discussed above, this met with only moderate success.

The New Normal

On 24 February 2022, Russia launched an invasion of neighbouring Ukraine, and Europe suddenly awoke to a major war on their doorstep – something that had last happened 77 years before, and had not been considered a realistic possibility since the collapse of the Warsaw Pact in 1991.

Concerning ammunition logistics, Western countries were faced with a quandary. Due to the factors reviewed above, national ammunition stockpiles were strictly limited, while at the same time, Western states were eager to support Ukrainian defence without creating a context for escalation. One way of doing this was to donate ammunition. As the European security situation had changed overnight, countries became nervous that they now lacked the capacity to supply themselves. This was foreshadowed during the 2011 Operation Unified Protector (OUP) when countries such as Denmark found themselves running out of precision-guided bombs within days of operations commencing, and expectations that the US would provide munitions support during OUP were greatly overestimated. While stockpiling such weapons is a considerable investment, the lack of sufficient resources is embarrassing for the state and its allies alike, especially when such weapons are considered an essential capability.

With European abandonment of national small arms ammunition production after the end of the Cold War, countries now face a choice with regards to how they want to supply their armed forces with small arms ammunition in the future. Perhaps greater defence spending will permit new opportunities for national investment. With NATO member states pursuing a target of spending 2% of GDP on defence, nearly EUR 100 Bn of additional funding could be made available. It's not clear if this funding increase will be supported by additional taxation or by cutting existing programs. Individual states and their voters will have to decide.

The Cost of Scaling Up

The decision to invest in a small arms ammunition capacity is as much an issue of economics as of military autonomy. The separation of budget allocation and military spending provides for an age-old conflict. Political financial controllers contrast with military decision makers seeking high quality outcomes. Regrettably, inefficiently low production rates for small arms ammunition are unlikely to motivate national investment. According to author John N. Petrie, not knowing the outcome or timing of international tenders reliant on industrial partners, who are also obligated to supply their own states (or the highest bidders) first, greatly complicates the task of military decision makers and leads to the unintended consequence of diminished control.

Do the advantages of constructing a new national small arms ammunition production plant make sense? Such a question bears significant familiarity to those faced by Napoleon and La Grande Armée. Logistics requires proper planning and implementation, both of which require time consistency in answering which capabilities and resources are needed now and which are needed for anticipated future action. While we might be able to risk an undesired outcome in a conflict such as OUP, can we risk the same with threats closer to home? ■

Integration of New Technologies and Power Management at the Soldier Level

Andrew White

The ongoing war in Ukraine has provided a glimpse into military operations in the modern age of strategic competition, illustrating a shift away from two decades focused on counter-terrorism and counter-insurgency towards more conventional peer conflict.

The war has also highlighted the importance of technology on the modern battlefield with dismounted infantry and special forces units on the ground being heavily reliant upon the use of handheld, weapon-mounted and man-packed equipment including radios, night vision goggles, thermal cameras and weapon sights – all of which require huge amounts of energy to power.

However, since the invasion of Ukraine by Russian Armed Forces on 24 February, dismounted ground forces on both sides have been isolated far beyond the reach of traditional combat support supply chains, meaning troops have been in situations where they have run out of food, water, ammunition and other critical equipment, significantly hampering operational effectiveness, survivability and morale.

Examples include the 'Siege of Mariupol' which saw hundreds of members of Ukraine's Azov Regiment (formerly 'Azov Battalion') taking shelter from Russian forces in the Azovstal' Iron and Steel Works for weeks. As defence sources explained, spending more than 24-48 hours beyond the reach of combat logistic support chains can have a significant impact on the operational effectiveness of a unit which must subsequently ration energy, ammunition, food and water supplies indefinitely.

This is one area of interest being hotly pursued by armed forces around the World, including the UK's Defence Science and Technology Laboratory (Dstl), which is exploring options to equip dismounted personnel with a next-generation in power solutions.

Dstl's 'The Science Inside 2022' corporate report, published on 16 November, proclaimed that: "The soldiers of the future will use multiple sensors and effectors to improve capability and situational awareness at the tactical level." The report added: "To achieve full benefit, these capabilities must be able to share information both within the individual soldier system and beyond via secure communication links. In addition, there is a need to reduce the battery burden and simplify logistics by powering such devices from a common battery rather than the multiple different types of batteries often carried by a dismounted patrol."

As a result, Dstl and its industry partners are working on a pair of future concepts which include "embedded power monitoring to allow the scale of the future power problem to be understood"; and "greater power transmission, higher data rates and a range of on-body wireless technologies to allow the removal of troublesome cables in some instances". The report suggested that "Ultimately, fully integrated systems will unleash the power of combination allowing a soldier system to achieve more than the sum of its parts."

Photo: US Army/Christopher Walters

The modern battlefield sees exponential growth in the types and amount of end user devices used by dismounted soldiers with examples including night vision devices, software defined radios and other sensors and specialist equipment.

Industry offerings

Next-generation power management is an area also being developed by the defence industrial base. According to US company Perfecta's vice president for business strategy, Mike Lawrence, power supply, energy storage and data management have become just as critical as food, water, and ammunition to the modern warfighter.

Author

Andrew White is a former British Army soldier and specialist author on special forces, infantry armament and personal equipment.

Lawrence said: "Power is required to operate virtually all the warfighter's tools, from radios for voice and data communications, night vision devices [NVDs] for night operations, to end user devices [EUDs] like tactical smartphones loaded with Tactical Assault Kit [TAK] to provide situational awareness [SA]. Power remains the one resource that is constantly in short supply during every phase of military operations."

According to Lawrence, the past decade has witnessed "incredible" advances in capability for the dismounted soldier, although there remain strong demand signals for solutions which can enable efficient management of available power on remote and austere battlefields as well as the capability to 'scavenge' power. "Power scavenging ensures the dismounted soldier a tactical advantage. It ensures that a soldier's load is lighter, provides the necessary energy to power their [TAK] for longer and simply operate for sustained periods of time without resupply by scavenging power for all their devices from sources found in quick resupply on the battlefield or recharge on the move by sourcing power from their vehicle or aircraft," Lawrence said.

The issue of power management has risen in prominence in recent years, coinciding with the development of software defined radios (SDRs) which often require numerous battery changes over the course of a mission. Many two-channel SDRs, capable of simultaneously running mobile ad hoc networks, satellite communications and even full motion video feeds from aerial assets, can consume a significant amount of energy.

As Lawrence explained, this "operator's problem" dictates the need to manage data and power across a soldier who could be operating multiple devices. "Smart management of power and data combined with power scavenging capabilities on a system with a form factor optimised for dismounted combat operations can enable the modern soldier to achieve and maintain overmatch at the tactical edge," he claimed. "In a battlefield that is growing more digitally connected, this need for more power and data capabilities will only accelerate. Perfecta believes that a comprehensive and robust system design approach is the key to addressing this issue successfully," Lawrence added.

In response, Perfecta has designed a system-level architecture with the primary goal of employing a standardised device and power interface which has the potential to exceed the current power and data needs of the modern warfighter. "The proposed solution is designed to handle more input power than current dismounted power solutions can provide; deliver and manage more output power per port than current devices can handle; and finally, provide a higher speed data connection for all downstream devices than most current devices operate at," Lawrence suggested. "A single USB Type-C compliant connector is utilised for primary device and host connections, simplifying the warfighter's experience by allowing any device to be connected to any port," he added.

Perfecta's Integrated Power and Data Management Kit solution features a processing device (currently a smartphone-based EUD); a power and data manager or hub; interconnect cabling; radio power and data adapters; and centralised power source. The core of the solution is the power and data management hub which supports an EUD with three dedicated downstream device ports. Each port supports USB 3.1 Gen 1 data rates of 5 Gbps and is USB Power Delivery compliant, providing up to 100 W, depending on configured voltage.

The proposed hub supports an input system power of 10-20 V DC at a maximum current of 10 A. The input power connector incorporates Nett Warrior [a US Army dismounted situational awareness system] power connector architecture, enabling smart battery data to be used and charging of the connected system battery.

A secondary power input connector supports an input of 10-35 V DC at a maximum of 10 A for scavenged power. "[Scavenged] power can be used to charge the system battery while simultaneously providing system power. The warfighter can then use Perfecta's Power Block to run SDRs and EUDs while simultaneously trickle-charging a connected handheld radio battery," Lawrence said. "The solution also supports most power and data functionality as a default state, requiring no input or interaction from the warfighter. More granular active control over power and data by the warfighter is supported through a software application running on the EUD," he added.

Lawrence also explained that the power block solution could be connected to Thales AN/PRC-148C/D and L3Harris AN/PRC-163 SDRs in operational environments, noting "The Power Block accepts system power from the hub and regulates to an acceptable voltage for radio power and handheld battery charging. Battery charging is limited to a trickle-charge level to ensure adequate power is available for the radio and the rest of the system. Charging starts automatically when a non-fully charged battery is attached and stops when a battery is fully charged."

In 2023, Perfecta will continue with the development of a Family of Systems Approach integrating together software and hardware solutions into a small, lightweight, rugged, and configurable body-worn tactical computing system. "This will enable the individual warfighter to effectively and efficiently power, monitor and control all attached radios and electronic devices with integrated Human Machine Interface (HMI), for use by US Special Operation Forces," Lawrence highlighted.

Photo: USSOCOM/Sgt. Brandon Julson

A US Joint Terminal Attack Controller (JTAC) uses an Android Tactical Assault Kit for Close Air Support (CAS) during a live fire range for Exercise Ample Strike 22 in the Czech Republic, on 9 September 2022.

Photo: Galvion

Galvion unveiled its Nerv Centr SoloPac II Lithium ion rechargeable battery at the Association of the US Army (AUSA) exhibition in October 2022.

"The hub's management application displays in real-time the model of the radio on each hub port and enables per port toggling of power, allowing the end-user to actively control their power usage based on dynamic mission needs," he added before concluding: "Live information regarding the system's main battery, including make and model, overall health, level of charge, rate of discharge, and time-to-empty (TTE) fields will keep the user informed and in control over their overall power footprint…finally, the application will render information regarding status of the scavenger port to indicate when an auxiliary power source is actively being utilised as the primary source of system power and whether the main system battery is being recharged by the auxiliary power source, such as one in the supported roll on/roll off scenarios."

Photo: US Army/Sgt. 1st Class Garrick Morgenweck

US Army Spc. Shawn Davis, a crew chief with Charlie Company, 1st Battalion, 214th Aviation Regiment scans the horizon with night vision goggles during a MEDEVAC as part of Saber Junction 20, on 22 August 2020, at Hohenfels Training Area in Germany.

Elsewhere, another US-based company, Galvion used the Association of the US Army (AUSA) exhibition to unveil the 'Nerv Centr SoloPac II' battery – a Lithium ion rechargeable battery. A company spokesperson for Galvion also described how power has become just as important on the modern battlefield as ammunition. "The ability to manage the usage, storage, supply and logistics of 'power' has become a new benchmark for a fighting force," the spokesperson suggested. "This change has been so rapid many NATO countries are still just defining the problem.

"Integrating an EUD into the power management ecosystem, along with an application like Galvion's 'NervCentr Hub' App, is the entry point to enable the soldier to have an accurate picture of their power supply and demand in real time," the spokesperson proclaimed before describing how the "proliferation of data to every soldier" on the modern battlefield now means every soldier requires some version of a power manager in order to ensure complex equipment operates smoothly and efficiently. "This could be a single port EUD charger, all the way up to advanced multi-port products. But at some point, every combat soldier will need this technology."

According to Galvion, the SoloPack II retains many of the functions of its predecessor, the 'SoloPack', but does include a number of additional features to support the modern soldier. Features include 40% more power storage (140 Wh) over legacy models, in addition to reduced form factor so the SoloPack II can be carried in an ammunition pouch. Weighing 750 g, the unit features a variety of connectors, including Nett Warrior connectors to enable faster charging and additional current flow, while remaining backwards compatible with NATO STANAG 4695 for ease of integration and improved logistic sustainability on the battlefield. "The SoloPack II has state-of-charge display for real-time remaining capacity at the press of a button, convenient bottom contact charging and can be recharged while in-flight and connected to Galvion's Squad Power Manager (SPM) which is certified safe-to-fly.

With an expected availability in early 2023, the higher capacity SoloPack II is designed to support operational power needs for missions of up to 24 hours, while the original 98 Wh SoloPack battery supports short-duration missions of up to 12 hours. Galvion also highlighted to some of the greatest technology gaps facing armed forces today in terms of power management, noting "Given that all voltages need to be converted between the battery source and the electronics, efficiencies converting between voltages is an engineering area for continued improvement." Galvion added: "Beyond the technology itself, there is a need for the establishment of common 'open' interfaces that are more agnostic in order to simplify interoperability; avoiding the proprietary interfaces required by large integrators which would facilitate broader interconnectivity between equipment and systems."

Looking to further futureproof its power management solutions, Galvion also identified a series of technology areas of interest to enhance its offerings. These include the ability to increase power conversion efficiencies with the spokesperson suggesting: "A 2% increase in voltage conversion efficiencies will result in a 2% reduction on logistics demand." Galvion is also increasing the data bandwidth capacity across its solutions, enabling high-definition video, audio and system data, as well as integrating wireless technologies for military wearable technologies.

Growing Requirements

Considering the future of the power management market in the next five to 10 years, Perfecta's Lawrence suggested: "The inclusion of additional equipment on a warfighter's kit only has benefit if it adds capability and improves overall performance in support of the mission. This is only achieved by prioritisation of minimising the overall SWaP of a solution." Lawrence also disclosed how the company is seeking to further reduce the physical form factor of its Hub solution. Presently, the hub measures 5.5" x 3.5" x .75", which is comparable in size to an overly thick mobile phone, he described. Galvion's spokesperson also confirmed soldiers will require "multiple times" more power across future operating environments, adding: "With the continued improvement in sensor technologies; the proliferation of small unmanned aerial systems; and the need for increased situational awareness to improve agility, lethality and survivability, soldiers will be plugging even more devices into their power systems." The spokesperson concluded: "Soldier power and data systems will have to embrace USB-C technologies, providing this extra power, extra configurability, higher data rates and more universal connectivity with military/commercial equipment. Power will be elevated alongside ammunition, diesel and rations as core army commodities." ■

The Sirius Patrol

Thomas L. Nielsen

For centuries, nations in the northern hemisphere have had their eyes on the Arctic. In some cases due to scientific interest, in others commercial, while others have been the searching for new colonies and new resources. As the climate has changed over the past decades, opening up previously inaccessible Arctic areas to shipping, this interest has increased and expanded, from the 'usual suspects' – the Nordic countries, UK, Canada, USA and Russia, to include new players such as China and India. This has, of course, encouraged the nations with traditional interests in the region to keep a close eye on things, which brings us to the subject of this article: One of the least known and most elite special operations units in the Arctic and the world – Sirius.

The crown at the top of the badge is the royal crown of Denmark, the star in the centre is the star Sirius, from which the patrol takes its name, and the black dog's head is, of course, a sled dog. The anchor in the background references the fact that Sirius was originally a Navy unit, and the red circular border symbolizes a dog collar.

Source: Sirius Patrol, via Wikimedia Commons

The badge of the Sirius Dog Sled Patrol.

History

The island of Greenland, nestled across the arctic circle in the North Atlantic, is the world's largest non-continental island. Its name brings to mind images of vast, snow- and ice-covered wastes, polar bears, icebergs and Inuit trappers. The island's area of roughly 2.166 million km2 makes it slightly larger than the combined areas of Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Poland, Portugal, the Netherlands and the United Kingdom, and with almost the entire permanent population of around 56,600 concentrated in the island's coastal areas, Greenland has an average population density of 0,028 people per km2, or roughly 1 person per 35km^2.

The first 'outsider' to successfully establish a permanent presence in Greenland, around the year 982 CE, was the Icelandic Viking, Erik Thorvaldsson, AKA Erik The Red, (c. 950 – c. 1003 CE). Having been found guilty of murder, and exiled from Iceland, Erik set sail for a little-known land said to exist to the northwest. Having found the island in question, Erik established a colony on a mostly ice-free part of the West coast, and, after the end of his exile, he returned to Iceland, bringing with him stories of the wonderful new land he had discovered. He called it 'Greenland', in the belief that the name would attract further settlers.

In 1776 the Kingdom of Denmark-Norway assumed full monopoly of trade with Greenland, and the Greenland coast was closed to foreign access. Norway lost its part in the sovereignty over Greenland in 1814, when the Danish-Norwegian union was dissolved, and Greenland became an integrated part of the Kingdom of Denmark.

Norway, and other nations, were not happy about the Danish claims of monopoly over the territory. In 1924, an agreement between Denmark and Norway gave Norwegians the right to hunt, fish and establish semi-permanent settlements in unoccupied parts of Greenland. Using this agreement as a 'springboard', in a challenge to the Danish monopoly, Norway claimed 'Erik the Red's Land' (a coastal part of North Eastern Greenland) in June 1931, and began establishing a settlement there. Denmark opposed this, and the two countries agreed to settle their dispute over the area at the Permanent Court of International Justice under the League of Nations in 1933. The Court ruled in Denmark's favour, and follow-

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ing after their ruling, Norway abandoned its claim on the disputed area. However, part of the ruling was also that, for 'Erik the Red's Land' to remain Danish, Denmark must be capable of asserting sovereignty there. Initially (1933-1941), this was done through the establishment of two fixed police stations in the area.

Then came World War 2 (WW2), where Denmark was invaded by Nazi Germany on 9 April 1940. As Denmark was occupied, Greenland became isolated and, having no armed forces of their own and fearing an invasion, the Greenland authorities requested and received assistance from the United States. In the summer of 1941, the 'North-East Greenland Sledge Patrol' was established, to conduct long-range reconnaissance patrols along the North-eastern coast of Greenland. During the war, Nazi Germany established several secret weather stations on the Eastern coast of Greenland, to provide meteorological information both to assist their U-boat campaign in the North Atlantic and to better predict the weather in the European theatre. The North-East Greenland Sledge Patrol's monitoring and disruption of these stations did much to deny Nazi Germany such information, with significant implications for their war effort.

Following the end of WW2, the start of the Cold War lead to a desire for increased surveillance of North and North-eastern Greenland and to the formation, initially in great secrecy, of 'Operation Resolute', as an outgrowth of the WW2 sledge patrol. Officially established on 18 August 1950, the name of the unit was changed to 'Sled Patrol Resolute' in 1951 and, in 1953, the name was again changed, this time to 'Sled Patrol Sirius', to avoid confusion with the Canadian Resolute Bay weather station. The name comes from the star Alpha Canis Majoris, also known as Sirius and, appropriately, also as the Dog Star, the brightest star in the night sky.

In 1953, Greenland was fully integrated into the Danish state, under the Constitution of Denmark, with home rule granted to the island on 1 May 1979. In 2008, Greenlanders voted in favour of the Self-Government Act, which transferred more power from the Danish government to the local Greenland government, including responsibility for the majority of government functions. The Danish government retained control of citizenship, monetary policy and foreign affairs, including defence. This latter is where the Sirius Dog Sled Patrol comes in.

The Sirius Patrol

The modern day Sirius Dog Sled Patrol, or 'Sirius Patrol' as it is informally known, is one of the Danish armed forces' special operations units and, as such, is organized under the Danish Special Operations Command, alongside the Frogman Corps (Navy special forces) and the Jaeger Corps (Army special forces).

The unit's primary Area of Operation (AO) is North-eastern Greenland. At 972,000 km2, the Northeast Greenland National Park is currently the world's largest national park, and the world's ninth-largest protected area.

The unit's tasks include surveillance, policing and law enforcement and sovereignty assertion in the AO. Additionally, the patrol keeps an eye on cruise ships, the various scientific and sports expeditions in the area, assists in search and rescue missions, and also serves as park rangers in the Northeast Greenland National Park. A further task, that has increased in importance over the last few years, is monitoring the impacts of climate change on the Greenland environment. Although 'dog sled' is part of the unit name, patrolling is also conducted by boat during the summer months, where the Northeast coast of Greenland is reasonably ice-free. In the winter months, though, patrolling is done by dog sled, in two-man teams who often spend months at the time on the ice, without contact with other humans.

Joining Sirius

As it can readily be imagined, joining the Sirius Patrol is not for everyone, and this is reflected in the requirements for joining.

Anyone who has completed basic training with the Danish Armed Forces or the Danish Emergency Management Agency can apply to join the Sirius Patrol. Applicants are first subjected to a 2-module admission test. The first module, which lasts 5 days, is an initial evaluation of the candidates in terms of physical and psychological fitness, cooperative abilities and a medical check. The 12 best candidates from Module 1 are then invited to take part in Module 2, which lasts 2 days, and is a final check and confirmation of the candidates' suitability.

In addition to the physical and psychological fitness, it is also important that the candidates have clarified the situation with their families since, if they are accepted into Sirius, they will be spending 26 months on patrol in Greenland.

Once candidates have successfully negotiated the admission test, they start the training for their service with Sirius. The training takes approximately 8 months and covers, among other things, the following areas:

- Winter training/survival
- Marksmanship and hunting
- Demolitions and explosive ordnance disposal (EOD)
- Engine operator and mechanic
- Reconnaissance
- Firefighting and smoke diving
- Radio and communications
- First aid (basic and expanded)
- Meteorology
- Cooking and hygiene
- Sewing
- Forklift operation
- Welding
- Speedboat piloting

The above training syllabus demonstrates well the multi-purpose nature of the Sirius Patrol – not just in terms of their mission, but also in terms of the very broad skill set required of their personnel. When on patrol, their logistical support consists almost exclusively of the face they see in the mirror in the morning, and whatever situation they face along the way, maybe short of an actual invasion or a zombie apocalypse, they must be able to resolve on their own.

Following successful completion of the training course, the accepted applicants sign up for 26 months' service in Greenland.

Currently, Sirius is an all-male unit. Although women have, for some time, been eligible for Sirius, only a few have requested to join and, at the time of writing, none have passed the complete series of admission tests.

Patrolling Greenland

The 26 months are spent patrolling the vast Sirius AO. As indicated above, patrols are conducted by dog sled in the winter months, where the two-man patrols often find themselves alone for 4-5 months at a time, with only themselves and their sled dogs for company,

Photo: Danish Armed Forces

Just another day at the office.

along with the occasional polar bear. Each two-man team is always composed of one 'old' member, who is serving his second year, and one 'new' member, serving his first year. This ensures that experience is handed over continuously as personnel are rotated. For a number of years, Sirius has maintained a patrol staff of just 12 personnel, amounting to six patrols each comprising 2 persons and 12 dogs.

Sirius typically conducts two sled patrols per year, one 'short' autumn patrol, in the November-December period, and one 'long' spring patrol in January-June. In June, the ice starts to break up, after which patrolling is mainly done by boat. During a year's operation, the Sirius Patrol covers an approximate distance of 15,000 km to 20,000 km.

Resupply during the patrols is provided via a series of pre-positioned supply huts along the patrol routes, which are typically re-stocked by helicopter. At these huts the patrols can resupply and also find shelter, should the Greenland weather suddenly turn against them.

It is difficult to imagine an environment more hostile than the one in which the Sirius Patrol operates. Temperatures in the southern coastal regions of Greenland typically vary between -10 °C and +10 °C, but in the interior and northern parts of the island, where temperatures are not stabilised by proximity to the Atlantic Ocean, winter temperatures of -50°C are not uncommon, and the temperature rarely climbs above freezing, even in summer. In Qaanaaq (Thule), the second-most northerly town in the world, located on the north-west coast, the average temperature ranges from -24.5 °C in February to +5 °C in July. Added to this are the winds sweeping down across the island from the Arctic, making the northern parts of the island particularly inhospitable to human life and most animals.

The snowstorms in Greenland are potentially lethal, and not just to the patrols, far out in the wilderness. In a 2015 article in the 'Greenland Today' online magazine, a former Sirius patrolman tells of how, during a snowstorm at the Sirius headquarters, he had to go out to check on his sled dogs. Shortly after leaving the headquarters building, a powerful gust of wind threw him into a shallow ditch and, although he wasn't injured, he did become disoriented. In the middle of the snowstorm, he suddenly found himself lost less than 50m from the headquarters building. Only by finding and following a fence did he find his way back. As he himself put it: "Regardless of your equipment, you're dead if you do not respect the weather."

Photo: The Swedish Army Museum.

Enfield M1917 rifle, chambered in .30-06, as used by the Sirius Patrol.

Equipment

As is apparent from what has been covered thus far, the individual patrols must carry all essential equipment with them, including tents, clothing, communication and navigation gear, food for themselves and the sled dogs, and weapons.

A vital part of the patrol's equipment is, of course, the sled itself. To this day, the traditional dog sled has proven itself to be superior to other forms of transport in the vast desert of ice, slush and snow in which Sirius operates. A snowmobile or a similar modern vehicle is likely to break down in the extreme conditions faced in the Sirius AO, and although dogs sleds can and do break down as well, they are relatively easily and quickly repaired with materials which are commonly on-hand.

Among the most important are the 'Kalaallit Qimmiat', the Greenland sled dogs. It would be unjust to refer to them as equipment, and the dogs are as much a part of the patrol as the two humans. However, although the Sirius sled dogs are bred and trained for the job, this doesn't mean that they don't occasionally act like dogs: fighting among themselves, getting entangled in their harnesses, striking off in 12 different directions. In the past, the Church of Denmark supposedly pre-emptively absolved missionaries, who, while visiting Inuit settlements by dog sled, yelled and swore at their dogs. In addition to pulling the sled, the dogs also make for an effective early warning system, since they react to the presence of large wildlife. The AO of Sirius is not without large predators, the polar bear being the most famous, as well as potentially dangerous large herbivores, such as musk oxen. For this reason, an unwritten rule for Sirius personnel is 'Don't go anywhere without a weapon'.

Standard personal weapons for Sirius are the M1917 Enfield bolt-action rifle chambered in .30-06 Springfield, and the Glock 20 pistol in 10 mm Auto. Both of these weapons have been chosen for two reasons: The first is their proven reliability in extremely cold weather, and the second is their respective calibres, which provide adequate stopping power and penetration against large, heavily-muscled animals. The Sirius Patrol was originally equipped with the standard Danish service handgun at the time, the SIG P210 in 9×19 mm. However, the calibre proved inadequate to the task, and something more powerful was sought.

Although the Glock 20 is an entirely modern handgun design, the choice of the century-old M1917 rifle might require a bit more explanation. Firstly, the weapon has the required the power and proven reliability, as mentioned above. Secondly, when the rifle was adopted, it was already in Danish service, as the Rifle M/53-17. Thirdly, the rifles carried by Sirius are not intended as combat weapons (even though the Sirius patrolmen could undoubtedly put them to good use as such),

but as hunting and self-defence weapons, where the manual bolt-action mechanism remains suitable. In short, the continued use of the Enfield essentially boils down to the old saying 'If it ain't broke, don't fix it'.

Notable Recent Events

In 2000, Sirius organized 'Expedition Sirius 2000', a 4 month, 2,795 km dog sled trek along the coast of North and North-eastern Greenland, to commemorate the 50th anniversary of the Sirius Patrol. Crown Prince Frederic of Denmark accompanied the expedition as its official photographer, and even celebrated his birthday en route.
On 19 May 2013, a team of Sirius 'students' completed the Copenhagen Marathon in 4 hours and 13 minutes. This might, in and of itself, not seem like an overly impressive performance, about average time for a male runner in good physical condition, but the team also dragged a 100 kg sled (which had been fitted with wheels for the occasion) behind them, and they completed the last kilometre of the marathon in arctic work clothes, including the so-called 'moon boots'.

The Future of Sirius

Although some might be of the opinion that the Sirius Patrol, two men, 12 dogs and a sled, looks obsolete in this age of surveillance satellites and autonomous reconnaissance drones, there are no plans in the Danish armed forces to disband the unit. Their basic and original mission, assertion of Danish sovereignty, remains as valid today as when the unit was founded, and a patrol on the ground can see, hear and smell things that no satellite or drone would pick up.
In addition, on-the-ground monitoring of the effects of climate change in the AO has gained in importance over the past decade, both among the population, the armed forces, and the Danish government. Last, but certainly not least, with the current security situation in Europe, it is evident that the Sirius surveillance mission has become even more important. The requirement to keep a watchful eye on the vast expanse of Northeast Greenland is unlikely to disappear any time soon and Sirius will therefore continue to patrol the icy wilderness. ■

Special Forces in Collective Defence Scenarios vs. Counter Terror Operations

Andrew White

The sudden withdrawal of NATO from Afghanistan in 2021 and Russia's latest invasion of Ukraine in February this year have thrown the international special operations forces (SOF) community into a state of flux as they prioritise future responsibilities.

After two decades of counter-terrorism (CT) and counter-insurgency (COIN) campaigns focused primarily on south-central Asia and the Middle-East, SOF have suddenly been called upon to prepare for more conventional warfare against highly capable, near-peer adversaries.
This is not to say NATO SOF organisations were not already preparing for such contingency operations many years ago. Indeed, members of the alliance from northern and eastern Europe in particular, have been identifying concepts of operation (CONOPS) and technology to counter Russian Armed Forces as far back as 2014, following the illegal annexation of Crimea. Many members of central and eastern Europe's NATO SOF community met in Budapest from 4-6 October 2022 at the Global SOF Symposium to discuss many of these emerging requirements. One of the headliners at the event was the commander of the NATO SOF Headquarters (NSHQ), Lieutenant General Antonio 'Tony' Fletcher who described how the World is getting more competitive and how SOF are already "campaigning in complex geopolitical climates". Fletcher promoted a vision of NATO SOF moving forward as an alliance to more effectively counter near-peer adversarial threats which have risen

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Photo: Ukrainian SOF

UASOF Ukrainian SOF operators from the 73rd SOF Naval Centre pose for a photograph after successfully liberating two villages in southern Kherson before 4 October 2022.

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Service members from Spain, Lithuania and Poland Special Operation Forces prepare to board a ship for maritime warfare training during Exercise Trojan Footprint 22 in Lithuania, 3 May 2022. Trojan Footprint is the premier Special Operations Forces (SOF) exercise in Europe that focuses on improving the ability of SOF to counter myriad threats, increases integration with conventional forces and enhances interoperability with our NATO allies and European partners.

to prominence over recent years, stating: "NSHQ's responsibility is to help build combat power in support of the alliance's defence objectives," he explained to delegates at the event. "Our team champions the ethos that SOF must continue to be unconventional, agile, adaptive and fully integrated in order to deter and defeat the threat and challenges we all face."

Fletcher also illustrated how NSHQ continues to "strive to contribute to the readiness of SOF through our policy, doctrine, education and capability development", acknowledging that his command fully understands that "capacity, capability and confidence underpin the trust that nations place in all of their SOF." He continued: "We will continue to identify those SOF-derived effects and persuade adversaries to question their chances of success; hold critical adversary capability at risk; and create strategic dilemmas for our adversaries, all in support of the joint force…To deliver these effects, SOF must perform military assistance, direct action and special reconnaissance focused on the most sensitive targets and the greatest threats that our nations face. While these activities vary, these SOF core tasks endure to continue adaptation to utilise current and future technology."

Fletcher also referred to a rapidly evolving curriculum of NSHQ's NATO Special Operations School, stating: "We are pivoting away from many of the exquisite skillset teaching that we were doing to ensure forces were ready to succeed in Afghanistan to what it means to deter, what it means to defend, what it means to support the alliance with a near peer competitor."

Materiel Requirements: Large-Scale Combat Operations

The so-called 'pivot' away from CT and COIN operations towards missions against near-peer adversaries requires a fundamental change in materiel requirements, not to mention tactics, techniques and procedures designed to overmatch a very different opponent.

The importance of materiel capable of overmatching modern pacing threats across the contemporary operating environment was uniquely described by the commander of Ukrainian Armed Forces SOF, Brigadier General Viktor Khorenko. As the war with Russia approaches a year in duration, the Ukrainian Armed Forces SOF (UASOF) are now quite easily the most educated special force when it comes to successfully engaging a near-peer adversary. Defence sources suggested that UASOF could be educating the wider NATO SOF community when it comes to engaging with highly capable SOF adversaries on the modern battlefield.

Referring to the ongoing conflict, Khorenko suggested that mission success very much depends upon "technology advancements" to enable the "quick-passing of intelligence; ability to strike behind enemy lines from positions of safety; and operate silently." Khorenko described how UASOF require additional modern weapons and solutions before warning: "Equipment and especially its procurement is unfortunately not a fast process and somewhat a complicated one. Under constant review, it is important to effectively manage national resources and donor aid from partner countries as well."

To date, UASOF have benefited from a variety of anti-tank guided munitions, software defined radios, tactical ground vehicles, personal protective equipment, night vision equipment and loitering munitions from NATO partners. However, Khorenko has demanded more equipment and used the GSOF symposium to call for "low visible, undetected and low profile ISR [intelligence, surveillance and reconnaissance] assets; EW [electronic warfare]-resistant UAVs [unmanned aerial vehicles] and Loitering Munitions; night vision goggles; secure, low visibility and low profile communications; and low visibility and low profile demolition charges".

"I would like to directly thank all the partners of the armed forces of UASOF. Please do not stop supporting us. Our success in this war very much depends on tech overmatch against the enemy," he continued before concluding: "Please do not stop supporting us. Our success in this war very much depends on technology overmatch against the enemy".

Intently listening to Khorenko's list of materiel demands, SOF commanders from across central and eastern Europe also disclosed some of their materiel requirements, based largely on lessons learned from UASOF. According to the commander of Slovakia's 5th Special Forces Regiment, Brigadier General Branislav Benka, SOF is leaning heavily towards technology to maximise operational effectiveness.

"We are trying to find different platforms, different ways and solutions to facilitate the technologies which are heavily in use on both [Russian and Ukrainian] sides and trying to adapt our teams [for challenges] ahead of us." Benka warned "It's not going to be easy," adding that "SOF operators are still going to carry a rucksack and rifle, but they are going to have to understand the information technology environment," he urged before stressing using technology to their advantage would be the "only way" to defeat near-peer adversaries in the future. "We weren't negotiating with industry what we needed. That's going to change so we can close the loop to get [materiel] faster. We need to be more open to discuss what is required et cetera," he concluded.

One of the most critical areas of interest outlined by SOF commanders at the symposium included a "hyper-focus" on the provision of the "right levels in command and control" (C2) to ensure SOF operators benefit from optimal levels of situation awareness (SA). In order to better operate across an information-centric battlespace, SOF must be supported by real-time common operating pictures which provide commanders with SA even when operating at the tactical edge, but also compress

decision-making processes, and so shortens the targeting cycle.

Specifically, the commander of the Hungarian SOF (HUNSOF), Major General Tamás Sándor, was one of the SOF leaders at the conference to demand for SOF operators benefit from a more effective C2 solution on the back of lessons learned from UASOF in Ukraine over the last year.

"We need effective C2, and we need to carefully listen to what our Ukrainian friends are telling us," he urged. "They can tell us how effective it is in the real world. We had C2 in Iraq and Afghanistan but it is not as available as we thought in the new operating environment," Sándor described while referencing currently employment of BICES (Battlefield Information Collection & Exploitation System) workstations across HUNSOF. "Is it going to be as effective as we need? We need to be open-minded, looking at how civilians are operating in this environment," he continued to ask before suggesting the design and development of a 'SOF-specific' C2 solution which could be implemented throughout NATO member states.

Slovakia's Brigadier General Benka also described a September visit to the Ukrainian MoD before the GSOF Symposium, suggesting: "We are spending hours and days to set up the network and set up the headquarters and tactical operations centres. We are doing something wrong. We need to bring a lot of equipment to set up while the peer-to-peer conflict is running a different way', he explained before also suggesting the development of a "totally different type of C2 system" suitable for SOF. "We are working on this as of now to develop practices and experiences coming from the ground in Ukraine," he added.

Another critical demand signal arising from the ongoing conflict in Ukraine is the number of aviation assets available to NATO

Photo: CANSOFCOM

Flintlock Norwegian partners work with Niger SOF Forces during Exercise Flintlock 2022 in Côte d'Ivoire from 15-28 February 2022.

Photo: US Army/Spc. Christopher Sanchez

Fuerzas Comando A CH-47 Chinook prepares to land for the water and land course of the Fuerzas Comando 2022 competition on La Base Naval de Amapala, Honduras on 20 June 2022. Fuerzas Commando is a multinational SOF skills competition that showcases the diversity of the SOF community in the western hemisphere, strengthens our regional partnerships, and demonstrates readiness and interoperability across regional boundaries.

SOF, particularly relating to helicopters. At the GSOF Symposium in Budapest, Lieutenant Colonel René Van Riet of the NSHQ Air Development Programme, claimed NATO SOF organisations do not have enough SOF aviation assets at present. The colonel's thoughts were echoed by Brigadier General Philip J. Ryan, Commanding General of the US Army Special Operations Aviation Command which retains operational control of the famed 160th Special Operations Aviation Regiment, known as the 'Nightstalkers'.

Describing the pivot away from CT and COIN operations in Afghanistan towards the modern, near-peer fight, Ryan explained: "We had air superiority almost all the time. We owned the night and used the element of surprise and night vision goggles to accomplish missions in Iraq, Afghanistan or anywhere else." Describing a new phase in "large scale combat operations" for SOF, Ryan added: "We may not have air superiority in the future". Ryan also suggested the deployment of specialist intelligence cells capable of providing SOF aviation task units with the ability to "identify, detect, defeat and survive" against near-peer threats in the future operating environment.

Such cells, he suggested, could feature a team of analysts able to run through specific mission scenarios before a special operations air task unit would even get in the air, allowing pilots and crew to best understand complex threats facing them in the area of operation. "They would need to understand various radar systems; utility of sensors and tactics so we can operate against [near-peer] adversaries; and proliferate those ideas back to the US Army and share with friends and allies to prepare for large-scale combat operations," Ryan suggested.

Also speaking at the GSOF symposium was the US Special Operations Command's (USSOCOM's) acquisition executive, Jim Smith, who listed a series of technology areas of interest currently being pursued by the Tampa-based organisation to support CT/COIN operations through to mission sets against near-peer adversaries. "USSOCOM is going to move quieter. There are things we did in the past that we did in a more transparent way. We need to get better," Smith disclosed while indirectly referring to the rapidly evolving pivot away from CT and COIN to global strategic competition.

Similar to some of the technology areas of interest announced earlier by Khorenko, USSOCOM priorities include the ability to communicate in contested environments. "We don't have the solution today we want," Smith warned. "We're not there yet. I want our operators to be able to talk without getting detected and have their output get to where it needs to without being altered."

Also highlighted by Smith was a pair of concepts being explored by USSOCOM to enhance levels in mobility, particularly in the Indo-Pacific. Both the High Speed Vertical Take-Off/Landing concept and amphibious variant of the MC-130J, referred to as the 'MAC' could be used for CT/COIN operations as well as mission sets associated with strategic competition, defence sources suggested. "There are significant engineering challenges, but these are something we are very interested in," Smith concluded.

Materiel Requirements: CT and COIN

Despite strong focus on operations against near-peer adversaries, NATO SOF must still retain capability to conduct CT and COIN, in some cases both at home and abroad. Materiel required to conduct such operations is typically very different to that required to support special operations against near-peer adversaries, industry sources explained.

More than two decades 'on the ground' in Iraq and Afghanistan in the 21st Century has significantly reduced the appetite of NATO members to deploy SOF abroad on a permanent basis. Furthermore, the withdrawal of SOF task groups from Afghanistan is now forcing NATO SOF to consider alternative means of successfully executing special operations.

For this reason, the international special operations community and particularly US Special Operations Command, is now concentrating on capability to successfully execute 'Over-the-Horizon' special operations which essentially rely upon remotely deployed technologies to target and prosecute targets. Examples include the successful targeting and neutralisation of Al Qaeda's leader, Ayman Al-Zawahri on 1st August 2022. Zawahri was understood to have been killed by a pair of Hellfire missiles launched from a UAV, most likely MQ-9 Reaper.

Few details were officially disclosed by the US Department of Defense about the operation but given the fact there was zero official presence of US SOF in the country at the time, it is highly likely the targeting process would have relied heavily upon beyond line of sight/over the horizon assets including satellites and semi-autonomous platforms, industry sources suggested.

Beyond over-the-horizon drone strikes, NATO SOF is expanding its CT/COIN capabilities through enduring partnerships with indigenous special mission units, particularly in the Middle East, Africa, Latin America and the Indo-Pacific. Examples include the annual Flintlock exercise which was once again resumed in February this year following its cancellation in 2021 due to the COVID-19 pandemic.

The event was last conducted in Senegal, West Africa over the course of February, with a large number of special mission units from across the region undertaking counter-VEO training under the auspices of NATO SOF units. Participating special mission units were

drawn from Benin, Burkina Faso, Cabo Verde, Cameroon, Chad, Cote d'Ivoire, Gambia, Ghana, Guinea-Bissau, Mauritania, Morocco, Niger, Nigeria, Senegal, and Tunisia with instruction from NATO SOF personnel from Austria, Belgium, Brazil, Canada, the Czech Republic, France, Germany, the Netherlands, Norway, Poland, Portugal, Spain, the United Kingdom, and the United States. Training focused on the tactics, techniques and procedures (TTPs) required by SOF units to conduct CT and COIN operations on the ground and at sea.

Given the relative smaller budgets of West African partners, materiel used to support training during the Flintlock exercise is restricted to small arms, personal protective equipment, tactical ground vehicles, small boats and small UAVs.

Similar instruction and materiel is provided to Latin American SOF units as part of the annual Fuerzas Comando exercise, which was last conducted in June 2022. The event was held in Honduras, and included SOF from the host nation as well as Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Haití, Jamaica, Panamá, Paraguay, Perú, Trinidad and Tobago, and the US. According to exercise officials, the programme is designed to improve levels in interoperability and cooperation, particularly in terms of CT, COIN, counter-narcotics and counter-organised crime on land, in the air and at sea.

Conclusion

The latest war in Ukraine has forced NATO to re-prioritise threats and has consequently placed greater urgency upon materiel requirements for strategic competition ahead of CT and COIN campaigns. However, these very different capability sets will both need to be catered for, particularly as violent extremist organisations continue to generate support around the World.

Unfortunately for government expenditure, there is little similarity in equipment requirements for CT/COIN and operations associated with strategic competition, meaning SOF commanders will be forced to make difficult decisions in the short to medium terms. ■

Libelle – Diehl Defence Enters the Loitering Munitions Race

Waldemar Geiger

Starting with the Nagorno-Karabakh conflict, and continuing with the current Ukraine war, virtually anyone can see the effectiveness of loitering munitions (LMs) on the battlefield for themselves. Technologically, LMs have been mature for a long time, with early examples having entered service decades ago. In Germany, however, these types of munitions have long been undesirable for political reasons relating to fears around weaponising drones. Since the conclusion of the drone debate, the German defence industry has re-evaluated the potential of LMs and has already demonstrated its first systems. One such loitering munition is Diehl Defence's 'Libelle' (ENG: 'Dragonfly'), which the manufacturer claims possesses unique capabilities.

The term 'loitering munition' is used to describe remotely operated precision munitions which can be launched without specific target coordinates, then circle or linger over a target area for extended periods of time until a worthwhile target is detected, and then engage it. In addition to target engagement, loitering munitions can therefore also be used for reconnaissance purposes. Loitering munitions can be broadly divided into three different categories based on their design:

The first type corresponds to the design of a classic surface-to-surface attack LM. This category of LMs are typically associated with long range and loitering times, with relatively low optical and acoustic signatures. Such LMs can only attack their targets only at shallow dive angles, due to their aerodynamic construction. Obstacles and cover in the immediate vicinity of the target can therefore be used to protect against strikes from these types of LMs. Additionally, the reusability potential of these systems tends to be limited due to their reliance on a parachute or net for recovery.

The second LM design is based on a typical guided missile design, albeit featuring larger, X-shaped wings and propeller engines instead of a rocket motor. Such designs can be used to achieve both long ranges and loiter times, but are also capable of engaging their targets at very steep dive angles, permitting top-attack engagements against their targets, and therefore possessing greater potential to defeat against armour than their shallower-diving classically aerodynamic counterparts.

The third type is the copter drone design. These LMs systems can take off vertically and, if necessary, land again independently. Since young soldiers in particular may be familiar with copter-type drones from their leisure time, the controls are quite easy to train. These systems are capable of attacking targets directly from above, so positions in partial cover offer little protection. The ability to hover in place or land and wait on rooftops of buildings makes LMs of this design particularly well-suited for urban combat. The disadvantages of such rotary-wing LM systems includes their typically slower speeds, lower ranges, and shorter flight/loiter times (often <1 hour), and greater

Photo: Waldemar Geiger

The Libelle Loitering Munition is available in two variants (pictured), the one on the left is intended for use with vehicles, while the one on the right is intended for dismounted operation.

susceptibility to wind conditions compared to the first two LM types discussed. In addition to these, they are easier to detect acoustically, since both forward movement and lift are provided solely by the rotors, they must turn at very high speeds, which translates to a relatively loud signature.

Libelle

Diehl Defence first publicly presented its concept for an LM in Autumn 2021. Since then, the concept has been further developed and, according to reports, a flight-ready system has already been demonstrated to interested customers, and will soon be ready for the market. For this to succeed, Diehl Defence engineers have combined already mature technologies and products in the creation of the Libelle.

According to Diehl Defence, Libelle will be available in two variants – a smaller version for dismounted use and a larger variant for mounting on vehicles. Both are reusable and designed for anti-tank applications. According to the manufacturer, the Libelle is absolutely fail-safe and designed to ensure easy operation even under combat stress. The total weight of the smaller dragonfly designed for dismounted use is said to be less than 13 kg. This means it can be easily stowed in a rucksack and carried by a single operator.

Munition Design

Strictly speaking, the Libelle is more of a classic munition shape with two coaxial contra-rotating two-blade propellers, rather than a more conventional copter design. The body of the Libelle consists of three main sections. The upper sections house the drive assembly with the electric motor, while the middle assembly directly below the lower propeller houses the electronics, power supply, and a fibre optic bobbin which can be used as a means of interfacing with the munition in the absence of radio. The lower assembly houses the warhead and the sensors, with the latter protruding out from the main body of the munition near the base. The sensors each appear to be provided with a cable conduit running up the side of the munition for power supply and interface purposes.

Warhead

The Libelle's operating principle can perhaps best be compared with the 'SMArt 155' family of munitions, which one or more sensor-fuzed submunitions. The warhead is strongly based on the explosively-formed penetrator (EFP) warhead used in SMArt, but some differences exist, such as in the fuzing system used. Whereas the SMArt relies on a combination of an infrared (IR) sensor and a millimetre-wave radar sensor to form the fuzing system, the Libelle uses cameras supported by modern image recognition algorithms. Beyond simply activating the warhead, these are also capable of discriminating between targets. In contrast to SMArt, the Libelle is not fired from a gun, but makes its way to the target under its own power and can hover in place or fly search patterns until a worthwhile target is detected. Using intelligent image recognition, the target can then be tracked, and the munition can fly to within engagement range of the warhead. Once within range, the Libelle's base is automatically aligned with the target to achieve maximum hit probability, and the EFP warhead is then activated. This provides sufficient penetration to defeat even main battle tanks if employed against their weaker roof armour.

Control

According to Diehl, controlling the Libelle is as simple as it gets. For example, the LM can autonomously approach the potential target area following the operator simply setting a marker on a digital map, and it will then loiter there. Once a suitable target has been identified, it is selected by the operator, also by placing an on-screen marker on the target, and the rest of the engagement is automated. All in all, this means that the system can be deployed in a targeted and safe manner even under combat stress and without requiring extensive training.

The control software developed by Diehl is app-based, meaning that no specific control unit or ground control station is required for the Libelle. The user can install the app on their smart device, and use it to interface with and control the Libelle. Interface between the operator and the munition can be radio-based, adapted to the user's radio systems, or via the fibre optic cable.

The fibre optic link has a length of several kilometres, and is immune to jamming, allowing the user to employ the Libelle even in on battlefields where the electromagnetic spectrum is contested. Moreover, in this interface mode the Libelle does not emit any radio or microwave signals, allowing it to avoid detection by hostile direction-finders. At a time when armed forces are increasingly investing in drone defence systems, this capability should not be ignored.

Conclusion

As soon as it is ready for the market, the Libelle certainly has the potential to complement the anti-tank capabilities of modern armed forces, finding its particular niche in urban or complex terrain where line-of-sight restrictions hinder the employment of anti-tank guided missiles (ATGMs). In these environments, the Libelle would offer an effective tool for both reconnaissance as well as strike, and thanks to the option of using a fibre optic interface, it can be equally effective under conditions of jamming by friendly or hostile forces. ■

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Sinking Feeling – How Vulnerable are Modern Warships to Anti-Ship Weapons?

Sidharth Kaushal

The threat posed to vessels at sea by anti-ship missiles (ASMs) is not a new one. Since the Israeli destroyer Eilat was sunk by a Soviet made P-15 Termit (NATO: SS-N-2 Styx) missile launched from an Egyptian Komar class patrol vessel during the Six-Day War, the potential for missiles to hold large surface vessels at risk was understood by navies around the world.

The lesson was reinforced by conflicts such as the Falklands War, which saw the Argentinian armed forces use the Exocet missile to good effect against the Royal Navy, as well as Western late Cold War naval planning which would have seen Western maritime power applied to force its way into Soviet bastions defended by layers of cruise missile equipped platforms. Equally, surface combatants and tactical formations developed a range of countermeasures against missile threats, from the interception of launch platforms to the fielding of capable shipboard air and missile defence systems such as the US Navy's Aegis system.

The missile threat to surface combatants has evolved in recent decades in several ways. First, Anti-Ship Cruise Missiles (ASCMs) have proliferated widely, with even non-state actors like the Houthis and Hezbollah fielding capabilities like the Chinese made C-801 and C-802 as well as, in the latter case, the supersonic Russian Yakhont ASCM. Secondly, ASCMs have been joined by Anti-Ship Ballistic Missiles (ASBMs) such as the Chinese DF-21D, DF-26 and YJ-21. Missiles like the DF-21D are capable of operating at theatre ranges of up to 2000 km, carrying payloads capable of inflicting 'mission kills' or even outright sinking aircraft carriers. They can be operated from ashore in positions that may be relatively difficult to identify, and, by virtue of their ballistic trajectories, present maritime air and missile defences with an additional challenge.

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Photo: US Navy/Don S. Montgomery

The sinking of the Israeli destroyer Eilat by a P-15 Termit (SS-N-2 Styx) missile in many ways announced the missile threat to the world's navies

Finally, the missile threat to vessels will likely be exacerbated by the fielding of hypersonic missiles both in the form of Hypersonic Glide Vehicles (HGVs) such as the Chinese DF-17 and Hypersonic Cruise Missiles (HCMs) such as the Russian 3M22 Zircon. Hypersonic weapons, which can travel at speeds over Mach 5, combine the characteristics of high speed and manoeuvrability, imposing substantial strains on the reaction times of shipboard air and missile defence systems. Moreover, they could in principle impart particularly high levels of kinetic energy on impact, which is noteworthy because kinetic energy, more than warhead size is the best predictor of lethality against large surface combatants.

Despite qualitative changes in the range, speed and manoeuvrability of the ASMs that can target surface combatants, however, it would be a mistake to assume that large surface combatants are white elephants. The complexity of the kill chains that enable missiles to be used over long ranges and the physical constraints of missiles themselves can curtail their effectiveness. Moreover, existing and emergent shipboard air defences – both active 'hard kill' defences and 'soft kill' methods – mean that large surface combatants will enjoy significant protection. This being said, however, there is an undeniable cost asymmetry between missiles and the vessels that they target, which means that an attacker can sustain more failures than a defender can sustain successful attacks. When high value naval platforms are deployed in contested environments, it will be on the assumption that they may be lost. For shrinking Western navies this can represent a substantial challenge, but in many ways it is one that mirrors a perennial lesson of naval combat – that fleet size and the capacity to sustain losses matter.

The Missile Threat

A number of factors work to constrain the operational effectiveness of missiles against moving targets, especially at very long ranges of over 1000 km (the ranges at which most ASBMs and HGVs would be used). Given the expanse of the areas in which a vessel or group of vessels such as a carrier task group might be at these

Photo: VOA, via Wikimedia Commons

The Chinese DF-21D is the world's first anti-ship ballistic missile.

ranges, it is difficult to maintain surveillance over them using assets with narrow fields of view. Even Optoelectronic and Synthetic Aperture Radar (SAR) -equipped satellites cannot, by themselves, provide sufficient levels of persistent ISR over a given area to enable the tracking and engagement of a target. They have substantial swath widths, of up to 100 km, but in a theatre such as the western Pacific or the North Atlantic, they would be surveying even larger expanses with a requirement for rapid revisit over an area. To use an example, it has been estimated that the revisit rate of China's Yaogan satellite constellation of Optoelectronic and SAR satellites was around 2.9 days in 2017.

In order to mitigate this challenge, states need to rely on assets that can survey a wider area, albeit with lower resolution. This can include Naval Surveillance satellites which the USSR used to cue in its Legenda radar-equipped satellites. It could also include Over the Horizon – Surface Wave (OTH-SW) and Over the Horizon – Backscatter (OTH-B; also known as 'Skywave') radar. China operates both types, known examples include an OTH-SW on the coast at Ruian, Zhejiang province, and an OTH-B at Xiangyang, Hubei Province. The challenge faced by these capabilities is one of resolution – OTH-B radars, for example, face a substantial challenge when surveying oceans due to the effects of oceanic backscatter. Moreover, they have an error radius of around 40-170 km due to the very large size of the radar's resolution cell. Similarly, ELINT satellites are potentially vulnerable to spoofing, as was practiced by the US navy during Operation Haystack. Moreover, relatively few nations maintain large constellations of Optical Surveillance and ELINT satellites. Russia, for example, has struggled to field its Liana and Persona satellites, which will substantially impact its ability to cue long range missiles like the KH-47M2 at their maximum ranges. While nations can rely on other sources of information, such as maritime patrol aircraft, this will come at a cost in capacity – drawing these assets from other missions.

There are additional challenges faced by countries seeking to cue ASBMs and hypersonic weapons at very long ranges. Bottlenecks, both technical and organizational, can limit the speed at which data can be passed from early warning assets to those that can provide targeting and finally to the platform launching a missile. These bottlenecks can be further exacerbated by adversary disruption in the form of either kinetic or electronic warfare against space-based assets, cyberattacks and the destruction of ground-based command and control nodes. None of this is to suggest that these problems are absolutely irresolvable, and countries can also receive intermittent targeting data from other sources. China, for example, could conceivably use longer-range UAVs like the GJ-11 for reconnaissance roles. States can even rely on non-traditional data sources. For example, the PLAN appear to be equipping fishermen with satellite communications and furnishing them with the basic training needed to identify targets of interest. Finally, the area covered by the seeker of a ballistic missile warhead dropping near vertically from altitude is substantial. Chinese estimates suggest that the 'kill radius' (here meaning the distance a target can deviate from its position and still likely be hit) of a terminally-guided ASBM such as DF-21D is around 20 km at a conservative estimate. This means that ballistic missiles, especially if launched in large numbers, can cope with a certain degree of imprecision in initial targeting data, though it would still take an especially large salvo to operate on the basis of ELINT or data provided from an OTH radar alone. It is nonetheless the case, however, that the threat posed by ASBMs to vessels will be somewhat attenuated by the complexities of the associated kill chain. ASCMs are somewhat easier to cue, as their sources of data are on board the launch platform. For example, most surface vessels would track targets using their own radar, such as the Chinese Type 364B AESA radar on China's Type 055 cruiser. This is not always the case, however. For example, cruise missile-armed nuclear submarines (SSGNs) can typically gather information on target range and bearing from their organic acoustic sensors, but rely on offboard sources for more granular targeting. For ex-

Photo: CNS, via Wikimedia Commons

Satellites like China's Yaogan Clusters (one of which is being launched in the image) are critical to cuing missiles like the DF-21D.

Photo: US Navy

Vessels like the US Navy's Arleigh Burke class (pictured) and the Royal Navy's Type 45 are optimised for active defence against air and missile threats.

ample, during the Cold War, Soviet Oscar Class submarines would have received data from satellites. This does pose certain challenges, such as high data latency and the fact that methods of communication such as a trailing wire can be spotted by Anti-Submarine Warfare (ASW) assets such as maritime patrol aircraft. Similarly, ground-based coastal missile systems like the Russian Bastion-P rely on a combination of organic Monolit-B radar and Ka-32 helicopters to triangulate target locations, and the loss of the latter could restrict the range at which a battery could accurately classify a target. The challenge of poor granularity regarding target location can be partially mitigated through the use of large salvos of cruise missiles to cover a search area with seekers. For example, the P-700 Granit launched by the Oscar were programmed to swarm – with one cruise missile rising to a high altitude to conduct a sweep and pass data to lower-flying missiles.

There is a second question regarding kill chains, namely that of coordinating assets from across multiple platforms. The gold standard of missile attacks is what Wayne Hughes described as simultaneous salvos, as opposed to dispersed salvos (the occasional single missile) or sequential salvos (grouped salvos in sequence). Many contemporary authors, including many Chinese ones, describe similar approaches. For example, one Chinese article in a journal associated with the PLA posited that six cruise missiles flying on different trajectories and one ASBM would be needed to overwhelm an Aegis destroyer. However, this represents a substantial coordination challenge given that these assets may be held on different platforms and indeed under different services. Notably, this challenge could be partially resolved by ever larger vessels. The Chinese Type 055 cruiser which can launch a YJ-21 ASBM from its large cold launch capable Vertical Launch System (VLS) cells (which have cells with a 60% greater volume than those of a US Ticonderoga class) could in principle coordinate such a launch independently. However, in most cases, coordinating salvos will remain a challenge.

Beyond the kill chains needed to sustain them, there are other more physical limitations faced by missiles. For example, hypersonic bodies travelling through the atmosphere form a plasma 'sheath' around the body which has the downside of effectively precluding offboard communication, but also has the benefit of making detection via radar much more difficult by lowering the effective Radar Cross Section (RCS) of the body. This plasma sheath effect also means that in order to operate their seekers they need to slow to speeds well short of their top speeds in their terminal phase. Hypersonic cruise missiles face an additional challenge – in order to compress air for their scramjet engines, they need to fly at altitudes of over 20 km, meaning that they cruise relatively high and cannot sea skim until late in their trajectories. The plasma sheath effect is also a challenge for the DF-21D which has to perform a 'pull up' manoeuvre in terminal phase to reduce its speed, identify a target, and then steer itself towards the target. The difficulty of doing this accurately likely increases the odds of missing, and may also provide a window for interception.

Photo: DTSL

Directed Energy Weapons such as the Royal Navy's Dragonfire could enable air-breathing threats to be engaged in a more cost-effective way.

Defences and Countermeasures

The second consideration when discussing the vulnerabilities of vessels is their defences and countermeasures against incoming missiles, both those currently fielded and those which can reach maturity. Modern air defence vessels, such as the Aegis-equipped destroyers (which form the lynchpin of a US carrier strike group's air defence picket), or comparable contemporaries like the UK's Type 45 destroyer possess credible air defence suites. Most modern air defence platforms are adopting active electronically scanned array (AESA) radar which can emit beams on multiple frequencies simultaneously, reducing inaccuracies caused by factors such as interference between systems and enabling the simultaneous tracking of a large number of targets. Moreover, battle management systems such as Aegis can enable engagement windows (the process between tracking and engagement) to be closed at pace – especially when they are operating in fully autonomous mode. Layered air defences

Photo: BAE Systems

Soft-kill tools such as the Nulka DRFM decoy will enable less explosive, non-kinetic methods of missile defeat.

aboard vessels typically include ballistic missile defences such as the SM-3, long-range assets such as the SM-2 or Aster-30 (which would typically be used against air breathing threats) and shorter-range interceptors such as the ESSM or Aster-15. Some interceptors, like the US Navy's SM-6 can be used both for area defence against air-breathing threats, and as point defence against ballistic threats. As such, overwhelming these systems, especially with cruise missiles, represents a challenge and so far there are no cases of an alert vessel with credible hard and soft kill capabilities being sunk by an ASCM. However, against less than alert vessels, or when crews are taken by surprise, the chances of missiles leaking through the defences are greater. Notable examples include the sinking of the HMS Sheffield and the Moskva, as well as damage to the INS Hanit in the 2006 war in Lebanon. Surprise may also depend on situational awareness regarding the proximity of launch platforms. For example, SSGNs, which can potentially surprise targets at relatively close ranges, can surprise their prey if launching from closer ranges, where they do not require offboard cueing.

Two factors can complicate air and missile defence against cruise missiles. The first is the increasing speed of incoming targets, such as Russia's 3M22 Zircon hypersonic cruise missile. However, as previously noted, the nature of scramjets may make it necessary for these missiles to operate on a higher altitude trajectory – meaning that while they are faster than a slow sea skimming missile, they are also spotted earlier by a ships radar or electronic support measures (ESM). Moreover, both HGVs and HCMs likely have to slow substantially in their terminal phase in order to use their seekers- meaning that they are potentially vulnerable to interception in the final stages of their trajectories.

A more substantial challenge for ship self-defence may be a lack of VLS capacity – especially if VLS cells have to be divided between offensive strike capabilities and defensive interceptors. Adversaries can exacerbate the challenge through the use of UAVs as decoys, or dedicated decoys such as the US' ADM-160 Miniature Air-Launched Decoy (MALD). The challenge of the cost curve can be partially solved by more effective close-in defences, particularly those involving Directed Energy Weapons (DEW). With their large powerplants, ships are a relatively easy platform onto which to incorporate DEWs, and though their effectiveness may be partially influenced by climatic factors, they could help shift cost curves in the defenders direction. Ballistic missiles can be intercepted during the midcourse, much like land attack missiles. In terminal phase, the pull up manoeuvres they perform to slow down and activate their seekers may make tracking and generating a fire control solution against them more difficult, but will also provide defenders with additional reaction time. Countermeasures and decoys, as well as other penetration aids can be used to confound a defender. However, in many ways the challenge is a fairly traditional BMD task.

Beyond hard-kill measures, vessels can also rely on soft kill methods such as dispensing chaff or decoys, and electronic jamming to confound missiles. The Israeli raid on Latakia during the 1973 Yom Kippur war illustrated how outranged Naval vessels equipped with capable electronic warfare suites could nonetheless outmanoeuvre their opponents. A vessel does however need a directional track on a missile's seeker in order to jam its signal, which makes this a relative last resort against missiles. Decoys by contrast have shown their effectiveness, with the Nulka Digital Radio Frequency Memory (DRFM) active decoys being used to good effect during the Houthi attack on the USS Mason in the Bab al Mandeb strait. DRFM decoys effectively detect a missile's active radar seeker frequency and then radiate it back to the missile. They can be launched to safe distances away from the vessel by rocket propulsion. To be sure, solutions do exist for attackers. Millimetric wave seekers, for example, are far less easy to defect and reflect back to their source using decoys – but this comes at a cost in the seeker's target detection range. Dual-mode seekers combining, for example, active radar and infra-red (IR) can also represent a potential adaptation – albeit one that increases, cost, complexity, size, and forces design trade-offs.

Neither Invulnerable Nor Sitting Ducks

Ultimately, neither hard nor soft kill methods can provide guaranteed protection for naval platforms – vessels are at risk in an age of proliferating missile threats. However, they are far from sitting ducks. The complexity of cuing large salvos of missiles, especially when dealing with particularly long range missiles, as well as the capabilities of layered shipboard air and missile defences, make sinking a vessel a resource-consuming task for the attacker. Moreover, launch platforms such as ships, submarines and aircraft are themselves vulnerable to interdiction left of launch.

That said, the cost of protecting high-value vessels in terms of the dense layered air defences they require, and the disproportionate costs of losses to fragile and shrinking maritime force structures do mean that the political constraints on deploying vessels may grow. In many ways, however, this is a reflection of shrinking force structures which make navies more loss-averse, and not the fact that missiles, though lethal, have necessarily upended the balance between offence and defence at sea. ■

Lessons Learned From Ukraine Conflict – UAV Operations, Options and Trends

David Saw

It is almost a year since Russia began what it called its 'Special Military Operation,' in reality its invasion of Ukraine. What was supposed to be a campaign that was to last a matter of days, that was supposed to see the decapitation of the political and military leadership in Kyiv, leading to the rapid collapse of Ukraine resistance has become a protracted and complex conflict. Many of the preconceptions held before February 2022 on the ability of the military in Ukraine to resist, the resilience of its leadership and the will of the people to support the fight in Ukraine have been proven incorrect. Equally, some of the preconceptions held about the capabilities, leadership and doctrine of the Russian Army have proven equally incorrect. In this article, we will look at the UAV aspects of the current Ukraine conflict, with our main emphasis being on the trials and tribulations of Russia's UAV capabilities.

What has occurred in Ukraine since February 2022 is only the latest, but most intense, bloody and destructive, phase of a conflict that dates back to 2014. The initial phase of the conflict in 2014/2015 saw the annexation of the Crimea and War in the Donbas leading to the establishment of separatist enclaves in Donetsk and Luhansk. At that time there was a great deal of speculation that Russia had managed to develop a 'new generation warfare' concept, integrating both conventional and unconventional operations, and that the Russian Army with its Battalion Tactical Groups had developed a new operational structure for manoeuvre warfare. Innovation was the name of the game, and all of a sudden the Russian military was taking the lead in generating what for many might be seen as a new revolution in military affairs.

Photo: Joint Forces Command, Ukraine

UAV utilisation in the Ukraine is not just about military-specification systems, here a Ukrainian soldier is shown with a commercial quadcopter UAV system. Ukraine will create Strike Companies using both commercial and military UAVs for both surveillance and attack missions.

The initial phase of the conflict in the Donbas inevitably led to a number of analyses being written, one that was somewhat influential was written by Phillip Karber, a defence analyst who had visited Ukraine on a number of occasions during the 2014/2015 phase of the conflict, and Lieutenant Colonel Joshua Thibeault, a US Army operations research system analyst, published in Army, June 2016. The authors note that: "the struggle in Ukraine has involved the largest-scale battles in Europe since the end of World War II." Until the February 2022 invasion, it was hard to disagree with that statement.

In the article entitled "Russia's New Generation Warfare," the authors describe a number of UAV-related developments. The first of these is in the context of electronic warfare (EW), commenting on the importance of EW for the Russian Army, they classify four key EW missions, one of which is defeating UAVs. They note that: "electronic warfare is the single largest-killer of Ukrainian systems, by jamming either the controller or GPS signals." It is important to bear in mind that Ukraine's military of 2014/2015 was a totally different proposition to Ukraine's military of 2022. Back in 2014/2015 the leadership was weak and slow to react, equipment was of variable quality, and often limited in quantity, and support services were indifferent. There were some Ukraine Ground Forces units that were well-led and of higher quality, but these were exceptions. It would be fair to say that in the initial period of the 2014/2015 conflict, Ukraine's forces were in second-place both qualitatively and quantitatively.

Moving on to a discussion of UAVs, the article states that: "Ukraine is the first conflict in which unmanned aerial vehicles have been present on both sides in significant numbers. Russia employs UAVs for intelligence, surveillance and reconnaissance; target acquisition and real-time engagement for massed artillery fires; and, most recently, as 'minibombers' carrying incendiary explosives targeting ammunition and fuel storage areas."

The article continued: "Ukrainian forces have observed up to eight Russian UAV overflights per day, and the constant awareness of being observed and targeted is often a traumatic experience that instils fear and inhibits movement, particularly in daylight. The combination of small-size, limited radar cross-section or infrared signature, and lack of acquisition until they are over or past the target, makes engagement with surface-to-air missiles a low-probability and high-cost proposition." Analysing these findings with the benefit of hindsight, seems to indicate that the impact of UAVs in terms of both physical and morale aspects in 2014/2015 seems to far outweigh the number of UAVs available to either side at that point in time. This in itself is an important development.

Lessons From The Past

What was significant in the first stage of the War in Ukraine as regards UAVs is that you had full military specification UAVs being

utilised, but at the same time you also had both sides using commercial/civilian-grade UAVs. Both Ukraine and separatists in the Donbas modified commercial-grade UAVs to increase their capabilities and survivability, as well as building new UAVs from commercial/civilian components that they could acquire on the international market.

At the start of the conflict, Ukraine had very little in the way of UAVs, they had some Soviet-era Tupolev platforms available, but these could hardly be called state-of-the-art. Realising the importance of UAV capabilities, ordinary Ukrainians got together and pooled their resources to purchase civilian UAVs that could be re-purposed for military use, this was the first instance of UAV crowdfunding. This led them to a company called Shenzhen Da-Jing Innovations (DJI) Technology, based in Shenzhen, Guangdong Province, China, and established in 2006. It is estimated that by 2021, DJI accounted for 70% of the commercial UAV marketplace. In 2019 DJI acquired a majority shareholding in the Swedish camera maker Hasselblad, best known for its professional medium-format cameras, this added high-end camera and optics to the DJI product lineup.

What happened in Ukraine was that DJI Phantom UAVs were purchased and then an off-the-shelf video camera was integrated, this resulting in a very cost-effective UAV capability, but it was a capability with significant limitations. The datalink from the controller to the UAV, and vice versa, can be easily detected and subject to electronic attack. Alternatively, the position of the UAV controller can be detected and subjected to a kinetic response. Here, the typical response would then be rapid, artillery or mortar fire on the position of the UAV controller, meaning that surviving required rapid changes of position and/or operating from a secure and protected location.

One comment that is often noted in post-2015 analysis of UAV operations in the Donbas conflict is how the Russians attempted to use their UAVs. If a Ukrainian position was overflown by a particular type of Russian UAV, within 10-15 minutes that position would be hit by an artillery or rocket strike. Another Russian tactic was to direct two UAVs to a particular area, one at low-level to draw fire from Ukrainian positions, with a second Russian UAV at a higher level observing proceedings and then providing targeting data for artillery to strike the unmasked Ukrainian position.

Russian Capability Development

There is no question that the Russian aerospace industry is capable of the design, development and production of advanced systems, yet like other parts of the Russian defence ecosystem, it had to cope with years of underinvestment in the post-Soviet era, limiting its growth and technical progression. The Putin era that began at the end of 1999 sought to resolve many of the issues which had emerged under Yeltsin – the power of central government was restored, there was a strategy for the future, and the national economy was gradually restored to health. As for corruption, it did not disappear, but became and a tool for the ruling elite to reward itself and its supporters.

More broadly, the underlying ideology of 'Putinism' calls for national renewal in Russia and a return to greatness. As a part of this process, the Russian government sought to reform its military and also return it to their perception of 'greatness.' In parallel with this, they looked to restore the Russian defence industry to being capable of supporting a sophisticated military power, and to invest in research and development to make up for the post-Soviet years.

If Russia was to dominate in the post-Soviet space then it needed a well-equipped, well-organised and well-led military. The ongoing conflict in Chechnya and the Russian invasion of Georgia in 2008, demonstrated the importance of military and defence industrial reform. The reform process was aimed at restoring capabilities that had been allowed to decay over the years, in addition Russian military thinkers had become fascinated by the possibilities of unmanned and autonomous systems, with interest in advanced UAVs being seen as an important development.

In the Soviet era, development of UAV-like platforms had been inconsistent, in the 1970s the Tupolev Tu-141 Strizh entered service at the end of the 1970s, followed soon afterwards by the Tupolev Tu-143 Reyes. The Tu-143 had a reconnaissance pod payload that was removed from the air vehicle for processing post-mission. The Soviets used the Tu-143 during the 1982 Lebanon War in support of their Syrian client state, and this was the conflict in which Israel first

Photo: Ukraine Ground Forces

A Ukraine Ground Forces air defender prepares to fire a Stinger MANPADS. Russian UAVs often operate in pairs, with a low flying system tempting air defences to unmask, so that the second UAV can pass the coordinates back for a strike mission.

deployed the modern battlefield UAV with tremendous success. No doubt the Soviets were aware of how useful these Israeli UAVs were, but there was no real response to this development. Interestingly both the Tu-141 and Tu-143 have been used by Ukraine in the current conflict, mainly as ersatz missiles with an explosive payload. In March 2022 a Tu-141 crashed in Croatia, allegedly it was of Ukrainian origin and had gone off-course, crashing once it ran out of fuel.

The next generation of Soviet UAV was the Yakovlev 'Pchela'. This entered service with the Soviet Air Force in the late-1980s and was used for reconnaissance, surveillance and targeting missions, and was fitted with a video downlink. The issue with these Soviet UAVs was that they were limited in comparison with what the Israelis or other Western manufacturers were doing and were increasingly falling behind the times in terms of capability.

In the post-Soviet era, the interest in UAVs was there, the ability to develop and field credible Russian UAV solutions was not. Furthermore, they were coming to the conclusion that UAVs would offer far more than a battlefield asset. If you look at Russia, the size of its borders are immense, this would be an excellent mission for UAV surveillance. Beyond that, UAVs could be used for pipeline and electrical transmission line surveillance, for emergency management and disaster relief applications. All of this created an expectation that Russia must have an effective indigenous UAV capability.

Foreign Suppliers

The Russian invasion of Georgia in 2008 provided another indication of the capabilities of UAVs, with Russian forces being on the receiving end of the Elbit Hermes 450 as used by the Georgian Defence Force. One consequence of this was that in April 2009 Russia signed a contract with Israel Aerospace Industries (IAI) valued at some USD 50 M, covering the acquisition of the Searcher II, the BirdEye 400 and the I View 150. In total 12 systems were said to have been acquired. This acquisition gave Russia access to modern UAV technology and allowed them to develop operational skills. It also provided the basis for further Israeli UAV acquisitions by Russia.

In October 2010 a second UAV contract, valued at USD 400 M, was signed by IAI and Oboronprom of Russia. Here the idea was assembly and license production of the BirdEye 400 as the 'Zastava' and the Searcher II as the 'Forpost' by the Ural Civil Aviation Plant in Ekaterinberg. It is important to note that despite the fact that these systems are produced in Russia, they relied on imported components, understood to be sourced from Israeli, German, Spanish and Swiss suppliers. In 2015 Israeli media reported another contract between IAI and Russia, said to cover the assembly of 10 Searcher II UAVs in Russia, however it is not known if this is connected to the October 2010 contract. Allegedly, Russia was also interested in the long-range IAI Heron system, but no deal was struck. Both Zastava and Forpost UAVs have been used by Russia forces in the invasion of Ukraine.

The acquisition of Israeli UAVs was an important development in the creation of an indigenous UAV capability in Russia, demonstrating what was necessary to create and deploy usable systems. Having this relationship with Russia had certain advantages for Israel, especially when Russia started to increase its involvement in the Middle East. The hope was that the relationship would see Russia restrain its clients, such as Syria and Iran, from anti-Israeli actions. Yet there were costs to the relationship as well – for instance, it appears Ukraine was interested in acquiring Israeli UAVs in 2015, but Russia heard of the potential sale and pressured Israel not to proceed. In the end Israel was unable to sanction a UAV sale to Ukraine.

Russia was also looking to acquire UAVs and technology from other sources as well. Austrian company Schiebel signed a cooperation agreement with OAO Gorizont of Russia covering the development of a variant of the S-100 Camcopter for a range of civil UAV applications in Russia. However, Schiebel's cooperation with the Russian company has ceased since the invasion.

Meanwhile, Russia has developed a rotary wing UAV system greatly resembling the Camcopter – the Dinamika Flight Technologies BAP system, which the entered Russia service at the end of 2020. Its primary function is to act as a target for air defence systems, replicating UAVs and helicopters. The system was apparently first used in a joint exercise between Russia and Serbia in January 2021, where it was used in the training of Pantsir-S missile crews. It has since been used operationally in Ukraine.

In sum, the fact that Russia was prepared to acquire foreign systems indicated how concerned that they had become that their UAV capabilities had fallen behind international standards. Since the first foreign acquisition contract signed in 2009, the Russian UAV sector has developed remarkably. By the end of 2020, the Russian military claimed 2,100 UAVs of various types in active service.

The Syrian Testbed

Apart from the first phase of the conflict in Ukraine (2014/2015), Russia also made extensive use of UAVs during its intervention in support of the Assad regime in Syria from September 2015 onwards. UAVs were used by Russian forces and by Wagner mercenaries, and Syria provided the opportunity for Russia to build UAV tactics and support strategies in an operational environment.

Apart from foreign and foreign-inspired UAV designs, Russian industry was gradually developing a range of indigenous systems that could meet many of the emerging requirements of Russia's military, as well as other emergent state-level customers such as the Border Guard Service/Coast Guard, the Ministry of Emergency Situations and the Ministry of Internal Affairs, among others. There were negative aspects to contend with though – there appeared to be dissatisfaction with the ability of Russian industry to meet user requirements in a timely manner.

The majority of the UAVs currently in use by Russian forces in Ukraine had previously made their full operational debut in Syria. The most numerous indigenous Russian UAV is the Orlan-10, produced by the Special Technological Centre in Saint Petersburg. More than 1,000 of these have been built, and the system has been exported to Myanmar amongst others. The Orlan-10 is available in a number of variants, including a reconnaissance, EW, and communications relay variants. Other Orlan-10 systems have been identified, with different sizes and functions. Over 100 Orlan-10 systems have been recorded lost over Ukraine.

At the smaller end, Russian domestic UAVs include the Eleron-3SV/T28M (Eniks), the Takhion mini-UAV (Kalashnikov concern), the Korsar (Rostec), and Zala Aero Group's offer a range of UAVs from the micro level up to tactical level. However, so far programmes to develop UAVs, occupying the same roles as the US Predator or Reaper systems have yielded little in the way of functional capability. Systems in this category include the Altius-M (Tranzas/Simonov) and the S-70 Okhotnik (Sukhoi), as well as the Orion, Sirius, Helios, and Grom UAVs from Kronshtadt Group.

Returning to Russian UAV operations, in Donbas and in Syria Russia worked on a concept called the Reconnaissance-Strike Complex (RSC). In an RSC, UAVs provide surveillance and targeting data to a central command node, who then coordinate the employment of tactical aviation, long-range missile systems or other long-rage fires to rapidly strike targets located by UAVs. Should everything work as intended, the RSC should allow Russian forces to effectively deploy long-range fires across the whole battle area.

Flexible, Reliable and Combat Proven: ATRI TINDS DVE in Ukraine!

Years prior to the February 2022 invasion by Russian forces, the Armed Forces of Ukraine understood the value of using technology for maneuvering and fighting at night or during periods of limited visibility. Similar to US Defense forces, they viewed night fighting solutions as "critical enabling technology". While soldier system night fighting equipment were readily deployed, a gap existed with combat and combat support vehicles, specifically for allowing drivers to maneuver safely while maintaining tactical operational speed.

The search in 2018 for a viable solution in led to ATRI UAB, headquartered in Vilnius, Lithuania. ATRI has a background in thermal imaging solutions for both defense and security applications. Additionally, the team at ATRI had previous experience with projects in the Ukraine. This technical expertise combined with customer familiarity provided for the delivery, installation and training of the first ATRI TINDS DVE systems to Ukraine in 2019. After significant technical evaluations and field trials, the ATRI TINDS was officially approved for acceptance for the armament of the Armed Forces of Ukraine by the Ministry of Defence Ukraine in April 2020.

The ATRI TINDS stands for Thermal Imaging Night Driving System and has been deployed to multiple countries around the world. But none have been as critical and important as the units provided to Ukraine. A thermal DVE system increases the service life of armored vehicles in modern combat operations by providing the driver with advanced thermal imaging capabilities. This allows the driver to detect and identify potential threats, such as enemy vehicles or concealed troops, even in low visibility conditions such as darkness or smoke. It solves the problem of traveling safely at operational speeds, providing a distinct advantage at night.

In the war in Ukraine, armored vehicles have been used extensively in both urban and rural environments. The ATRI TINDS DVE system has been particularly useful in urban areas where visibility is often limited by buildings and other structures. The thermal imaging capabilities of the system allows drivers to detect and identify potential threats, even in the dark or smoke-filled streets. In rural areas where visibility is often limited by trees and other vegetation, the thermal imaging capabilities provide an advantage even in the dense forests or open fields of Ukraine.

The ease of use, effectiveness and combat advantages afforded by the ATRI TINDS resulted in additional requests and delivery of units since the Russian invasion. The commitment and delivery of numerous armored and security vehicles ranging from US-made M113 APCs, M117 ASVs, HMMWVs to Soviet made BMPs poses an inter-operability challenge for the users. However, the flexibility and ease of installation affords ATRI the ability to install and train users on a variety of platforms.

Due to growth and with the signing of the LT-US Reciprocal Defense Procurement Agreement between the U.S. and Lithuania in December 2021, ATRI opened up their US offices in 2022. Now, in addition to providing flexibility for differing vehicle platforms, ATRI can support installations in multiple geographic locations…

Photos: ATRI

United States, Lithuania, other European countries or even in the Ukraine if needed.

The information provided has focused on ATRI's involvement in supporting Ukraine since 2018 and the benefits associated with a combat-proven DVE solutions. A technical overview of the TINDS is based around three models offered as ATIC Series, ADSC-90 Series and ADSC-180 Series. While the ATIC is equipped with only a thermal imager, the ADSC-90 is a dual spectrum camera combining the benefits of both a thermal imaginer and low-light day camera with IR-illuminator in one housing. In both configurations, a single imager is used offering a wide field of view of 90° at a cost-effective price. Technical details associated with the ATRI TINDS can be found on our website **www.atri.lt** or **www.atri-usa.com.**

More information:

Photo: US DoD

Iranian UAV wreckage on display in the US as part of an effort to expose Iranian weapons proliferation in the face of UN sanctions. The Russian decision to turn to Iran for UAVs was an unexpected development that shows how far Iran has progressed in this area.

In Syria, Russian UAVs also had to cope with an operational environment were counter-UAV systems were employed, they also had to practice deconfliction as they were operating in an area where others were flying aircraft and helicopters, as well as UAVs, some hostile and some not. Russia also deployed its own EW systems in Syria, some of which were optimised for the counter-UAV mission. As to the intensity of Russian UAV operations in Syria, an official statement as of October 2017 noted that 16,000 UAV missions had been flown, totalling 96,000 flight hours. By the end of 2017, Russian officials were claiming that they had 60 to 79 UAVs in operation daily. By July 2018, Russia released figures stating a total of 23,000 missions had been flown, totalling 140,000 flight hours. The main lesson drawn from Syria was that modern operations were not possible without the possession of an effective UAV capability.

Unexpected Solutions

The twin weaknesses of Russian industry's inability to meet domestic demand and its reliance on foreign components were exposed after the February 2022 invasion of Ukraine turned into a protracted high-intensity conflict. The Russian military was expecting a lot from its UAVs, but found itself unable to replace losses a quickly as it would like. On top of that, the imposition of trade embargoes by US, European and other suppliers made it increasingly difficult to acquire the necessary components.

To resolve this situation, Russia did something unexpected by turning to Iran to supply a range of UAVs. As Iran was used to operating under embargoes, it could supply systems that not vulnerable to supply chain interference. Added to this, many Iranian UAVs were successfully combat proven across the Middle East, both in reconnaissance and attack missions, many of which were over long-ranges, against both land and maritime targets. It should be noted that analysis of Iranian UAVs indicates the presence of components of US and European origin. These should not be available to Iran under UN sanctions, indicating that Iran has found a way to circumvent sanctions.

More recently there have been media reports that a new factory to manufacture Iranian UAVs is to be built in Russia. This makes sense from both a Russian perspective and from an Iranian perspective, especially since Iranian UAV manufacturing facilities were hit in a UAV strike recently by 'unknown assailants'. The systems most likely to be manufactured are the Shahed-131, Shahed-136 and the Mohajer 6, which appear more capable than previous Iranian models investigated in the Middle East. Obviously, both Russia and Iran have a high degree of confidence that they can continue to acquire UAV components, many of which are military-grade, without interruption from foreign suppliers.

Iran probably has the capacity to meet Russian UAV demands, assuming that the damage to their manufacturing facilities from the recent attack was not too heavy. Once the new Russian manufacturing facility comes online, there will be a secure production site likely capable of meeting Russian and Iranian UAV requirements. This is arguably one of the most important Russian UAV developments since the decision to acquire Israeli systems in 2009 and 2010.

The Other Side

When you consider the size of the Russian defence industrial base, its undoubted capabilities, engineering resources and, in recent years, access to development funding, their progress in terms of UAVs has not been a success story. In many ways, the need to acquire Iranian UAVs is a rather damning indictment of Russian efforts to develop their own capabilities in this area and to ensure that they had a secure supply chain.

For Ukraine the situation was very different, they did not have the massive defence industrial base, or the resources to fund UAV development and acquisition on a large scale. What they could do was develop some innovative small-scale indigenous UAV solutions, and purchase the rest from foreign suppliers, although their financial resources were limited prior to the current conflict.

Photo: Quantum Systems

German company Quantum Systems has received substantial orders to supply Ukraine with Vector UAVs.

Ukraine is now in a position to buy UAVs if necessary – in August 2022, they purchased 33 Vector UAVs systems from a German company, Quantum-Systems. In January 2023, they placed an order for 105 more Vector systems and, according to German media reports, each Vector is priced at EUR 180,000. There can be little doubt that Ukraine will look to bolster its UAV capabilities through more foreign acquisitions, as well as local developments. If little else, this war is demonstrating that UAV capabilities are becoming ever more central to modern military operations. ■

Who are you?

Thomas Withington

Identification Friend or Foe (IFF) technology helps to prevent fratricide. How does this technology work and how has it evolved since its development over eight decades ago?

For the United Kingdom, the Second World War almost started with an acute military embarrassment. The governments of France and the UK told Germany to cease military operations on 3 September 1939. The Nazi regime had invaded Poland two days before. At 11.12 British Summer Time (10.12 Greenwich Mean Time) air raid sirens wailed over London. Writing in his diary, the then First Lord of the Admiralty Winston Churchill recorded that "there were planes in the sky. Whose, we could not be sure." It would be another 370 days until the Luftwaffe (German Air Force) would drop its first bombs on the British capital. Mr. Churchill, along with millions of other Londoners had heard a false alarm. This was triggered by an Armée de l'Air (French Air Force) aircraft bound for RAF Northolt airfield in West London. The crew had failed to file a flight plan informing the British of the plane's arrival. Fortunately, the aircraft landed safely unscathed by Royal Air Force (RAF) fighters or British Army anti-aircraft guns.

Chain Home

The incident did, however, highlight the risk of mistaken identity to aircraft. Four years previously, Scottish engineer Robert Watson-Watt have proved the viability of radar. Mr. Watson-Watt and his assistant Arnold Wilkins demonstrated that radio waves could detect and track aircraft. This was done during an experiment performed from a field near Daventry, central England. Radar was undoubtedly a breakthrough. Aircraft could now be tracked in all weathers, day or night, beyond the range of the human eye.

Radar was instrumental to the RAF's victory in the Battle of Britain in summer of 1940, but it had a shortcoming. A radar could detect and track an aircraft providing information on its range, speed and altitude but provided no details on the aircraft's identity. The RAF's AMES Type-1 Chain Home (CH) radar system used frequencies of between 20 MHz and 55 MHz. These frequencies are comparatively low compared to those used today by ground-based air surveillance radars. As such, while they provide the information detailed above, their wavelengths do not provide a good, detailed picture of the aircraft. Higher frequencies like X-band (8.5 GHz to 10.68 GHz) were unavailable during the Second World War. These wavebands can indicate aircraft type based on its radar cross section (RCS). Alas, this was not possible with the Very High Frequency (VHF) transmissions of Chain Home.

Shooting down the wrong aircraft is an expensive mistake in blood and treasure. It is probably impossible to eliminate all incidents of friendly fire during air operations, or indeed in warfare writ large. Nonetheless, efforts must be taken to reduce its likelihood. A solution was found in the form of Identification Friend or Foe (IFF), which was pioneered by both Britain and Germany using similar principles. In Britain, IFF was Mr. Watson-Watt's brainchild. An initial IFF system was trialled but found to have shortcomings – when the aircraft was broadside to the radar it returned a strong echo on the radar screen, but this was not the case when the aircraft presenting its forward or aft aspect.

These shortcomings led to further developments yielding a system unimaginatively called the IFF Mark I (IFF Mk.I) introduced in 1939. This was built around a radio receiver tuned to the CH's transmission frequencies. When the receiver detected an incoming CH radar signal it would transmit an amplified version of that signal back to the radar on the same frequency. The result was that the radar operator would see a very strong radar target on their display which was the friendly aircraft. IFF Mk.I was very simple – an aircraft returning a strong signal was a friendly, and one which did not was un-

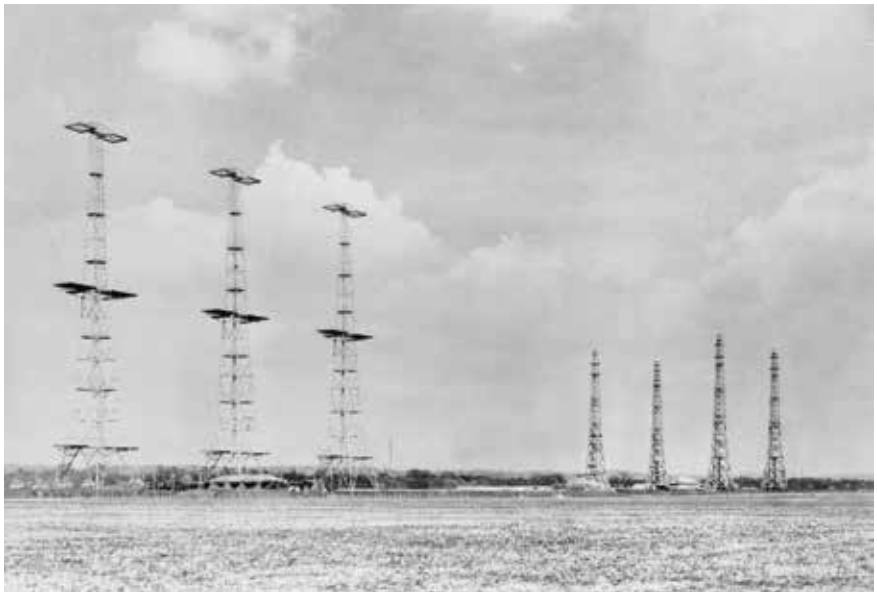


Photo: Imperial War Museum

The Royal Air Force's AMES Type-1 Chain Home radar made a decisive difference during the Battle of Britain. These radars needed a way of determining whether aircraft were friendly or hostile. This spurred the development of IFF.

Author

Thomas Withington is an independent electronic warfare, radar and military communications specialist based in France.

known, hence possibly hostile. Nonetheless, IFF Mk.I had shortcomings, the main one being gain. Put simply, gain is the amount of transmission power a radio or radar can send in a particular direction. The problem for IFF Mk.I was that its gain had to be continually manually adjusted to ensure it stayed working. The system was only sensitive to one radar transmission frequency, which meant it had to be retuned every time a new transmission frequency was encountered. Setting these parameters in flight added to the pilot's workload. A 2003 article by the late radar engineer Richard Trim in Measurement and Control remarked on how the author "had the experience of trying to set this control under laboratory conditions and found it quite difficult."

IFF Mk.I would soon be overshadowed by IFF Mk.II/N entering service a year later. This introduced an automatic gain control ensuring the gain remained consistent. The equipment also continually scanned radar wavebands looking for an incoming friendly radar transmission. Once detected, the IFF signal was sent. IFF Mk.II/N could also cover the 200 MHz frequency bands of the AMES Type-2 Chain Home Low (CHL) low-altitude radars introduced from 1939 ,and radars being introduced by the Royal Navy. These changes brought a high level of automation to the RAF's approach to IFF, helping reduce the crew's work burden.

Indicative of the pace of innovation in wartime, a radically different approach to IFF was pioneered from late 1940 by British radar expert Dr. Frederic Williams. His idea was to have what Mr. Trim called a 'separate band' IFF system. Dedicated transmitters sent out a pulsed IFF interrogating signal on a frequency of 150 MHz. The pulses of the interrogating signal were synchronous with the pulses of the radar equipped with this IFF. This allowed the correlation of the aircraft's radar echoes with its IFF 'reply'. Thus, the radar operator would immediately see that a particular target was friendly. Moreover, this new IFF Mk.III system's gain was stabilised and needed no manual adjustment from the crew. It entered service in 1941 and even became the basis for the standard IFF system used by the US Navy, known both as IFF Mk.IV and ABK. In RAF service, IFF Mk.III continued to be used some time after the Second World War.

IFF research continued, and in late-1943 Canada, the UK and US pooled their IFF development efforts into the United Nations Beaconry initiative. This worked on an IFF system which could accept interrogations and replies on frequencies of 950 MHz to 1.260 GHz. In 1945, the end of the war in the Pacific brought this work to an abrupt end. Nonetheless, the US Navy continued development of what would have become known as IFF Mk.V with the design coming to fruition in 1951. IFF Mk.V could send out three distinct challenges known as Mode-1, Mode-2 and Mode-3/A. These modes differed by the octal response sent by the aircraft when challenged. The octal numbering system uses eight digits of 0, 1, 2, 3, 4, 5, 6 and 7. A Mode-1 interrogation will cause the aircraft to transmit a two-digit octal. Each digit of this code would match the aircraft type with its mission, for example, 'Bomber, Training'. Mode-2 was like Mode-1 but used a four-digit octal code for responses. Both these modes were reserved for military use. Mode-3/A also used a four-digit octal code, but it was also used by civilian aircraft.

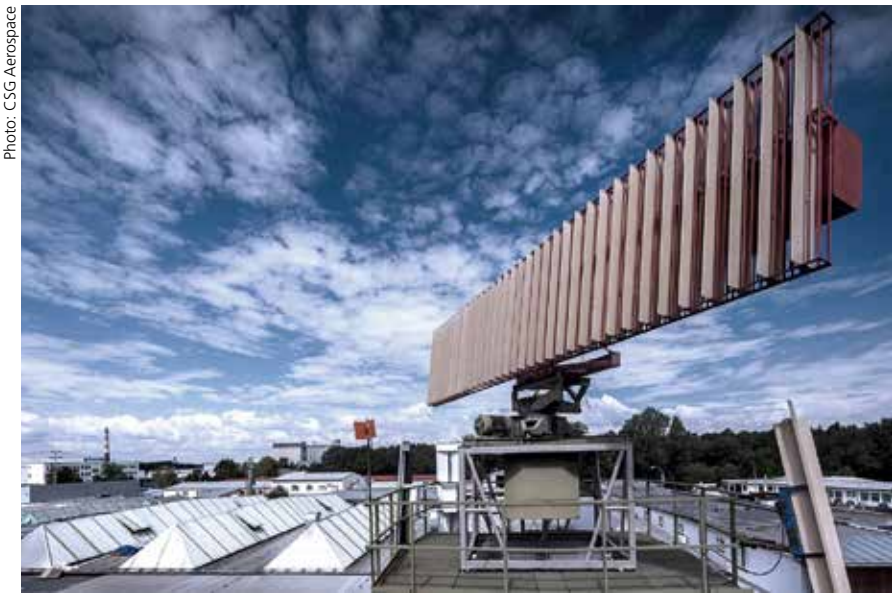
Secondary Surveillance Radar

Post-WWII, pioneering IFF work during the conflict triggered the development of Secondary Surveillance Radar (SSR). SSR is used extensively for civilian and military Air Traffic Control (ATC), and is almost identical to the philosophical underpinning of IFF. An aircraft has a transponder and an SSR collocated with a standard primary air surveillance radar sends out a challenge on a frequency of 1.030 GHz. This is received by the aircraft's transponder which transmits its reply on a frequency of 1.090 GHz. Like IFF, the transponder provides details of the aircraft's identity. This takes the form of a four-digit octal 'squawk' given to an aircraft by an air traffic controller. The transponder also transmits details of the aircraft's altitude taken from its altimeters. Like other air surveillance radars, these can only detect an aircraft as a target on a screen. SSRs are indispensable to providing the controller with information on the aircraft's identity.

IFF development continued and by the mid-1950s, plans were afoot to replace IFF Mk.V with the new IFF Mk.X standard. IFF Mk.X was adopted by military and civilian aircraft alike. Among the enhancements introduced for IFF Mk.X was an expansion of the codes relayed by the aircraft transponder. IFF Mk.X relayed four A, B, C and D codes. Mode-A corresponded to the Mode-3/A response of IFF Mk.V, Mode-B was mostly used by British and French civil ATC, while Mode-C encoded the aircraft's altitude information in 100 ft (30.5 m) increments via a four-digit code. Mode-D was developed to allow some expansion of IFF Mk.X if required, an addition which was never needed. Over time, Mode-B's use declined in favour of Mode-A for military and civilian ATC while Mode-C was used for altitude reporting.

One shortcoming with IFF Mk.X which was also present in the earlier IFF versions was that neither the interrogation nor response was encoded, which was a significant problem for militaries. Hostile IFF interrogators could transmit a challenge and triangulate an aircraft's position via its response. IFF Mk.X attempted to introduce a modicum of security by using a two-pulse method. IFF inter-

Photo: CSG Aerospace



IFF technological development during the Second World War aided the development of secondary surveillance radar for air traffic control in the years following the conflict.

rogation had hitherto been based on a single pulse interrogation signal sent to the transponder, and with the reception of this pulse triggered the transponder's response. The reason why a single pulse was used was because the trigger for the response was the radar signal itself. The introduction of dedicated SSRs and military IFF interrogators, which performed a similar task, rendered this unnecessary. Instead, two pulses on a specific frequency with specific timing were transmitted. The transponder would be tuned to only accept interrogations of these specific timings and frequencies. If a hostile interrogator did not match these characteristics, the transponder would not respond. If the challenge did, the transponder replied with a single pulse.

IFF interrogators must be used by any platform or weapons system tasked with identifying friendly and hostile aircraft. Telephonics has supplied the AN/UPX-44 IFF interrogator shown here to the Swedish armed forces.

Mode-4

The next significant development in IFF's post-war history was the adoption of Mode-4 in the mid-1960s. This provides a three-pulse reply to an encrypted challenge, although this was only used by the US military. As Mr. Trim's article noted, researchers at the UK's Royal Signals and Radar Establishment (RSRE) flagged concerns over its technical integrity. Moreover, European NATO members had concerns over dependence on the US National Security Agency (NSA), which was the sole source of the cryptographic computers needed to run Mode-4. As Mr. Trim notes, the technical concerns flagged by the RSRE were taken onboard by USS IFF experts. Remedies were made in the form of the IFF Mode-4 Technical Improvement Programme.

A major problem for NATO as the 1970s unfolded was that alliance members were using a hodgepodge of differing IFF systems and protocols. There was a distinct need across the alliance to harmonise and standardise how IFF was being employed. The result was NATO's Next Generation IFF programme which introduced the IFF Mk.XII standard accommodating the Mode-S, Level-3 and Mode-5 protocols.

Mode-S/Mode-5

Mode-S was a major step forward. Firstly, it stopped the excessive interrogation of transponders which could be a problem in areas where several ATC radars operated. It also allowed the protocol to share information from an aircraft's Traffic Collision Avoidance System (TCAS). This helped reduce risks of mid-air collisions. TCAS information was shared from one aircraft's transponder to others in the aircraft's locale. Basically, TCAS is a way of saying 'I'm here' to other aircraft nearby. Usefully, Mode-S also assigns each aircraft carrying the system to transmit its call sign and a unique address to SSRs. The address is a 24-bit identifier assigned by the International Civil Aviation Organisation (ICAO), and is specific to each aircraft. This is like the internet protocol address of a computer. The address is sent by the transponder as a response to a Mode-5 interrogation. It is displayed on the air traffic controller's radar screen as a six-digit hexadecimal code. Hexadecimal code uses 16 symbols from zero to nine and A to F.

Mode-5 is the cryptographically secure version of Mode-S for the military. Work commenced to adopt Mode-5 across NATO in 1995. The US Joint Chiefs of Staff ordered a new IFF protocol to replace the IFF Mk.XII Mode-4 system. As a result, in 2002 NATO ratified Standardisation Agreement 4193 (STANAG 4193), which introduced IFF Mk.XIIA Mode-5 as the alliance's standard IFF architecture. Mode-5 included some important additions. The 1990s witnessed the adoption of the US Global Positioning System (GPS) to provide positioning, navigation and timing information. GPS came to the fore during the 1991 US-led Operation Desert Storm to liberate Kuwait from Iraqi occupation. Mode-5 would send GPS information from the aircraft, providing additional precision on its location.

Hensoldt is one of several IFF vendors. The company provides its MSR-1000I IFF interrogator to users throughout NATO. This product is compliant with the Mode-5 IFF protocol.

Market Demands

One of STANAG-4193's requirements was that all NATO military aircraft have

Sagetech has developed several IFF systems for use with UAVs. The company's MX12B transponder weighs just 190 grams.

their IFF equipment updated to Mode-5 by July 2020, sounding the death knell for Mode-4. Mode-5 IFF is now big business. A raft of companies provide Mode-5 compatible IFF systems in all shapes and sizes. BAE Systems, General Dynamics, Elbit Systems, Hensoldt, Leonardo, Raytheon, Telephonics and Thales are the big vendors. Nonetheless, smaller firms are providing niche IFF capabilities. This has been propelled in recent years by the growing proliferation of Unmanned Aerial Vehicles (UAVs). All aircraft are, to a greater or lesser extent, space and weight constrained platforms yet this is especially true for UAVs. Companies like Uavionix and Kratos provide miniature IFF transponders for UAVs, and the latter says its wares can also adorn cruise missiles. Sagetech has carved out a useful niche providing very small IFF transponders, for instance, the company's MX12B Mode-5 IFF transponder weighs a mere 190 g (6.7 oz).

The demand for UAV IFF transponders will likely increase in the coming years as more of these aircraft take to the skies. Research company 'marketsandmarkets' expects the combined civilian and military UAV market to grow from USD 26.2 Bn in 2022 to USD 38.3 Bn by 2027. Many of these aircraft will need IFF transponders, particularly those with military applications. Although it is over 80 years since the first IFF systems were introduced, the basic principles behind the technology remain the same. The practicality of this question-and-answer approach has allowed IFF to stay relevant. Expect further technological refinements in the future. ■

Combat Engineer Resources: Learning from the Past

Manuela Tudosia

Years of deployment abroad to combat terrorism forced innovation in many combat engineering areas. The question is whether these developments are sufficient to meet the challenges of the new geopolitical context and of future warfare.

The conflicts of the past 20 years have demonstrated that warfare is unpredictable. Moreover, several types of conflict can quickly succeed each other or worse, coexist. For the first time in many years, Europe is witnessing high intensity conflict at its borders, but hybrid warfare, actions below the threshold of conflict, or insurgency have not disappeared. Today, combat engineers need to respond to rapid changes in conflict intensity and conflict type. Resources are typically taken to include personnel, facilities, equipment, and supplies, though more subtle aspects such as processes and interoperability could also be considered resources, especially in a coalition setting where multinational readiness is key.

From a materiel perspective, combat engineer resources generally fall into one or several of the following broad categories: mobility, counter-mobility, support and survivability. The last two decades have seen improvements and innovations in all these areas, often forced by operational circumstances.

Route Clearance: an Established Asset that Should not be Lost

A serious and highly dangerous impediment to freedom of movement in Afghanistan and Iraq, was the use of Improvised Explosive Devices (IEDs). Expertise on route clearance (RC) and related technology have significantly developed during Operations Enduring Freedom and Iraqi Freedom, which have shown once again the importance of adapting equipment and techniques to different terrains. Some of the most sophisticated RC equipment has proven its critical role in saving lives, like the vehicle-mounted mine detector (Husky), the mine-protected clearance vehicle (Buffalo), and the medium mine-protected vehicle (RG-31).

Recently, several European countries have updated their combat engineer vehicle capabilities. In 2021 Germany ordered 44 Kodiak armoured engineer vehicles (AEV) to be delivered between 2023 and 2029, and Belgium ordered four JCB High Mobility Engineer Excavators (HMEEs), referred to as 'Armoured Combat Engineer Vehicles' (ACEVs) by Belgium. Sweden ordered two new variants of the CV90, a Forward Maintenance vehicle and a Combat Engineer vehicle between 2023 and 2027.

To be able to clear roadside bombs and other obstacles remotely in counterinsurgency efforts, significant investment and innovation has been poured into robotics and vehicle autonomy. This need also stimulated cooperation among NATO allies in the form of a 'Smart Defence' project to support the identification and joint procurement of the best remote-controlled robots for route clearance operations.

In the meantime, the market for Unmanned Ground Vehicles (UGVs) has significantly expanded beyond bomb disposal tasks. However, these initial achievements have likely contributed to the development of more sophisticated combat engineering applications, which today tend to be increasingly multi-mission and multi-role. For example, Milrem Robotics and Krauss-Maffei Wegmann (KMW) have signed a contract to deliver 14 THeMIS UGVs to Ukraine, seven of which to be configured for RC and seven for casualty evacuation.

With the progressive withdrawal from Afghanistan and the end of intervention in the wider region, RC has lost visibility and even interest. It may be deemed that there are many solutions available now to do the

Photo: AirBoss Defense Group

The two-operator Husky 2G clearance vehicle was born from an operational requirement for longer, more complex, mounted clearance missions and employment of more sophisticated vehicle payloads.

Author

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job, if needed. Two questions arise: the first, whether all the lessons learnt from using individual or combinations of such solutions have been integrated into well-structured concepts; and secondly, whether these solutions will still be there in a few years (including from a manufacturing capacity point of view) if we disinvest now.

Area Access Control: A Bridge between Past and Present

The signing of the Ottawa Convention and the related ban of Anti-Personnel Mines (APMs) also meant that alternative obstacle solutions had to be found for counter-mobility and area access control (AAC). Significant technological improvements have been made since the convention entered into force, for instance in the field of non-lethal effectors, and various sensors.

In the beginning, these advances were not necessarily integrated within a fully-fledged ACC concept. However, such a concept has been progressively defined by NATO countries to address the gap left by the ban of APMs, and to overcome the indiscriminate and often terrible consequences of their employment. As such, NATO member countries stated to integrate compliance with NATO's concept of Area Access Control in their procurement plans. For example, the announced Future Acquisitions for The Norwegian Defence Sector 2022–2029 include "procurement of a modern, state of the art deployable system for area control" that "must be based on NATO's concept". Acquisition will be in two phases: the first between 2024-25, with an initial system to be procured based on existing equipment and COTS, and the second between 2026-28, to include further development and procurement of new equipment.

The illegal annexation of Crimea by Russia in 2014, and more recently the 2022 invasion of Ukraine, have taken the issues of AAC, and of anti-access and area denial (A2AD) to a new level. It should be noted that Russia is not a signatory state of the Ottawa Convention and that Russian forces have been accused of using APMs in the current war by organisations like the Human Rights Watch. This conflict has also seen the extensive use of anti-tank mines, a decisive capability in high-intensity ground warfare. Ukraine has received and used German DM22, DM31, and AT-2 anti-tank mines, and reported to have captured the highly modern Russian PTKM-1R anti-tank mine.

These technologies have also seen new developments and innovations. The generic term 'smart mines' is being used to label the most sophisticated examples. For instance, the Russian PTKM-1R tends to be presented as a smart mine, since it is capable of striking the top of the armoured vehicle, which is usually the least-protected spot, through the use of a sensor-fuzed submunition. PTKM-1R was announced by Russia several years ago but shown for the first time in 2021. Nonetheless, the ability to 'guard' an area and strike a target from the above is not entirely new for mines, with the US M93 Hornet developed in the late 1980s operating on the same principle as the PTKM-1R.

Next-generation anti-tank mines have to offer better discrimination of targets, counter-mobility options against hostile forces but also freedom of manoeuvre for friendly forces. For example, advances in remote control solutions could help to apply very targeted counter-mobility techniques, but also to facilitate advance of friendly forces through remote deactivation. The US Close Terrain Shaping Obstacles (CTSO) programme includes remote deactivation as a design goal. According to the US Joint Program Executive Office "The obstacle created by the munitions will be networked and controlled by an operator using a remote control station. If the munitions in the munition field have not fired or dispensed, they can be turned off and reused." The CTSO development includes three increments: a top-attack munition, a bottom-attack munition, and development of a full network capability to allow mines to be connected to the Army's mission command system. The winner of the competition for developments under the first increment, Textron Systems, was announced at the end of 2022.

Photo: AirBoss Defense Group

Airboss' Bandolier is a lightweight, pre-packaged, multipurpose explosive charge.

Other Developments Relevant for the Combat Engineer

Apart from highly visible solutions like the above, in recent years, innovation has occurred in many sub-fields of combat engineering. They receive less media attention but many offer significant capability improvements. For example, an innovative, lightweight and scalable, Multi-Purpose Line Charge, Airboss Defense Group's 'Bandolier' has become available, which is employable across various mobility, counter mobility, and demolition missions.

Power generation and distribution have also evolved a lot in the past decade, in the context of 'smart energy' projects supported by NATO or the EU. These have generated knowledge and new solutions for both power generation and reduction of environmental impact, and are likely to be extremely useful in future deployments. The European Defence Agency's project 'Smart Energy Camps Technical Demonstrator' (SECTD) aimed to improve power generation and lessen the environmental impact of military encampments. It was deployed to the EU Training Mission Mali in 2015-16, and in 2021 was transferred to the EU's Military Planning and Conduct Capability. The Canadian Armed Forces Project 'Camp Sustain' was a similar initiative, aimed at achieving significant reduction of field camps fossil fuel consumption, water demand and waste.

A Glance at the Future: Gap Crossing

The return of conventional war so close to Europe's borders has forced introspection focused on how prepared Europe's own terrain and infrastructure are to cope with the mobility requirements of conventional conflicts. As already highlighted in the January 2022 issue of ESD, "military bridging is high on the agenda of many allied militaries across Europe, with programmes and projects underway (…)". Indeed, decades-long focus on stabilisation operations abroad may

have shifted the attention away from mobility infrastructure and capabilities like dry and wet gap crossing. However, these used to be very high priorities for armed forces during and before the Cold War. Aside from the requirement of being able to accommodate heavy loads, modern technical solutions in this field need to be easy and quick to install, while also being interoperable.

Development and procurement of Wide Wet Gap Crossing (WWGC) Solutions appear to now be an important priority, as indicated by the OCCAR Business Plan 2022. The WWGC Programme is a cooperative acquisition between Germany and the UK that covers development, production and Initial In-Service Support for a "river crossing capability that goes beyond actual systems currently on the market". Its overall timescale is between 2022 and 2036, with total cost estimated at between EUR 1 Bn and EUR 2 Bn. The project originates from two initially national programmes, the UK TRITON planning to replace the M3 amphibious bridge and ferry system, and the German SSB2 programme. Collaboration between the two countries was a natural next step, since their respective capabilities in this area are already interoperable. France has also expressed an interest in joining the OCCAR programme, but it is not yet clear if this has materialised.

Wider Policy and Political Initiatives

At the political level, military mobility is high on the agendas of both the EU and NATO, and is likely to remain so for a while. The topic is a 'flagship' of NATO-EU cooperation through structured dialogue on shared priorities. Cooperation topics include transport as well regulatory aspects of military mobility, like border-crossing legislation, regulations and procedures.

Over the past decade, military mobility in the EU has been supported in various ways, for example through the Connecting Europe Facility, EDA activities to support implementation of the 2018 European Commission Action Plan on Military Mobility, or through Permanent Structured Cooperation (PESCO). The PESCO project on Military Mobility supports member states in the effort to simplify and standardise cross-border military transport procedures and serves as a "political-strategic platform" where progress and issues identified at expert working group level can be discussed. It is noteworthy that the USA, Canada and Norway have jointed this project in May 2021, and the UK in November 2022. This shows the critical importance of this topic, even before the onset of the current conflict in Ukraine.

Photo: NATO

NATO Troops Rehearse River Crossing Drills Ahead of 'Defender Europe'.

More recently, in November 2022, the Commission and the High Representative proposed an Action Plan on Military Mobility 2.0 aimed at helping European armed forces "to respond better, more rapidly and at sufficient scale to crises erupting at the EU's external borders and beyond." The new Plan builds upon the achievements of the previous 2018 Plan, and is centred on the need to develop a well-connected military mobility network. A number of actions were announced, structured along four main pillars: multi-model corridors and logistical hubs, regulatory support measures, resilience and preparedness, and partnerships.

More than Technology Alone

The aforementioned initiatives remind us that combat engineer resources are not just about technology, but include factors that are independent of the skills and will of the deployed engineer. Such factors include:

- Solutions need to be interoperable, especially when missions envisaged are multinational. While industry can usually fulfil technical interoperability requirements, defining the latter necessitates close coordination between all actors involved. Certain future solutions may require 'interoperability by design'.
- In light of fast-paced technological developments and the unpredictability of future operations, military engineering doctrines may require some adaptation to allow for fast and dynamic responses. While attention is now focused on conventional and hybrid warfare, the conflict in Ukraine itself demonstrates that there is always scope for surprise.
- There are never too many engineers. A question that we need to ask is if our armed forces have enough combat engineers for the formidable operational requirements that seem to lie ahead, and the ever growing complexity of technologies that they are required to integrate. If not enough engineers are available, how can we mitigate this?
- The success of combat engineer tasks can be influenced by the quality of the coordination with the civilian sector, including in some cases, with civilian actors such as non-governmental organisations (NGOs) or local structures.
- Combat engineers' success, like that of other forces, also depends on logistics and on the capacity of industry to deliver materiel in time. This brings us to a larger discussion about how we could use existing manufacturing capacity more intelligently, and how we can improve procurement processes to avoid duplication while meeting everyone's needs.

Each type of conflict comes with its own characteristics, driving priorities and focus, for combat engineering and other areas. Smart investment helps to cope with capability challenges, but divestment coming from a shift in focus is certainly not an option anymore in a word where so many conflict scenarios are on the table. Post-Cold War cuts in defence budgets have stimulated a 'joint' model of investment, including procurement, which has increasingly become the norm as a means of managing costs and optimising resources. This model has shown its added value in the current context. The challenge ahead is to scale up investments, not only in defence, but also down the supply chain, in industrial capacity and human resources, though a smart industrial policy. ■

Energy Security in Europe – A Problem Rediscovered

David Saw

There used to be very little attention paid to energy security in Europe, and it was hardly thought of as a critical problem. Instead, the conversation was dominated by themes such as climate change, or the climate crisis. To this you could add decarbonisation, net-zero, renewables, green new deal, energy transition or 'Energiewende' as it is known in Germany, 'build back better' and other similar topics. This was where politicians, and international organisations had their focus, that is until Russia began its invasion of Ukraine.

Photo: EDF

The EDF wind farm at Fallago Rig in the Lammermuir Hills, Berwickshire, Scotland has 48 wind turbines and was commissioned in 2013. Currently wind is the third largest source of electricity generation in Britain.

The conflict between the energy demands of a modern society and environmentalism surfaced in Europe in the 1970s, with major protests against nuclear power station construction in Germany. Then in March 1979 there was the Three Mile Island nuclear accident in Pennsylvania, which saw a partial meltdown in the TMI-2 reactor. This accident acted as a catalyst to the anti-nuclear power movement globally and contributed to a slowdown in nuclear power station construction. Post-Three Mile Island, the stage was set for environmentalism to enter the political sphere and in January 1980, the Green Party was formed in Germany.

Environmentalism and Energy in Germany

In many respects, the Green Party was an evolution from the youth protest movements of the 1960s in Germany, these then developed into themes such as environmental concerns, an anti-nuclear energy policy and a peace movement. The anti-nuclear/peace movement themes were strengthened in the early 1980s as NATO decided to deploy new nuclear-capable systems, the Pershing II Medium-Range Ballistic Missile (MRBM) and the BGM-109G Ground Launched Cruise Missile (GLCM), in Europe in response to an escalation in Soviet nuclear capability via the deployment of the SS-20 (RSD-10 Pioneer) Intermediate-Range Ballistic Missile (IRBM) from the mid-1970s onwards. Massive demonstrations were held to protest Pershing II and GLCM deployment.

Growing anti-nuclear, peace movement and environmental sentiment in Germany allowed the Greens to make the political breakthrough and win representation at the Länder or state level in Germany (prior to 1990, Germany was divided into ten Länder). Then in 1983 national elections the Greens won 27 seats in the Bundestag (the German parliament), with 5.7% of the vote. The Chernobyl nuclear disaster of April 1986 with a reactor meltdown followed by an explosion, would see a further rise in European anti-nuclear activism and green politics.

Following the 1998 federal election, the Greens would remain in government as part of a coalition until 2005. The broader Green movement was not particularly impressed by the Greens in government, despite the fact that one of their major objectives would be reached through a law passed in 2000, under which Germany's 19 nuclear power plants were due to be shut down by 2020.

Following a dip in the Green vote at the 2005 federal election, events elsewhere would conspire to reinvigorate Green politics. In March 2011 the Fukushima Daiichi nuclear power plant in Japan was damaged in a tsunami following an earthquake, resulting in a large radiation leak. The International Atomic Energy Agency (IAEA) classified the incident as Level Seven on their International Nuclear Event Scale (INES), the same as Chernobyl. After Fukushima, the German government of Angela Merkel, which in 2010 had decided to extend the service life of German nuclear power stations, changed tack and decided to totally phase out nuclear power.

It was the Merkel government that had committed Germany to the 'Energiewende', energy transition programme, with legislation passed in December

2010. Their target was low carbon, a focus on renewables, energy efficiency and energy demand management to lead to energy transition. What is noteworthy here is that it was a centrist/centre-right government under Angela Merkel that put Germany on the path to its environmentally sound low-carbon energy policy. This demonstrated how far the message of environmentalism and green politics had seeped into the German weltanschauung, across many traditional political divides.

Environmentalism has continued to be a key priority in German politics, with the first post-Merkel election in September 2021 seeing the Greens finish as the third largest party, with 14.8% of the votes, winning 118 seats in the Bundestag and joining a government coalition with the SPD and the Free Democratic Party (FDP). The government of Chancellor Olaf Scholz that took power in December 2021 has five Green Party ministers.

Transition in Name Only?

Germany had put itself in the lead in terms of energy transition in Europe and clearly there was significant popular support for this policy, as indicated by the electoral performance of the Greens and the other major political parties becoming more focused on environmental issues.

In reality, this energy transition did not quite evolve as planned. The idea that the transition would aid energy becoming more affordable has proven inaccurate, as energy has remained expensive. In terms of fossil fuels, Germany is the largest consumer of oil, gas and coal in Europe. According to the BP 'Statistical Review of World Energy 2022,' Germany consumed 2,199 thousand barrels per day (TBPD) of oil, in comparison France consumed 1,499 TBPD and the UK 1,271 TBPD. In terms of gas Germany consumed 90.5 billion cubic metres, France consumed 43 billion cubic metres and the UK 76.9 billion cubic metres.

Germany can point to the fact that it has successfully invested in renewables. In 2021 Germany generated 584.5 Terawatt-hours (TWh) of electricity, 217.6 TWh came from renewables, to which one could add 19.1 TWh from hydroelectric. However, 162.6 TWh came from coal, 89 TWh from natural gas and 69 TWh from nuclear. As we can see, ten years into the energy transition, fossil fuels and nuclear provide almost 55% of the electricity generated in Germany. Added to this, the plan (which has been halted for the moment) was to decommission the last two nuclear power plants, that provide nearly 12% of the electricity generated in Germany. Electricity generation from coal was also to be scaled back significantly in 2022, but that plan was set aside as Germany faced up to the Europe-wide energy crisis.

Given time, the idea was that renewables would take an ever larger share of electricity generation in Germany. Obviously this would require further investment in renewables and a significant breakthrough in electricity storage to provide electricity when there was no sun or wind, for example. In parallel, there would have to be major investment in the national grid to increase efficiency and reduce transmission loss. All of this required spending, but the German government was content to pay the price.

While waiting for the revolution in renewables, the temporary solution was to use fossil fuels, while decommissioning nuclear power plants. Neither of these moves particularly helped the low carbon

Photo: RWE

Solar power along with wind power provide the primary elements of renewable energy. This particular solar array belongs to RWE. Solar does not function everywhere though, at the end of July this year, the height of summer, solar was the lowest contributor to electricity generation in Britain.

energy cause. Indeed, scrapping nuclear power plants led to a return to coal, which was hardly a sound environmental move. It also led Germany to rely upon natural gas to balance the various elements of its electricity production and to stabilise its grid, and the primary source of this was Russia.

It would appear that from Germany's perspective, sourcing its gas from Russia was a purely commercial transaction. Bearing in mind the history of German-Russian relations, warm diplomatic and commercial relations between Berlin and Moscow were a very positive development and one to be encouraged. On the other hand, this was the same Russia that would seize the Crimea from Ukraine in 2014 and then go on to carve out substantial areas of the Donbas. Not content with that, Russia would take a threatening posture against the Baltic States and Poland amongst others. Clearly Russia was emerging as a disruptive force in the European security architecture, as a strategic competitor to both NATO and the EU. On this basis, relying on Russian gas to provide some 15% of the fuel for German electricity generation was problematic, and compounding this was the volume of Russian oil in Germany's energy mix as well.

As far as energy was concerned, the emphasis was on a low or no carbon future and insufficient attention was given to energy security. It is easy to criticise Germany for dependence on Russian gas, but many other European countries were in a similar position.

While the winter of 2022/2023 has been mercifully mild thus far, and Europe broadly has plenty of hydrocarbon reserves left, this was incredibly lucky, and a harsh winter could have easily caused serious problems. During harsher winters, demand for electricity rises for heating and other applications, and the amount of power generated by wind and solar renewables declines, increasing the reliance on non-renewables.

In Search of Solutions

Solutions to Europe's current energy problems do exist to meet both near term and future needs. Around the end of 2022, Germany was receiving more gas deliveries from the United Arab Emirates (UAE), while Nigeria has been supplying Poland. Given enough time, Europe could establish new and more secure sources of gas supply. These sources could be both external and within Europe, the key is to see that fossil fuels still have a role to play for the time being, and are a critical part of any strategic energy reserve needed to reach energy security. Candidates here include the gas fields shared by Israel and Cyprus, which could meet gas demands in Southern Europe and beyond, though this will require a pipeline to connect to the existing gas supply networks in Southern Europe.

More broadly Europe has to be realistic about its energy mix, it all very well to come up with targets for zero carbon by 2050, especially since most of today's decision makers will not be in power in 2050. A realistic energy mix for the next 20 years and most likely beyond will likely include a mix of fossil fuels, nuclear and renewables. Given time and technology development, it could be that renewables will become the dominant factor in the energy mix, but that is unlikely in the short term.

Nuclear energy also remains a viable stopgap, and most notably France is basing its energy security on nuclear power plants. Existing facilities will be restored to full functionality where necessary and new generation nuclear systems will enter service. In Britain one of the last acts of the Boris Johnson government was to give the go ahead for the new Sizewell C nuclear power plant. Nuclear energy is not cheap, but it does offer Europe energy security while being less polluting than fossil fuels. Recent breakthroughs in nuclear fusion may offer a third alternative over the longer term, with various such efforts already underway within Europe, but while the technology remains immature it probably cannot be relied upon for planning purposes over the medium-term.

Finally, Europe needs to be honest about renewables and what they can and cannot do in terms of energy security. The key enabler to growth in renewables will be energy storage, but there are some challenges here too. The environmental damage caused by lithium mining is already well known, additionally there are performance limitations in lithium-based battery technology. Possible alternatives exist though, including gravity-based energy storage (such as 'water batteries'), thermal energy storage (such as 'sand batteries'), or more sophisticated types such as vanadium reflux flow batteries (also known as vanadium redox flow batteries). Potentially these could be the answer for energy storage from renewables, though a potential problem arises insofar as the main source of rare earth elements required to build batteries and various other electrical equipment is China. A similar story arises with vanadium, where the largest source is China, and the second-largest is Russia.

Europe can achieve energy security, of that there is no doubt. Yet to do this it needs to be realistic in constructing its energy mix and carefully balancing fossil fuel, nuclear and renewables. There is political pressure to make the transition to renewables immediately, however this will not be realistically possible without implementing large reductions in energy demand and risks economic decline. The balanced approach is to develop effective low-environmental impact energy storage solutions, as well as new and potentially affordable fuel sources such as hydrogen. Although the past winter was relatively mild, future winters may be less kind, with Europe paying the price for not taking energy security seriously. ■

In the Gulf and Beyond – Iran as a Disruptive Strategic Threat

David Saw

Clearly Iran is a disruptive element in terms of the strategic environment in the Middle East, it seeks to change the strategic situation to meet its own needs. However, Iranian interests run counter to those of the majority of Arab states and other regional actors. Increasingly, these ambitions are not just limited to the Middle East; Iran and its proxies are developing a global strategic footprint, increasing the ability of Tehran to project power and to disrupt the strategic environment in other parts of the world.

From the perspective of the Gulf States, the growing military power and political influence of Iran is profoundly destabilising and represents a clear threat to their security. To them it is obvious that Iran seeks to be the dominant regional power, it is also obvious that Iran is moving towards a nuclear weapons capability that will inevitably cement that position of dominance. This threat perception is based upon more than observation of Iran's current military and political strategy, it is also based on historical and religious/ideological conflicts.

The Gulf States, though wealthy, in the majority of cases do not have the military, industrial, or population resources to confront Iran, hence their reliance on external actors, principally the US, to provide a deterrent against any Iranian adventurism. The problem is that doubts are growing over the will of the US to continue to provide an effective deterrent. The current US administration has a seemingly forgiving attitude towards Iran, and a broadly similar position is held by European states. As Iran has expanded its control and influence through Iraq, into Syria and beyond into Lebanon, the lack of response or countermeasures has incentivised the Gulf States to seek other solutions.

The opening of diplomatic relations with Israel by some of the Gulf States, offers some interesting security possibilities. It also opens the way to purchasing Israeli defence equipment and potentially working collaboratively with the Israeli defence industry. Other more traditional approaches to enhancing Gulf security have seen invitations to non-US foreign powers to establish local bases, such as Britain, France and Turkey. Saudi Arabia has military forces from Pakistan based in-country, while Kuwait has a contingent from Bangladesh. While the United Arab Emirates (UAE) has used foreign military contractors in service and support roles, as well as forming combatant units staffed by foreign troops.

Photo: French Army

French Army Leclerc tanks of the 5e Régiment de Cuirassiers (5e RC) participate in Exercise Pearl of the West in late 2022, with the Kuwaiti military. The 5e RC form part of the Forces françaises stationnées aux Émirats arabes unis (FFEAU) and are stationed in the United Arab Emirates (UAE).

A Different Kind of Threat

There is no doubt that Iran presents a significant threat to the security architecture in the Gulf and beyond into the greater Middle East. However, the situation is more nuanced than it might seem at first glance. Iran is a strategic threat for Gulf states, but it is not an unstoppable force, and it has security problems of its own to deal with.

To develop an understanding of what Iran is trying to achieve, it is necessary to understand the myriad factors that motivate the Iranian leadership, inform their strategic world view, and shape their security policy. These include theocracy, the ideology of the regime, traditional security interests and threat perceptions. Fundamentally though, the primary interest of the Iranian leadership and its strategic planners is the survival of the theocratic regime, the leadership of the regime and the elites that benefit from the regime against a multitude of real and perceived threats, both internal and external.

It is very easy to portray Iran as a singularly focused malevolent strategic actor determined to bring about chaos wherever and whenever it can. In reality, as a part of its strategic toolbox, the regime in Tehran is content to export chaos when it suits its interests, but this is not about generating chaos for the sake of chaos. Rather, it is about disrupting the strategic architecture of a particular state or region, for the sake of reshaping it to better suit Iranian interests and objectives. What is significant is that these interests and objectives are becoming more globalised and, in consequence, Iran's pursuit of these interests and objectives is far more disruptive to an international system that Tehran sees as inimical to its interests.

Core Threat Perceptions

As previously stated, the fundamental interest of the Tehran regime is to ensure its own survival against internal and external threats. Although many look at Iran as a unitary state, that is not the case – non-Iranian ethnic minorities such as Arabs, Azerbaijanis, Baluchs, Kurds, Turkmen and others now make up some 50% of the Iranian population. Located away from the Iranian heartland around Tehran, these ethnic minorities face poverty and discrimination, their children cannot be educated in their native languages and their cultures are diminished as unworthy. It is estimated that some 40% of the Iranian population is not able to converse properly in Farsi. Many of these minority ethnic groups are situated in border regions, sharing linguistic and cultural ties with ethnic groups over the other side of the borders.

In the face of such discrimination and outright oppression it is hardly surprising that the ethnic minorities continue to be a growing source of opposition to the Iranian regime. It should be remembered that the latest series of anti-regime demonstrations started with the murder of Mahsa Amini, a Kurdish woman, on 16 September 2022. She was arrested for improperly wearing a hijab by the 'Morality Police' and then beaten to death. Anti-regime protests spurred by the death of Mahsa Amini quickly spread across the country. The cost of protesting against the regime in Iran is high, with human rights groups claiming that by December 2022, 476 protestors had been killed by Iranian security forces.

Photo: US Navy

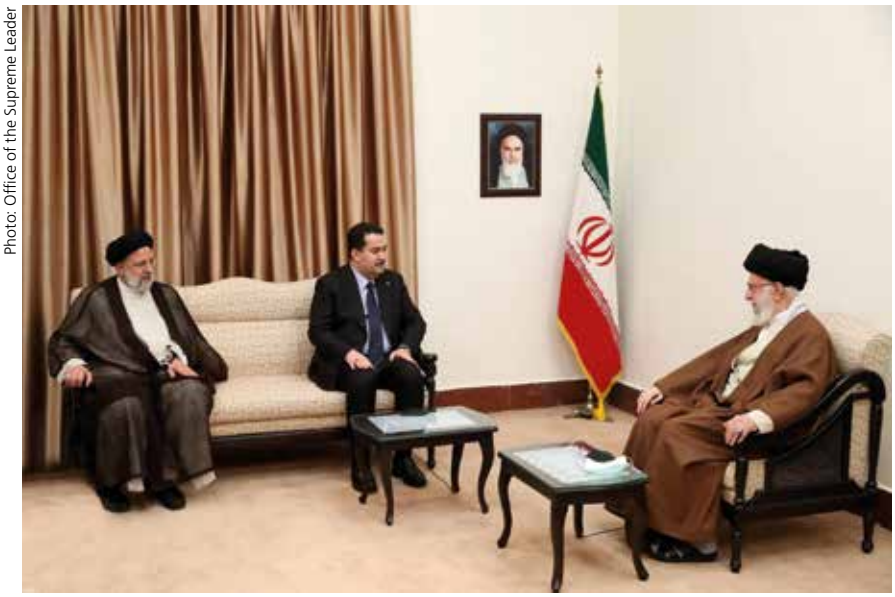
A Boeing AH-64D attack helicopter of the United Arab Emirates Air Force (UAEAF) participating in a joint exercise in the Gulf with the US Navy. The UAE continues to invest heavily in defence acquisition programmes, though like many Gulf States it has increasing concerns over US policy.

Opposition to the regime is not centred on ethnic minorities, with ethnic Persians quite prepared to take to the streets in the face of state repression. This is hardly surprising, as in recent years economic conditions are hard for ordinary people, with consumer price inflation running at 39.91% in 2019, 30.59% in 2020, 43.39% in 2021 and 52.2% by August 2022. Inefficiencies in the state-dominated Iranian economy and rampant corruption further weaken the regime's hold on large sectors of the population. What holds the state together though is the security forces, such as the Islamic Revolutionary Guard Corps (IRGC), the Basij paramilitary forces and similar pro-regime groupings. All of these have a stake in the survival of the regime and will do whatever it takes to ensure the continuation of the status quo.

Long-standing anti-regime forces do exist in Iran, most notably the Mojahedin-e-Khalq (MEK; ENG: People's Mojahedin Organization of Iran). MEK started out in 1965 as an opposition group to the Shah, by 1979 MEK played a key armed role in the Iranian Revolution that led to the end of the Shah. After the revolution the clerical regime of the Ayatollah Khomeini, saw the MEK as an obstacle and was suspicious of its ideology, said to be a unique blend of Shia Islam and Marxism. As a result, MEK was brutally suppressed by the Iranian regime, and many MEK members fled Iran, while others went undercover to resist the regime.

The MEK still continues to fight the Iranian regime to this day and forms the central element of the National Council of Resistance of Iran (NCRI), the umbrella organisation of anti-Iranian government groups. They represent a threat to the regime, hence the constant level of anti-MEK measures by the regime, but they are not strong enough to effect change in Iran. Should the repressive capabilities of the Iranian government weaken, that might change the game and lead to the MEK becoming more active in Iran.

Photo: Office of the Supreme Leader



The Ayatollah Ali Hosseini Khamenei, the Supreme Leader of Iran, a position he has held since 1989, receiving the President of Iraq in a state visit in November 2022. Iran has its enhanced its strategic position in Iraq, Syria and Lebanon in recent years.

Drugs and Decline

There is another challenge to the regime and that is illegal narcotics. Drug abuse was not uncommon in pre-revolutionary

Photo: US Army

M1 Abrams tanks of the 2nd Brigade Combat Team, 1st Armored Division, at the Al Hamra Training Centre in the United Arab Emirates (UAE), participating in a joint exercise with UAE Land Forces. The US still remains the primary guardian of Gulf security.

Iran, but after the revolution, the Khomeini government took extreme action against both drug dealers and users. This might have controlled the drug problem in the short-term, but around that time came the collapse of Afghanistan after the Soviet invasion, the resistance movement against the Soviets, civil war and the Taliban. If there was one way to make money in Afghanistan it was the cultivation and sale of opium. As Iran bordered Afghanistan it became a transhipment point for opium, as well as a major market for opium as domestic consumption grew year-on-year. A recent study noted that: "Iran has the highest rate of non-medical opium use in the world." Iran's problem also extends beyond opiates, with crystal methamphetamine becoming a major problem as well. Drug abuse is one of the top four causes of negative health outcomes in Iran.

Another negative factor that the regime has to contend with is emigration by the urban middle classes, people who are highly educated and who would normally fill high-level positions in a country like Iran. According to a paper on Iranian emigration: "since 1979, some 8 million people, almost 10% of the population, have left Iran, including an estimated 4.2 million with higher education and skills." Apparently the scale of skilled emigration is increasing, over the last four years on average 4,000 qualified medical doctors have left each year. IRNA, the official Iranian news agency, has stated that some 30,000 Iranian doctors and senior nurses are waiting for 'good standing certificates' that will confirm their medical credentials and allow them to practice abroad.

Emigration of this nature removes people from Iran who could turn into regime opponents and provide leadership for anti-regime movements, as such this could be seen as a positive for the Iranian government. There is more to it than that though, a lot of these people who are leaving come from families that are the Iranian elite, hardly a ringing endorsement of the regime, especially when you consider that these were the people best-placed to benefit from the regime.

The Regime Survives and Advances

The Iranian regime has faced severe internal challenges for a considerable period of time, yet the regime has survived, and its coercive powers do not appear to have weakened in any major way. What is somewhat surprising is that in spite of its execution of regime opponents at home and abroad, its sponsoring of proxies to conduct terrorist attacks in Asia, South America and even Europe, and its strides towards a nuclear weapons capability, large sectors of the international community are willing to overlook these in favour of a more pragmatic stance on Tehran.

The EU stresses the fact that respect for human rights is central to their foreign relations policy, yet according to a recent report by the Iranian semi-official Mehr News Agency, quoting figures released by Eurostat: "Iran and the European Union's 27 member states traded EUR 4.36 Bn worth of goods during the first 10 months of 2022, registering a 14.28% rise compared with last year's corresponding period." Germany remains the main Iranian EU trading partner, trade between the two countries amounted to EUR 1.6 Bn, up 15.44% on the year before. In second place was Italy with EUR 555.39 M worth of Iranian trade, up 11.14% on the year before.

While the Iranian regime faces significant domestic threats to its hold on power, what is surprising is that there has been very little effort to leverage these internal challenges to the regime by foreign powers who wish to limit Iranian adventurism. Inevitably, the regime labels any act of domestic opposition as being directed by the CIA, SIS, or Mossad, yet the truth is that the US has been strangely reluctant to offer support to these opposition forces, with Europe following the US' lead. The reasoning behind this inaction is the continuing belief that some 'grand bargain' can be reached with Iran that will see Tehran tone down its adventurism and happily join the international community, who in turn will be poised to benefit from Iran's oil and the domestic Iranian market for goods and services. However, thus far this 'grand bargain' has remained out of reach.

Despite the domestic threats, the regime ought to be satisfied with the way events are turning to their advantage internationally. China remains Iran's largest trading partner and that seems set to continue, helping to strengthen Iran's economic situation. Arguably the most interesting recent development is the evolution of the Iranian relationship with Russia since the latter's invasion of Ukraine.

Iran has a long-standing defence relationship with Russia, but that relationship is growing ever closer. Ironically, Iran had been prepared to supply artillery ammunition to the Ukraine earlier in the conflict, but more recently Iran has been supplying Russia with a range of UAVs and loitering munitions, plus training and support. In return, Iran will be receiving Sukhoi Su-35 fighter aircraft, plus an accompanying support package – a major boost to their air power. Other defence technologies are also being transferred to Iran, and additional economic and financial links are being forged between Tehran and Moscow.

This situation is a win-win for Iran, advanced defence equipment and technology will increase Iranian combat capabilities and allow them to enhance their defence industrial base. A closer economic relationship with Russia, added to the already close relationship with China, will strengthen the ability of the Iranian economy to resist US and European economic sanctions. All of this represents an important set of developments for Iran.

What comes next though? There has been considerable speculation that Iran could supply Russia with Fateh-110 (300 km range/500 kg unitary of submunition warhead) and Zolfaghar (700 km range/579 kg warhead) theatre ballistic missiles (TBMs). Thus far Iran has dismissed this possibility as mere speculation, but the recent attacks on Iranian defence and defence production facilities by 'unidentified' UAVs indicate that Iran will have to make a difficult risk assessment before it agrees to supply Russia with missiles. Should it decide to proceed, Iran might find itself suddenly dealing with a host of active measures from foreign agencies aimed at regime targets and boosting domestic opposition. Whatever happens next, Iran will remain a disruptive element in the Gulf security architecture. ■

Photo: Suman Sharma

C-295 becomes India's First Production Unit from a Private Defence Manufacturer

Suman Sharma

Giving indigenisation a push towards its 'Self-Reliant India' initiative, the foundation stone of the first project by an Indian private defence manufacturer, was recently laid in Vadodara, Gujarat. Under this deal Tata Advanced Systems Limited and Airbus Defence and Space Spain, will collaborate to build 40 C-295 military transport planes, in a joint venture deal valued at USD 2.72 Bn for 56 aircraft to replace the Indian Air Force (IAF)'s ageing Avro-748 transport aircraft. Out of the 56 planes, 40 will be manufactured in India, while 16 will be bought off-the-shelf.

The announcement of that manufacturing line will be in India comes at a significant time, when the Indian Government is pushing for major reforms such as 'Make in India, Make for the World', thereby achieving low-cost manufacturing and high output. Prime Minister Narendra Modi stated: "We aim to scale our defence manufacturing beyond USD 25 Bn by 2025, defence exports will exceed USD 5 Bn."

C-295: The Path to Avro Replacement

Dating back to the 1960s, the 56 Avro transport planes in service in the IAF have long been in need of a replacement. The Request for Proposal (RfP) was issued in 2013 and the Defence Acquisition Council (DAC) approved the solo bid by the Tata Group and Airbus in 2015, however the conclusion of the contract was delayed for a variety of reasons.

Of India's 56 aircraft, 16 will be delivered in flyaway condition between September 2023 and August 2025, while the remaining 40 aircraft, are to be manufactured in Vadodara, with the first plane rolling out in September 2026.

The modern C-295 military transport plane is in service with 14 countries. Powered by Pratt & Whitney PW127 engines, the aircraft is robust, versatile and efficient tactical transport aircraft. It has a flight endurance of up to 11 hours, and can carry out multi-role operations day or night under all weather conditions. The aircraft, also comes installed with an indigenous electronic warfare (EW) suite and is capable of short take-off and landing from semi-prepared surfaces. In addition to replacing the Avro, the C-295 is capable of replacing the IAF's An-32s in maritime roles.

Summarising India's procurement plans, IAF's former Assistant Chief of Air Staff, Air Vice Marshal Manmohan Bahadur (retd.) stated: "The Avro had been reduced to ferrying passengers and the An-32s were being used for logistics support. However, the IAF has planned its acquisition of transport aircraft well with Dornier-228 at the lower payload end, and IL-76 and C-17 for heavy lift. That left the 6-8 ton capability, which the C-295 will fill."

Major component assembly will be undertaken in India, while systems such as engines, landing gear, avionics, and the EW suite will be provided by Airbus Defence and integrated by the Tata Consortium. Flight testing and delivery will be undertaken through a delivery centre at the Tata Consortium facility.

Gujarat – The New Defence Hub of India

Located on the West coast of India, Gujarat is on the path to becoming a major defence hub in the near future. By virtue of being the Prime Minister's home state, Gujarat has had political backing in matters of defence manufacturing and has already proven to be industry-friendly and therefore a natural choice for defence production lines. More than 100 medium small and micro enterprises (MSMEs) are associated with the C-295 project, which will give a boost to the promise of 'Make in India, Make for the World', as the project will be able to take orders for export to other countries in future.

From artillery guns to modern submarines, and now C-295 transport planes, Gujarat is fast positioning itself as a defence hub, with the likelihood of more factories and production units being lined up. Vadodara is expected to develop a new identity as an aviation sector hub. The Tata Consortium has identified more than 125 in-country MSME suppliers spread over seven states. This will act as a catalyst in employment within the aerospace ecosystem of the country and is expected to generate 600 highly skilled jobs directly, over 3,000 indirect jobs and an additional 3,000 medium skill employment opportunities. Nearly 240 engineers will be trained at Airbus facility in Spain.

IAF's AVM Bahadur (retd.) stated: "The Ministry of Defence (MoD) has its work cut out to monitor and ensure that Tatas help develop an ancillary eco-system and source their inventory from there. A bigger challenge would be to generate skilled manpower for the expansion which must lead to exports."

Hazira in Gujarat is becoming another hub for defence platforms, such as the 155 mm K-9 'Vajra' self-propelled howitzers under an Indo-Korean joint venture for the Indian Army. The city is also seeing noteworthy naval ventures, including the construction of hulls for the Indian Navy's strategic nuclear submarines and the six indigenous nuclear-powered 6,000-tonne tactical attack submarine programme valued at USD 11.85 Bn, both of which are being undertaken by Larsen & Toubro.

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TOPAZ Integrated Combat Management Systems. Scalable from small recon teams to complete combat theaters, learns and adapts to the user needs.

BATTLEFIELD DOMINANCE AT YOUR FINGERTIPS
Our engineering team are experts at integrating weapons, sensors and C2 systems into a unified control interface sets. WB GROUP's FONET vehicle integration platform creates a broad reaching integration platform to efficiently host applications such as TOPAZ-ICMS.

AI ENHANCED
TOPAZ-IMCS leads the market with the integration of unmanned aerial systems and other optical sensors into weapon systems.

DYNAMIC BALLISTIC CALCULATIONS
TOPAZ-ICMS integrates a wider range of weapon specific inputs to achieve superior first shot accuracy.

UAS INTEGRATION
TOPAZ-ICMS increases battlefield efficiency, safety, and accuracy with the inclusion of high resolution and location data from our unmanned systems.

NATO INTEROPERABLE
TOPAZ is fully interoperable with NATO standards.

MODULAR
With five submodules, the TOPAZ-ICMS can be scaled for the user needs.

ECOSYSTEM
TOPAZ-ICMS can be delivered out of the box as a complete ecosystem made up of WB GROUP equipment. Targets are surveilled, identified, targeted and prosecuted from a singular interface.

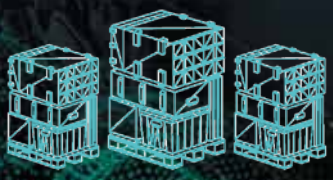
BATTLE PROVEN IN FULL-SCALE WAR

[TACTICS]

[RECON]

[FIRE]

[STRIKE]



[LOGISTICS]

WB GROUP

www.wbgroup.pl