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Credit: author

Defence is the Best Form of Attack?

Over the past few months, the world has watched as Ukraine has made incremental gains in the Zaporizhzhia front in the South, and Bakhmut front in the East. In many ways this has not been a surprising state of affairs – as stated in ESD 05/2023, "expectations for a rapid victory are probably over-optimistic, and any Ukrainian gains are likely to be hard-won." So far this prediction has been borne out by the available evidence, as hopes of a rapid breakthrough have generally subsided.

Nonetheless, a common narrative is that since Ukraine remains on the offensive, this in of itself demonstrates a lack of capability in the Russian military, which finds itself on the back foot. This is partially true. However, opting to defend its existing gains was also a logical response in Russia's strategic position, and one which appears to be paying dividends. Since moving to a defensive posture, Russia's loss rates have fallen quite sharply. Using figures from the Oryx blog, we can compare confirmed Russian materiel losses incurred in 2022, to those incurred in 2023, the latter of which has been characterised by a largely defensive response to Ukraine's counteroffensive:

Type	Losses from 24/02/2022 to 31/12/2022	Losses from 01/01/2023 to 22/08/2023	Mean Average Losses per Month 2022	Mean Average Losses per Month 2023	Change Losses per Month 2022 to 2023
Tanks	1600	653	160	81.63	-49%
Assorted AFVs	743	206	74.3	25.75	-65%
IFVs	1872	808	187.2	101	-46%
APCs	283	60	28.3	7.5	-73%
MRAPs	43	3	4.3	0.38	-91%
Infantry Mobility Vehicles	176	25	17.6	3.13	-82%
Command Posts	217	30	21.7	3.75	-83%
Engineer Vehicles	261	74	26.1	9.25	-65%
SP Anti-Tank Vehicles	32	9	3.2	1.13	-65%
Artillery Support Vehicles	90	17	9	2.13	-76%
Towed Artillery	151	132	15.1	16.5	+9%
SP Artillery	302	197	30.2	24.63	-18%
MRLs	166	90	16.6	11.25	-32%
AA Guns	16	1	1.6	0.13	-92%
SPAAGs	23	1	2.3	0.13	-95%
SAM Vehicles	84	65	8.4	8.13	-3%
Radars	20	23	2	2.88	+44%
Jammers	22	28	2.2	3.5	+59%
Fixed-Wing Aircraft	67	18	6.7	2.25	-66%
Helicopters	74	28	7.4	3.5	-53%
UCAVs	4	10	0.4	1.25	+213%
Recce UAVs	152	121	15.2	15.13	-0.5%
Ships	12	1	1.2	0.13	-90%
Trucks, Utility Vehicles	2156	619	215.6	77.38	-64%

Of course, this is not an entirely fair comparison, not least since one is a 10-month timespan and the other an 8-month timespan. Nonetheless, the broad trend has been toward a sharp reduction in confirmed Russian average monthly losses in nearly all materiel categories, with only a few notable exceptions such as UCAVs, which have risen, or reconnaissance UAVs, which have stayed roughly the same. At the same time, although reliable figures remain difficult to come by, Ukraine's own losses are estimated to have risen quite considerably as it has pushed into well-entrenched Russian lines. This should be no surprise given the scale of Ukraine's task, or given that attacking is generally much harder than defending.

In light of these difficulties, Ukraine has been promised new capabilities in the form of F-16 fighter aircraft, as well as more cruise missiles and air defence systems. These are likely to alleviate some of the strain, but success will still ultimately hinge upon a major breakthrough on the ground. Looking at the observed fall in losses, it is hard to escape the impression that Russia is gradually starting to get the kind of war it prefers to fight. For Ukraine's allies, reversing this trend is likely to require providing more ambitious assistance.

Mark Cazalet

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Cover Photo: A battery of L118 105 mm Light Artillery guns manned by 103 Regiment (V) Royal Artillery opens fire during a military pageant.
Credit: UK MoD

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AS21 Redback Emerges Victorious in Australia's Land 400 Phase 3 IFV Contest

(pf) South Korea's Hanwha Defense has secured the Australian Defence Force's (ADF's) Land 400 Phase 3 infantry fighting vehicle (IFV) requirement with its AS21 Redback, beating out a rival bid from Rheinmetall with its KF-41 Lynx, local news sources reported on 26 July 2023.

Credit: Hanwha Defense

The prize contract, however, will be much smaller than originally envisaged, as in April this year the Australian government of Prime Minister Anthony Albanese announced that it was slashing the procurement of IFVs under Land 400 Phase 3 from 450 vehicles to 129. The decision was made in response to Australia's Defence Strategic Review (DSR), which the Albanese government received in February 2023.

Land 400 Phase 3 is intended to replace the ADF's fleet of M113AS3/4 armoured personnel carriers, around 400 of which remain in Australian Army service.

According to the Australian Financial Review on 26 July, the Australian Cabinet's national security committee made the IFV decision on 25 July, informing the bidders and the South Korean and German governments the following day. As of 26 July, however, the decision had not been officially announced.

The Australian news website Defence Connect, meanwhile, stated in a report on 26 July, "It is understood that the Redback performed marginally better than its German competitor, the KF-41 Lynx, with [the Australian Department of] Defence deferring the decision ultimately to Government as both vehicles were deemed 'suitable' for Defence's requirements."

Some observers had thought the KF41 was the favourite to win Land 400 Phase 3 because the ADF had already selected Rheinmetall's Boxer 8×8 AFV to replace its wheeled Australian Light Armoured Vehicles (ASLAVs).

The AS21 Redback is an advanced version of the K21 IFV already in service with the Republic of Korea Army. It features an EOS T-2000 turret armed with a Bushmaster MK44S 30 mm cannon, a MAG 58 7.62 mm coaxial machine gun, 76 mm multi-barrel smoke grenade dischargers and two Spike LR2 missile launchers. The vehicle is protected by the Elbit Systems Iron Fist active protection system and powered by an MTU eight-cylinder diesel engine generating 1,000 hp.

The Australian Department of Defence shortlisted the Redback and Lynx for Land 400 Phase 3 in September 2019 and signed risk mitigation activity contracts with Hanwha and Rheinmetall the following month that called for three test vehicles to be delivered from each bidder. These were delivered in early 2021 and an announcement of the winning bidder was originally set to be announced in 2022.

Local subsidiary Hanwha Defense Australia will build the Australian Redbacks at a new factory near Avalon Airport in Geelong, Victoria.

Zelenskyy Footage Shows Ukrainian Air Force is Launching SCALP-EGs

(pf) Video footage of President Volodymyr Zelenskyy visiting a Ukrainian airbase has confirmed that the Ukrainian Air Force is now actively using French-supplied SCALP-EG air-launched cruise missiles: French versions of the Storm Shadow missiles already provided to Ukraine by the United Kingdom.

In the footage, posted on 'X' (formerly Twitter) by the Ukrainian Ministry of Defence (MoD) on 6 August 2023, President Zelenskyy is seen writing 'Glory to Ukraine' on a missile brightly labelled as a SCALP-EG that has been loaded under the wing of an Su-24 'Fencer' strike aircraft.

Credit: Ukrainian MoD

The Ukrainian MoD subsequently posted imagery on X indicating that "Storm Shadow missiles" had recently been used to attack and damage two road bridges to Crimea: one at Chonhar and another connecting Henichesk to the Arabat Spit. Both bridges have previously been targeted; putting them out of action would add significantly to Russia's burden in running resupply routes between occupied Crimea and Russian-held territory to its north.

French President Emmanuel Macron announced on 11 July 2023 that his country would provide SCALP-EG missiles to Ukraine, joining the UK, which first delivered Storm Shadow missiles to Ukraine in May this year.

The Storm Shadow/SCALP-EG, which is made by MBDA, is a turbojet-powered deep-strike missile that is officially quoted by MBDA as having a range "in excess of 250 km". However, its actual range is likely to be much further than that, with its use putting all Russian-occupied Ukrainian territory under threat.

The missile, which is 5.1 m long and weighs 1,300 kg, carries a blast/penetrator warhead and travels to its target using INS, GPS and terrain reference navigation.

UK MoD Awards GBP 870 M ECRS Mk2 Contract

(pf) BAE Systems has received a GBP 870 M (EUR 1.02 Bn) contract from the UK Ministry of Defence (MoD) to continue development and integration work on the European Common Radar System (ECRS) Mk2 for installation on the Eurofighter Typhoon, the company announced on 4 July 2023.

Credit: Leonardo

The majority of this funding will flow on to Leonardo UK as the lead for the aircraft's main sensing and survivability systems, which includes the ECRS Mk2: an advanced active electronically scanned-array (AESA) radar that also features electronic attack (EA) and electronic warfare (EW) capabilities.

Development and integration work on the ECRS Mk2 thus far has been conducted under a GBP 317 M contract awarded to BAE Systems and Leonardo in September 2020. This saw the first ECRS Mk2 delivered by Leonardo to BAE Systems' Warton site in April this year, where it is undergoing integration work and ground-based testing in preparation for its first flight tests next year on board Typhoon BS116, which is a Royal Air Force (RAF) test and evaluation aircraft loaned back to BAE Systems for its work.

The new funding announced on 4 July, a BAE spokesperson confirmed, will see the ECRS Mk2 progressed to the point where it is ready to go into production, with 12 radar sets produced under this latest contract.

ESD has previously been told by a BAE Systems spokesperson that the work required to fit the ECRS Mk2 into a Typhoon "is an incredibly in-

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vasive, intrusive modification involving the entire front end of the aircraft, [involving a] new radome, new line-replaceable units, not just the antenna itself, [and] new cooling equipment. It's a very involved, invasive upgrade."
The current planning assumption of the UK MoD is that the ECRS Mk2 will be integrated on all 40 of the RAF's Tranche 3 Typhoons, although the MoD has announced it is retaining the option to also fit the radar onto the RAF's 67 Tranche 2 Typhoons.
The RAF's initial operational capability with the ECRS Mk2 is currently forecast for 2030.

Israel to Acquire a Third Squadron of F-35As

(pf) The Israeli Air Force (IAF) is to acquire a third squadron of Lockheed Martin F-35 Joint Strike Fighters.
The Israeli prime minister's office announced on 2 July 2023 that Defence Minister Yoav Gallant had approved a proposal by the IDF Chief of the General Staff, Lieutenant General Herzi Halevi, the Director General of the Israel Ministry of Defense (IMOD), Major General (Res) Eyal Zamir, and the Commander of the Israeli Air Force, Major General Tomer Bar, to procure a third F-35 squadron for the IAF).
The Israeli MoD is to purchase 25 additional F-35As, which are known as Adirs in Israeli service, to add to the 50 F-35s already procured. The deal, valued at approximately USD 3 Bn (EUR 2.74 Bn), will be financed by US Foreign Military Financing.
Following the defence minister's approval, the IMOD Mission to the USA will issue an official letter of request to the F-35

Credit: IAF

Lightning II Joint Program Office (JPO). This step will facilitate the approval and signing of the transaction in the coming months.
Israel became the first country to select the F-35 through the US government's Foreign Military Sales process when a letter of agreement was signed in October 2010. The IAF received its first F-35A on 22 June 2016 and declared its F-35 fleet operationally capable in December 2017. The IAF's second F-35 squadron was inaugurated in 2020.

Russian Landing Ship Damaged in Ukrainian USV Attack

(pf) The Ukrainian armed forces appear to have significantly damaged the Russian Ropucha-class landing ship Olenegorskiy Gornyak during an unmanned surface vehicle (USV) attack in the Russian Black Sea port of Novorossiysk on the night of 3-4 August 2023.
The Russian Ministry of Defence claimed on the morning of 4 August that an attack carried

Original footage: SBU

out by two Ukrainian USVs in the port of Novorossiysk had failed when both of them were destroyed "by fire from the standard weapons of Russian ships guarding … the naval base".
However, a video post on the Telegram messaging channel from the 'Operational Ukrainian Armed Forces', which various news sources described as being sourced from the Security Service of Ukraine (SBU), featured footage of what appeared to be a USV clearly closing on the port side of a Ropucha-class landing ship at night. Despite the ship's searchlights being on, no gunfire is apparent in the footage, which cuts out as the USV makes contact with the ship and presumably detonates.
Text accompanying the 'Operational Ukrainian Armed Forces' posting of the footage is entitled "SBU conducts special operation in Novorossiysk Bay - large amphibious assault ship Olenegorskiy Gornyak damaged".
The text goes on to state, "The video shows an SBU surface drone loaded with 450 kg of TNT attacking an enemy ship with about 100 crew members.
"According to Security Service sources, the special operation was carried out jointly with the navy. As a result of the attack, the Olenegorskiy Gornyak sustained a serious hole and is currently unable to carry out its combat missions. So all the Russians' claims about the 'repelled attack' are fake."
The text then concludes with, "We remind you that this is not the first successful SBU special operation using surface drones. Earlier, SBU Head Vasyl Malyuk said that the attack on Russian ships in Sevastopol Bay last October and the recent bombing of the Crimean bridge were the work of the Security Service."
Photographs subsequently appearing on social media show a Ropucha-class landing ship presumed to be Olenegorskiy Gornyak listing to port and accompanied by tugs in what looks very much like the bay at Novorossiysk. Ropucha-class landing ships are 112.5 m long and have a full-load displacement of 4,080 tons. Destroying or heavily damaging one presents Ukraine with its most significant naval 'win' since the sinking of the Russian cruiser Moskva on 14 April 2022.
Moreover, if ever Russia's troops in Crimea are cut off from the rest of the Russian forces and the Kerch Strait Bridge is compromised, ships like Russia's Ropucha-class vessels could be needed to resupply them.
Within hours of the attack on Olenegorskiy Gornyak a Ukrainian USV damaged the Russian oil tanker Sig, while subsequent USV attacks have targeted bridges between Crimea and occupied Ukraine.

US State Department Approves F-35 Sale to Czech Republic

(pf) The US State Department has approved the Foreign Military Sale (FMS) of Lockheed Martin F-35 Joint Strike Fighters to the Czech Republic, the US Defense Security Co-operation Agency announced on 29 June 2023.
The sale, which covers 24 F-35A conventional take-off and landing (CTOL) variants as well as munitions and other related equipment, is valued at up to USD 5.62 Bn (EUR 5.15 Bn) and has been passed to the US Congress for final approval.

Credit: USAF

The Czech Republic selected the F-35 in July last year to replace the 14 leased Saab Gripen C/Ds currently operated by the Czech Air Force, the lease on which expires at the end of 2027. Prague had also considered Gripen Es and Eurofighter Typhoons to replace its leased aircraft.
As well as 24 F-35As and 25 Pratt & Whitney F135-PW-100 engines (ie one spare); the proposed sale to the Czech Republic includes 70 AIM-120C-8 Advanced Medium Range Air-to-Air Missiles; 86 GBU-53/B Small Diameter Bomb - Increment II (SDB-II) StormBreaker all-up-rounds; 12 Mk-84 general purpose 2,000-lb bombs or BLU-109 2,000-lb penetrator bombs for the GBU-31 Joint Direct Attack Munition (JDAM) guidance kit; 12 KMU-556/KMU-557 JDAM tail kits; 50 AIM-9X Block II/II+ Sidewinder short-range air-to-air missiles; plus associ-

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ated spares and training systems for the munitions listed.
The wider contract also includes extensive engineering, technical, maintenance, logistics and programme support.
The principal contractors for the deal will be Lockheed Martin as the F-35 manufacturer as well as Boeing and Raytheon Missiles and Defense as the producers of the munitions.

Baykar Signs Major Deal with SAMI for Saudi Akıncı UCAV Production

(pf) Turkish unmanned aerial vehicle (UAV) manufacturer Baykar has signed a comprehensive deal with state-owned Saudi Arabian Military Industries (SAMI) for the production of Bayraktar Akıncı high-altitude long-endurance unmanned combat air vehicles (UCAVs) in Saudi Arabia.

Credit: Baykar

The agreement was announced on X (formerly Twitter) on 6 August 2023 by Baykar CEO Haluk Bayraktar, who stated, "With Bayraktar Akıncı exports, we signed the biggest export agreement in the history of the [Turkish] Republic in defence and aviation with the Saudi Ministry of Defence last week."
Bayraktar added, "Thus, a strong and strategic co-operation takes place between Turkey and Saudi Arabia."
SAMI was founded in 2017 to grow Saudi Arabia's defence-industrial base and reduce its reliance on foreign defence products. While the group has signed memoranda of understanding and established joint ventures with numerous Western defence companies, the relationship with Turkey's Baykar promises not only technology transfer but a significant advance in the country's indigenous unmanned airborne strike capabilities.
The Bayraktar Akıncı can fly at an altitude of 40,000 ft and has an endurance of 24 hours. Equipped with a multi-function active electronically scanned-array radar, it has dual-redundant satellite communications and navivigate with internal sensor fusion without having to depend on GPS. Baykar claims the Akıncı can conduct operations in co-operation with manned fighters and can perform air-to-air as well as air-to-ground missions.
The Akıncı can carry a range of ordnance, including Bozok, MAM-L and MAM-C mini-smart munitions; Cirit and L-UMTAS air-to-ground missiles; SOM-A stand-off air-to-ground missiles; Gokdogan amd Bozdogan air-to-air missiles; and a range of guided bombs.
While Saudi Arabia bought 50 Italian Selex Galileo Falco UAVs in 2012, its subsequent armed UAV purchases have been Chinese; an unspecified number of Chengdu Wing Loong medium-altitude long-endurance armed UAVs were ordered in 2016. Since then the kingdom has increasingly sought to develop its own capability to produce UAVs.

Canada Orders Four New A330 MRTTs, Conversion of Five More

(pf) The Canadian government has contracted Airbus Defence and Space to supply four newly built Airbus A330 Multi Role Tanker Transport (MRTT) aircraft and convert five used A330-200s into MRTT platforms for the Royal Canadian Air Force (RCAF), the company announced on 25 July 2023.
The order is worth approximately CAD 3 Bn or (EUR 2.1 Bn) excluding taxes).
Known as the Strategic Tanker Transport Capability (STTC), this new fleet of aircraft will replace the RCAF's ageing CC-150 Polaris (A310 MRTT) fleet, which is used to perform air-to-air refuelling operations, military and personnel and cargo airlift, medical evacuations, as well as transport Canadian government VIPs.
The newly built A330-200s will be assembled at the A330 final assembly line in Toulouse, France, and are scheduled to enter the conversion process at the A330 MRTT facilities in Getafe, Spain, in mid-2025. The first completed MRTT is to be delivered to the RCAF in 2027.

Image: Airbus

Under the agreement the A330 MRTTs will be equipped with both hose-and-drogue and boom refuelling options, maximising their compatibility with allied aircraft. The aircraft will additionally feature cyber security solutions and countermeasures and could also receive Airbus Medical Evacuation kit solutions, which consist of two intensive care units and additional stretchers.
The contract covers a full suite of training services, including full flight simulators, to prepare and maintain crew readiness as part of the modernisation of the Canadian armed forces' air operational training infrastructure.
Airbus was selected as the only qualified supplier for the RCAF's CC-150 tanker replacement in April 2021 following an open procurement process.
The A330 MRTT now has 76 orders from 15 customers, representing a market share outside the United States of 90%, according to Airbus. The aircraft, which can carry up to 300 troops, has clocked up more than 270,000 flight hours.
As an aerial refuelling platform the A330 MRTT can carry up to 111 tonnes of fuel – the highest capacity of all tanker aircraft, according to Airbus – and can offload 50,000 kg of fuel to a broad range of receivers during a four-hour loitering mission at over 1,000 n miles from its take-off point.

Rheinmetall Announces it Will Produce F-35 Fuselage Sections at Weeze

(pf) Germany's Rheinmetall announced on 4 July 2023 that, in co-operation with US partners Lockheed Martin and Northrop Grumman, it plans to build an "ultra-modern" factory at Weeze in the Kleve district of the German state of North Rhine-Westphalia (NRW) to produce fuselage sections for the F-35A Lightning II Joint Strike Fighter.
The decision on where to place the factory followed a review of possible locations around Germany, Rheinmetall said.
The new plant is due to produce at least 400 F-35A fuselage sections for the air forces of Germany and other friendly nations, with production expected to begin in 2025.
Germany officially joined the F-35 programme on 14 December 2022, when it signed a letter of offer and acceptance to acquire the aircraft.
The German decision to acquire the F-35 came in March 2022, when it was decided that 35 F-35As would be sought to replace the Luftwaffe's fleet of Panavia Tornado strike aircraft.
Featuring state-of-the-art technology, the planned factory will be operated through Rheinmetall Aviation Services GmbH and will feature 60,000 m2 of floorspace, with over 400 highly skilled personnel crewing the assembly line. In addition, the plant will include logistics and warehouse facilities, research and test centres, classrooms and quality control units.
"We're proud that our longstanding partnership with Northrop Grumman and Lockheed Martin and our decades-long relationship with the Bundeswehr is resulting in a genuine transfer of know-how to Germany," Rhein-

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Credit: Northrop Grumman

metall chief executive Armin Papperger was quoted as saying in a company press release. "And we're very pleased to be contributing to the future viability of Germany as a technology powerhouse, and especially NRW: our long-standing corporate home. Close to the state capital in Düsseldorf, we're going to build a factory that sets standards Europewide. We're very grateful for the political and administrative support we experienced in Weeze during our search for a location."

"Northrop Grumman will replicate our automated and manufacturing technologies of the Integrated Assembly Line in Weeze," said Glenn Masukawa, vice president for the F-35 programme at Northrop Grumman. "Combined with Rheinmetall's capabilities, our collaboration with Lockheed Martin to manufacture the centre fuselage is critical in bolstering global security. We look forward to the success of this newest F-35 facility."

Romania Cancels Corvette Deal With Naval Group

(pf) The Romania Ministry of Defence (MApN) has cancelled the long-delayed EUR 1.2 Bn deal it had with France's Naval Group to acquire four Gowind 2500 corvettes.

According to the DefenseRomania website the decision was approved on 7 August and covers the whole process, meaning that a runner-up bid by Damen of the Netherlands will not be considered.

The MApN was quoted as stating, "The decision to cancel the specific procedure was taken … since the tenderer declared the winner did not sign the framework agreement within the terms requested by the contracting authority and the funds necessary to declare the economic operator in the next place as the winner were not identified".

Credit: Naval Group

Naval Group, teamed with local company Constanța Naval Shipyard, won the Romanian corvette contest in 2019, which would have seen four Gowind 2500 corvettes built in Romania, but a contract for the ships was never signed. Initially stalled by legal challenges, the deal became increasingly stymied by disagreements over rising costs.

The deal would also have covered the renovation of the Romanian Navy's two existing frigates.

Romania has a 245 km-long coastline on the Black Sea that stretches from the country's eastern border with Ukraine to its southern border with Bulgaria. Already tense in terms of security issues, the Black Sea has seen open conflict on its waters since Russia's invasion of Ukraine in February 2022: giving good reason for Romania to pursue stronger naval capabilities.

IDEF 23: Turkey's FNSS Unveils Kaplan Hybrid Vehicle Prototype

(pf) Turkey's FNSS has unveiled its Kaplan Hybrid Vehicle, exhibiting it for the first time at the IDEF 23 defence exhibition, held in Istanbul from 25 to 28 July.

The project has essentially involved FNSS taking its Kaplan-10 AFV platform and replacing its diesel engine with a unique hybrid diesel/

Credit: FNSS

electric powerpack featuring a 400 hp diesel engine and two PMSM electric motors providing a continuous 397 hp or peak output of 617 hp. This solution can also be integrated into other tracked platforms in the current and future FNSS portfolio, as well as other tracked vehicle families in need of capability enhancement and life extension, the company stated in a press release.

While the Kaplan hybrid propulsion system has been developed for tracked vehicles weighing up to 20 tonnes (the Kaplan Hybrid Vehicle has a combat weight of 17.5 tonnes), the system is intended to be resized for tracked vehicles of different tonnages in the near future.

The hybrid propulsion system of the Kaplan Hybrid Vehicle not only offers silent drive in electric-only mode but also the ability to integrate new-generation weapon systems with high energy needs: capabilities well suited to combat and reconnaissance scenarios. With a lithium ion battery offering 800 V and 56 kWh, the vehicle can operate in silent drive mode for 20 km at a constant speed of 10 km/h and can operate in stationary silent surveillance mode for 48 hours (or 14 hours if the vehicle is using its air conditioning system), according to the specifications detailed on the FNSS website.

FNSS states that its hybrid powerpack "offers remarkable off-road performance for a tracked vehicle with its external transmittable power and increased fuel economy". The company notes that the high torque provided by the new hybrid propulsion system give the vehicle better acceleration than other tracked platforms, providing a critical advantage in the field and the ability to respond quickly to battlefield conditions.

The Kaplan Hybrid Vehicle is stated by FNSS to have a power-to-weight ratio of 22-35 hp/tonne compared to 21 hp/tonne for the conventionally powered Kaplan-10. The vehicle has a maximum road speed in excess of 65 km, a 0-32 km/h acceleration of 6 seconds and a range greater than 525 km.

FNSS added that, while some subsystem components were imported to expediently produce the Kaplan Hybrid Vehicle, development of local alternatives is underway. One of the most important components to be produced locally is the cross-drive gearbox. This has a design unique to FNSS, which claims it has become one of the few companies with the technological competence to develop this type of system.

The project started in the FNSS Research and development centre in 2021. With assembly of the first prototype vehicle now completed, control software development and other improvement activities continue. Critical verification tests are planned to start towards the end of 2023.

Tunisia Receives Eighth and Final T-6C on Order

(pf) The eighth and final Beechcraft T-6C Texan II turboprop trainer on order for Tunisia has been delivered to the Tunisian Air Force's No 13 Squadron at Sfax Air base, the aircraft's manufacturer, Textron Aviation Defense, announced on 10 August 2023. The US Department of State approved a

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potential USD 234 M (EUR 212.6 M) Foreign Military Sale to Tunisia of 12 T-6Cs plus related equipment in 2019, after which Tunisia decided in 2021 to buy eight with an option for an additional four.
The Beechcraft T-6C Texan II Integrated Training System for the Tunisian Air Force at Sfax Air Base will also include a ground-based training system, an operational flight trainer and a computer-based training lab.
Speaking at a 17 July 2023 event marking the arrival of the first four T-6C aircraft, US Ambassador to Tunisia Joey R Hood stated, "Tunisia plays an important role in ensuring not only its own national security but also that of northern Africa and the continent as a whole." He reiterated the US commitment to supporting Tunisia's efforts to strengthen its air force's capacity to respond both to security and humanitarian needs.

Credit: Textron

No 13 Squadron currently operates 17 SIAI-Marchetti SF-260 piston-engine-powered basic trainers, while Tunisia's jet trainer fleet consists of nine Aero L-59Ts. The T-6Cs are expected to replace both these types.
The T-6Cs will also serve as lead-in trainers for the four Beechcraft AT-6E Wolverine light attack aircraft Tunisia has on order, the sale of which was approved in February 2020. The T-6C and AT-6 share an 85% commonality in structure, avionics, and other systems.

USMC Trials F-35Bs Operations From Disused Highway

(hum) The Republic of Singapore Navy (RSN) submarine RSS Impeccable was received at Changi in Singapore on 20 July 2023, marking the arrival of the RSN's first boat of the Kiel-built Invincible class, according to the Singaporean Ministry of Defence (MINDEF).

Credit: MINDEF

The boat had left Kiel on board the transport ship *Rolldock Storm* at the beginning of June. A photograph published by MINDEF shows RSS *Impeccable* entering RSS Singapura – Changi Naval base, where a homecoming ceremony was held.
As build number 2 of the four-boat programme, Impeccable is the first submarine of the class to arrive in Singapore. The first boat, Invincible, will remain in Germany to support crew training, but was christened in 2019 and delivered in the meantime. According to MINDEF statements from late February 2023, Invincible is "expected to return to Singapore later this year following completion of sea trials".
Illustrious, boat number 3 in the programme, was named alongside sister ship *Impeccable* in Kiel on 13 December 2022 in the presence of German Chancellor Olaf Scholz. Shipyard thyssenkrupp Marine Systems (tkMS) was able to complete the factory sea trials of Illustrious this spring, but is not yet known when the boat will set sail for the Southeast Asian city state.
Impeccable will now carry out a series of sea trials to reach full operational capability.
The Type 218 SG/Invincible-class submarines are specially designed for deployment in the shallow and heavily trafficked tropical waters around Singapore. They will replace the RSN's Archer- and Challenger-class submarines, which are now more than 60 and 40 years old respectively and were procured by Singapore to gain experience and expertise.

US Company Looks to Put Catalina Flying Boat Back Into Production

(pf) A US company based in Longboat Key, Florida, is aiming to resurrect production of the iconic Consolidated PBY Catalina flying boat in the form of the Next Generation Amphibious Aircraft (NGAA) Catalina II.
Catalina Aircraft announced the initiative on 25 July 2023 at the AirVenture Oshkosh air show in Wisconsin. The company, which is the official type certificate holder for the 28-5ACF Catalina variant, is offering two new production versions of the aircraft: a military NGAA Special Use Variant and an NGAA Civilian Variant.
"The NGAA Catalina II is a modern amphibian with advanced engines and avionics and will offer capabilities no other amphibian can provide today," Lawrence Reece, president of Catalina Aircraft, was quoted as saying in a company press release. "We are looking forward to moving this program forward rapidly."
Catalina Aircraft states on its website that the NGAA Catalina II "carries forward the history and legendary performance of the currently Transport Category, Standard Airworthiness certificated 28-5ACF Catalina by exploiting today's advances in digitisation, systems, materials, corrosion control, avionics, and engine/propulsion technologies".
The aircraft will be powered by twin turboprops, with the Special Use Variant having a maximum take-off weight of 40,000 lb (18,144 kg).
Catalina Aircraft states that "pricing has not been announced yet, while deliveries are anticipated to begin in 2029". There is currently no evidence of an initial customer so far, however.

Credit: Peter Felstead

Although US Air Force Special Operations Command is currently looking to trial a flying boat variant of the Lockheed Martin MC-130J Hercules tanker/transport variant known as the MC-130J Amphibious Capability (MAC), this effort is said to be two to three years away from making a maiden flight and is currently only moving towards a critical design review.
Meanwhile, the only major producer of military flying boats today is Japan's Shin-Maywa, which introduced the US-1A in the 1970s and has produced the US-2 since 2003. Six US-2s are currently in service with the Japan Maritime Self-Defense Force, which has a requirement for up to 14, while the Indian Navy and Indian Coast Guard have also shown interest in the type.
The original Catalina first flew on 21 March 1935 and between 1936 and 1945 a total of 3,308 of the type were built. The PBY was the most widely used flying boat during the Second World War and saw wartime service mostly with the armed forces of the United States, United Kingdom, Canada, Australia, New Zealand, Brazil and Russia. It was operated primary for maritime patrol and reconnaissance, anti-surface and anti-submarine attack, air-sea rescue and cargo transport.
The type also saw service both militarily and commercially with several nations after the war and a small number are still flying. Catalina Aircraft states on its website that it "has been supporting the continued airworthiness of legacy Catalinas around the world for the last 14 years".

First Two Czech Viper Attack Helicopters Arrive In Country

(pf) The Czech Air Force has received its first two AH-1Z Viper attack helicopters, the aircraft's manufacturer, Bell, announced on 28 July 2023.

The two AH-1Zs arrived at the 22nd Helicopter Air Force Base in Náměšť nad Oslavou on 26 July on a US Air Force C-17 airlifter. By mid-September the base will receive four more aircraft: two Vipers and the first two UH-1Y Venom utility helicopters.

Credit: Czech MoD

"Delivery of the first American helicopters is a significant moment for the modernisation of the military; it moves the helicopter air force into the 21st century," Czech Defense Minister Jana Černochová was quoted as saying by the Czech Ministry of Defence. "In this way we are getting rid of our dependence on Russian technology and switching to a modern Western platform supplied by an important ally."

The US government confirmed in August 2022 that it would donate six AH-1Zs and two UH-1Ys to the Czech Republic as Excess Defense Articles. These are being added to the four AH-1Zs and eight UH-1Ys that the Czechs had already ordered in 2019 to give an total inventory of 10 of each type.

Acquisition of the AH-1Zs will allow the Czech Air Force to retire its Soviet designed Mi-24V/Mi-35 attack helicopters.

US Navy Awards DDG 51 FY23-27 Multi-Year Procurement Contracts

(pf) The US Navy awarded contracts on 1 August 2023 to Huntington Ingalls Industries' Ingalls Shipbuilding Division (HII Ingalls) and General Dynamics Bath Iron Works (GD BIW) for the fiscal years (FY) 2023-2027 multi-year procurement (MYP) of Arleigh Burke (DDG 51)-class destroyers.

The MYP awards cover the design and construction of nine MYP ships: HII Ingalls was awarded a fixed-price-incentive firm target (FPIF) contract for six DDG 51-class ships in FY 2023-2027, while GD BIW was awarded a FPIF contract for three DDG 51-class ships in FY 2023-2026.

Additionally, each shipbuilder's contract contains options for additional ships over the next five years, providing the navy and Congress with flexibility to increase DDG 51 build rates if authorised and appropriated.

"Arleigh Burke-class destroyers are the backbone of the surface fleet and one of the most successful shipbuilding programs in the history of the navy," Carlos Del Toro, Secretary of the Navy, was quoted as saying in a Naval Sea Systems Command (NAVSEA) press release. "These awards provide a long-term stable demand signal to the shipbuilder and industrial supply base, encouraging industry investment in the workforce. With our industry partners we are going to continue to build them; and they will continue to secure the seas for decades to come."

"These contract awards will allow the navy to continue delivery of lethal capacity in an affordable and effective manner," added Frederick J Stefany, acting Assistant Secretary of the Navy for Research, Development and Acquisition. "The navy saved USD 830 M [EUR 758 M] for these nine ships through multi-year procurement contracts and also has options for additional ships to accelerate delivery of the critical DDG 51 Flight III capabilities to our naval force."

Captain Seth Miller, DDG 51 class programme manager within the US Navy's Program Executive Office (PEO) Ships, was quoted as saying, "These contracts will provide next-generation integrated air and missile defense capability for our future fleet while ensuring a stable shipbuilding and defense-industrial base for the foreseeable future. The navy is proud to be teaming with the dedicated shipbuilders at HII Ingalls and GD BIW to construct and deliver these warships to the fleet."

These latest DDG 51-class destroyers are

Credit: HII Ingalls

being procured in a Flight III configuration, relying on a stable and mature design while delivering critical integrated air and missile defence capability with the AN/SPY6(V)(1) air and missile defence radar, NAVSEA noted.

The US Navy's first Flight III destroyer, Jack H Lucas (DDG 125), was delivered by HII Ingalls in June 2023.

The first DDG 51 destroyer, USS Arleigh Burke, was commissioned on 4 July 1991, meaning that the Arleigh Burke class has the longest production run of any US Navy surface combatant.

USS Michael Murphy (DDG 112) was originally intended to be the last Arleigh Burke-class destroyer procured, but in July 2008 the US Navy announced its intention to restart DDG 51 production.

Seventy-two of the class are currently in active service, with 18 more planned.

Largest Ever 'Mobility Guardian' Exercise Initiated

(pf) The Air Mobility Command (AMC) of the US Air Force (USAF) and a number of allied air forces initiated Exercise 'Mobility Guardian 2023' (MG23) in the Indo-Pacific region on 5 July.

An evolution from the exercise's previous three US-based iterations, MG23 is the largest full-spectrum readiness exercise in AMC history. The exercise's aim is to understand and overcome distance to deliver the mobilisation, deployment and sustainment functions that the Joint Force, allies and partners depend on to respond to challenges worldwide.

"It should be evident by now that success of the Joint Force requires a capable and integrated Mobility Air Force [MAF]," General Mike Minihan, AMC commander, was quoted as saying in a USAF press release. "MG23 will turn planned integration into operational integration within the theatre, stretching MAF capabilities to meet future demands and protect shared international interests with our allies and partners."

MG23 involves around 70 transport aircraft from the USAF and the air forces of six US allies: Australia, Canada, France, Japan New Zealand and the United Kingdom. The exercise is being held until 21 July across multiple locations spanning 3,000 miles.

"MG23 will employ 3,000 personnel in direct support of the exercise and expects to support more than 15,000 US forces, and allied and partner participants associated with other exercises this year: seven times that of MG21 and nearly three times that of MG19," the USAF stated.

"Each participating country has the opportunity to hone vital readiness skills and enhance interoperability in operationally limited environments among multiple mission areas to include airlift, aerial refuelling, aeromedical evacuation, the [USAF's] Global Air Mobility Support System, command and control, and humanitarian and disaster assistance."

A UK Royal Air Force asset in the form of an A400M Atlas transport aircraft made history in advance of attending MG23 when it flew for 20 hours and 36 minutes from RAF Brize Norton to the US Western Pacific island territory of Guam on 3-4 July: the type's longest-ever non-stop flight. The A400M was refuelled mid-flight three times during its flight by RAF Voyager aerial refuelling aircraft, one of which also attended MG23.

Admiral Gilday Completes Tenure as US Chief of Naval Operations

(pf) Admiral Mike Gilday relinquished his post as the US Navy's Chief of Naval Operations on 14 August 2023 after successfully concluding his four-year tenure as the navy's top military leader.

In a ceremony at the United States Naval Academy in Annapolis, Maryland, Adm Gilday handed over to Vice Chief of Naval Operations Admiral Lisa Franchetti, who has been nominated by US President Joe Biden to be the next CNO and will perform the duties of the CNO until someone is formally appointed to that role in accordance with law.

Adm Gilday became the 32nd CNO in August 2019. As a member of the Joint Chiefs of Staff, the CNO acts as an advisor to the President of the United States, the National Security Council, the Homeland Security Council, and the Secretary of Defense. Under the direction of the Secretary of the Navy, the CNO is responsible for the command, utilisation of resources, and operating efficiency of naval forces and shore activities.

As keynote speaker at the ceremony Secretary of the Navy Carlos Del Toro emphasised Adm Gilday's "transformational leadership" and prioritisation of readiness during an era of strategic competition.

"Admiral Gilday boldly charged forward, leading and inspiring sailors at every level, from the tactical, to the operational, to the strategic… he's also championed our strategic relationships with allies and partners," said Del Toro. "He served as our 32nd Chief of Naval Operations during a pivotal – and perhaps sometimes even a bit chaotic – time for our fleet, for our nation, and for our friends around the world."

Credit: US Navy

For his part, Adm Gilday reflected on the adaptation and change the US Navy has undergone in adjusting to a new and challenging security environment, while also calling for the Department of Defense to "act with urgency and purpose" in order to maintain maritime superiority. He expressed confidence and optimism in the navy's direction, while praising sailors and families around the Fleet for their resilience and service.

"We have the best Navy in the world," said Gilday. "Every day, our people are standing the watch, operating globally and at the tip of the spear, strengthening our alliances and partnerships."

Adm Gilday described Adm Franchetti as exceptionally well qualified to take up his post, stating, "I am proud that she will be my CNO. She is a fleet sailor, an operator, a warfighter. She has already made the navy better as our Vice Chief of Naval Operations; the navy is in good hands with her at the helm."

'Stolty' Sees his Term Extended as NATO Secretary General

(pf) Former Norwegian prime minister Jens Stoltenberg has had his tenure as NATO secretary general extended by a further year, until 1 October 2024, the alliance announced on 4 July 2023.

The decision is to be endorsed by NATO heads of state and government at the alliance's 2023 Vilnius Summit, which takes place on 11-12 July.

Stoltenberg took office as NATO secretary general on 1 October 2014, meaning he will eventually have been in post for a full decade. He is already the second-longest-serving NATO chief after Joseph Luns of the Netherlands, who served for 12 years and 268 days from October 1971 until June 1984.

In response to the announcement, Stoltenberg was quoted by NATO as saying, "I am honoured by the decision of NATO allies to extend my term as Secretary General. The transatlantic bond between Europe and North America has ensured our freedom and security for nearly 75 years, and in a more dangerous world, our great Alliance is more important than ever."

Extending Stoltenberg's tenure gives continuity to the NATO leadership at a time when the allies need to maintain a united front in supporting Ukraine against the Russian invasion that began in February 2022. However, it is also a sign that the allies cannot reach a consensus on who should succeed him.

Candidates mentioned as being in the frame for the job include the prime ministers of Spain and the Netherlands, Pedro

Credit: NATO

Sánchez and Mark Rutte respectively, as well as two female candidates: Ursula von der Leyen, the president of the EU Commission; and Mette Frederiksen, the Danish prime minister. While UK Defence Secretary Ben Wallace had openly aspired to the job, he withdrew his candidacy in June this year after it became clear the United States would not support it ahead of keeping Stoltenberg in position or promoting a candidate from one of the 'new NATO countries' most keenly feeling Russia's belligerence.

The UK, at any rate, has already provided three NATO secretary generals – Hastings Ismay, Peter Carrington and George Robertson – which is surpassed only by Italy, which has provided four (although Alessandro Minuto-Rizzo was an acting head who only served for 15 days), and equalled by the Netherlands, which has also provided three. Stoltenberg was the first Norwegian to take up the post, succeeding the first Dane, Anders Fogh Rasmussen, who served from August 2009 until October 2014.

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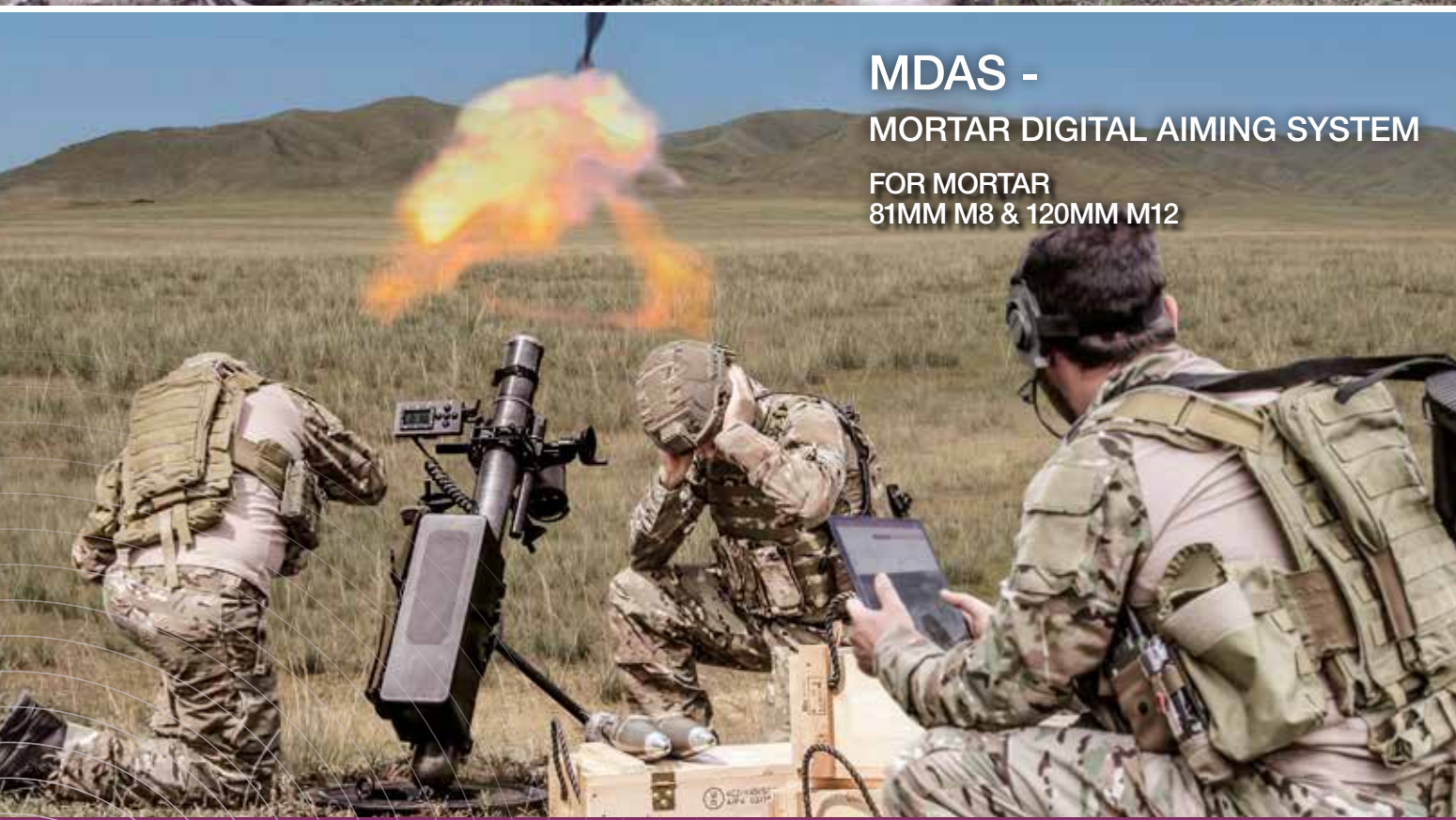

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Delivery rather than Perfection: ESD Interviews the UK Minister for Defence Procurement

Credit: UK MoD

James Cartlidge MP, Minister for Defence Procurement (MinDP).

In August 2023, ESD interviewed the Honourable James Cartlidge MP, Minister for Defence Procurement (MinDP) at the UK's Ministry of Defence (MoD). The interview was conducted by Mark Cazalet and Stephen Barnard.

At the June House of Commons Defence Committee (HCDC) hearing, MinDP said there are "positive changes happening" regarding defence procurement. What are these changes at a granular, technical level? Do these "positive changes" factor in any of the lessons learned from HCDC's recent report?

We are delivering practical change and improvement across our acquisition system. That progress is demonstrated by us already seeing a one-year reduction in the average time it takes to deliver a capability to our forces – the kind of positive progress we must capitalise on and continue to drive forward. As acknowledged by the HCDC, we have also seen positive changes at DE&S – not least the very effective effort undertaken to procure for Ukraine, often at great speed.

Work is ongoing to learn the lessons from Ukraine but also the HCDC report, and in particular, the Sheldon Report into Ajax – but should lead to a recognisably improved procurement system in the future, as we start to implement those lessons. This will in particular include ensuring we have the right people in place, to build a cadre of qualified programme leaders. We are ensuring our procurement processes are proportionate to each programme. And we are engaging the right experts, and industry, earlier in the process so that we set programmes up for success from the outset.

With the next general election just over a year away, and current polling not favouring the Conservative party, is meaningful reform of UK Defence procurement a high priority for the current government? If so, which resources are being committed, or major structural changes being implemented to help bring this about?

Reform of defence procurement is absolutely a priority for this government and we're leading the most robust review of the end-to-end acquisition system for a decade. We need to drive greater pace and agility into how we acquire military capabilities for the front line, ensuring we can outmatch the threats we face both now and emerging threats we'll face in the future.

This could well see us breaking from past practice and accepting capabilities that are 80% developed to ensure we're not losing the strategic advantage. The priority will be delivery rather than perfection – a key lesson we've learned from Ukraine, with the emphasis on spiral development 'once in service' rather than overly lengthy procurement up to that point.

Ultimately, what matters here is the national interest. We have played a huge role in supporting Ukraine, and procurement has been a big part of that – not just in terms of direct support, but in ensuring that the 20,000 Ukrainians trained in the UK have adequate kit, where it is our responsibility to provide it. Whatever the political calendar, the overriding strategic imperative is to keep maximising our support for Ukraine, whilst reforming procurement processes to ensure our armed forces have the best possible equipment.

New IOC dates for Ajax have been announced. What has changed to make this date a realistic target?

Careful, detailed measurements and analysis of the noise and vibration characteristics on the vehicles was completed to allow the correct design changes to the seating. To ensure these are the correct solutions has required extensive and complex analysis and testing of the platform. A range of modifications beyond revised seating have also been integrated onto the vehicle and its electronic architecture.

With a delivery schedule completely rebuilt, in recognition of the mistakes of the past and the optimism bias that existed in the previous schedule, we're clear that Ajax remains at the heart of the Army's modernisation programme. When I was recently given a test drive of the Ajax platform, the soldiers I was sitting alongside were incredibly positive – describing a real step change in capability, including greater lethality but also manoeuvrability, and absolutely cutting-edge sensors and comms. The Army recommenced regular field training on Ajax in June and Reliability Growth Trials continue to progress well, with well over 10,000 km driven since January, testing the durability of the platform and components through a series of battlefield missions.

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Under the Defence Command Paper 2021 (DCP21), the UK's Warrior IFV is slated for retirement from 2025. What is the MOD's plan to fill the IFV capability gap – bearing in mind that none of the Boxer variants currently on order have the right weaponry mix to fill the IFV role? Is the MoD considering pushing back Warrior's retirement date, or re-roling Ajax to become Warrior's de facto replacement?

There's been no change in plan from our 2021 Defence Command paper, which made clear Warrior will remain in service until the introduction of new capabilities, including Boxer, which we anticipate will happen from the middle of this decade – Boxer is still expected to enter service from 2025 and we have no plans to extend Warrior to 2030.

Although Boxer is not directly replacing Warrior, this approach will ensure that, alongside capabilities including Apache AH-64E, Challenger 2 tanks and Ajax, the Army can continue to meet its operational commitments.

The Defence Command Paper 2023 (DCP23) provided little new money for procurement programmes and stated: "there are deliberately no new commitments on platforms at all – because on that we stand by what we published in 2021." Yet this claim rings somewhat hollow considering the War in Ukraine started since DCP 2021 was published, and stands in stark contrast to what many UK allies have done over the same time period. How does the MOD plan to meaningfully modernise the Armed Forces without committing to new platforms?

The Defence Command Paper 2023 was developed in lock-step with the lessons we're learnt – and continue to learn – from Russia's illegal invasion of Ukraine. The publication followed an uplift of GBP 5 Bn over the next two years to improve the readiness and resilience of our Armed Forces. The document was also underpinned by an additional GBP 2.5 Bn being prioritised on bolstering munitions and stockpiles over the coming years – new investment that is very specifically the result of the war in Ukraine, and our need to replenish following the extraordinary support we have provided to the Ukrainian armed forces.

We already have a GBP 242 Bn Equipment Plan to cover procurement programmes for the next decade and we are focusing on how to drive the lessons of Ukraine into our core business and to recover the warfighting resilience needed to generate credible conventional deterrence.

DCP23 demonstrated how we will modernise and adapt to the changing global picture and, in particular, how we will prioritise investment in science and technology to ensure we have a force greater than the sum of our parts.

In this more volatile, complex and ambiguous security environment, we must embody a fully integrated approach to deterrence and defence – including across domains, across the spectrum of competition, across government, and with our allies and partners.

Credit: UK MoD

The Boxer family of wheeled armoured fighting vehicles is slated to enter service with the UK from 2025.

Recently, we have seen that the Urgent Capability Requirement (UCR) system works well in terms of delivering necessary capabilities in-theatre. Why not adopt that system for broader acquisitions?

When time is of the essence, we have shown that we can prioritise early delivery of capability. But by definition, every acquisition programme cannot be a priority. With UCRs, the time imperative means we take greater risk, balancing this against the need to deliver equipment into the hands of our personnel quickly. We need to consider where we could take more risk in order to drive pace. We are placing increased emphasis on timely delivery across the board, including through iterative or 'spiral' development where, for example, we might accept an initial solution that does not fully meet our requirements if we can get it more quickly. We can then build on this, improving the capability over time.

The message has also been reinforced in recent months and years that rebuilding sovereign manufacturing capabilities, and the supply chains to support them, is fundamental to national security. What steps have been taken to address the UK's apparent shortcomings in these areas?

To an extent, Defence has always recognised the importance of having onshore industrial capability – warships and submarines being obvious examples.

The Defence and Security Industrial Strategy took that a step further and set out a more systematic approach for looking at the national security and operational needs for an onshore industrial capability, including those where there is a strategic imperative for the majority of the industrial capability to be onshore. It doesn't mean we should try to do everything onshore – that's not affordable, practicable, or even necessarily desirable – but it does mean we shouldn't revert to international competition by default in our commercial strategies. We need to be smarter, look at the military and operational requirements for an onshore industrial capability, and shape our approach to the market accordingly.

The Defence Command Paper 2023 also recognises this, making the point that we needed to go further in looking at our supply chains so they are resilient to disruption and can ensure we have access to key materials, components, and critical technology. We will be enhancing our national resilience through a combination of shaping MOD orders, exports, and civil demand. But it also means working with our international partners to improve our supply chains' collective resilience including through friend shoring, particularly where our supply chains are global in nature. ■

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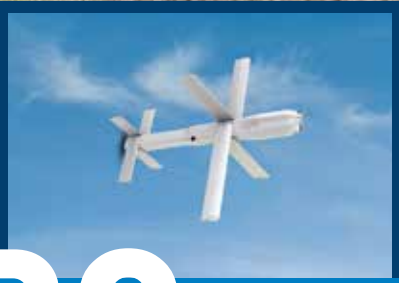

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UK Defence Command Paper 2023: Making a Virtue of Necessity

Conrad Waters

On 18 July 2023 the United Kingdom released a long-awaited Defence Command Paper setting out how the British Armed Forces will adapt to the lessons of the Russo-Ukrainian War. Limited by financial realities, the new document is long on words but short on tangible detail. Nevertheless, the measures it contains offer the prospect of a more resilient and effective military over time.

Responding to a Changing World

Russia's invasion of Ukraine in February 2022 has seen countries across Europe scramble to adapt their defences to meet the changed geopolitical landscape. In March 2023, the United Kingdom revealed its own response to the new threat environment with the publication of an updated security strategy, the *Integrated Review Refresh 2023: Responding to a more contested and volatile world* (IRR23). Building on an earlier strategic review published in 2021, this revised security blueprint affirmed its predecessor's focus on responding to a more competitive and fractured world order typified by the varying challenges posed by Russia and China. However, IRR23 also concluded that the "transition into a multipolar, fragmented and contested world has happened more quickly and definitively than anticipated." Whilst IRR23 established a revised strategic framework, it was left to a new Defence Command Paper (DCP23) to provide details of how the capabilities of the British Armed Forces would be altered to reflect the new environment. Entitled Defence's response to a more contested and volatile world, DCP23 was published on 18 July 2023. Widely anticipated to set out the equipment and personnel changes that would be required to address the acceleration of the threats identified in IRR2023, the new document ultimately offers very little in this regard.

Credit: UK MoD

The aircraft carrier HMS Prince of Wales departs Portsmouth Harbour in August 2022. Constrained by financial realities, the 2023 British Defence Command Paper focuses more on how existing equipment and personnel can best be used rather than new equipment or force structures.

Author

Conrad Waters is Editor of Seaforth World Naval Review, Joint Editor-in-Chief of Maritime Defence Monitor and a regular contributor to other Mittler Report publications.

Restricted by Resources

DCP23 explains its lack of commitment to any new equipment on the basis that this is a deliberate choice fostered by the fact that the decisions on procurement taken during the previous 2021 security review had stood the test of time. This assertion seems disingenuous. Instead, the real basis is more likely a lack of sufficient financial resources to fund significant new acquisitions. The British Ministry of Defence (MoD) has received modest increases to its funding since the start of the Ukrainian War. This has sustained existing procurement programmes, advanced investment in infrastructure in the nuclear sector to support the AUKUS submarine programme, and helped replenish diminished stocks of munitions. However, the overall defence budget has failed to receive the material uplift to its finances envisaged, for example, by Germany's 'Zeitenwende' or even France's newly-approved military programming law. Whilst more money is planned once economic circumstances allow, this hardly seems an appropriately urgent response to IRR23's identification of an accelerating decline in the threat environment.

In addition to providing nothing new in the way of acquisition programmes, DCP23 is also disappointing in the lack of information provided in terms of future force structure. This is presumably also largely on the basis that the 2021 plans remain appropri-

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ate to the changed circumstances despite ongoing questions about reductions to the size of the British Army at the time of a major European land war. However, the document follows a disconcerting tend in recent British defence documents in being long on the latest 'buzz-words' and full of aspirational rhetoric but short on actual detail of the means that will be employed to achieve their ends. For example, DCP 2023 announces the formation of a Global Response Force; an all-domain task force bringing together deployed and high-readiness forces. However, nothing is said about its size, structure or the capabilities it will provide. Similarly, emphasis is given to a Strategic Reserve built around former regular personnel to generate surge capacity and provide expertise in times of crisis. Unfortunately, little is revealed of what is actually envisaged. Throughout the document, it is only rarely that the occasional hard fact is allowed to penetrate the fog of official imprecision and ambiguity.

Credit: UK MoD

A Mission Master AUGV (Armed Unmanned Ground Vehicle), seen during a demonstration at Lulworth Range in the United Kingdom. Predictably, the Defence Command Paper maintains an emphasis on the use of new technology to respond to a deteriorating security background.

Steps in the Right Direction

Despite – and possibly even because of these reservations – there is much to commend DCP23. In essence, the lack of new funding means that the document is heavily driven by the need to make the most of existing resources and do more with what is already in hand. Given that DCP23 was published in the same week as a parliamentary report highlighting ongoing inefficiency and waste in British defence procurement, this emphasis is certainly timely. More specifically, the new strategy focuses on enhancements to four key areas to secure and maintain strategic advantage.

Credit: UK MoD

Training rounds and missiles seen ready for loading into a British Army Apache helicopter. The Defence Command Paper has reallocated funds to accelerate the rebuilding of munitions stockpiles.

- **People:** Reflecting the global challenge to attract the increasingly skilled workforce demanded by a modern military, DCP23 makes several changes to workforce management. Most importantly, a new 'Spectrum of Service' approach will be adopted that reflects the current trend away from lifetime employment with one company or industry towards a 'portfolio' career. Under this new approach, it will be easier for somebody joining the British Armed Forces to zig-zag between employment with the military, civil service and industry, as well as between full-time and part-time roles. Other initiatives include looking at military pay in terms of total reward with an eye to making compensation more compelling and attractive. A GBP 400 M (EUR 460M) reallocation of resources to improve service housing is one tangible reflection of this policy. Human resources systems will also be modernised with digital technology to make them more effective.
- **Innovation and Technology:** Perhaps unsurprisingly, DCP23 places science, innovation and technology at the heart of defence modernisation. There is an emphasis on aligning MoD efforts in these areas with wider governmental science and technology goals, with artificial intelligence (AI), engineering biology, future telecommunications, semiconductors and quantum technologies

all listed as priorities for investment. However, the GBP 6.6 Bn (EUR 7.6 Bn) allocated to research and development had already been announced previously. There will only be so much that can be done to accelerate work in this field in the absence of new money.

- **The Relationship with Industry:** DCP23 implicity recognises that the MoD's relationship with the defence sector has not always been optimal by making this a revived area of focus. It is acknowledged that previous acquisition programmes have often taken too long to deliver required capabilities, partly due to over-specification. As such, there will be greater emphasis on buying simpler platforms that can be delivered quickly and then subsequently upgraded as the need arises. The progress achieved with implementing the UK's National Shipbuilding Strategy is held up as a prime example of the approach the MoD would like to adopt. Within this, the Type 31 frigate acquisition (see article elsewhere in this edition of ESD) is seen as a programme that has produced a platform that is modular by design which thus makes spiral development and adaptation simpler and quicker.
- **Departmental Reform:** Concluding that "ruthless" productivity gains will be required to meet the rapidly changing threat, DCP23 aims to drive a process of cultural and organisational change away from a peacetime mentality, to create a leaner and more effective MoD. The strategy cites the removal of unnecessary layers of bureaucracy that are no longer fit for purpose and work to modernise the function of the MoD's head office as examples of progress that has already been achieved. Whilst a cynic might point to the distinctly mixed legacy of previous attempts to improve MoD efficiency, renewed efforts in this direction are welcome.

Operationally, these much-needed enhancements are supplemented by a focus on deterrence through warfighting capability, with a welcome emphasis on frequently ignored but vital areas such as logistics and resilience being particularly marked. The recent focus on replenishing 'hollowed-out' supplies of munitions that has been given impetus by the Ukraine War is reflected in the reallocation of an additional GBP 2.5 bn (EUR 2.9 bn) over the decade to advance work in this area.

Conclusion

All-in-all, the new Defence Command Paper seeks to make a virtue of necessity. Faced with a deteriorating security situation but a lack of appreciable new funding, DCP23 attempts to implement a programme of reforms and reprioritisation to make the most of the resources that are already available. If these meet with a measure of success, the British MoD will be much better placed to utilise the improvement in its funding that has been promised once the economic backdrop is more favourable. This outcome is, however, uncertain. The pending departure of respected British Defence Secretary Ben Wallace, who announced he would be standing down shortly before the report's publication, is a further complication that does not engender confidence. [Editor's note: Ben Wallace stepped down from his position on 31 August 2023. He was replaced by Grant Schapps]

A more fundamental problem with DCP23 is the contradiction between the acknowledged rapidity with which the level of threat is evolving and the delay to additional resources. The new approach is essentially a gamble that the security situation will not further deteriorate before more concrete enhancements are forthcoming. ■

How 'Special' is this Relationship? The USA and the UK

Dan Kaszeta

There is over a century of broad amity between the United States and the United Kingdom. The defence and security alliance between the United States and the United Kingdom is, indeed, a special one. Americans and Britons fought alongside each other in two world wars, Korea, and several conflicts in the Middle East. Both were pillars of NATO throughout the Cold War.

Some of the most prominent and significant US-UK defence and security relationships have been daily routine for decades and thus not often the source of headlines or controversy. One of these is basing. The United States has had military bases on British soil since 1942. Although the size and scope of these bases is reduced since the height of the Cold War, significant US air base infrastructure continues to exist in the UK. Approximately ten thousand US military personnel, as well as significant numbers of contractors and civilian employees, are based in the UK.

Sensitive Issues

Two of the deepest relationships between the US and UK are in more sensitive areas. The USA and UK have worked together in the area of nuclear weapons technology since collaboration on the Manhattan Project. After the war, Britain set up its own nuclear weapons programme, but by the late 1950s British and American scientists and engineers were working closely once again. There is a comprehensive agreement, dating from 1958, on nuclear weapon technology. It has been periodically revised, amended, and extended. While cooperation in this area is very close, the exact details are highly sensitive. Figures from some years ago indicate thousands of person-days in visits by UK persons to US sites and activities relevant to nuclear weapons programmes. Political and economic questions about the future of the UK nuclear deterrent, which at present is the venerable Trident programme, will have a direct bearing on this cooperation.

Credit: US ANG/Senior Airman Wesley Jones

The sun rises over a KC-135 Stratotanker, 117th Air Refueling Wing, as crew members conduct a pre-flight meeting at RAF Mildenhall, UK 24 August 2016.

Another area of close cooperation is the 'Five Eyes' agreement. Dating originally from US-UK cooperation in intelligence collection in World War II, Five Eyes is an intelligence alliance. The original US-UK agreement expanded to include Canada, Australia, and New Zealand. While each country has things that they do not share, there is widespread liaison as well as sharing of raw and finished intelligence. The exact details of this cooperation are, understandably, shrouded in secrecy. Numerous sources, speaking off the record, attest that the overall relationship is very good both at the headquarters level and at operational levels. It should be noted that there are numerous other agreements in a number of somewhat less highly sensitive areas, such as chemical and biological defence, with decades of history of technical cooperation along those lines.

Cooperation extends down to the lower levels. Across the various branches of the military, relationships between US and UK counterparts are good. Forces train with each other, both in the US and UK, but also in joint exercises with NATO and elsewhere. By all accounts, the relationships at service and unit level are good. Numerous liaison and exchange officers serve in various roles in each other's country, at various levels. A general air of professional respect exists and serves as a weighty buffer against frictions. Jokes about being divided by a common language aside, a common language helps significantly.

Current Collaborative Efforts

All of those areas of cooperation have been running in the background for decades. New issues come up, and some of them are things that really do require some coordination. Ukraine is obviously the big story

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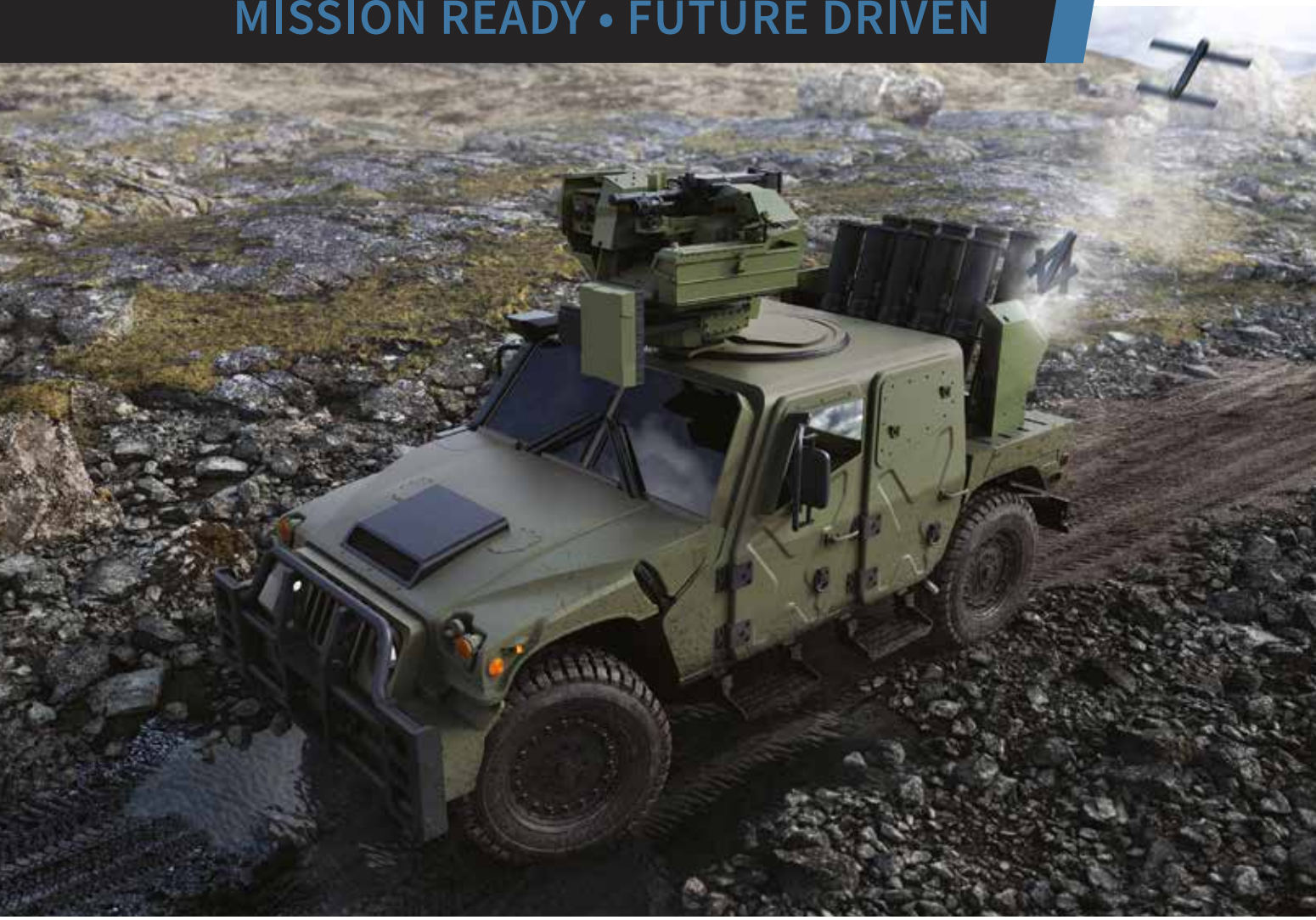

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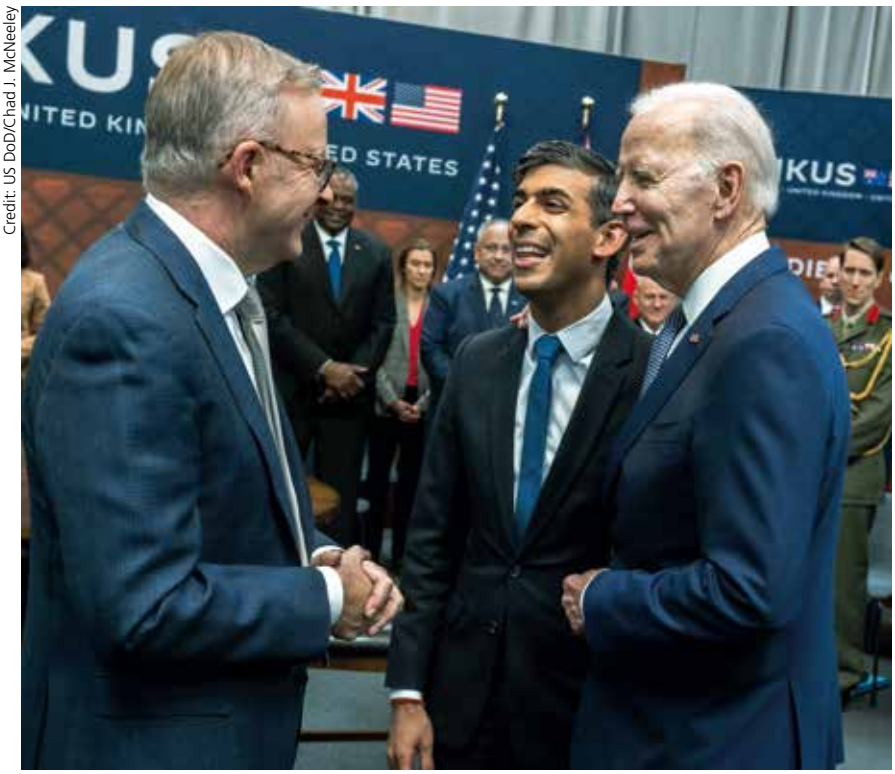
Credit: USAF/Staff Sgt. Gaspar Cortez

A US Air Force F-35A Lightning II assigned to the 495th Fighter Squadron takes off from RAF Lakenheath, UK, while participating in cross-servicing on 21 March 2023.

of the day. The US and UK are working closely on arming and supplying Ukraine in its existential struggle. This is not merely a bilateral effort, but a multi-lateral one in which both the US and UK are leading by example. The extent of unilateral versus bilateral versus multilateral efforts is hard to unpack at present, and likely to be a useful subject for future discussion.

The F-35 fighter programme, which has been analysed in this magazine numerous times, is an emblematic example of US-UK cooperation. An American advanced fighter jet programme which has been in development for decades, the F-35 has entered or will be entering service in a number of countries, including the UK. Lockheed Martin is the prime contractor, but like any such intricate item, it has a complex array of subcontractors and a complicated supply chain of components. The UK is foremost on the list of F-35 components from non-US suppliers. The F-35 includes an ejection seat from Martin-Baker, a refuelling probe from Cobham, and tail components from BAE Systems. According to Lockheed Martin's own releases, it claims to have over 100 UK firms in its supply chain for this new fighter. Thousands of UK jobs are supported by this large procurement effort. The F-35B is in service in the UK and USAF F-35As are being based at RAF Lakenheath in increasing numbers. While the F-35 is by no means the only major procurement project with US and UK involvement, but it is one of the biggest.

Credit: US DoD/Chad J. McNeeley



President Joe Biden greets British Prime Minister Rishi Sunak and Australian Prime Minister Anthony Albanese at the AUKUS trilateral meeting in San Diego, California, on 13 March 2023.

The other major ongoing collaboration that gets much attention is the new 'AUKUS' trilateral security agreement between Australia, the UK, and the USA. Although all partners have various forms of longstanding bilateral and multilateral security cooperation agreements already, AUKUS represents a regeneration and repackaging into a trilateral arrangement. It does not involve intelligence collection and sharing, as this is already covered by the long-standing Five Eyes agreement. AUKUS also demonstrates a resolve by its members to confront the geopolitical threat posed by China. For the US, which has always had a security focus in the region, it is a modest readjustment of resources and intent. For the UK, it's a reassertion of interest in a region where British interests have long been a tertiary concern. The most prominent component of AUKUS is the Australian attack submarine pro-

gramme, which was analysed in detail in this magazine in April 2023. The US and UK will share sensitive nuclear propulsion technology with the Australians, allowing Australia to field submarines with much longer endurance. The ability of Australia to project power in the Western Pacific and Indian Ocean region is currently hampered by the operational radius and endurance of Australia's existing diesel submarine fleet. In the near-term, Australia will purchase Virginia-class submarines from the US. Longer-term, the Australians will work with Britain to develop a new Australian SSN based on existing British designs. It should be noted that this submarine plan has seriously discomfited the French as the AUKUS agreement brought Australian cancellation of an earlier submarine deal with France.

The submarine deal and the concomitant political drama with France have taken the lion's share of the publicity with the AUKUS agreement. However, there are other components in this agreement that might yield promising developments. The agreement promotes cooperation in cybersecurity, artificial intelligence, quantum technology, and autonomy. Developments or breakthroughs in any of these areas could be significant. Another plank of the AUKUS agreement includes work on hypersonic systems. This is an area with ongoing US-Australian work in the form of the SCIFiRE cruise missile programme. Perhaps this is a portent of British entry into that project, or at least some comparable British benefit.

Credit: BAE Systems

Artist's impression of the SSN(R) design, the basis for the SSN-AUKUS.

Money Matters: Procurement

Like many long-standing relationships, issues involving money can be the most tendentious. Britain's tendency to underinvest in defence annoys many in Washington. This correspondent can almost guarantee that, if his old Pentagon building pass was re-instated, it would not take long to hear some quiet grumbling. The murmuring would be about the UK not investing enough in defence and letting its capabilities atrophy. There will be much lament about Britain being very respectable and having high quality forces, just not enough of them to make much difference in many conflict situations. Britain spends less on defence as a percentage of GDP, than the USA – as do many NATO allies. Fairer 'burden sharing' has been, and likely will be, a permanent talking point from Washington.

Some of this criticism is honest and fair, as Britain has, objectively, less warfighting capacity in many areas than previous years. Its capabilities and capacity have shrunk in many ways, and the Pentagon is right to worry about that. Yet some of this is also economic angst. The subtext below concerns for defence often has a component of "the UK needs to spend more and more of what they spend needs to come to US companies." Few will say that quiet part out loud. The US wants the UK as a market for its defence sector. The UK wants the US as a market for its industry as well. Defence procurement makes for both competition and cooperation. The major manufacturers and contractors have significant footprints in the other country. Some percentage of the US defence budget will support jobs in the UK and vice versa. However, with the perennial weakness of the UK's overall economy, one suspects that this burden-sharing issue will not go away any time soon.

The symbiotic relationship could be made smoother. A recent House of Commons Defence Committee report on 13 June 2023 spelled out the UK concerns in uncharacteristically blunt words. "Regulatory and bureaucratic constraints provide significant barriers to our ability to collab-

Credit: USMC/Lance Cpl. Tyler W. Stewart

US Marine Corps Sgt. Nathaniel E. Knipp (left) speaks with Royal Artillery Battery Sgt. Maj. Dan M. Parker, during helicopter support team (HST) training at Camp Lejeune, North Carolina, on 12 October 2017.

orate bilaterally between the UK and the US, negatively impacting the UK-US defence industrial partnership." It only takes a few hours at a defence trade show before one hears complaints about export control regulations hampering collaboration between American and British governments and companies. Additionally, protectionist policies make it far easier for the US government to procure items made in the USA. Numerous UK firms have had to open America-based subsidiaries or joint ventures in order to satisfy Washington's rules and regulations. One example of many is the Smiths Detection factory in Maryland. When the US DOD awarded the Joint Chemical Agent Detector contract to Smiths Detection (UK), Smiths opened a factory in Maryland to mass produce the item and employed many US staff.

Specific Friction Points

The US-UK defence and security relationship, while broadly solid, does occasionally have a few cracks showing at the edges. While none are existential threats, various issues do come up from time to time. These can be likened to the occasional spats of an old married couple who, at the end of the day, still love each other but just now and then drive each other nuts.

One generic area of friction that does come up from time to time in UK commentary is periodic sourness over the 'Special Relationship' being less special in Washington than in London. Sometimes London gets overly anxious, to the point of being just a bit sensitive to a sometimes-insensitive American partner. More than once, officials from Washington have used words like 'special relationship' in public appearances with officials in places like Japan, South Korea, Canada, France, Poland, Mexico, and Ireland. This is a matter of semantics and diplomacy, but given how much UK politics appears to be driven by newspaper headlines, the slightest lack of calibration of a remark has been known to cause trouble.

Two interrelated issues that occasionally rear their heads and intrude into the US-UK relationship are Brexit and Northern Ireland. Britain's exit from the European Union has caused many problems and reaped few benefits. The Brexit spill-over into Anglo-American relations has not yet been fully measured, nor have the defence and security ramifications emerged in full. However, the informal consensus in Washington may be leaning towards the notion that Brexit was a poor idea in both conception and execution. It may eventually make the UK a less compelling base for the European or EMEA outposts of American corporations. Brexit will continue to harm the UK economy and has likely reduced the ability of the UK to buy US defence goods, both through budgetary contraction from the weakened overall economy, and from a loss of buying power through a decline in the value of Sterling.

Northern Ireland is intricately intertwined with both the Brexit issue and the United States. America worked hard to achieve the Good Friday Agreement. This effort was rightly seen as a great foreign policy achievement and the USA often views itself as a guarantor of the agreement. There are millions of Irish Americans, and their views and votes are not inconsequential in US elections. On the other hand, the UK's land border with the EU is in Northern Ireland. Trying to manage Brexit, Northern Irish political dynamics, and the land border issues, while not breaking the Good Friday Agreement has been a very difficult task. Adding the American dynamic into it only makes it harder. Current rhetoric about the UK government wanting to exit from the European Convention on Human Rights (ECHR) will further complicate affairs. The Good Friday Agreement requires ECHR membership in Northern Ireland and the UK cannot have one part of the country under the ECHR and one part not under it. This would be an obvious point made by American diplomats and politicians.

The Future

Whatever cracks exist in the US-UK relationship, we must remember that they would be cracks in a fundamentally solid foundation. The US-UK 'special relationship' has weathered challenges in the past and will endure future challenges. Nothing we have seen so far is an actual threat to the underlying relationship, which has been good far more than it has been troubled. Furthermore, current and future projects such as F-35 and AUKUS will combine with daily cooperation on more routine matters to buoy the 'special relationship' through most problems.

Coordinating Naval Programmes in Europe

Guilia Tilenni

The War in Ukraine and a general increase in military spending is pushing several countries to modernise their ageing naval fleets, thus boosting the order books of shipyards after years of negative outlook. If this is good news, the situation remains complicated within the EU, where shipbuilders' economic outlook is less prosperous compared with Asian and US competitors, and coordinated programmes often struggle to kick off.

In a study published in 2020, the EU Institute for Security Studies (EUISS) noted that between 1999 and 2018, EU navies lost more than 30% of their frigates and destroyers and more that 20% of their submarines. Surprisingly, these significant reductions came at a time when navies were increasingly called to action. Tensions in the Mediterranean, Black and Baltic Seas, exacerbated by the war in Ukraine, coupled with the "intense geopolitical competition" taking place in the Indo-Pacific region and around the key maritime chokepoints all represent crucial threats to EU security. More than 70% of the EU's external borders are maritime and combined, its member states form the largest exclusive economic zone in the world. Maritime communication lines remain crucial for trade and oil and gas supply, and undersea cables account for 99% of global data transmissions.

By 2025, EU countries are expected to spend EUR 55.5 Bn on maritime technologies. However, official EU documents report that less than 20% of investments in defence programmes are coordinated among its member states. In the absence of a common foreign policy agenda, cooperation is pursued only when the political objectives and operational requirements of two or more EU countries converge.

Moreover, several of the most important member states in military terms have national shipyards they can be relied upon to modernise their respective fleets: Fincantieri for Rome, Naval Group for Paris, Navantia for Madrid, Lürssen and ThyssenKrupp Marine Systems for Berlin, Saab for Stockholm, and Damen for Amsterdam. Most of these are first-class system integrators, with a strong positioning on the global market.

Credit: US Navy/Petty Officer 3rd Class Ezekiel Duran

An Arleigh Burke class guided-missile destroyer USS Forrest Sherman (DDG 98) conducts a replenishment-at-sea with Italian Navy Vulcano class logistics support ship ITS Vulcano (A5335). The LSS is a cooperative programme between France and Italy.

So far, EU member states have fought to keep each of these national champions alive, often for electoral or national security considerations (keeping occupation levels unchanged, maintaining national know-how, etc.). On paper, each member state has officially identified collaboration as an interesting opportunity in industrial, economic, and strategic terms. Indeed, joint programmes help in reducing costs and increasing interoperability. Yet in practice, EU members have largely rejected calls for EU-wide cooperation coming from the European Commission or the European Parliament.

On the one hand, they act in this way to protect their respective national companies. On the other, they have done so because joint projects led by consortia have often proved ineffective so far. As a result of a compromise among several member states, common programmes are often a sub-optimal solution in terms of operational requirements. Their management might be complicated due to the high number of relevant stakeholders, resulting in products delivered behind schedule, and sometimes no longer consistent with the initial needs and scope. Cooperation in the naval sector therefore remains mainly bilateral or multinational, and limited to specific programmes.

For their part, shipyards are generally not attracted by joint development programmes, as a significant part of their backlog originates from export, following tenders in which they often compete with other European producers. And in some cases, export opportunities can be found in the EU countries that do not

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Credit: Italian Navy

Italian Navy FREMM frigate ITS Carlo Margottini (F 592) during Exercise Formidable Shield 2023. FREMM vessels are one example of bilateral cooperation under the OCCAR umbrella.

have the know-how needed to build up their own fleet.

As with other defence-related industrial segments, a multiplicity of producers and systems has been the preferred choice so far. However, the evolving situation of the global naval market requires a new approach. The World Defence Shipbuilding 2022 report confirms that East Asian countries, in particular China, Japan and South Korea have joined the club of the largest producers of military vessels. Even though they remain significant on the global market if considered in aggregate terms, EU shipyards are lagging behind. In the short- to mid-term, they will lose much of their competitiveness on the global market, and their aggregation might become the only solution to survive mounting international competition. For the time being, companies and states are simply trying to maintain the status quo, and aggregation is not on the agenda. Indeed, aggregation would mean a sacrifice for each shipyard, as it would require profound changes in their structure, with consequent job losses.

In the coming years, EU countries will have to redefine the structure of their shipyards. Focusing on enhancing the position of the whole European shipyard sector rather than the positioning of each shipyard would probably be the most effective solution. However, such a shift is almost impossible without a rapprochement of foreign policy agendas, which currently seems unlikely. Again, member states officially agree that a broader integration of the European defence-industrial base is crucial to maintaining the bloc's independence, as all the EU strategic documents on the matter stress. Maintaining the status quo will likely bring about a loss of strategic autonomy, as foreign buyers might put the survival of European shipyards at risk.

Shifting from the multiplication of national naval programmes to an EU-wide coordination of naval programmes might be a first step to reconfigure EU shipyards and to work on shaping the future functioning of the European market. Numerous EU tools might help in this shift and, as will be further analysed, some forms of coordination are already emerging.

Coordinating Naval Programmes at EU Level

To help EU member states fill their capability gaps and encourage them to favour EU solutions to off-the-shelf purchases abroad, the EU is trying to revamp a range of management and financial tools that have barely been exploited so far. The Coordinated Annual Defence Review on Defence (CARD) is intended to support member states in the identification of common capability gaps and, consequently, of potential cooperative programmes that might be developed jointly by using EU tools. The Permanent Structured Cooperation (PESCO) provides a framework and a structured process to gradually deepen cooperation starting from the most sought after missions, according to CARD reports. The European Defence Fund (EDF) plans to pledge EUR 8 Bn for defence projects between 2021 and 2027 with funds allocated to the programmes selected through an annual call for proposals. The relevant topics, which include naval combat and underwater warfare, are identified according to existing PESCO programmes and the priorities identified in the CARD and in the Capability Development Plan (CDP) outlined by the European Defence Agency (EDA).

Concerning the coordination of programmes, member states have the option of entrusting the Organisation Conjointe de Coopération en matière d'ARmement (OCCAR) with facilitating and managing cooperative armament programmes through their life cycle. OCCAR's portfolio currently includes 17 major armament projects, five of which concern naval vessels, with different configurations and objectives.

Among these, the FREMM programme was launched in 2005 for the construction of 18 multi-mission frigates. Italy and France remain the only participants, and the vessels produced within the programme are slightly different in terms of equipment. Similarly, the LSS (Logistic Support Ship) programme is another Franco-Italian collaboration producing substantially different ships. Another notable example is the Maritime Mine Counter Measures (MMCM) programme, under which France and the UK aim to equip their navies with autonomous mine hunting capabilities by 2024.

Despite being integrated into a more European framework, these programmes are managed with a standard structure, which sees the collaboration of two states and the relevant national companies. In recent years, however, an interesting example of coordination has emerged in the European landscape.

Naviris: A New Approach for Coordinating Naval Programmes?

In 2019, Italian company Fincantieri and the French Naval Group negotiated the acquisition of Chantiers de l'Atlantique (a shipyard located in Saint Nazaire, France) and decided to establish a 50/50 joint venture. The main idea was to combine their respective expertise to launch new programmes and find new export opportunities, thereby somehow trends that were emerging in the global market.

Since then, Naviris has been involved in six R&D projects and has overseen the development of the European Patrol Corvette (EPC). Approved in November 2019 as part of the third batch of PESCO projects, the EPC programme aims to design and developing a shared modular

corvette, with a displacement of under 3,000 tonnes, a maximum draft of 5.5 m and a length no longer than 110 m. The development of a European Patrol Class Surface Ship (EPC2S) is defined as an "EU-wide approach for modular naval platforms adaptable to various sea basins and member states' requirements/ programmes". It was identified as a potential area of cooperation in the 2020 and the 2022 CARD reports. Led by Italy, the programme also involves France, Spain and Greece, and was joined by Romania in June 2023. The EDA supports participants through the development and the adoption of Common Staff Targets (CSTs), Common Staff Requirements (CSRs) and a Business Case (BC). The first prototype is scheduled for 2026-2027.

In December 2021, Fincantieri, Naval Group, Naviris and Navantia submitted an industrial offer for the Multirole and Modular Patrol Corvette (MMPC) call opened within the European Defence Fund's framework to support the development of the EPC programme. In July 2022, Naviris was officially appointed as prime contractor for the consortium, and was joined by Greece, Denmark and Norway. This grant is valued at EUR 60 M and involves a 24 month initial development phase dedicated to technological building blocks for military units and the initial study for a joint project, which does not include a combat system, at least for the time being. As of June 2023, the partner countries were still finalising the Memorandum of Understanding, and the programme was expected to start in the autumn. In March 2023, the European Commission issued a second call for tenders dedicated to the completion of the original design and details of the MMPC, which may end with the creation of prototypes of the platform. The funding for this second call amounts to EUR 714 M. A Naviris source told the author that the exact list of participants to this second call, whose deadline expires in November 2023, is still to be defined, and will likely include only the nations that plan to produce and procure the vessels at the end of the study.

Credit Courtesy of Naviris

The EPC programme focusses on the creation of a modular platform, likely to be modified according to the needs of each country.

Between 2020 and 2022, Naviris has been prime contractor of a feasibility/de-risking study for the modernisation of the Horizon class destroyers in service with France and Italy, jointly developed between 2000 and 2010 by Fincantieri and Naval Group. Following the signing of a Memorandum of Understanding during the 2023 Paris Air Show, the joint venture was officially selected for the Mid-Life Upgrade (MLU) of the platform and its combat systems, while co-contractor Eurosam will work on the modernisation of air defence systems. According to sources in Naviris and Fincantieri, the joint venture can be considered a success story so far, with the EPC programme progressing on schedule for the time being.

Is Coordination Enough to Solve Market Fragmentation?

Most official EU documents argue that coordination in the naval sector is crucial to protect EU interests. The need for "effectively and comprehensively" assessing security challenges at sea and responding to them is so strong that the naval operational environment is the only one with a dedicated EU strategy. First approved in 2014, the EU Maritime Security Strategy (EUMSS) identified cooperation as a good way to develop the "necessary sustainable, interoperable and cost-effective capabilities" required to protect EU interests. In the 'Enhanced EU Maritime Security Strategy for evolving maritime threats' release published on 10 March 2023, the European Commission reiterates the need to step up the EU common response to naval threats by developing a full spectrum of maritime capabilities.

Credit: US Navy/Petty Officer 3rd Class Kenneth Abbate

French destroyer FS Chevalier Paul (D621), belonging to the Horizon class, jointly developed by Naval Group and Fincantieri. The upcoming upgrades will be managed by Naviris.

The EU has committed to develop common requirements for surface and underwater defence technologies, build interoperable unmanned systems and joint test and experimentation exercises to develop future maritime capabilities. It will also increase modern mine countermeasure capabilities and support the development of joint enhanced maritime patrol aircraft capabilities.

When it comes to European defence, the lack of consistent political commitment from member states often ends in lofty announcements followed by insufficient action, or, more often, simply remaining on paper, despite the official commitments undertaken by EU governments when signing official documents. As regards shipyards, at a time when China is deciding on mergers to create a few big players in the market, mergers are no longer on the agenda in Europe, with competition between shipyards remaining the norm in recent years.

The relationship between Naval Group and Fincantieri is an interesting example. In February 2018, the French L'Agence des participations de l'État (APE) and Fincantieri Europe signed a share purchase agreement for STX France, supposed to mark the last step of a year-long acquisition dispute around St.Nazaire's Chantiers de l'Atlantique. According to the preliminary agreement, the Italian group was expected to purchase a 66.6% share of STX France for EUR 79.5 M. However, the French state (a 33.3% shareholder of STX France with pre-emption rights on the remaining shares) opposed the agreement for several reasons, including job preservation, maintaining local production, and avoiding a technology drain abroad. Worried about Fincantieri's operations outside Italy (mainly in the US), France finally offered the company a 51% share of STX France. Following Fincantieri's refusal, Paris decided to purchase the remaining STX France shares, thus becoming the 100% shareholder. After several years of negotiations, Rome and Paris officially announced the termination of Fincantieri's acquisition programme in January 2021, officially due to the economic consequences of the COVID-19 pandemic.

The ties between these two shipyards highlight the current distortions of the EU naval industry: they share a 50/50 joint venture and work together on some EU-wide programmes, but remain competitors in some tenders, such as the one for the corvettes in Greece (one of their EPC partners). In the meantime, Fincantieri is also one of Naval Group's subcontractors for some joint projects, a rare case in which the company supplies something to another EU country that has a primary role in shipbuilding, a Fincantieri source told the author. The same source also recalled that all the main European countries have their own shipbuilding capacities, which makes them "self-producers". In other words, this means that the respective national Navy is the main reference customer for each of these companies.

As EU nations do not seem particularly committed to finding viable and long-lasting solutions to the problems affecting shipyards, a solution might come from the shipyards themselves. Indeed, they might use their experience and lessons learned to suggest how the EU naval market can evolve. In his intervention during the first Euronaval talks in June 2023, Davide Cucino, head of European Union Affairs at Fincantieri and Chairman of SEA Naval, noted that a stronger collaboration among European shipyards and between shipyards and users is crucial to find the best balance between a complex industrial development, characterised by long life cycles in a changing security environment, and limited budgets. SEA Naval is a permanent working group established within the Shipyards' & Maritime Equipment Association (SEA Europe), which advocates for European shipyards' priorities. The idea is to support EU institutions and members states by providing an industrial point of view and expressing their needs when it comes to EU programmes and the European Defence Fund. It includes 90% of naval systems integrators and shipyards in Europe, namely Damen, Fincantieri, NVL, Naval Group, Navantia, Saab, and thyssenkrupp Marine Systems. Three industry associations Assonave (Italy), GICAN (France) and VSM (Germany) are also part of the working group.

So far, the EPC programme seems a good starting point towards stronger cooperation at the European level, and Naviris is proving effective regarding programme coordination, with projects progressing on schedule. According to the interviewed industry sources, Naviris might go beyond the coordination of a couple of joint naval programmes, paving the way to a transition towards a more integrated sector. In fact, this is one of the reasons the joint venture has been established. "Confronted with similar market challenges on both sides of the Alps, Fincantieri and Naval Group are pooling a portion of their strengths to jointly develop new synergies and retain their leadership position. Building our sovereignty and controlling our future is tantamount to reinforcing our autonomy", the Naviris' website states.

Despite the fact that the direction to take and results to be achieved are yet to be defined, a profound transformation of the EU naval market might be the only solution that European countries possess in order to maintain their strategic autonomy and avoid buybacks from non-EU companies. This is particularly important given that competitors are continuing to grab market share, and the capability shortages triggered by the War in Ukraine might divert attention away from naval programmes, potentially risking the progress made to date. ■

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The Time for Comprehensive Changes has Come

Dr Nenad Miloradović

History teaches us that all militaries, even the strongest and the most modern ones, almost as a rule, are preparing for 'the previous war'. Experiences from the current war in Ukraine are showing that military conflict on European soil between peer competitors is fought on completely different principles than those predicted and prepared for in more than half of a century.

As a case in point, we don't see large-scale 'combined arms' manoeuvre thrusts (not even on a battalion level), even though the terrain is favourable, a large volume of appropriate equipment is available (armoured fighting vehicles, combat helicopters, self-propelled artillery, breaching equipment, etc.) and multi-decade doctrinal and training preparations have been performed for such operations on both sides. Also we don't see the strategic impact of 'airpower' deciding the outcome of the war, not even deciding the outcome of current operations. We do see the relevance of 'revamped' artillery, which is increasingly capable of delivering long range precision strikes with smart ammunition, which is operating in the unprecedented level of 'battlefield transparency'. Alongside this, we see the importance of dismounted infantry with portable anti-tank/air defence weapons, as well as the effectiveness of EW and AD systems.

In general, we can state that defensive weapons and tactics are, in this war, far superior to the offensive ones, hence we are witnessing the WWI style 'meat grinder' static operations lasting for eighteen months.

Drones are the prevailing phenomena of this war, even commercial ones that are more or less adapted for military purposes, for their capability to influence the battlefield dynamics swiftly and in a very cost-effective manner. They have also shown themselves capable of overcoming the opponent's advantage with much more expensive weapons, which are much more difficult to produce and deliver to the warfighters in relevant timescales. With their usage en masse, they have provided the aforementioned battlefield transparency (much greater situational awareness at the lowest tactical level). Used as loitering munitions they have greatly limited freedom of 'armoured manoeuvre'. They have also managed to stress the opponent's territorial air defence and inflict damage on their infrastructure, on par with much more expensive cruse and ballistic missiles or air-launched guided weapons. Naval unmanned surface vehicles (USVs) have managed to produce similar blockading effects on an opponent's shipping routes and greatly limit freedom of manoeuvre of far superior naval forces. One can only imagine what impact on the future battlefield will be dealt by drone swarms and combined human-machine teamed armies which are currently being planned and/or developed in most modern militaries. Therefore, both soft- and hard-kill countermeasures and effectors against this threat have become mandatory and urgently needed.

Credit: Serbian MoD

Dr Nenad Miloradović, Serbia's Assistant Minister of Defence for Materiel Resources

The time for comprehensive changes in the doctrine and strategy of modern warfare has come, as well as for changes in the structure and organisation of both combat units and the administrative bureaucratic portion of national defence systems dealing with procurement and development. The latter should follow the rapid pace of innovation seen in the commercial industry sector.

Ministry of Defence of the Republic of Serbia is actively following current global trends in development of armament and defence equipment as well as drawing lessons from contemporary armed conflicts around the world, and plans the development of the Serbian Armed Forces (SAF). Accordingly, the Serbian military-industrial complex has 180 years of experience in industrial armament production and great

Author

Dr Nenad Miloradović is Serbia's Assistant Minister of Defence for Materiel Resources

Credit: Serbian MoD

The 'Osica' loitering munition.

technological potential, and supplies SAF and partners all over the world. It is directed to transform and increase its capabilities in identified key future technologies needed for equipping modern armed forces, especially in the fields of unmanned platforms, long-range artillery, new generation and smart ammunition, air defence systems, armoured vehicles and soldier technologies.

Changes in Military Affairs as Result of the Fourth Industrial Revolution (4IR)

The new possibilities for military purposes created by the 4IR has the potential and tendency to change the philosophy of combat operations, from the existing doctrines of each service branch of the armed forces, to the strategy and the usage of armed formations in war. Unmanned combat platforms are greatly increasing the operational capabilities of modern armed forces, and nowadays, they are one of the main force multipliers, providing collaborative human-machine capabilities to combined arms operations. They are capable of being integrated into units equipped with manned combat platforms and supported by command and control (C2) and battle management systems (BMSs) of the new generation based on artificial intelligence. Such a combination enables the user to combine the sensor potential, reaction speed and lethality of robotic systems with the cognitive capabilities of soldiers in manned platforms. Under this model, the level of force protection is significantly improved, as is situational awareness, and the quality and speed of decision-making by commanders. Such accelerated combat dynamics will radically change and reshape combat philosophies in the near future. Therefore, it is necessary to take a holistic approach and develop robotic platforms and in parallel with the related doctrines of their usage, and most importantly, the structure of the forces that use them. A lot of experimentation will be required before we reach the optimal solution.

Future Serbian Armed Forces Capability Development

The Serbian Armed Forces have been equipped with various ground and airborne unmanned platforms for many years. They were developed and procured at the request of individual branches of the armed forces. They have been developed domestically, produced in cooperation with foreign partners, or acquired as finished products from the foreign suppliers. To successfully reap the benefits of the 4IR in the armed forces, we need a comprehensive approach to equip all branches of the Serbian Armed Forces with mass quantities of unmanned platforms.

Special attention should be paid to the transition from remotely operated to fully robotic platforms. In this way, the emphasis will be on development and procurement of new unmanned platforms with greater autonomy based on artificial intelligence, but also through the spiral development of systems that have already been introduced into service without the aforementioned functions, in order to expand their autonomous capabilities. We emphasise that fielding and operating alongside robotic combat platforms is significantly more complex than usage of purely reconnaissance robotic platforms, but combat platforms contribute much more to overall operational capability, due to their ability to perform a wider range of tasks.

Conclusion

Today, the pace of changes makes a clear distinction between 'small' and 'big' players, that is, between those who are only able to use the results of 4IR technological breakthroughs, and those who develop these breakthroughs. We predict that even small (in terms of territory, population, economic strength, etc.) countries that can manage to keep pace with the development, production of unmanned and fully autonomous combat platforms, and integrate them into their combat units, will be in a position to elevate the capability and competence of its armed forces to ensure necessary levels of deterrence to ensure security and independence. Only time will tell if this prediction holds water.

Today, Serbia's military and industry has significantly increased its capabilities in the aforementioned areas, and has reached further than many of the larger and more developed European countries, especially in terms of the development/procurement and operational use of both aerial and ground unmanned platforms. Serbia's primary effort in the near future will be focus on increasing the quantity, level of autonomy and firepower of new-generation unmanned platforms, along with their wider integration into the lowest tactical level combat units, together with new or modernised manned combat platforms, supported by new generation, AI-enabled battle management systems.

The Ministry of Defence of Serbia intends to further expand the country's technological base primarily by including more scientific research organisations, technical institutes, and private companies (both Serbian and those from friendly countries) with capabilities in the 4IR sphere, as well as supporting appropriate technologies needed for the development and production of robotic and manned combat platforms.

In the next ten-year period, a huge gap in capabilities will arise between the armed forces that will implement the results of this 'robotic revolution', and those that fail to do so. Consequently, the Republic of Serbia, as a militarily neutral country, must not lag behind. ■

Major Procurements Mask Immediate Equipment Concerns for Canada

David Saw

So far in 2023, Canada has signed up for some major high-value procurement programmes, while working on existing high-value procurements, and is already laying the groundwork for future major procurements.

In terms of high-value procurement programmes, the Royal Canadian Air Force (RCAF) started 2023 with the announcement that it would be purchasing 88 Lockheed Martin F-35A fighters as the replacement for its aged FA-18 fleet. Then in late June, the US Defense Security Cooperation Agency (DSCA) notified Congress of a possible Foreign Military Sale (FMS) of P-8A Aircraft and related equipment to Canada for an estimated cost of USD 5.9 Bn. This programme would cover the supply of up to 16 Boeing P-8A Maritime Patrol Aircraft (MPA) to replace the current RCAF CP-140 Aurora MPA fleet.

The Royal Canadian Navy (RCN) is in the midst of significant modernisation programmes linked to a National Shipbuilding Procurement Strategy (NSPS). One of the first programmes to get underway was the Arctic and Offshore Patrol Ship Project, which saw the acquisition of six Harry DeWolf class offshore patrol vessels, with three units still to be delivered. The key RCN surface warfare programme is the Canadian Surface Combatant (CSC) that will replace the Halifax class frigates as the primary RCN surface warfare asset. The plan is that a total of 15 CSCs be acquired; clearly this is a high-value procurement programme.

As regards the future, the RCN is looking to make progress with another major programme, namely the Canadian Patrol Submarine Project (CPSP) to replace the four Victoria class conventional submarines (SSK) by the mid-2030s. The Victoria class were originally laid down for the British Royal Navy between February 1983 and March 1990 as the Type 2400 Upholder class. With the end of the Cold War, and reductions in British defence spending, it was decided that an SSK capability was unnecessary, and the mission could be undertaken by nuclear boats (SSN). The programme to build more Upholder SSKs was cancelled, and the four existing boats were taken out of service between April and October 1994.

Credit: Canadian Armed Forces

As part of its contribution to the NATO enhanced Forward Presence Group (eFP) in Latvia, Canada has supplied an M777 artillery battery. This image is from a live firing exercise at Camp Ādaži, Latvia, in March 2023.

The idea was to sell the four Upholder vessels to a foreign customer, but that was easier said than done. Meanwhile Canada, which had been flirting with a SSN acquisition to replace its aged Oberon class SSKs, decided to ditch the SSN programme and in 1994 stated that it would negotiate with the British about purchasing the Upholder vessels. It took until April 1998 for the Canadian Government to announce that they were intending to purchase the submarines and eventually a purchase contract was signed in July 1998. The contract included a refit of the SSKs and modifications to meet Canadian requirements.

The SSKs, now renamed as the Victoria class in RCN service, saw three units commissioned between December 2000 and March 2003, with the first becoming operational in June 2005. The final unit, HMCS Chicoutimi (SSK 879), the former HMS Upholder, was on her delivery voyage from Faslane to Canada in October 2004, when a fire broke out aboard. As a result, the SSK returned to Faslane, the damage was assessed, and in April 2005, the SSK was transported to Canada by heavy-lift vessel. Eventually in late April 2009, HMCS Chicoutimi entered refit in Canada, with the work completed in January 2014. After sea trials, the SSK was finally commissioned into the RCN in September 2015.

The RCN CPSP Victoria replacement programme calls for the acquisition of up to 12 new SSKs to be built in Canada. However, there is no real indication that the RCN has been able to persuade the Canadian Government to fully support and fund this acquisition programme at this stage. On the other hand, a programme of this magnitude would certainly fit the intentions of the NSPS and would offer long-term shipbuilding employment and associated economic benefits.

In a Canadian industrial context, preparations are already being made as regards CPSP participation. Babcock Canada, which already has the Victoria class support contract, signed technical cooperation agreements earlier this year with Hanwha

Credit: Canadian Armed Forces

Members of the NATO enhanced Forward Presence Group (eFP) in Latvia from Canada, the Czech Republic and Spain, dig trenches and build bunkers as part of a pioneer course at Camp Ādaži, Latvia, in February 2023.

Ocean and Hyundai Heavy Industries (HHI) from the Republic of Korea (ROK). Both of these ROK shipyards are involved in the construction of the KSS-III, also referred to as the Dosan Ahn Chang-ho class SSKs for the ROK Navy (ROKN). Prior to this, Babcock Canada signed a Memorandum of Understanding (MoU) with the predecessor of Hanwha Ocean in 2020, covering systems integration collaboration on Canadian vessels.

International Involvement

At the 2016 NATO Summit, it was agreed to deploy multinational battalion-sized battle groups to the Baltic States and Poland. Canada was named as the 'Framework Nation' for the NATO enhanced Forward Presence Group (eFP) in Latvia, with the eFP coming under the command of a Canadian Lieutenant Colonel (OF-4). The Latvia eFP was stood up on 19 June 2017 at Ādaži in Latvia, where it works with the Latvian Land Forces Mechanised Brigade. There are some 700 Canadian personnel in the eFP, consisting of a mechanised infantry company, an artillery battery (M777), a combat support company and a combat service support company.

More recently, at the NATO summit in Madrid in June, Canada and Latvia agreed to develop the eFP battle group into a brigade-sized unit. First steps to making that a reality came on 16 June 2023, when Canadian Minister of National Defence Anita Anand announced at the NATO Defence Ministers meeting in Brussels that Canada would deploy 15 Leopard 2 tanks to Latvia as part of the upgrade to a brigade-sized unit.

All of this sounds truly positive, with Canada continuing to modernise its military capabilities through major acquisition programmes for the RCAF and the RCN. Added to this, it is fulfilling its NATO commitments and even increasing its contribution via helping to build the force in Latvia to brigade strength. The problem is that that once you scratch the surface the reality is somewhat different.

The Leopard Issue Emerges

In January 2023, Canada committed to sending Leopard 2A4 tanks from Canadian Forces' stocks to Ukraine. Initially it was just four tanks on offer, then in February another four tanks had been found for a total of eight. According to the Canadian Government: "An initial allotment of 120 mm ammunition, sourced from existing CAF stocks, will be provided as part of this donation. Donor nations are working together to address sustainment and spare parts." The question of sustainment and spare parts is important, as there had been suggestions that there were problems in sourcing viable tanks that could be sent to Ukraine. This then led to some Canadian media sources to try and establish what the actual state of the Canadian tank fleet was. In 2007, Canada purchased 80 surplus Leopard 2A4 tanks from The Netherlands, in addition to purchasing 20 Leopard 2A4 tanks from Germany that would be broken up for spares. Of the 80 ex-Netherlands tanks, 18 would be converted to AEVs, 42 would be used for training and 20 would be upgraded to the Leopard 2A4 CAN configuration. Subsequently Canada would acquire 20 Leopard 2A6 tanks from The Netherlands. According to the official statement from April 2007: "For deployed operations, the Canadian Forces need two combat-ready squadrons of approximately 20 tanks each: one for deployment and a second for rotation into theatre to allow for depot repair and overhaul of the first. An additional two squadrons of 20 tanks each are required for collective and individual training in Canada." This all seemed logical as it gave Canada the tank capability it wanted for Afghanistan, allowed them to replace the Leopard C1 tanks that had been in service for 30 years, and demonstrated that Canada was continuing to commit to its interna-

Credit: Canadian Armed Forces

A Leopard 2A4 from Lord Strathcona's Horse (Royal Canadians) conducts a live fire at Camp Wainright, Alberta, in March 2023. Canada is to send a tank squadron to join the eFP in Latvia. Concerns have been expressed over the state of the Canadian tank fleet.

tional defence obligations. It only became apparent that something was wrong with the picture in 2018, when an article was published by a serving officer studying at the Canadian Forces College. The primary takeaway in the article was the estimate that only 15% to 20% of the Leopard 2 fleet was usable, although that could rise to 30% with some effort.

The cause of this condition, according to the article, was that the maintenance requirements of the Leopard 2 had been massively underestimated. It appears that the maintenance burden estimate was based on experience with the Leopard C1, a significantly simpler vehicle from the earlier Leopard 1 family. Other problems were a shortage of qualified maintenance personnel and the fact that there was no dedicated infrastructure for tank maintenance and overhaul. Then there was a shortage of spare parts to take into account, leading to some tanks being cannibalised for spares.

Another article then appeared from another officer studying at the Canadian Forces College on the subject of tank serviceability in the Canadian Army. The article made it plain that the tank situation had not improved since 2018, with the author describing the cause as a lack of investment in tank sustainment. According to the article, of the 39 tanks supposedly available, only 15 were operational, giving a serviceability rate of around 18% when counted against the entire fleet of 82 tanks.

In 2007, a Canadian tank squadron was described as having 20 tanks, though now the 15 tanks destined for Latvia are described as a squadron. Unless the tank maintenance and serviceability situation in Canada has improved significantly, and there is no real evidence that it has, Canada will be committing all of its functional tank force to Latvia as it will have to rotate the deployment of its two active tank squadrons. All this means they will have to ensure they can have enough available tanks for training in Canada and must accept that they have zero margin for tank deployment to another location internationally.

Meanwhile in Latvia

In early June 2023, some 11 days before Defence Minister Anand announced that Canada would deploy the squadron of 15 Leopard 2 tanks to Latvia, CBC News published an article titled: 'An 'embarrassing' gear shortage has Canadian troops in Latvia buying their own helmets'. The article does stray into to hyperbole at certain points, but it also brings to light some significant issues that impact Canadian Forces in the field in Latvia.

Credit: Canadian Armed Forces

Members of 3rd Battalion, Royal 22nd Regiment, on an urban warfare exercise. Canada wants to replace its existing C7 and C8 weapons with the Canadian Modular Assault Rifle (CMAR), initial deliveries of which are due in 2026/2027. However, funding problems could limit CMAR capabilities.

The CBC article states: "They've been buying their own modern ballistic helmets equipped with built-in hearing protection that doubles as a headset. They've also personally purchased rain gear and vests and belts to carry water and ammunition. And the number of complaints about the ill-fitting body armour issued to female soldiers has been growing." There is no great surprise that Canadian soldiers are purchasing clothing and load-carrying equipment from commercial suppliers, since you can find better quality commercially than the issued equipment. In response to the article, a Department of National Defence spokesperson stated the work was underway to introduce a new helmet, combat clothing, boots and other equipment in the near future.

Personal kit deficiencies are undoubtedly annoying, but there are bigger problems for the Canadians in Latvia. According to CBC: "Canadian troops in Latvia are grappling with more urgent equipment shortages as well. The battlegroup of roughly 1,500 soldiers, including more than 700 Canadians, lacks modern anti-tank weapons, systems to counter drones and a dedicated short-range air defence system."

CBC also got hold of an e-mail from Lieutenant Colonel Jesse van Eijk, the Canadian battle group commander in Latvia, who wrote: "In general, it was concerning, verging on embarrassing to see the differences in issued soldier equipment between us and the Danes. This was only exacerbated by the fact they were carrying more advanced Canadian-made Colt Canada rifles, mounting more advanced Canadian Elcan DR sights."

Canada took the C7 rifle and C8 carbine into service in the 1980s and paired these weapons with the Raytheon Elcan Specter OS (C79) optic. Denmark acquired the C7 as the M/95 and the C8 as the M96, along with the C79 optic in the mid-1990s. Then in 2010, the Danes decided to buy a new rifle, selecting the Colt Canada C8IUR as the Gevaer M/10. The 'IUR' designator stands for Integrated Upper Receiver, which includes an integrated rail. Since 2010, Denmark has upgraded the M/10 and in 2020 announced that it would be acquiring the Raytheon Elcan Specter DR 1-4x optic, with first deliveries in 2021.

Canada is actually working towards the acquisition of a new rifle to replace the C7 and C8 in the form of the Canadian Modular Assault Rifle (CMAR) programme, with the rifle to be manufactured by Colt Canada. According to the Canadian Defence Capabilities Blueprint: "The project could deliver a two-tier fleet with Tier 1 Full Spectrum (CMAR-FS) rifles optimised for complex Urban and Open Terrain operations, and Tier 2 General Service (CMAR-GS) rifles designed for common personnel protection. The project could deliver modern modular rifles with suppressors, advanced optics, night vision, grenade launcher and new improved rounds."

The high-end CMAR-FS would equip infantry units, while the low-end CMAR-GS would equip support units. The CMAR programme is currently in the definition phase, to be followed by the implementation phase, with a target date for initial deliveries being 2026/2027. In parallel, development of a new Canadian 5.56 × 45 mm round is already well underway.

There is a lingering problem though and that appears to be funding. The suggestion is that while the Canadian Army can afford a new weapon, a suppressor and a new Canadian round, advanced optics and night vision might break the budget. Indeed, it seems that, at least initially, CMAR could arrive without an optic, making it arguably less capable than the C7/C8 weapons and C79 optic it is supposed to replace. From the perspective of an outsider, fielding an 'austere' CMAR would put Canada into real false economy territory. Taken altogether, it would appear that the Canadian Army is in serious need of additional funding to restore its capabilities. ■

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The British Army – Still Searching for a Sense of Direction?

David Saw

This author's original intention was to uncover some positive trends within the British Army at a time where it has repeatedly come under fire for various failures. However, this task has proven quite challenging. Finding positive narratives at the current time requires a deep faith in the soundness of the institution and a willingness to ignore obvious problems.

To provide some context for our discussion, and to be fair, Britain is not alone in Europe in having let the capabilities of its ground forces decay since the end of the Cold War. However, unlike some of Britain's peers, there is perhaps a larger gap between aspirations and reality. The British Government still seems to assume that it can commit its military anywhere at any time and somehow it will get the job done. All of this despite the fact that it has so far largely failed to properly fund, equip and sustain its military.

There is, of course, more to it than that – there have been many contributors to the current parlous state of the British Army. Indeed, there is a level of dysfunction which appears to afflict the British defence ecosystem in its entirety.

Credit: UK MoD

According to the most recent edition of the MoD's 'UK Armed Forces Equipment and Formations', the British Army still has 851 FV432 Bulldog armoured vehicles in service. The FV432 first entered service more than 60 years ago, a replacement programme, the Armoured Support Vehicle will receive funding from 2025 onwards.

British Defence Ecosystem

To talk of a defence ecosystem would seem to suggest an integrated whole. Unfortunately, the British defence ecosystem would seem to amount to less than the sum of its parts. The players in the game are as follows; a government that provides strategic direction and policy, a Treasury that is supposed to pay for it, and a Ministry of Defence (MoD) that should manage it and make it a reality. Then there is the civil service whose role is to manage the reality as defined by government policy. In the British system, the bureaucracy is tasked with procurement and sustainment. At the end of the line comes the military, in the form of its three services branches, the Royal Navy (RN), Royal Air Force (RAF) and British Army.

Another element of the defence ecosystem that has to be accounted for is the British defence industry. It does not require a tremendous leap of logic to see the wisdom in having a highly capable defence industry to supply and sustain equipment in service with the British military. Furthermore, having a capable defence industry offers the opportunity to penetrate export markets with the economic advantages that can bring, as well as the influence that can be gained in meeting the defence equipment needs of friendly nations.

Bearing that in mind, it makes sense that Britain has a defence industrial policy to sustain its domestic industry. In an era where talk of resilience and supply chains is paramount, having the ability to meet defence needs from local sources makes perfect sense. The two leading European nations in defence terms have for a considerable period of time been France and Britain. That situation could well change with Poland now becoming a European defence leader and Germany might yet put its defence house in order. Focusing on France and Britain for the moment, both make reference to the fact that they have a defence industrial policy. When France asserts that point it is hard to disagree, though sadly a British defence industrial policy is much, much harder to discern.

Britain's Defence Industry

All across Europe in the post-Cold War world, it was inevitable that national defence industries could not remain as they were. Moreover, in an era of the 'peace dividend', national defence spending levels were continuously contracting. In turn, this led to a period of industrial consolidation, and initially this was on a national basis, before expanding to become a multinational phenomenon across Europe. Eventually in Britain, a defence industrial giant emerged

in the form of BAE Systems, though sadly relations between the company, the British defence establishment, and the procurement authorities have not always been cordial. Mention should also be made of the other major pillar of the British aerospace and defence industry in the form of Rolls-Royce, which, much like BAE Systems, has transitioned to become a global company.

The word 'global' is important here, as globalisation has changed the industrial picture in Britain just as it has, to a lesser or greater extent, in other parts of Europe. Certainly, globalisation has been a significant contributor to the decline of manufacturing industry in Britain and inevitably that has impacted the British defence industry and its capabilities. Another contributing factor as far as land systems are concerned has been the limited scale of orders from the British Army. By way of example, confirmation of that trend can be seen from just looking at British armoured vehicle orders, or lack thereof, over the past 20 years. This trend is understood to have largely motivated BAE Systems' sale of a 55% stake in its BAE Systems Land UK business segment to Rheinmetall, which resulted in Rheinmetall BAE Systems Land (RBSL).

Britain still has tremendous skills to offer in the automotive sector, notably in highly specialised areas, but British car and truck manufacturers in this sector have broadly either gone bust or come under foreign ownership. Only one truck company remains in Britain, which is DAF, a Dutch company owned by US multinational Paccar. In terms of the British defence industry, capability has been sustained through foreign domiciled companies acquiring local companies. Italian, French, German, Israeli and US primes have all built a presence in Britain, often through acquisition of existing companies. Notable examples of the latter include Cobham, Inmarsat, Meggitt, Ultra Electronics, Meggitt, and a majority stake in Babcock purchased by US-based organisations, and Pearson Engineering purchased by Israel's Rafael. Finally, one should not forget the emergence of transnational companies such as MBDA, with its joint ownership by Airbus, BAE Systems and Leonardo.

The British Government has never been protectionist as far as its defence industry is concerned, unlike other countries in Europe. Partially that is due to a free-trade mindset, and partially due to the fact that its post-Cold War leadership has never really seen sustaining a national defence industry as a critical issue. At an industrial and financial level, many British companies and financial institutions were never convinced that the defence sector was a lucrative investment and with government providing little evidence to the contrary, it is little wonder the British defence industry has shrunk.

The lack of a realistic industrial policy is an area that should have been addressed many years ago. Another issue that should also have been resolved is the procurement system as a whole, which involves the MoD, the civil service, the procurement bureaucracy, the end-user, and industry. Put simply, for many years Britain has not been very good at defence procurement. Cost overruns, multi-year delays, and programme cancellations became regular events. Few if any players in the British procurement scene emerge with any credit. Even worse, for all of the talk of reforming and improving defence procurement over the past few years, few if any success stories emerge.

Credit: UK MoD

Warrior IFV participating in May 2023 Exercise Spring Storm, a deployment to Estonia to demonstrate the reinforcement of the UK-led NATO enhanced Forward Presence (eFP) Battlegroup to Brigade-strength. The Warrior Capability Sustainment Programme (WCSP) upgrade was cancelled in March 2021.

Credit: UK MoD

British troops on exercise in Estonia in January 2023, part of the enhanced Forward Presence (eFP) NATO Battlegroup in Estonia. Plans to reduce British Army personnel strength from some 78,000 down to 72,000 or perhaps even less have proven extremely controversial.

Numbers and People

One increasingly controversial area for the British Army is personnel strength and the fear that the government is committed to reducing regular forces numbers to a level that is not adequate for the tasks to be performed. It appears that the government believes that an increased use of volunteer reserve personnel and an increased use of

Table 1: British Army Personnel Strength 2012-2022											
Personnel /Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
UK Regular Forces	104,454	99,726	91,066	87,058	85,038	83,561	81,116	79,029	79,624	82,231	80,738
Gurkhas	3,824	3,510	3,047	2,886	2,855	2,992	3,150	3,429	3,757	4,011	4,108
Full-Time Reserve Service*	1,269	1,529	1,985	2,798	2,278	3,026	2,987	2,964	3,141	3,318	3,311

Note: The Full-Time Reserve Service heading covers reserve personnel currently on active service with the regular Army.

Table 2: MOD Quarterly Service Personnel Statistics, British Army, 1 January 2023				
Personnel/Year	**2020**	**2021**	**2022**	**2023**
UK Regular Forces	78,620	80,810	80,980	78,060
Gurkhas	3,370	3,720	3,950	4,060
Volunteer Reserve	29,860	29,790	29,400	27,570
Other Personnel	4,180	4,310	4,600	4,520

civilian contractors in support functions will be as effective and cost less than regular personnel.

Research from the House of Commons Library on UK Defence Personnel Statistics published in August 2022 provides a picture of the strength of the British Army from 2012 to 2022 (up to 1 April 2022), as shown in Table 1 above. Table 2 utilises the Quarterly Personnel Statistics from the MoD as of 1 January 2023. Differences in numbers for regular personnel and the inclusion of the full strength of reserve forces can clearly be seen.

According to MoD statistics, as of January 2023, the UK Regular Forces strength had declined by 3.6% from the year before, while over the same timespan the Volunteer Reserve strength had declined by 6.2%. Where the controversy arose was when reports of a reduction of regulars down to 72,000 or 72,500 surfaced, and more recently, a reduction in numbers down to 70,000 was suddenly being discussed. This culminated in a rupture in relations between the Defence Secretary Ben Wallace and the Chief of the General Staff (CGS) General Sir Patrick Sanders, who believed the cuts in headcount were too severe. This has led to the CGS opting to retire early in 2024. Then in mid-July 2023, Wallace announced that he would resign as Defence Secretary in the next cabinet reshuffle and stand down as an MP before the next general election, and stood down from his ministerial post on 31 August 2023.

The MoD's falling personnel strength numbers suggest there is a risk of increased reliance on reservists. However, given that reservist numbers are also falling, there is no guarantee that the plan to replace regulars with reservists will deliver. Then comes the issue of retention of regulars and here, decent pay, overall employment conditions and housing would certainly help. Sadly, taking military personnel for granted has long been a weakness of the British system.

The Broad Economic Outlook

While promises have been made for an increase in the defence spending as a percentage of Gross Domestic Product (GDP) of 2.25% by 2025 and up to 2.5% in the long-term, it does not mean that a new golden age for defence spending is at hand. In Britain, as in other countries around Europe, the impact of COVID-19 and price of recovery has been a massive increase in government spending and debt. Then you have the economic consequences of Russia's invasion of Ukraine, another causal factor in the rise of inflation. This has brought a demand for wage increases, which risks leading to wage/price inflation that further worsens the economic situation.

The current negative economic environment calls into doubt any government promises on increased defence expenditure. The recent government offer of increased pay for the military of 5% and a GBP 1,000 bonus will not come from new funding, but rather from within the existing defence budget. This means that the funds will have to be taken at the expense of something else.

Improving the economic trajectory of the country appears to be beyond the current government. Unless they manage to achieve a spectacular change of fortune and can convince the electorate that they have not run out of ideas, polling suggests that they are on track to lose the next general election. One of the few certainties is that a new government will hold a defence review and that puts current budgets and programmes at risk.

For once, the problems with the defence procurement system are now being treated as a serious issue at the political level. The catalyst for this was the Sheldon Review released in June. Clive Sheldon KC was commissioned to lead the Ajax Lessons Learned Review with the objective to identify lessons from this programme and "make recommendations to help [the] Ministry of Defence (MoD) deliver major programmes more effectively in future." Soon after, the House of Commons Defence Committee noted that the Sheldon Review had "found that a number of systemic issues within the defence procurement process." Will this be enough for the current government to make progress on defence procurement reform? Or will that be a task for the next government? Or will nothing really change? As painful as it may be to admit, the latter may be a distinct possibility when one considers that the next government will have numerous competing priorities calling for greater investment, including healthcare, housing, and education. Competing with these for funding may be a tall order.

Looking Ahead

What is clear is that things cannot continue as before, and this applies especially to the British Army, which has arguably seen the greatest capability reduction among all three service branches. In terms of funding, the Army must be able to fight for its fair share of the budget against the RN and the RAF. Once it has this share, it must demonstrate it can define the equipment that it needs and participate in an effective procurement process to ensure that this equipment is delivered with the appropriate capability at the desired time.

Admittedly, it is extraordinarily difficult to specify equipment when there is very little clarity, and in a strategic sense, to identify the primary mission of the service branch. For years, the Army's primary mission was the British army of the Rhine (BAOR), but

with the end of the Cold War, it became about peacekeeping/peacemaking, and later evolved into being drawn into asymmetric conflicts in Afghanistan and Iraq. Since 2014 in Ukraine, with the Russian annexation of Crimea and conflict in the Donbas, and later the full-scale invasion in February 2022, the focus has shifted back to Europe.

The reality is that if a resurgent Russia was seen as a threat post-2014, then the British Army was woefully unprepared to meet such a threat from a peer-level competitor. Although the war has demonstrated numerous weaknesses in the Russian armed forces, to a great extent it has done much the same for Ukraine's allies. In the case of the UK, it laid bare that the country was limited in terms of tanks and armoured vehicles, with core artillery capabilities virtually non-existent, and as rapidly became apparent, ammunition stocks were far too low for high-intensity combat against a peer opponent. Thankfully, ammunition orders have now been placed to replenish British stockpiles, although whether this will actually provide the stocks necessary for modern high-intensity operations remains an open question.

So, is the future of the British Army now to be Europe-focused? Not quite would be the answer. The British Government seems wedded to a Global Response Force idea, which, according to the MoD, "Enables the UK to 'get there first', bringing together our deployed and high-readiness forces, and drawing on capabilities from all domains." Bearing in mind the current fascination in British political circles with China and the Indo-Pacific, this begs a question, is Britain deluding itself by looking to take on board new global commitments, on top of its European commitments, at a time like this?

Are we asking too much of the British Army in its current state? Having a credible deterrent capability in Europe and now building a credible expeditionary capability will be a big ask. The danger is that the British Armed Forces may indeed be able to 'get there first,' but the fear would be will they have the tools necessary to deter or fight once they get wherever 'there' is? Pure reliance on allies to fill capability gaps cannot be a panacea here, since it reduces overall resilience, increases over-reliance on key units which cannot be easily replaced, and more broadly the capability mix among allies may not meet the requirements of the battlefield they find themselves upon. Moreover, if multilateral alliances are to serve as a credible deterrent, their members must all possess some a meaningful baseline level of capability. Something has to change.

Credit: UK MoD

Ukrainian gunners train on AS90 155 mm self-propelled guns in the UK in March 2023. The poor state of British artillery capabilities is evident from the fact their donation to the Ukraine was a battery of eight AS90 guns at high readiness and a further two batteries at varying states of readiness.

Silent Struggle: Accounts from the Frontlines of Ukraine's Electronic War

Mark Cazalet

Electronic Warfare (EW) in Ukraine has been a critical enabler for both sides of the war in Ukraine, with each scrambling to adapt to modern battlefield possibilities within the electromagnetic spectrum. This domain has been used for a variety of purposes, including gathering information, target locating/positioning, disruption, deception, and even downing UAVs. While EW has been a common sight on many battlefields of the 20th and 21st centuries, it has perhaps never been as sophisticated, or as target-rich a domain as it is today in Ukraine. To explore its role in this war, during the Association of Old Crows (AOC) Europe Event from 15-17 May 2023, ESD sat down with Iaroslav Kalinin, CEO of Ukrainian EW specialist firm 'Infozahyst' to discuss the role of EW and communications in shaping the conflict so far, including Russia's performance in this sphere.

Kalinin explained that Infozahyst was founded back in 2002, and the company's name approximately translates to 'Information defence'. Initially the company operated on providing information protection for high-level government officials, such as the cabinet of the President of Ukraine. However, following the fall of the Yanukovich Government and Russia's annexation of Crimea in 2014, Infozahyst switched to developing radio monitoring and communications intelligence (COMINT) equipment. Then as recently as 2020, the company expanded its capabilites, adding the development of electronic intelligence (ELINT) and electronic support measures (ESM) to their portfolio.

Credit: Infozahyst

A Ukrainian ELINT operator performs combat tasks from the basement of an abandoned building. The use of light and portable equipment gives the operators relative freedom to position themselves, and to reposition quickly if their position is discovered by enemy forces.

Credit: Infozahyst

Plastun-RP3000 has been in service with Ukraine's armed forces for several years, and these systems have seen operations in a number of conditions.

Kalinin joined the company in 2016, when the company began work on developing their 'Plastun-RP3000' man-portable direction finder (DF), and later its extended-range, containerised truck-mounted version, the Khortytsia-M. These developments caught the attention of the Armed Forces of Ukraine (ZSU), who began to procure both, with Plastun-3000RP entering service in 2016, followed by Khortytsia-M in 2018. By the time the War in Ukraine broke out on 24 February 2022, the ZSU had approximately 300 Infozahyst-developed systems in service, primarily comprising the Plastun and the Khortytsia-M, according to Kalinin.

Since the war broke out, these and other systems have been an important tool in Ukraine's arsenal, having been used for locating enemy positions and assisting artillery targeting, intercepting communications, and counteracting unmanned aerial vehicles (UAVs), among other tasks. Throughout the ongoing War in Ukraine, much of Infozahyst's focus has been on the lower-frequency portion of the electromagnetic (EM) spectrum. According to Kalinin: "the challenge in this war now, is working against low-band emissions" adding that: "in my experience, really few of the…international companies [are] really good at addressing this challenge." He noted that: "no one take care about this particular band for really long time, like band from 25 or 20 MHz up to 50 MHz…not for the field trainings, but for the real work with the real world radios."

Hunting Over the Airwaves: The Utility of Direction-Finding

With wireless communications such a critical component of modern warfighting, the need for ELINT, COMINT, and direction finders has greatly increased in importance over the past couple of decades. Kalinin recalled: *"I spent like in total, more than eight months on the frontline, starting from the 2014. And from this time, I have multiple stories, how helpful [it] was having the direction finding system right in the hand of the commander. So he understood exactly where exactly enemy plan to do…some activities, even if we failed or intercept some communication, but still he knows the exact grid area where [there's] going to be operation."*

Infozahyst's Plastun-RP3000 portable DF system is capable of direction finding Radio Frequency (RF) and Microwave band signals from 25 MHz to 3 GHz, out to approximately 15 km (or 45 km in the case of the longer-range Khortytsia-M), with an average instrumental error of >0.5°, and root mean square (RMS) error of >3°. Furthermore, as the distance between DF and signal source decreases, so does the circular error probable (CEP). The table below illustrates approximate CEPs at various ranges, though readers should bear in mind that these are approximate figures, since accuracy is also affected by the frequency of the detected signal:

Distance from DF to Emitting Target	Approximate CEP
45 km	393 m
35 km	305 m
25 km	218 m
15 km	131 m
10 km	87 m
7 km	61 m
5 km	44 m

While most of the above CEPs are still too high to allow precision targeting by themselves, they can nonetheless offer various options to a force, depending on the tactical scenario they find themselves in:

1) Artillery fires directed at lower CEPs, may be sufficient to permit engaging the target when combined with other means such as satellite imagery and pattern analysis over time. Kalinin provided an example from the defence of Kyiv: *"when you have enemy mortar unit, which [is] constantly running from position to position…but they are lazy…they are just simply switching between like say four positions and you already get the satellite imagery and you'd exactly know X, Y [coordinates] of this position. And once immediately you get interception, when battery start preparing to fire, you [are] already ordering your artillery to that exact X, Y, even if you don't have the UAVs or something, and you do the strikes even before they [can]."*
2) Artillery fires directed against higher CEPs, may be sufficiently close to cause the enemy to reposition out of concern that their position is known. While this is more a psychological effect than a material effect, it can nonetheless still be useful depending on the scenario, such as counter-battery fire. In this vein, Kalinin recalled the early days of the war, where Ukraine managed to halt the Russian advance into Kyiv: *"it's sometimes inefficient because at that time we didn't have any precise artillery systems. Sometimes it was just a fear factor, because even if 200 m from you [is an] exploding 152 mm shell, you would be considering changing position. Even losing your [artillery] barrels, but you won't be conducting the artillery strike anymore."*
3) When paired with more accurate cueing by reconnaissance assets such as UAVs, DFs can speed up precision targeting cycles considerably, by greatly narrowing down the search area for the UAV. This would mean hostile emitting targets can be detected and engaged much more quickly compared to searching out enemy positions without a semi-defined target area.

A Plastun set comes in the form of two man-portable semi-sets. Each semi-set weighs 39 kg and consists of a large duffle bag containing the mast and antenna, as well as a rucksack carrying the battery and associated electronic equipment. The operator uses a ruggedised laptop connected to the electronics via a wired datalink so as to avoid unnecessary emissions. The wired link is 50 m long, allowing the operator to work at a safe distance from the antenna in case it is located and targeted by enemy forces. Additionally, if paired with a

Credit: Infozahyst

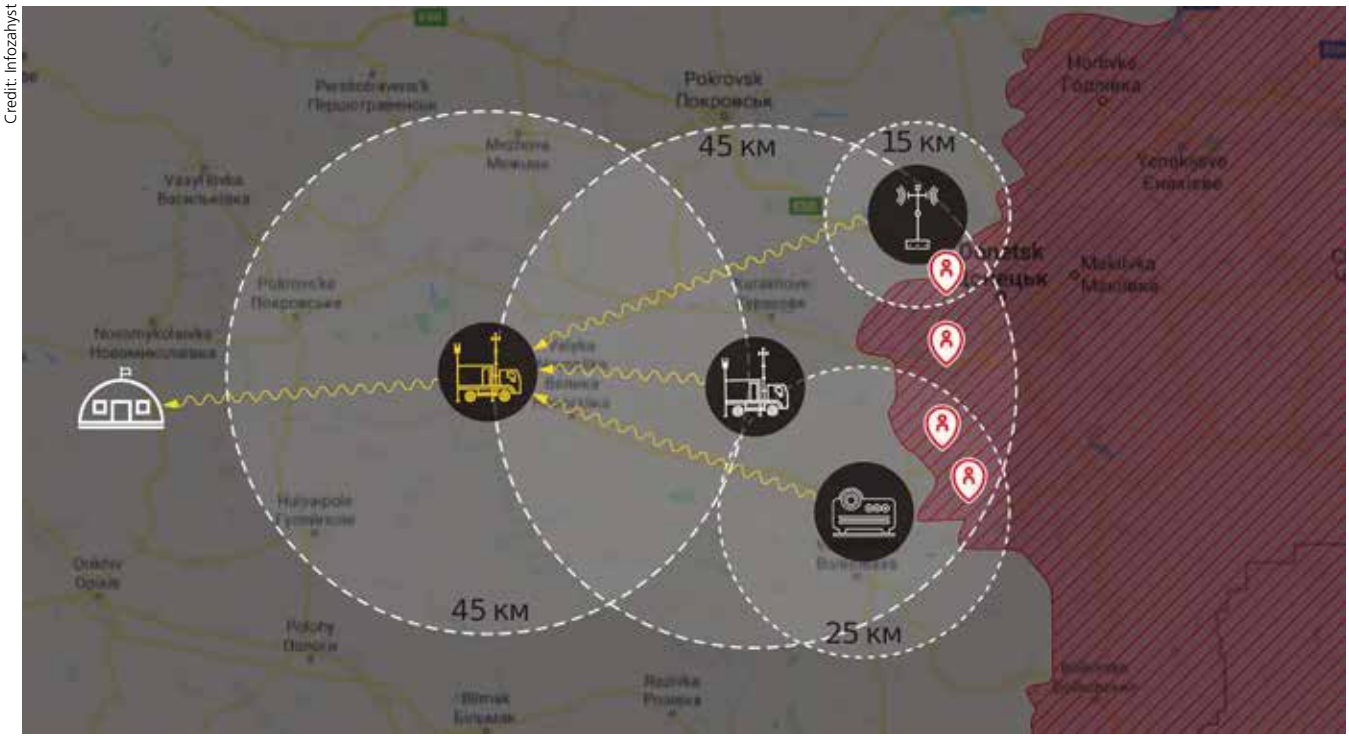


Diagram shows the operating principles and typical maximum ranges for Plastun and Khortytsia-M.

'master' semi-set, the second 'slave' semi-set can be operated remotely, thereby decreasing the crewing requirements. A Plastun semi-set can be assembled in just 20 minutes, and once activated, can operate continuously on battery power for up to 8 hours. An Infozahyst representative stated that the set could also be connected to an electrical power generator to extend its operation time.

The basic operating principle by which these antennas function under is that they are usually placed at a specified distance several kilometres apart from one another, and connected either by coaxial cable or one of two possible wireless connection options, forming a bistatic antenna. These antennas then passively detect incoming signals within their area of responsibility and classify them. Since the distance between the two antennas is known, by exchanging information and comparing the respective angle of arrival (AOA) and time difference of arrival (TDOA) between the two antennas, the direction of the incoming signal can be triangulated using trigonometric principles. Kalinin noted that the system was small and light enough to easily carry and mount on high ground, in order to gain the best range performance from the system.

A further major factor behind Plastun's design is cost, Kalinin noted that Ukraine's wide use of SIGINT and COMINT systems "goes in contrast with the strategy of the NATO countries when you have the SIGINT unit, one or two for our whole army, and you don't have the own direction finder for every brigade". By contrast, he noted that "in our army, we even sometimes have multiple systems for one brigade. So we can easily solve the task of the multiple sensors in one. And if some sensor doesn't see it, other sensor will."

Credit: Infozahyst

The Khortytsia-M mobile COMINT/ Direction Finder system shown with its two telescopic masts extended, ready for operation. The system can be used either standalone or as part of a COMINT network, as a node or managing other systems subordinated to it.

At the tactical edge, DFs can provide commanders with a highly valuable tool for detection of enemy presence and tracking their movements over time. While DFs can to an extent be rendered less effective by practicing good communications discipline, avoiding them entirely is extremely difficult, especially given that modern warfare is highly reliant on communications and networked systems, and this problem becomes more pronounced the larger the formation. Simply put, there is no escaping use of the electromagnetic spectrum.

Radio Retaliation: Defeating Russian UAVs with COMINT

Among the more impressive wartime feats performed by Infozahyst, Kalinin stated that their company has succeeded in being able to tap into the signals of some of Russia's UAVs. ESD is not at liberty to disclose the model(s) of UAV involved, or to provide more details on the techniques and methods used by Infozahyst, however, some small details of a particular instance can be shared.

In this particular instance, Kalinin stated that Infozahyst were able to develop the capability to tap into the signals of a specific model of Russian UAV, and by doing so, were also able to build soft-kill electronic countermeasures against it. These combined measures were reportedly so effective, that following a number of losses, the

Credit: Infozahyst

The interior of the Khortytsia-M mobile COMINT complex has two workstations for operators who control the operation of COMINT and direction finding devices, including the Apella automated multifunctional COMINT complex, and Plastun-RP3000. Additionally, the container is equipped with a living area for the crew during extended operations.

Russian armed forces stopped using this model of UAV entirely. This is an extremely impressive achievement, removing a threat from the wider battlefield.

The extent of what is possible with modern COMINT against UAVs is quite remarkable. According to Kalinin, by tapping into the signal: "We got the position of operators, UAV, their forces, part of job, their UAV, if they run with turned on camera, we even do that part of recording once UAV getting to our position. So, yeah, they understood that this is a failure."

As well as demonstrating the truly impressive ingenuity which can come from a determined defender, Kalinin's account is a stark reminder of the importance of using secured communications at all levels, and the harsh consequences of failure to do so.

Ears in the Sky: Developing an Aerial ELINT/ESM System for the Modern Battlefield

Going beyond their existing portfolio, Kalinin revealed that the company was in the process of developing an aerial ELINT/ESM reconnaissance platform for operating at medium to long ranges. The system is known as 'Gekata', named after the ancient Greek goddess Hecate. Kalinin explained the envisioned role for the system is to provide situational awareness of enemy aerial surveillance radars stationed along the frontline, all the way out to and strategic long-range radars.

According to Kalinin, this task is relatively simple when dealing with coastal radars at ranges of around 200-300 km, due to ground wave propagation (in which radio waves propagate parallel to a conductive medium such as seawater), resulting in relatively low signal losses even over fairly long distances. However, since dry land is a dissipative (lossy) medium, detection of propagating signals is much more difficult, and would require a receiver to be placed at a reasonable altitude, or to rely on obtaining signals which have been refracted from the ionosphere. The problem with relying on ionospheric signals, Kalinin explained, is that *"in order to detect this emission, you need to have a really big antenna and it's harder to manoeuvre with that. You're immediately the target – satellite imagery, SARs [Synthetic Aperture Radars] will much or less immediately spot you…and the human intelligence, [will] easily recognise the system. So it's not that safe to operate that kind of equipment in this kind of conflict."*

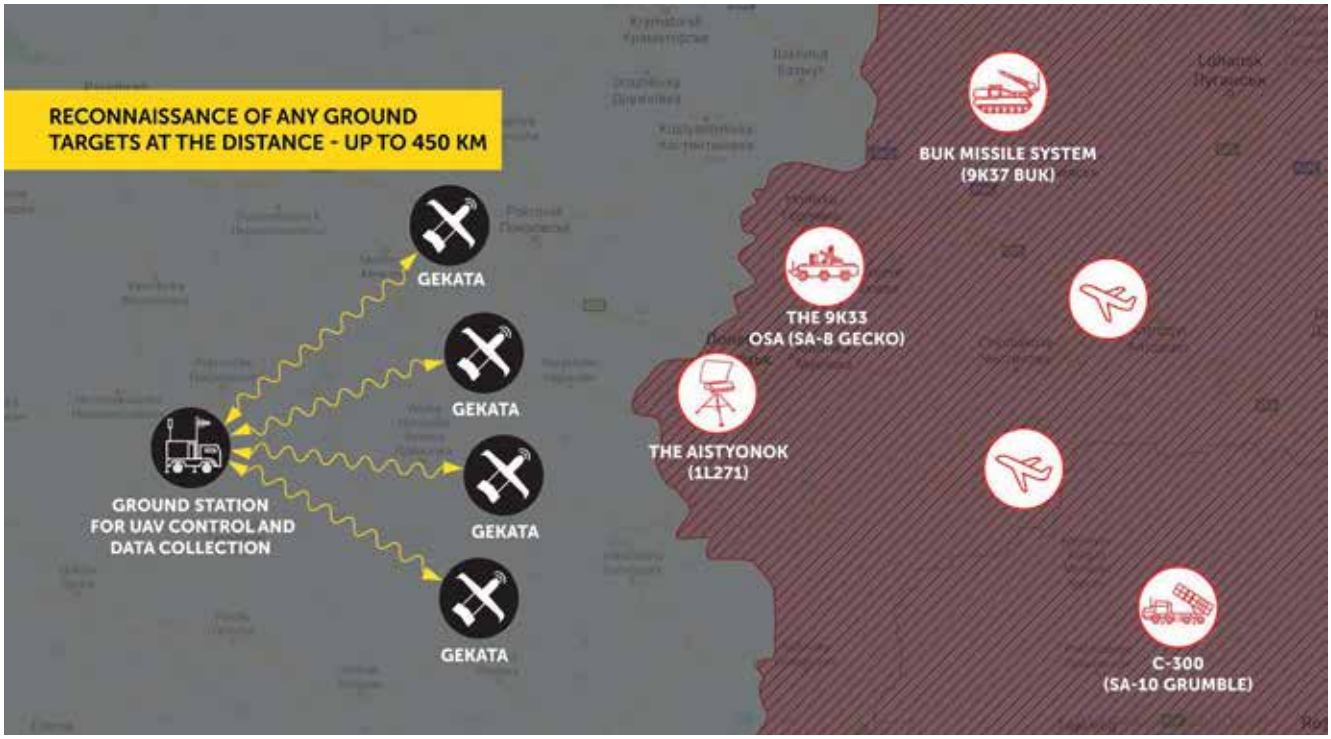
As such, the more prudent alternative was to mount this detection equipment on a flying platform, but these came with se-

Credit: Infozahyst

The PD-2 UAV being tested without the ELINT package.

Credit: Infozahyst

The PD-2 VTOL UAV fitted with Infozahyst's ELINT package forms the aerial component of the Gekata system.



Credit: Infozahyst

Diagram shows the operating principles and expected ranges for Gekata.

rious risks given the nature of Ukraine's contested airspace. Kalinin described the process of testing such a system with a helicopter, and explained how the risks of being targeted increase rapidly as the platform gains altitude. Even at very long ranges of approximately 120 km from the enemy sensors, Kalinin said "for helicopter…you have like 15 minutes" before the platform was at serious risk of being engaged.

Elaborating further, he said: *"So you're getting [to] the altitude of 500 m, you're getting spotted by enemy radar, long range radars. Once you climb to the 1,000 m, you're getting the emission from the airborne radar from the fighter. Once you get to thousands [of metres], you see the very wrong signals from the enemy airborne radar, and no one tested further" he said laughing, before smiling and adding: "The pilot said, "okay, okay, let's go below that tree", and usually it ends up with the extremely high-speed landing".*

As such, the selection of a relatively small platform became necessary to avoid such attention, Kalinin noted: *"We had that experience, and it doesn't work for helicopters. Same story for the bigger platform, like AWACS. If Ukraine had the Bayraktar UAVs, it's sometimes the same problem. So you have to be smaller than that and cheaper than that."*

Aside from being cheaper and more difficult to detect, Kalinin also noted that such small platforms also make far less-tempting targets for enemy long-range weapons: *"even if it was detected, it's hard to launch and a questionable reason to launch a long-range air-to-air missile like R-37M on this distance…100 and something kilometres from the frontline. So it doesn't look like a reasonable target for enemies."*

As such, the company decided to use the relatively small PD-2 UAV from Ukrainian company Ukrspecsystems as the host platform for their Gekata ELINT/ESM reconnaissance system. The platform is available in three configurations – a vertical take-off and landing (VTOL) variant provided with four lift rotors for take-off and landing, and a pusher prop for level flight, or a two conventional take-off and landing (CTOL) configurations (4 m wingspan and 5 m wingspan versions), which are only provided with a pusher prop for propulsion. The manufacturer claims that the system's modular design enables it to be converted from CTOL to VTOL configuration in just 15 minutes. Gekata is due to use the VTOL configuration, which in terms of performance, has a service ceiling of 4,500 m, a maximum range of 800 km at a cruising speed of 100 km/h, giving an endurance of 8 hours, while carrying a maximum payload of 11 kg. The UAV ground control station comes with a communication antenna tracking unit designated 'AT-1', which facilitates communications with the UAV out to 200 km on the primary datalink, or 150 km on the backup datalink.

Under Infozahyst's operational model, the complete Gekata system would comprise eight PD-2 VTOL UAVs fitted with Infozahyst's ELINT/ESM package, and a ground control and data collection station. The UAV payload consists of an omnidirectional receiver antenna in a cylindrical housing fitted to the UAV underside, just aft of the nose, along with on-board and signal processing and classification systems. This ELINT/EMS package has an operating frequency range of 2-18 GHz, and is capable of measuring both angle of arrival (AOA) and time difference of arrival (TDOA) of intercepted signals, as well as processing up to 2.5 million pulses per second to protect it against high pulse repetition jamming attacks. The ground station is intended to control up to four UAVs at a time, with four kept as in reserve. These latter four allow the user to rapidly re-establish coverage when the first four head back to refuel, or can serve as replacements in case of attrition.

The fact that Ukraine is looking to small and cheap UAVs over larger and more capable platforms is also somewhat telling of the high attrition rate such platforms of all classes have suffered in Ukraine. When facing an opponent with numerous and relatively capable air defence systems such as Russia, the planning expectation seems to be that such platforms will not last long. As such, their best bet for surviving is to draw as little attention to themselves as possible, and to have backups available for when platforms are lost.

Falling on Deaf Ears: Russia's Communications Woes

A key theme during ESD's conversation with Kalinin, were Infozahyst's assessments of changes to Russian communications observed over the course of the war. The paucity of the Russian Armed Forces' communications has been a well-documented thread running through much of the war, and according to Kalinin: "They failed, in my opinion, communication at the start of the war."

This failure of communications resulted in numerous problems, including frequent interception of Russian Armed Forces' communications, leading to discovery of their positions on the defensive and loss of operational surprise on the offensive, as well as many cases of officers being out of communications reach of their subordinate units, leading to organisational chaos during key moments. At an even more basic level than these, Kalinin explained that poor communications had also negatively impacted the accuracy of Russia's artillery: *"So in Russian, they go through the books, like classic books, like "target 150 metres, two shells, full battery, this kind of shelling, fire!"… It doesn't work like that. First of all, all the shells from the first fire [mission] go completely other side, because everyone didn't hear you clearly on the radio… and no one admitted [it]."* Consequently, Kalinin noted: "So…because of efficient intercommunication, we were two steps ahead of start of firing".

Credit: Infozahyst

As a result of widely using unsecured radios, such as those made by Chinese company Hytera, Russian communications were prone to frequent interception by Ukrainian ELINT systems. These vulnerabilities are gradually being addressed, albeit not in a systemic manner.

Credit: Arms of Russia Information Agency

An R-168-0,5UM radio set from the Akveduk fifth-generation family of radios. The family was developed by the Voronezh Scientific-Research Institute of Communications (VNIIS), and began entering service with the Russian Armed Forces in the year 2000.

though the Russian armed forces have not stood still, and definite progress had been made, Kalinin was keen to emphasise that many of the changes seen so far have been fixes of previous mistakes: *"it's not like evolving, it's just fixing. So they managed to fix it in the middle of summer last year [2022], less or more. And they started finally get out of the pit with their Soviet-era radios then. But they didn't manage to fix it completely."*

Since "fixing" some of their early problems in the summer, ESD asked Kalinin whether the overall challenge of combating Russians communications had become more difficult in early 2023, to which Kalinin responded: *"I would say staying same or simplifying…our forces managed to destroy most of the less or more modern systems like Akveduk. And [the Russians] have no choice, but switching to the civilian radios, like DMR [Digital Mobile Radio] protocols from the Chinese Hytera system…for instance, or other Chinese manufacturers. But this is not a systematic move – this is more volunteers who supply Russian army with those systems, and…by private organizations such as Wagner [who use] this station. And again, because of nature of this protocol, it's only tactical level solutions."*

From Kalinin's account, many of the Russian Armed Forces' tactical communications fixes seem to be occurring in a fairly patchwork and localised fashion, largely through the initiative of individual units than a systematic and concerted effort. Looking beyond the tactical level, Kalinin noted: *"On the operational or strategic level, they're still using the approach they have way before the war. But again, it's not something same for all the forces and all the positions. In some units, they start using the new systems [Azart] to communicate. But again, it's more initiative work than [a systemic] approach."*

To a large extent, the adoption of 'lessons learned' and adaptation of Russia's armed forces seems to be unevenly distributed. Some may have better equipment, others more experience, or better training, or more diligent commanding officers. To be fair, this is not a particularly new phenomenon in any armed forces, however the unevenness seems to be particularly pronounced in Russia's armed forces, where even before the war, capabilities could vary greatly from unit to unit, at least on paper. Beyond these patchwork fixes, Kalinin noted that in some areas there were signs of more noteworthy progress being made, particularly when it came to Russia's newest radio 'Azart'.

The Rise of Azart

The most modern radio family in service with Russia's armed forces is the 'Azart' sixth-generation family of Software-Defined Radios (SDRs), developed by Russia's NPO Angstrem. They have been gradually trickling into service since around 2014, when a batch of R-187P1 handheld radios was delivered to the Central Military District's Peacekeeping Brigade, the 15th Separate Guards Motor Rifle Brigade, based in Samara.

Credit: NPO Angstrem

Promotional render of the 'Azart-2' handheld radio, released in 2021. The radio has yet to be seen in service.

Aside from the R-187P1 'Azart-P' short-range (up to 4 km range) handheld variant, with an operating frequency band of 27-520 MHz, the family also includes the R-187N 'Azart-N' medium-range (up to 12 km range) vehicle-mounted, and R-187BV 'Azart-BV' longer range (up to 40 km range) vehicle-mounted variants. However, it should be noted that only the handheld version has been noted in service, with even Russia's more modern vehicles such as the T-80BVM and T-90M main battle tanks continuing to use the older Akveduk family.

Credit: Rosoboronexport

The R-187P1 handheld variant of the Azart family, shown here fitted with the AB standard-capacity battery (left) and the larger AB-12 expanded-capacity battery (right).

Beyond these, NPO Angstrem has also exhibited an improved handheld variant, known as 'Azart-2' at a closed pavilion during the Armiya-2021 defence and security exhibition at Kubinka in August 2021. Shortly after it was shown, some Russian sources speculated that this newer version could enter service with the Russian armed forces as early as 2023. However, little has been heard about this variant since the war broke out in February 2022, and given that not even the first generation of the Azart family has seen full adoption, it remains doubtful that this variant will enter service in meaningful quantities anytime soon.

Over the course of the conflict, Infozahyst have become deeply familiar with the Azart radio family, thanks largely to managing to get hold of captured samples for study and analysis. During ESD's discussion with Kalinin, he painted a fairly nuanced picture of the radio, pointing out both strengths and weaknesses, as well as noting some of the changes to it observed over the course of the conflict.

Azart saw more limited use during the early phases of the war, but has now started to become much more commonplace in Russian service, albeit not for all units. According to Kalinin, part of the reason for its low usage was that some units had problems using the system, leading to patchwork usage and various units falling back on simpler systems for communication. He explained: *"It's supposed to replace old Akveduk, but it didn't happen for whole army. It happened for the Central District [CMD], but for Southern District [SMD], it doesn't look like finished process. And [at] the start of war, they heavily use Akveduk systems. And again, Central District failed to use the Azart system – they have it, but they failed to use it [for] different reasons. That become [an] opportunity for us, because they fall back to their analogue systems to communicate."*

When ESD asked whether the root cause of these problems were hardware or training, Kalinin responded: "That was the multiple factors. One of the lack of training, one of the hardware issues." Expounding on the hardware issues, Kalinin stated: "So they have a brilliant, very good design station with a really poor, inefficient antenna".

However, he noted that the Russians had been taking measures to improve the radio, stating "now they fixed them". When asked if this fix included adding newer antennas, Kalinin simply said "yes" before expounding: *"it was a simple mistake, obviously, but it was there. So some of the commander find a better antenna of their own, some unit…they managed to put multiple station in the retranslator mode onto UAV to extend the coverage of the radio links. So they're doing whatever they need to somehow organise their radio communication. They [had] very significant issue with that, I would say, at least at the start of war. Now, they more or less, they fix it – some issues with Azart and now they are massively use it, but still you might notice Akveduk, Arakhis systems and DMR systems."*

As such, the Azart of today seems to be a different beast to the version Russia started the war with, and one sign of the Russian armed forces' increasing confidence with the radio is the rise in its usage. Kalinin noted: "they changed the hardware design slightly…they definitely will fix problems they spotted in the field, and we see the signs of this process. And one of the major signs, they're more and more using the Azart systems as a main system. So yes, they managed to fix most of the problems."

Benchmarking Azart's Performance

When asked to give a comparison to a modern and capable Western system in service with Ukraine's forces, the L3Harris Falcon IV family, Kalinin responded: *"I didn't have experience with Falcon IV, I only have experience with Falcon III. I would say it's completely different mat-*

Credit: L3Harris

The AN/PRC-152A Falcon III family radio from L3Harris is one of the more capable Western stations serving in Ukraine. The Falcon III family entered the market back in 2007, and has seen use with a number of armed forces worldwide. In 2019, the company introduced the more capable Falcon IV family.

ters… [Falcon is] pure frequency hopping, they exactly do what they state. For Azart, it was much longer story. I believe they shown to their commanders initially a working concept, which was built completely only with TETRA protocol. So it's fixed frequency, no frequency hopping, nothing like that, just commercial grade protocol. And then they slowly but surely come to the frequency hopping mode, at least what we could call frequency hopping, and then they develop it even further, so [now] they have the mesh mode. I believe from the perspective of vulnerability to electronic countermeasures, it's harder to attack Falcon. Azart is more vulnerable from this perspective. However, the Azart station has more advantages, because I didn't see personally [the] evolution of the physical layer of the Falcon."

When asked to clarify what changes Infozahyst had observed at the physical layer, Kalinin clarified:

"When you see the station [as an] unknown emission on the spectrum, first of all, [you] have to identify it. You could identify [it] by signature, hop lengths, whatever parameters. So if we talk about Harris, it's pretty much the same system with the known modes and it's not change significantly its behaviour. If we talk about Azart, it significantly changed how [the] emission looks like, what's inside the emission, so on, so on, so on. So it might become completely new station in [the] near future. So having the same hardware, they completely change how it looks in some perspectives, with new firmware updates, for instance.

Regarding this pattern of rapid evolution ESD asked: "you think the Azart is evolving faster and adding new capabilities faster?" compared to radios such as the Falcon family. Kalinin responded: "Looks like that," adding "we cannot name changing [the] antenna as a hardware [change] – by definition it is – but let's name it 'fixing the problem'. But from the perspective of [the] software/firmware layer, yes, they are moving forward much faster."

A Fancy Thing in the Hands of a Barbarian

Despite its strengths and the present pace of its evolution, the Azart family has faced criticism for being complex compared to its predecessors. *ESD* asked Kalinin his opinion on whether he considered the radio to be designed more for use by engineers rather than for soldiers. Kalinin's response was somewhat surprising: "For Generals" he said, later adding: "it was designed by brilliant engineers, to be shown to generals."

In this vein, Kalinin noted that the radio had some truly "questionable features," particularly compared to Russia's earlier 'Akveduk' family of fifth-generation radios, elements of which started entering service with the Russian Armed Forces in the late-1990s/early-2000s. Comparing the two, Kalinin said: *"I saw multiple user interface of radios, and I want to state, Akveduk has [a] 'boots-driven' user experience and interface. What I mean [is] you can operate with the radio by your boots, it has durable everything, and…you cannot press [the] wrong button, physically. With the other system [Azart], you have beautiful TFT display, colourful, and you have the infrared access port."*

When asked about the purpose of the infrared access port, Kalinin burst out laughing and said: "I don't know!", and with wry smile, he added: "I know, but…I still cannot imagine [a] real-world case to use it." Indeed, it seems difficult to imagine why such a feature is needed in a tactical radio, aside from the questionable utility of allowing soldiers to use it for changing TV channels or turning on building air conditioning units. Alongside this feature, Kalinin highlighted that with Azart, "you can change the wallpaper on the screen – THAT's a good radio!" he joked, "I don't see Falcon IV, but I bet they don't have feature to change the wallpaper!"

Such questionable features are indicative of over-engineering and unnecessary complexity within the design. A complaint previously levelled at the Azart was that it was too complicated for many average Russian soldiers to use. Here, another Infozahyst representative noted that even among those Russian soldiers using Azart, many were not even close to using the full capabilities of the radio, and by way of example stated that they had a habit of using just eight out of 256 possible channels, and speculating that the main reason for this was laziness.

When questioned on the usability of the Azart, Kalinin laid the blame primarily

Credit: Rosoboronexport

The R-187P1 Azart VHF/UHF radio possesses a host of features, including AM/FM modes, data transfer, text-based messaging, satellite communication, and GNSS navigation. It is capable of frequency hopping at a maximum rate of 20,000 hops/second; it can be used to communicate with aircraft, and even over GSM 1800 networks without a SIM card. While it has some noteworthy capabilities, it also possesses some questionably-useful features such as Bluetooth, an infrared port, and a full-colour TFT display.

on the level of training and education of the Russian soldiers: *"you need to understand that here you can raise up the engineers who could develop…state-of-the-art radios, but if your country failed in preparing soldiers, [with] basic education, general knowledge, school or knowledge institution, university… and you're giving this sixth-generation radio, SDR – fancy thing, in the hands of barbarian – you shouldn't be expecting much from this guy. He has to have engineering knowledge, understanding what he's doing, the station itself. Yeah, they are not using the full spectrum of features of the station, but it's not the failure of the station or engineers for the station, it's particular failure of units which doesn't have enough training, time for preparation… multiplied by issues with the station itself, multiplied by very poor education of the end user."*

When asked about Russia's industrial capability to continue production of the Azart family despite the heavy sanctions regime on the country, Kalinin stated: *"I believe that they are still in production, even though they're using…national instrumental chips, they avoid the sanction and restriction in buying those chips, because this is something, I believe, industrial grade or even civil grade chips. So it's not that easy to control how these chips is, where they're supplying [from]. And they have a lot of allied countries which [are] buying those chips and supply to the production. So yeah, I think they will be in the production till the end of [the] war."*

Flooding the Receiver: EW Threats

With regard to the Russian jamming threats faced by Ukraine, Kalinin noted that sometimes even relatively simplistic jamming techniques can be very complicated to deal with. By way of example, he cited Russia's 'Rychag-AV' system developed by the Concern for Radio-Electronic Technologies (KRET), and is mounted on the Mi-8MTPR-1 helicopter variant. According to Kalinin, the system "could be used for just overloading ESM systems, because it generates simply 500,000 pulses per second. It's just too much."

According to Kalinin, the problem lies in the fact that each pulse needs to be processed by the receiver before it can be rejected, and every receiver has an upper limit for how many pulses it can process in a given span of time. As such, an airborne system such as Rychag-AV with a very high pulse repetition frequency (PRF) can pose a significant problem for ELINT systems, even without having to use particularly high-power emissions – according to Kalinin "it's airborne, so 100 watts [is] enough to do the trick."

Credit: KRET

Concept render from KRET, with the key components of the Rychag-AV's L187A electronic warfare package highlighted in orange. However, readers should be aware that unlike the graphic implies, the forward-most antenna on the fuselage is actually a receiver antenna, rather than a transmitter. The transmitter on the other hand is the antenna located just behind the rear-most window at the back of the fuselage. This setup is mirrored on both sides of the aircraft.

Expounding on the problem, Kalinin said: *"You can't just simply ignore it. It would be definitely pulse on pulse, giving you additional pulses to be processed. And many of the systems on the market are limited by 1 million pulses per second. So…if you have one or two systems like that, you will have overload of the data on the receiving side."*

By way of example, Kalinin described a simple scenario: *"So in case if you have two fighters in support of two systems with Rychag, you will spot around up to 1 million pulses per second. And out of the shelf system of the ELINT, for instance, one of the big company…could process 500[thousand]."*

Credit: TV Zvezda

Screengrab showing the Mi-8MTPR-1 coming in to land. The starboard emitter antenna can be seen toward the rear of the main fuselage, level with the windows and behind the strut for the landing gear.

According to Kalinin, the problem remains technically very difficult to solve: "It's like a DDoS kind of attack…Even if you have separate pulses, processors, encoders, whatsoever, you simply would be overloaded with the amount of the pulses."

Russia's emphasis on EW has been a feature of the armed forces since the end of its 2008 war with Georgia. From that point, Russia invested heavily into EW as a means of countering NATO's network-centric warfare, and such systems have proliferated widely within their armed forces, with Russian manoeuvre brigades gaining an organic electronic warfare company.

At the start of the War in Ukraine, Russia's EW units failed to be particularly effective, but this was in large part down to the fact that many of these systems were ground-based, and had to first get into position to work effectively without fragging their own side's communications. Yet, as with many of their capabilities such as air defence, their EW units in the War's opening phase were often limited by where they could advance to by logistics, or simply stuck in traffic jams.

Credit: Infozahyst

A Ukrainian Armed Forces ELINT operator, remotely controlling equipment from the basement of an abandoned building. Due to the risk of Russian strikes, many Ukrainian systems allow the operator to control the equipment from a safe distance.

However, once they were able to reach their required positions, their effectiveness increased considerably. By contrast air-based jamming systems such as Rychag-AV faced fewer such operational limitations.

Answering the Call: Lessons to Learn

With Russian communications gradually improving, albeit in a patchwork manner, the challenge for InfoZahyst and Ukraine's armed forces does not appear to be getting any easier. However, there is also room for hope – Ukraine's unique experience in dealing with Russian communications technology and techniques provides them with a strong foundation on which to base their future response to Russia's own adaptations in the electronic warfare arms race.

With regards to the future of the conflict, speaking to representatives from Infozahyst including Kalinin, the mood seemed cautiously optimistic, but not bullish. While they had witnessed grievous flaws in the Russian armed forces, they were also cognisant of the fact that these were being gradually addressed, and their foe was adapting.

The key lessons which can be derived from Ukraine's experience with EW are:

- Smaller, more affordable and plentiful systems are more useful and less-vulnerable than larger, more expensive solutions procured in small numbers.
- ELINT systems should be integrated with other ISR assets or reconnaissance techniques to augment the capabilities of both and speed up the targeting cycle.
- EW systems should be distributed right down to the tactical edge to provide frontline commanders the flexibility to react to or predict their opponent's movements without having to rely on higher-echelon ISR assets.
- De-coupling the equipment and the operator positions is vital to preserving the crew in case the equipment is detected and targeted by enemy strikes.
- Unsecured links are highly vulnerable to COMINT from a determined opponent – therefore secured communications at all levels are critical.
- Retaining redundant forms of communication is critical. Poor communications can have knock-on effects in a myriad of ways, from hindering C2 and coordination between units, to reducing the accuracy of artillery fire missions.

The electronic war in Ukraine may lack the explosive drama of high-explosive artillery and missile strikes, but both of these usually follow in its wake. Given the centrality of network-enabled equipment to modern as well as future warfighting, armed forces the world over would be wise to heed the hard-won lessons of Ukraine's own silent struggle for control of the electromagnetic spectrum. ■

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Clouds on the Horizon

Thomas Withington

The US Army is changing how it organises and deploys its manoeuvre force in response to ongoing and future threats. This reorganisation will have an impact on how this force communicates.

In 2016, the US Army created the Brigade Combat Team (BCT) as the basic, deployable manoeuvre unit. For all intents and purposes, the BCT is a combined arms formation. This means the brigade possesses organic infantry, armour, artillery, engineer and combat support elements. Three principle BCT configurations comprise the army manoeuvre force, namely Infantry (IBCT), Stryker (SBCT) and Armour (ABCT).

These formations are weighted according to their role. For example, an IBCT has three infantry battalions, a cavalry squadron providing the infantry battalions' mechanised capability, an artillery battalion, plus engineer and combat support battalions. The SBCTs have a similar structure. The SBCT's key difference is that it is built around General Dynamics Stryker family wheeled 8×8 Armoured Fighting Vehicles (AFVs). The Stryker BCT was conceived by the US Department of Defence (DOD) to be an air-deployable manoeuvre unit which could be in theatre within 96 hours. The ABCT has three combined arms battalions. These battalions contain rifle companies, as per the SBCTs and IBCTs, but each also has two armour companies. These companies deploy General Dynamics M1 Abrams family main battle tanks (MBTs) and BAE Systems M2 Bradly series tracked Infantry Fighting Vehicles (IFVs). As per the other brigade combat teams, the ABCTs has a cavalry squadron, plus artillery, support and engineering battalions.

According to the DOD, as of late 2022, the US Army has 58 BCTs, 31 of which are in the regular army and 27 of which are in the Army National Guard (ANG). The regular army has 14 IBCTs, the ANG has 20. Eleven ABCTs are in the regular army with five in the ANG. Two Stryker Brigade Combat Teams are in the ANG and seven are in the regular army.

Author

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Credit: US Army

US Army Brigade Combat Teams routinely use SATCOM for beyond-line-of-sight communications. The move towards a division structure could see a heavier reliance on satellite communications, given the larger geographic footprint such a formation will occupy.

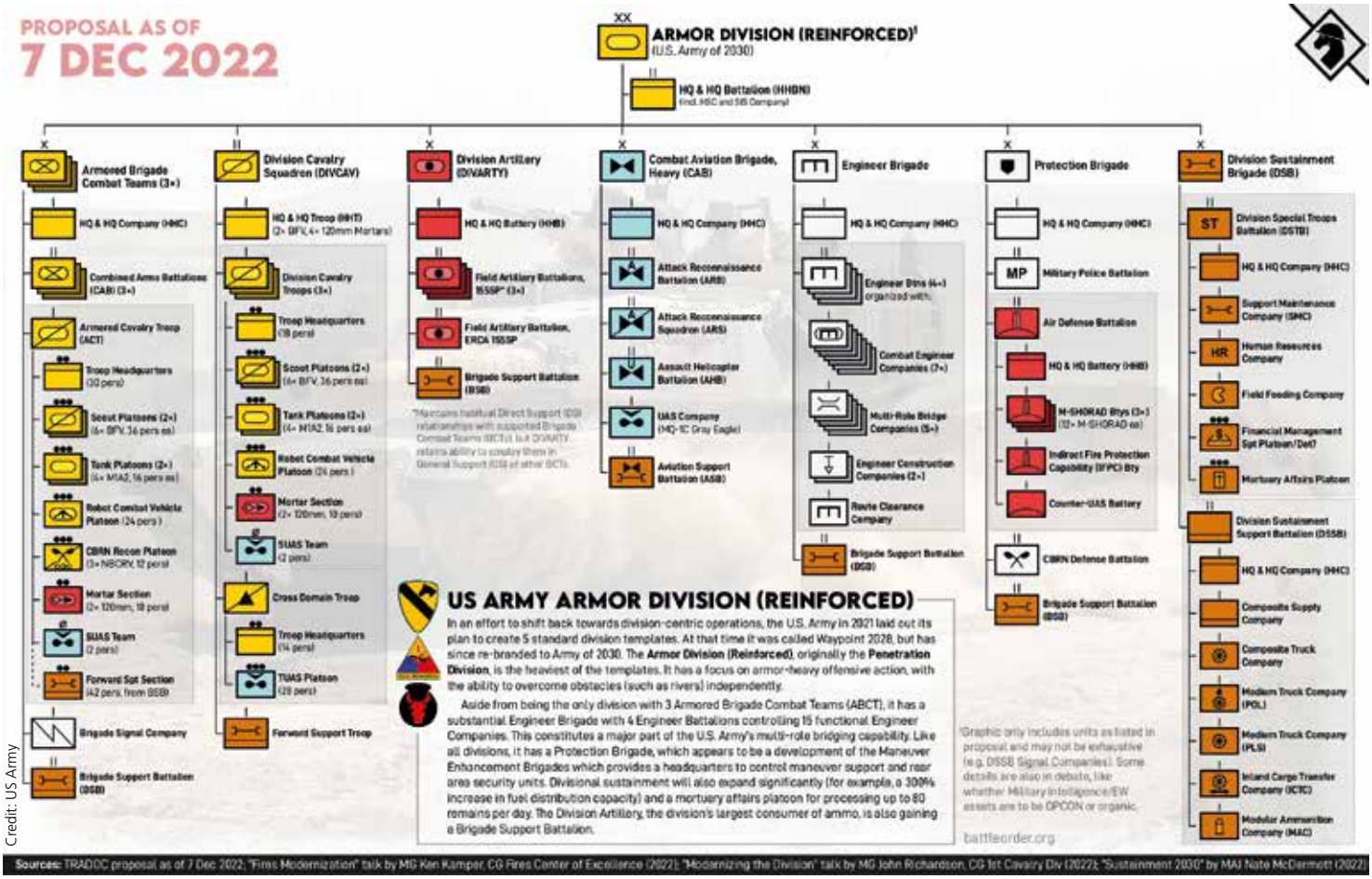
The US Army began developing the BCT structure in 2002. As a paper by Adam Davis entitled 'The Brigade Combat Team: A Revolution in Organisational Structure' published by the University of Southern Maine in 2020 makes clear, the BCT concept was to develop comparatively small combined arms units of circa 2,500 soldiers. This was to offer improved agility compared to previous combined arms formations focused on the division. Divisions typically had strengths of around 10,000-15,000 troops.

The BCT reorganisation arguably reflected the United States' contemporary strategic reality. The 11 September 2001 attacks perpetrated on US soil and the subsequent Global War on Terror, which began that same year with Afghanistan as its fulcrum, greatly influenced the BCT structure. US Army manoeuvre units would need to be largely self-sufficient. Self-sufficiency translated into organic combat units like artillery, engineer, and support units, and the wherewithal to rapid deploy across global distances. As Davis' paper makes clear, the division was the ideal unit for fighting conventional war. Divisions were less ideal for waging the unconventional counter-insurgencies the US led in Afghanistan, and in Iraq from 2003.

Return of the Division

The only constant in military organisation is change. Once again history has played a card that has prompted another major reconfiguration of army manoeuvre formations. In a twist of irony, the US Army is returning to the division structure. To be clear, divisions did not disappear during the BCT era. Army division headquarters (HQs) would routinely deploy providing operational HQs with subordinate BCTs.

Two major, interlinked factors are driving the readoption of the division as the army's principle, tactical unit of manoeuvre. These factors are the return of great power competition, as underscored by the rivalries existing between the US and her allies, with the People's Republic of China (PRC) and



Several proposals have been drafted by the army regarding how their future divisions may look. This schematic sets out the potential order-of-battle for a reinforced armoured division. It is immediately obvious how much larger this formation is compared to the current Brigade Combat Teams.

Russia. As such, the army needs to be able to perform large-scale combat operations. The second is the adoption of the Multi-Domain Operations (MDO) philosophy by the US DOD. Both factors have major implications for how the army organises its manoeuvre force communications.

The Army 2030 vision, announced in January 2022, articulates the plans to move towards a division structure. Army 2030 emanated from the army's Combined Arms Centre's (CAC) 2018/19 Large Scale Ground Combat Operations multi-year study. Equally important was the work of the army's Capability Integration Centre on Russia's military modernisation. Readers interested in the background to Army 2030 should read the excellent white paper 'How the Army 2030 Divisions Fight'. This paper was jointly published in February 2023 by the US Army's Training and Doctrine Command (TRADOC) and the CAC.

The advent of MDO likewise influences the move towards the division. MDO envisages the connection of all personnel, platforms, weapons, bases and capabilities, henceforth known as assets, in a manoeuvre force, to perform synchronous operations at all levels and across all domains of war. MDO strives to improve the pace, quality, and efficiency of navigating the 'OODA' (Observe, Orient, Decide and Act) loop vis-à-vis one's adversary. MDO is seen by the DOD as integral for defeating the Anti-Access/Area Denial (A2/AD) postures of potential adversaries such as the PRC.

The white paper cited above states that army divisions and corps will function as an integral part of a larger, joint force employing capabilities from sea, air, space and cyberspace domains. Divisions will sustain high-tempo combat operations over distance, protect critical nodes and assets, defeat land forces, and support and sustain all operations their assigned areas. As of mid-2023, it appears that the exact composition of the US Army's divisions and timelines for their implantation are still being decided.

Credit: US Army

The move towards decentralised, mobile command and control will be aided in no small measure by the advent of cloud computing to provide a survivable 'clearing house' for C2 and intelligence, surveillance, and reconnaissance data.

Centres of Gravity

BCTs currently use a bewildering array of radios and communications networks move voice and data traffic between their constituent elements and outwards to other formations and services. These systems were examined in detail in the author's 'Connecting the Force' article in the March 2023 edition of ESD. The radios used by the BCTs, the waveforms they carry and their purposes are detailed in figures 1 and 2.

A recent US Army round table event entitled 'Paradigm Shift: Division as Unit of Action', provided some clarity on the influence that the adoption of the division could have on the army's tactical communications posture. The event examined the communications networks that

Figure 1 – Standard US Army Tactical Radios

Manufacturer	Radio	Type	User	Frequencies	Selected Waveforms
Thales	Combat Net Radio	Single-channel handheld radio	Individual soldier radio	V/UHF: 30 MHz to 512 MHz	SINCGARS, HAVEQUICK, IW, APCO-25
L3Harris	Combat Net Radio	Single-channel handheld radio	Individual soldier radio	V/UHF: 30 MHz to 512MHz	SINCGARS, HAVEQUICK, IW, APCO-25
Collins Aerospace	AN/PRC-162	Two-channel backpack radio	Vehicle mounted, dismounted, fixed site	V/UHF: 30 MHz to 1.850 GHz	SRW, MUOS, SINCGARS, WREN TSM, IW, MUOS, SATURN, HAVEQUICK
L3Harris	AN/PRC-158	Two-channel backpack radio	Vehicle mounted, dismounted, fixed site	V/UHF: 30 MHz to 1.850 GHz	SRW, MUOS, SINCGARS, WREN TSM, IW, MUOS, SATURN, HAVEQUICK
L3Harris	AN/PRC-163(V)2/3 Leader Radio	Two-channel handheld radio for team leaders and above	Team, squad, platoon leaders.	V/UHF: 30 MHz to 2.6 GHz	SINCGARS, APCO-25, SATURN, HAVEQUICK, MUOS, TSM, UHF SATCOM
Thales	AN/PRC-148C/D MBIRT/IMBITR Leader Radio	Two-channel handheld radio for team leaders and above	Special operations forces	V/UHF: 30 MHz to 512 MHz	HAVEQUICK, SINCGARS, WREN-TSM
Thales	AN/PRC-170 Javelin Single Channel Data Radio	Single-channel handheld radio to support IVAS	IVAS	V/UHF: 225 MHz to 2.6 GHz	TSM

will underpin this new structure. One takeaway was that networks and systems must change to support the way the army wants to fight. A key change is the need to share information to and from the combat cloud. Manoeuvre force assets, and assets from other co-deployed services will continually share tactically relevant data with the cloud. Data could include video imagery, pictures, written reports or maps, for example. It will be necessary for the army to ensure that the division's communications networks have the bandwidth to move this data. These links will have to be secure. The red force will realise the importance of the cloud and the networks moving data into and out of it. As a result, the red force will work hard to disrupt, degrade, and destroy these links using kinetic, electronic and cyberattack means. The centrality of the movement of information to aid efficient decision-making makes combat clouds and their communications links prime Clausewitzian centres of gravity in the opposing force's eyes.

Credit: US Army

US Army BCTs still routinely use static command posts. Combat in Ukraine has underscored the vulnerability of these posts, making it imperative that HQs remain mobile and decentralised in future conflicts.

Technology

The good news is that much of the current technology the army needs to make this vision a reality already exists and is in service across the BCTs, said Matt Maier during the aforementioned round table. Maier is project manager for interoperability, integration and services at the US Army's Command, Control, Communications-Tactical Programme Executive Office (PEO C3T). This includes commercial/civilian technology that the manoeuvre force is receiving in the form of the Integrated Tactical Network (ITN). The ITN uses civilian and commercial technology such as smartphones and tablets. These devices can use a variety of links, including civilian cell phone networks, to carry unclassified traffic around and beyond the manoeuvre force.

Speakers agreed that the need for communications to be survivable is paramount. This author estimates that Rus-

Figure 2 – Standard US Army Tactical Communications Waveforms

Waveform	Frequency	Purpose
ANW2 (Army Networking Waveform-2)	UHF	Data communications between dismounted troops, vehicles and command centres.
APCO-25	UHF	Used for first responder communications in the United States.
HAVEQUICK	V/UHF	Air-to-surface/surface-to-air tactical voice and data communications.
HF SSB with ALE (High Frequency Single Sideband with Automatic Link Establishment)	HF	Long-range over-the-horizon backhaul.
IW (Integrated Waveform)	UHF	Tactical SATCOM.
MUOS (Mobile User Objective System)	V/UHF	Tactical SATCOM.
SATURN (Second Generation Anti-Jam Tactical UHF Radio for NATO)	V/UHF	Surface-to-surface/air-to-surface/surface-to-air tactical voice and data communications.
SRW (Soldier Radio Waveform)	UHF	Surface-to-surface tactical voice and data traffic.
SINCGARS (Single Channel Ground and Airborne Radio System)	VHF	Surface-to-surface/air-to-surface/surface-to-air tactical voice and data communications.
TSM (Tactical, Scalable, Mobile Ad-Hoc Network) WREN-TSM (Warrior Robust Enhanced Network Narrowband TSM) WREN NB (WREN Narrowband)	V/UHF	Surface-to-Surface tactical voice and data traffic.
UHF SATCOM	UHF	Tactical SATCOM
WNW (Wideband Networking Waveform)	V/UHF	Tactical voice and data traffic.

Credit: Lockheed Martin

MUOS-2, the second satellite in the constellation, during assembly. The MUOS constellation was developed to provide UHF communications for the US' mobile forces.

sia's land forces deployed circa 80% of their Electronic Warfare (EW) capabilities into Ukraine. Division communications will need to operate in a contested EW environment, said Jeff Smith, L3Harris' vice president of business development. This survivability will need to extend to reducing reliance on GNSS (Global Navigation Satellite System) services such as the US Global Positioning System (GPS). As well as navigation, GPS provides precise timing signals that electronic systems, including radios, depend on. Operating in a GNSS-denied environment will be a reality, said Smith. Here, the Ukraine theatre is instructive. Russian EW forces have enjoyed considerable success in jamming GNSS signals. Jamming has disrupted Ukrainian UAV operations and GNSS-reliant precision guided weapons like the US-supplied Joint Direct Attack Munition (JDAM). At the software level, low probability of detection/interception radio waveforms are vital alongside strong emissions control. Units should only be transmitting when they must. The rest of the time, they must remain electromagnetically opaque, said Smith.

The advent of digital fires tactics is indicative of the MDO direction of travel for US Army's land manoeuvre force. Digital fires involve the rapid movement of precision fire coordinates digitally between computerised Command and Control (C2) and fire control systems (FCSs). This approach aims to reduce artillery sensor-to-shooter time and improve precision by reducing the danger that calls for fires will be misinterpreted. Returning to the combat cloud, this is where such a capability will become so important. For example, let us suppose an Unmanned Aerial Vehicle (UAV) detects a concentration of troops some distance from the tactical edge. The target's coordinates and supporting imagery are uploaded to the cloud from the UAV. Commanders are advised by the UAV that a potential target has been spotted. The UAV's target information is downloaded from the cloud and accompanies the subsequent call for fires sent to the division's artillery.

Cloud computing could, in some cases, remove the need to have fixed command centres. A key lesson from Ukraine is that mobility means survival. Fixed headquarters are easy prey for Russian artillery, close air support and battlefield interdiction. Real-time, decentralised C2 is a must for the division, said Smith. Can headquarters elements remain mobile and dispersed but fully networked? One can think of this as the military equivalent of working from home - civilian office life regularly sees workers performing tasks remotely, but remaining networked with their colleagues and managers through the internet.

LOS and BLOS

Another challenge the division structure must contend with is land area. As a comparatively larger formation than the BCT, a division will by nature have a greater footprint. This brings challenges from a communications perspective. Manoeuvre formations such as the BCT rely on Very/Ultra High Frequency (V/UHF) radio spanning a waveband of 30 MHz up to 3 GHz for Line-of-Sight (LOS) communications.

Put simply, V/UHF cannot bend around the horizon. Thus two V/UHF radios must have a largely unobstructed line-of-sight to communicate with each other. A soldier carrying a V/UHF radio with a total height of 2 m (6.6 ft), including the radio's antenna, on flat ground will have a LOS range of 5.8 km (3.6 miles). They will struggle to communicate with another V/UHF radio beyond this distance. For comparison, a vehicle with a V/UHF radio antenna with a total height of 5 m will have a LOS range of 7.9km (4.9 miles), and a 20 m high V/UHF antenna will have a LOS range of 18.4 km (11.4 miles). These ranges can be extended by using Mobile Ad Hoc Networking (MANET). This process lets radio traffic skip from one radio to another until it reaches its intended destination, the radio equivalent of a game of pass the parcel. Subordinate units in a BCT use Satellite Communications (SATCOM) to communicate at Beyond Line-of-Sight (BLOS) ranges. One example in this regard is the Mobile User Objective System (MUOS) SATCOM constellation.

Reliance on BLOS links will only increase in the future. Division units may sometimes be separated across hundreds of kilometres. Even MANET networks will not reach that far, meaning units will also depend on BLOS capabilities such as SATCOM. One capability which has shown its potential are comparatively low-cost commercial SATCOM constellations such as SpaceX's Starlink system in widespread use in Ukraine. These constellations make use of comparatively inexpensive 'CubeSats' placed in Low Earth Orbit (LEO). Commercial SATCOM constellations could be used to move less-sensitive traffic, with classified communications moving across more secure networks such as MUOS. CubeSats typically have a mass not exceeding 10 kg (22lbs). Satellites in LEO are typically at altitudes under 1,000km (540 nautical miles), according to NASA's definitions.

Established technologies can help as ranges increase, said Smith. High Frequency (HF: 3 MHz to 30 MHz) radio transmissions skip across the horizon by bouncing off the ionosphere. The ionosphere is a layer of the atmosphere between 48 km (25.9 NM) and 965 km (521 NM) above Earth. HF helps to provide mobile voice and data while Very Small Aperture Terminals (VSATs) can be used for SATCOM. VSAT terminals have dish antennas between 750 mm to 1200 mm in diameter. As such they are relatively easy to move and set up, providing high bandwidth SATCOM at data rates of up to 16 mbps according to open sources. Smaller, directional SATCOM antennas are under development, according to the US Army. These antennas can equip vehicles and aircraft, automatically tracking where a satellite is in the sky. This ensures that transmissions and accurately sent and received while assets are mobile.

Interestingly, much of the effort of designing the division's networking is focused on reducing complexity. Allied to this is an acceleration, and improvements in efficiency, concerning how the army introduces new communications and networking technologies. Agility is key to getting software and data-focused improvements into division networking, since much of the hardware is already there. The US Army is overhauling its tactical communications via the Handheld, Manpack, Small Form factor (HMS) programme. As noted above, civilian and commercial hardware forms part of the ITN. The software-centric nature of this hardware makes it relatively easy to update with new software applications as and when these become available.

People Potential

the manoeuvre force's tactical communications is not just about the kit. Personnel form a vital part of the effort. The US Army round table event also noted that training forms a major part of the move towards the division and adapting communications and networking accordingly. Colonel Paul Howard, commandant of the US Army Signal School at Fort Gordon, Georgia, and the Army's Chief of Signals, remarked during the round table that training processes and syllabi are already accommodating these changes.

The US Army faces the most formidable challenge to its combat power in a generation resulting from the changing strategic landscape and the threat posed by the PRC and Russia et al. Moving towards a division structure makes sense. Todays' and tomorrows' adversaries are numerically larger and more technologically sophisticated than those engaged by the US military in Afghanistan and Iraq. The challenge will be reorganising the manoeuvre force's current networks to make them fit for purpose. Fortunately, the army already has several of the systems and architectures it needs for this effort. The embrace of new technologies such as cloud computing and CubeSats will help plug gaps and confer new capabilities. Investing in people will also pay dividends. Threats do not remain static. The US Army's manoeuvre forces are showing they can move with as much, if not more agility, both technologically and tactically.

Through the Looking Glass

Tamir Eshel

Intelligence gathering, surveillance, and reconnaissance (ISR) are time-honoured cornerstones of military strategy. From the era of horse-mounted scouts to the epoch of globe-circling satellites, the potency of ISR lies in its power to collect, analyse, and leverage information about adversaries in the carrying out of successful military operations.

While the modes of ISR have evolved over the years, the underlying principles have remained rooted in their foundations. Before the dawn of revolutionary technologies such as drones, cameras, balloons, telescopes, and artificial intelligence (AI), ISR was vital in military affairs. Armies relied on human observation and the skills of experienced commanders to understand the terrain and evaluate enemy posture, positions, movements, and capabilities. The information gathered by observers was fundamental for operational planning, shaping the battlefield, executing the right move at the right time, and consequently, often determining the victor.

Fast-forwarding to the modern era, technology has profoundly transformed how ISR is conducted. No longer reliant on field reports by observers and reconnaissance patrols, ISR has embraced high-tech observational tools, delivering real-time, detailed, and accurate information and insight. Yet, for all the technological leaps, the age-old tenets of ISR remain as significant today as they were millennia ago. This article analyses the evolvement of ISR and offers a look ahead.

At the tactical edge, handheld solutions such as the TacFusion binoculars from Photonis are capable of fusing low-light day and thermal channels to enable target detection out to 3 km in low-light conditions.

The domain of intelligence gathering has traditionally been rooted in long-range observation. For many years, holding the highest ground equated to seeing the furthest thereby giving your own forces a critical advantage. However, inventions such as the hot air balloon and aircraft revolutionised this dynamic, facilitating aerial dominance over vast, flat landscapes. However, these advances came at an elevated risk to the observers and platforms.

With the advent of reconnaissance satellites equipped with powerful telescopes or synthetic aperture radar (SAR), the risk was mitigated by providing the world's leading governments the means to monitor any area of interest around the globe, though not in real-time.

The ushering in of unmanned systems has since democratised this realm, empowering every military, paramilitary, insurgent, and terror actor to observe and strike from

Application	Observation Means	Mission Characteristics
Intelligence Gathering	LORROS, MALE/HALE UAS, Observation & SAR Satellites, SIGINT, 2D/3D Mapping	Long-range, high-volume, data collection from a stand-off range, change detection capabilities
Target Acquisition	MALE/Tactical/Mini UAS, Covert Ground Observation, Special Forces, JTAC	Long-range, very high accuracy, fast turnaround, concealment
Counter Terrorism	Mini UAS, WAMI, SAR/GMTI, Mobile Observation Systems, 3D Mapping, Change Detection	Relatively short-range, short-term persistent surveillance over designated areas, high accuracy, forensic investigation capabilities, rapid turnaround, concealment
Terrain Analysis	Multispectral Reconnaissance (materials, composition, ground), Change Detection, Measurement and Signature Intelligence (MASINT), Light Detection and Ranging (LIDAR), FOPEN	Broad area coverage, multispectral measurement, 3D mapping
Force Protection	Elevated Surveillance, Aerostat, Mini-UAS, UGVs, Ground Surveillance Radars, Unattended Sensors, WAMI, SIGINT	Wide-area persistent surveillance, life pattern analysis, anomaly detection, forensic investigation
Border/Coastal Protection	Physical Obstacles, Sensory Fences, Mast-mounted Sensors, Aerostats, UAVs, UGVs, Unattended Sensors, Change Detection, SIGINT, WAMI	Linear persistent surveillance, life pattern analysis, anomaly detection

the sky or sea. Visual Intelligence (VISINT) is often considered the gold standard for state and military entities. VISINT harnesses a plethora of visual information from all sources, processes it, and presents it to decision-makers for comprehensive analysis and subsequent action.

Visual Intelligence

Image acquisition methods for VISINT span a broad spectrum, ranging from spy satellites orbiting hundreds of kilometres above the Earth to high-altitude UAVs surveying vast expanses of land or sea, and even down to small, low-flying drones that capture detailed imagery of specific targets. Although the means to secure the imagery might vary, the techniques and goals remain consistent.
These systems commonly employ multispectral imaging, which includes visible (VIS), near-infrared (NIR), short-wave infrared (SWIR) components to sense direct and reflected light. Going beyond these, medium-wave (MWIR), and long-wave infrared (LWIR) infrared thermal sensors can detect tiny temperature variations, providing imaging of thermal signatures of objects and their surroundings. As such, these latter two can operate in total darkness, identifying objects based on their unique heat signatures rather than reflected light. These sensors are typically designed for long-range performance, extending visibility beyond national borders and facilitating stand-off operations while keeping the reconnaissance systems themselves safely out of range.

Credit: Safran

Safran Vectronix's tripod-mounted GonioLight provides a stable platform for observation and target acquisition equipment. The configuration shown here includes the Vector 23 rangefinder binoculars and JIM LR FLIR.

Credit: Teledyne FLIR

Developed for US defence and federal agencies, the R80D SkyRaider delivers a range of versatile Group 2 and 3 payload capabilities with the agility and single-operator deployment footprint of a proven Group 1 Vertical Take-Off and Landing (VTOL) aircraft.

Modern VISINT systems frequently combine various sensors, some even operating simultaneously to extract a fused image that conveys more information than each channel could provide. This data is processed to highlight objects of interest. If past images of the same area exist, they are compared with new images to reveal changes indicative of enemy infrastructure build-up, force movements, logistics activities, and other preparations.

Multispectral imaging merges observations across several spectral bands, providing a deeper understanding of the scene. With this technology, analysts can see through camouflage and vegetation, identify earthwork and fortifications – even when covered – and potentially spot land mines and improvised explosive devices (IEDs) based on the subtle disruption they cause to the soil.

Previously, such processing demanded extensive communication and computing resources, available only at national-level intelligence and imagery processing centres. These centres also served other purposes, such as maintaining a 'target repository' for precision-guided munitions or resources for mapping and analysing potential battlefields. Today, some of these resources are more accessible, with some even available at the operational level, supporting counter-terrorism activities and special operations.

Credit: EVPU Defence

Longer-range vision systems, such as the EVPU Defence Sirius optronic sight pictured above, incorporate day and thermal sensors, and are capable of detecting targets out to ranges of 25 km, depending on the variant.

Observation systems fill intelligence and situational awareness gaps at multiple levels of a force, with ground observation posts, UAVs, and satellites are employed. However, at the tactical edge, the general trend leans toward Vertical Take-Off and Landing (VTOL) UAVs, which can deliver high-quality and responsive ISR. Sensor manufacturers are adapting to meet this need, integrating multi-sensor payloads into the low-space, weight, and power (SWaP) form factor of a few kilogrammes. Such payloads require the drone to be equipped with sufficient power to process images and videos, providing tactical users with actionable intelligence and targets. Similar capabilities have also been extended to tactical vehicles.

The intelligence-gathering process becomes more time-sensitive at the lower echelons for activities carried out close to one's own forces. The time to acquire, process, and disseminate information to the user is paramount. This forms part of the 'sensor to shooter' cycle of target acquisition, which gained relevance with the introduction of guided munitions in the 1990s. Today, as both sides of the war in Ukraine demonstrate, target acquisition and fire direction are routinely conducted using unguided artillery, mortar, and rocket fire, with spotter drones flying over the combat zone.

Target Acquisition

Target Acquisition (TA) and Battle Damage Assessment (BDA) frequently merge observation, range finding, and target designation equipment. These systems are mounted on a goniometer to ensure the alignment and precision necessary for the weapon in use. Targeting systems might be integral to the weapon systems – for example, combat aircraft, attack helicopters, or tanks – or utilised by a specialised reconnaissance or fire support vehicle. Vehicular systems, less restricted by space, weight, and power, achieve longer ranges and higher resolution. However, since these assets must maintain a direct line of sight with their targets, they are inherently exposed and vulnerable to enemy fire.

To enhance the survivability and resilience of dedicated TA assets, sensors are affixed to telescopic masts. This setup enables the vehicle to operate from a defilade position or under a tree canopy. Dismounted teams also manage portable equipment. Both methods rely heavily on camouflage systems to conceal their position and favour maintaining a static

position as long as they remain undetected. With the advent of smaller, lighter payloads, these missions are increasingly assigned to unmanned systems – autonomous ground vehicles, fixed-wing, and multirotor drones. The latter also excel in BDA as they can maintain continuous coverage of the target throughout the engagement.
Besides improving crew security and safety, these platforms have introduced a new capability: the ability to conduct tactical observation and target acquisition Beyond Line-of-Sight (BLOS). Matching this function with precision-guided weaponry has introduced a new and transformative capability to the modern land battle.

Surveillance Systems

Observation systems are critical in surveillance missions, encompassing border and coastal defence, force protection, and public or infrastructure security. These missions necessitate ongoing surveillance of specific areas, a task often challenging for human operators due to the high concentration and alertness required over extended shifts. The employed equipment blends a myriad of sensors designed for day, night, and adverse weather operations. The fusion of visual intelligence and radar is highly beneficial due to the radar's ability to detect movement and cue the observation system to scrutinise the detected activity.
This integration can also harness unattended sensors placed throughout the area under surveillance. Modern devices capable of wide-area surveillance also provide data for video motion detection and automatic target recognition. This enables systems to undertake much of the routine surveillance tasks, allowing operators to concentrate on analysing suspected targets and high-alert situations.
While most surveillance networks depend on a static sensor network, even the most robust system has some vulnerabilities that seasoned and determined adversaries could exploit. Incorporating mobile segments into such a network enhances the overall system's efficiency. Mobile observation posts may use relocatable unattended sensors, mounted patrols, or drones. These can be deployed pre-emptively based on intelligence information or ad-hoc to strengthen specific lines of access where adversary activity is anticipated.

Summary

Intelligence gathering, surveillance, and reconnaissance have always been pivotal elements of military strategy. Despite the profound transformation of ISR methods through technological advancements, their founding principles remain relevant. This article explored various facets of ISR, from intelligence gathering and target acquisition to border surveillance and security.
Visual intelligence plays a critical role in amassing and processing visual information. With advances in video processing, AI/machine learning, and automatic target recognition, users are now better equipped to exploit this information. Consequently, sensor operators are transitioning into analytical roles, and information processes are being automated into real-time information systems. As technology continues to evolve, the future of ISR holds immense potential to elevate situational awareness and decision-making capabilities within military operations. ■

Marketing Report: Will-Burt

The Will-Burt Compact Elevation System

The concept for Will-Burt's Compact Elevation System (CES) was driven by the desire to have a highly efficient mobile elevation system that could accommodate large and heavy sensor payloads while being small enough to conceal the entire package. This is no small task when one considers the size and weight of advanced sensor packages that combine a pan and tilt, multiple video sensors and radar.
The requirement is to quickly and covertly deploy sensors for UAV defence, border surveillance, and force protection. Flexibility is critical. The system is based on a pallet design that can be installed on a variety of vehicles, trailers, and shelters. Will-Burt offers multiple integrated solutions for small trucks and military spec trailers and the Compact Elevation System can also be purchased as a standalone product as well, so that a customer may integrate the system onto their own specialised platform.
The low-profile design makes it possible to conceal the stowed elevation system and its payload below 630 mm and conversely allows it to elevate the payload to a height of 8,540 mm. Will-Burt offers two telescopic mast types for the Compact Elevation System that are field proven and MIL-STD 810 tested and certified to perform under the most difficult environmental conditions. The Stiletto AL mechanical mast with a payload capacity of 181 kg and the Super Heavy-Duty Pneumatic mast with a payload capacity of 241 kg can be fully integrated into the system, offering power, precision, and rock-solid stability for the customer-installed sensors. Both telescopic masts have full-length external keys that minimise rotational twist, allowing the sensors and radars to perform at their full potential.
Lastly, the entire system is fully integrated with a single CAN-Bus/Serial user interface that is easy to operate and supplies system status feedback as well. It may also be integrated directly into the customer's control system.
Will-Burt is a global organization founded in 1918 and headquartered in the USA with manufacturing and support locations in the UK, Germany, Turkiye, and Singapore.

Credit: Will-Burt

Future Soldier Systems: Current Programmes

Sidney E. Dean

Current Future Soldier programmes aim to upgrade infantry capabilities through technology, but display more realistic goals than some previous initiatives.

From Afghanistan to Ukraine, modern conflicts have proven that dismounted infantry remain the decisive military force. Airpower, artillery and armoured vehicles are of course indispensable, but ultimately serve to enable the infantry to conquer the proverbial 'last 100 yards' of the battlefield. Dismounted soldiers' role is even more prominent in post-conflict, peacekeeping or counterinsurgency operations.

Armed forces regularly upgrade infantry gear, with an eye to enhancing both survival and lethality. The first decade of the current century was marked – especially in the United States – by some highly ambitious projects which aimed to leverage conceptual technology to create 'super soldiers' equipped with strength-multiplying exoskeletons and 'Iron Man' suits offering ballistic protection and integrating non-traditional weapons options. After years of research it became evident that such concepts still belonged, at least for the time being, to the realm of science fiction.

Credit: French Army

The French Army's new F3 Ballistic Helmet is evolved from the original FELIN helmet. Function rails, hook-and-loop brackets, and new side parts enhance the ability to mount accessories.

French Army

Programmes with more moderate parameters, such as the French Army's FELIN (Fantassin à Équipement et Liaisons Intégrés; ENG: 'Infantryman with Integrated Equipment and Communications'), were more readily implemented. The industry team led by Safran Electronics and Defense delivered circa 23,000 FELIN sets to the French Army between 2010 and 2015. The system is operational with airborne, mountain and mechanised infantry units, and was successfully deployed in Afghanistan, and Africa. The modular system includes improved communications gear and sensors, infantry weapons and advanced aiming aids, ballistic protection and ergonomically optimised uniforms and harnesses. The kit can be configured to meet mission parameters and the role of the individual soldier within the unit or echelon.

Immediately after completing procurement of the original FELIN kits, the DGA (Direction générale de l'armement; ENG: General Armaments Directorate) in 2016 awarded Safran the contract to upgrade the system to the FELIN V1.3 standard. Improvements include software upgrades for targeting sensors and fire support, more modular protective gear, and enhanced combat vests optimised for the SitComdé tactical terminal and battle management system. V1.3 promised to reduce system weight by 40% without compromising protection. Then in 2019 the DGA launched the Centurion initiative. The programme runs through 2026 and aims to accelerate innovation by French industry and integrate new technologies into existing programmes including future increments of FELIN. The goal is to enhance "individual, collective and collaborative capabilities of the fighter" through technologies such as connectivity and communication, positioning and navigation, innovative interfaces, protective and stealth equipment, mobility aids, observation and identification means, innovative energy sources, soldier health monitoring, and functionalised textiles.

Other countries' ongoing Future Soldier System programmes are following the same approach of systematically adopting incrementally-improved equipment and new materials, and fielding them as holistically balanced packages to improve soldier performance. Wearable electronics and advanced networking capabilities are considered vital elements in all of these programmes. The US Army and the German Army present two typical approaches.

US Army

The US Army's current infantry modernisation effort is focussed in several compartmentalised, parallel but independent projects to develop new infantry weapons, wearable sensors and situational

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Credit: French Army

In 2017 the French Army introduced the new generation Structure Modulaire Balistique (SMB) or 'modular ballistic structure'. Inspired by soldier feedback, the SMB is a fusion of the ballistic protection vest and the combat equipment transport system. It improves mobility and comfort through lower weight and improved ergonomics over its predecessors.

awareness tools, and personal protective equipment (PPE). The Next Generation Squad Weapon (NGSW) programme, the Integrated Visual Augmentation System (IVAS) and the Enhanced Night Vision Goggles – Binoculars (ENVG-B) are among the Army's highest priority or 'signature' development efforts. Their development is being guided by the Army Futures Command's Soldier Lethality cross-functional team.

NGSW

The NGSW system consists of four elements. The XM7 rifle will replace the M4 carbine. The belt-fed XM250 automatic rifle will replace the M249 light machine gun. Both gas-operated weapons are being developed by Sig-Sauer under a 2022 contract. They will be equipped with the optional 'smuzzle', a combined sound suppressor and muzzle brake developed by Army engineers. Army testing shows the smuzzle provides a 33% reduction in felt recoil, 25% reduction of flash signature downrange, and 50% reduction in acoustic signature.

The NGSW-Fire Control (NGSW-FC) is an integrated optic system designed to provide enhanced target acquisition and aim correction for both weapons. The design contract was awarded to Vortex Optics in 2022. The FC's main components include a variable-power scope, a laser rangefinder, a ballistics computer, a disturbed reticle (referring to two aim-points observed when looking through the sight, with one aim point aligned with boresight, and the second tracking the electronically 'tagged' target), and a wireless link to soldier devices. It autonomously calculates range, wind and elevation and adjusts the aim point accordingly, while projecting target location, distance, and status to the soldier's display.

The final component of the NGSW is the new 6.8 × 51 mm (.277 Fury) cartridge designed for its greater projectile weight and muzzle velocity over the M4's 5.56 × 45 mm ammunition. Overall, NGSW is expected to significantly increase range, accuracy, and target penetration over current infantry weapons; the Army's stated goal is "achieving overmatch against global adversaries and threats that emerge on the battlefield of today and tomorrow." The system recently completed production qualification testing, and the first operational unit is scheduled to be equipped with NGSW during the second quarter of FY 2024. The Army plans to procure 250,000 XM7s and 150,000 XM250s over a ten-year period.

IVAS

IVAS is derived from Microsoft's Hololens 2 headset, which uses holographic technology to overlay digital imagery over real-world imagery. According to Microsoft, the system combines the HoloLens' mixed-reality technology with thermal imagery, sensors, GPS technology and night vision capabilities in order to improve soldiers' situational awareness and impart tactically-relevant information. Holographic images, three-dimensional terrain maps and a compass are superimposed onto the heads-up-display (HUD) of the otherwise transparent lens. This includes reconnaissance and targeting data from the squad's unmanned aerial vehicles (UAVs). Major components are the helmet-mounted visor, a computer (called the 'puck') worn on the body, a networked data radio and three conformal batteries. A wireless interface connects the goggles to a family of weapon sights, projecting the weapon reticle and a thermal image of the target onto the goggle display; this enables soldiers to remain under cover while extending their weapons – even around corners – in order to aim and fire at enemies.

Initial IVAS 1.0 demonstrators were tested by troops in 2022, followed in short

Credit: US Army

The Sig Sauer XM7 Rifle will replace the M4 carbine as part of the US Army's Next Generation Squad Weapon (NGSW) programme.

order by improved IVAS 1.1 prototypes. Soldier feedback has exposed numerous issues such as disorientation and neck strain which are to be alleviated with iteration 1.2. The first IVAS 1.2 prototypes were delivered in July 2023, with operational fielding expected in 2025.

ENVG-B

The helmet-mounted Enhanced Night Vision Goggle-Binocular (ENVG-B) developed by L3Harris combines white phosphor image intensification and long-wave infrared (LWIR) thermal imaging to create an enhanced view of the battlefield under low-light and degraded visual conditions. By integrating with the NETT Warrior system (described below), the goggles can also display maps, navigation, and blue force tracking. Like IVAS, the ENVG-B is intended to enhance mobility, survivability, and lethality in complex environments by significantly expanding situational awareness and improving soldiers' ability to identify and engage targets. The Army plans to acquire 40,000 units through 2028.

NETT Warrior

NETT Warrior (NW) is an integrated situational awareness system for dismounted infantry leaders (team level and above). The cross-platform system uses the handheld military radio as an interface to link a commercial off-the-shelf (COTS) smartphone into the brigade-level command and control network. Via the smartphone, the soldier can access apps to track friendly forces, coordinate movements with other units, request fire support, send messages and share data; the system can also network with sensors of small unmanned ground vehicles (UGVs) and UAVs. NW employs the map-based Tactical Assault Kit (TAK) situational awareness software suite along with custom applications. The system was introduced in 2010, but has undergone several iterations to date, both to enhance performance and to reduce weight. The third increment is currently undergoing testing, and could be delivered to selected units in 2024. A major goal of the newest design is enhanced artificial intelligence to optimise the interface with other new Future Warrior equipment.

Soldier Protection System (SPS)

The SPS body armour system entered production (depending on the component) between 2016 and 2019, and consists of: Torso and Extremity Protection (TEP), which includes the Modular Scalable Vest (MSV), the lightly armoured, flame-resistant Ballistic Combat Shirt and the Blast Pelvic Protector to reduce the risk of groin injury; the Vital Torso Protection (VTP) set of front, back and side armour plates for insertion into the MSV; and the Integrated Head Protection System (IHPS) consisting of a base helmet which can be augmented with mandible armour and goggles. The SPS is intended to provide equal or greater degrees of protection than legacy body armour against small arms fire and fragmentation, but at reduced weight. The modular system's individual components can be configured for various tiers of protection to meet mission parameters and soldier needs. Three elements of the SPS are currently being upgraded. The new components are the Second Generation Modular Scalable Vest (MSV Gen II), the Third Generation Vital Torso Protection (VTP Gen III), and the Next Generation Integrated Head Protection System (NG-IHPS). MSV Gen II and VTP Gen III began early fielding in 2021. Ballistic testing is ongoing, and failure rates so far remain below 5%. The Army plans to acquire 150,000 of each system subset.

Credit: US Army

A soldier tests an IVAS headset during a training exercise at Fort Bragg, North Carolina.

German Army

Germany's Infanterist der Zukunft (IdZ) (ENG: Infantryman of the Future) programme was initiated in 2004 as an urgent operational requirement to equip personnel deployed to Afghanistan. The initial IdZ – BS (Basissystem; ENG: Base System) phase was based on COTS components in order to speed up implementation. The currently fielded iteration is designated IdZ – ES (Erweitertes System; ENG: Expanded System) Gladius. Development began in 2006 by prime contractor Rheinmetall Defence Electronics, with deliveries beginning in 2013. The 'ES' suite was conceived as a clean-sheet development because, as the German army stated, "the essential capabili-

Credit: German Army

German soldier with the 'Future Infantryman' (IdZ) kit.

Credit: Rheinmetall

The System Panzergrenadier forges the Puma IFV and its infantry dismounts into a fully digital team sharing situational awareness and enhancing lethality.

ties required by the infantryman can only be fulfilled via a closed and coordinated system approach." In addition to performance enhancement, the new equipment is also optimised for ergonomic comfort and weight reduction, improving soldier mobility, and reducing fatigue or risk of injury.

The German armed forces currently have circa 165 platoon-equivalent kits, sufficient to equip 6,600 servicemembers (mostly Army, although other services have been provided a limited number of kits as well). IdZ consists of three subsystems: BST (Bekleidung, Schutz- und Trageausstattung; ENG: Clothing, Protective and Load-Carrying Equipment), WOO (Weapons, Optics and Optronics), and C4I (Command, Control, Computers, Communications and Information). The entire system is modular, permitting elements from each subsystem-group to be put together to meet the needs of either light or mechanised infantry or reflect an individual soldier's function within the unit. The common core is formed mostly of vest-mounted communications and networking equipment including a USB hub (into which electronic communications, data and sensor devices are plugged), tactical radios, a visual display unit, digital navigation devices, multiple conformal batteries, and a communications headset. This core is augmented by selecting from nearly 80 options organised into various categories including helmet- and weapon-mounted vision modules and fire control units, multi-mode binoculars, augmented reality devices, numerous customisable firearms and grenade launchers, and personal protective equipment (PPE).

The IdZ family continues to be upgraded regularly, and is considered one of the most advanced infantry systems in the world. Regarding the BST and WOO subsystems, recent improvements have largely focussed on reducing weight and improving user-friendliness. Individual sensors and sights have incrementally improved performance, and the greatest effort is now being placed on C4I systems as the key to tying all elements together into a force multiplier package. Deliveries of the newest IdZ iteration, designated 'IdZ-ES VJTF 2023', began in 2021, with additional orders placed in January 2023. This variant is optimised for the German contingent leading the NATO Very-high-readiness Joint Task Force (VJTF) in 2023. New aspects include upgraded software-defined radios as well as enhanced situational awareness and target acquisition features; these include the chest-mounted CeoTronics CT-MultiPTT 3C central operation and control unit which displays blue-force locations on a tactical map. The IdZ-ES VJTF 2023is compatible with the German military's new Digitised Land-Based Operations (D-LBO) programme, which is designed to provide a framework for mobile command and control (C2) networks.

Together with upgraded electronics and communications equipment on the Puma infantry fighting vehicle (IFV) and other armoured combat vehicle classes, the IdZ-ES VJTF 2023 also forms the basis for the System Panzergrenadier which will deploy for the first time with the NATO VJTF. The System Panzergrenadier fully networks vehicle sensors and weapons with those of the mounted and dismounted mechanised infantry, creating a seamless common operating environment. This amalgamation of dismounted infantry and IFVs into a true fighting unit enables opposing forces to be detected, identified, and effectively engaged at greater range and with improved precision. With this, the German Army has set a new baseline for integrating dismounted infantry with their IFVs.

In 2021 the German Army tasked Rheinmetall with initiating a study for the next generation Future Soldier System, to be designated IdZ 3.0. It will build on the digital backbone of the current variants, while incorporating new hardware. Full details have not yet been decided, although a few new components are known. These will include the new G95A1 and G95KA1 assault rifles (more widely known as the HK416 A8) which will begin replacing the current G36 as of 2024. New sensors and weapon sights are also expected. One is the FCS 12 fire control system which combines several functions including day or night weapon sight, laser rangefinder, ballistic computer, and video recorder. As Jan Gesau, First Director of the Bundesamt für Ausrüstung, Informationstechnik und Nutzung der Bundeswehr (BAAINBw) or Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support, stated in an interview in the August 2023 edition of this publication, findings of the relevant studies "will be continuously incorporated into the design of the next steps towards the realisation of the third generation" of the IdZ system.

An Unending Road

Ultimately, 'the future' is always one step ahead of any ongoing programme. Once a particular suite of equipment enters service, the military must begin planning the next system of upgrades in order to keep pace with technology and with potential adversaries. In this, the German, French and US land forces – and all of their counterparts – face the truth that the only constant is change.

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Preparing Tactical Command Posts for the Next War

John Antal

Nearly every day, the news from the fighting in Ukraine includes the unmasking, targeting, and destruction of a Russian or Ukrainian tactical Command Post (CP). Imagine what it takes to reconstitute a destroyed brigade or division CP. Numerous generals, hundreds of colonels, and senior operators have been killed in these strikes since the start of the war. NATO cannot afford to lose CPs the way the Russians and Ukrainians have in the Russia–Ukraine War. Russian CP configurations at the start of the conflict were not much different from NATO's CPs. Based on these insights, it is vital to rethink how modern military forces prepare their CPs for combat.

As the authors of a March 2023 article, 'The Graveyard of Command Posts,' in the US Army's Military Review stated: "We must rethink command posts for this new era of warfare. In the face of this immediate threat ... command posts will need to adapt to such an extent that they will be unrecognisable to the generation of leaders that fought in Iraq and Afghanistan."

NATO's tactical CPs, as they are currently equipped and operated, are not ready for combat and will not survive the first strike of the next war. Lessons from three recent wars, the Second Nagorno-Karabakh War (2020), the Israel–Hamas War (2021) and the ongoing Russia–Ukraine War (2022-?) demonstrate that CPs are high-value targets and at great risk in the modern battlespace. These recent conflicts are the future of military combat: the Second Nagorno-Karabakh War (2020) was the first war in history won largely through mass employment of robotic systems; the Israel Defence Forces (IDF) declared the 2021 war with Hamas as the first to be won primarily by artificial intelligence; and the Russia–Ukraine War is the largest conflict in Europe since 1945 and employing perhaps the greatest range of military technology in history.

Author

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He writes and speaks extensively about the art of war and the changing methods of warfare.

Credit: USAF

In today's battlespace, Command Posts (CP) are vulnerable. We must reimagine how we prepare CPs for war. In this image, a target explodes after being struck by rounds from an AC-130J Ghostrider Gunship near Hurlburt Field, Florida, 20 June 2023.

The primary takeaway is that destroying command and control is the essence of 21st century warfare. Today, CPs are nearly impossible to hide and extremely difficult to defend. Finding and targeting a CP is at the top of the enemy's to-do list. Preparing survivable CP configurations now, and equipping them to win, must be a priority.

Towards a Transparent Battlespace

In the past, the enemy had to be seen and heard with human eyes and ears, and visualised with the use of analogue maps and terrain models. Seeing at night and in extreme weather was particularly difficult. Winning armies undertook extraordinary means to mask their locations; in addition to taking advantage of low night-time visibility, they have made use of environmental conditions including storms and fog, and terrain obscurants such as forests, mountains, and urban terrain. Knowing what was over the next hill, or around the corner in an urban setting required human reconnaissance.

Today, however, a range of sensors are quickly augmenting or in some areas replacing such forms of reconnaissance. Multidomain sensor capabilities, now possessed by even third-tier military powers, have made it much more dif-

Credit: US Army

Large command posts in tents, as shown here, provide a tempting target.

ficult to hide on the battlefield. Multidomain sensor networks employ technology able to scan from space down to the mud at ground level to reveal targets. Creating an unblinking eye that identifies, locates, and tracks targets in a congested battlespace is not simple. It takes sophisticated planning and systems to reveal the enemy, but it offers a battle-winning advantage and is worth the investment. When ubiquitous sensors are coupled with long-range precision fires, capable of hitting and destroying targets at extreme ranges, staying alive on the modern battlefield can be a challenge.

In the Nagorno-Karabakh War in 2020, Gaza in 2021, and Ukraine from 2022, the combined effort of sensors, drones, and long-range precision fires have shaped the conduct of these conflicts. Seeing enemy forces in the battlespace, and being able to strike them nearly anywhere, is a revolutionary disrupter to traditional methods of warfare. The battlespace is becoming more transparent – a layer of sensors can stream real time information to reveal the battlespace and confirm battle damage, putting every CP potentially at risk. General Mark Milley, the US Chairman of the Joint Chiefs of Staff, stated: "The probability of being seen is very high. In a future battlefield, if you stay in one place for longer than two or three hours, you'll be dead." With the rapid acceleration of sensor technology, even two or three hours may be optimistic. Our CP mindset should embrace the concept that there are no longer any safe areas, and we are likely in range of enemy fire. Anything less is inviting disaster.

Reimagining Tactical Command Posts

Command and Control (C2) of military forces and executing mission command is the most important warfighting function. The purpose of a CP is to assist the commander in the execution of Mission Command (MC). MC contends that human decision-making 'at the point of contact' generates a flexible and winning approach that fosters harmony, initiative, and speed by understanding the commander's intent, carrying out mission-type orders, and empowering lower-level initiative. The CP facilitates the commander's execution of MC by enabling the commander to better understand, visualise, describe, direct, and evaluate combat operations.

For decades, tactical CPs have been set up in tents and vans, some elaborate enough to house scores of operators with banks of computers, large display screens and other ancillary equipment. Today, gathering critical, human-brainpower in one location, within range of enemy sensors and fires is a recipe for catastrophe. Tents offer no protection from drones or artillery strikes. Modern alternatives, including CP trailers, called 'Expando-Vans,' such as the US Army's M1087 Expandable Van Shelter, are not much better. Although these vehicles provide an easier CP set-up, they are not truly mobile CPs, as soldiers cannot operate from inside them when they are on the move. These shelters are relocatable, meaning they take time to set up, break down, and move. During an attack by drones, artillery, or missiles, they provide little protection. To improve survivability in the modern battlespace, CPs should be armoured, mobile, masked and dispersed. This is not the traditional CP thinking, but is the harsh reality of modern

Credit: John Antal

An Armoured Brigade Combat Team (ABCT) Tactical Operations Centre operates at the National Training Centre, Fort Irwin, California, in September 2022. ABCTs now have M1087 Expandable Van Shelters, known as 'Expando-Vans', to use for CPs. These vans are easier to set up than tents but offer no significant protection.

combat. We must not hesitate in rapidly defining the major design parameters that will prepare a modern CP to meet these requirements.

Armoured: In the Second Nagorno-Karabakh War, Azerbaijan destroyed Armenian tactical CPs in the first weeks of fighting as they were easily discovered and primarily housed in tents and unhardened facilities. In the Israel–Hamas War, the IDF tracked the locations of Hamas leaders and synchronised their attacks with sophisticated, artificial intelligence. As we are witnessing in the Russia–Ukraine War, many Russian CPs have been destroyed by Ukrainian long-range precision fires.

The logical alternative to 'soft' cover CPs is to maximise available armoured vehicles for protection from enemy fire. Any armoured vehicle furnished with the necessary Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) equipment is far superior to a tent or soft-skinned tactical vehicle. Forming a mesh network of mobile, armoured CPs makes the enemy's reconnaissance and targeting problems more difficult. Each armoured vehicle node must be equipped with the C4ISR systems necessary to independently take over the fight.

In 1982, US Army Gen. Donn A. Starry said, "... experience convinced us that the Corps battle cannot be fought from the Main CP and we believe the evidence is sufficiently compelling for us to field an armour-protected TAC CP [tactical command post] with sufficient equipment and personnel to track the battle and issue timely orders." His insight was true then and is more poignant today in against even a near-peer opponent. Military forces will need to either adopt armoured vehicle CPs, occupy hardened urban facilities, or 'dig in' deep and fast.

Mobile: CPs can no longer stay in any position for extended periods. While most current CP solutions are re-locatable, they require too much time to set-up, breakdown, and reposition, and cannot operate on the move. A mobile CP that is agile and can move in an instant will reduce vulnerabilities to incoming fire. In a transparent battlespace, only mobile and protected CPs will survive and be capable of conducting MC on the move, thus increasing the probability that the CP will survive. MC on the move allows commanders to lead closer to the front, with a smaller tactical footprint, and with a higher chance of survivability. CPs must have the capacity to conduct MC on the move, consistently practice this ability, and never forget that if we do not rise to the level of our expectations, we fall to the level of our training.

Masked: To hide in this transparent battlespace, CPs must mask to survive. Masking calls for full spectrum, multidomain effort to deceive enemy sensors and disrupt enemy targeting. CPs require the equipment, and the tactics, techniques and procedures (TTP), to mask in the areas of optical (be the best at physical camouflage), thermal (reduce heat signatures), electronic (lower emissions and manage electronic signatures), and acoustic (dampen sounds). CPs can also generate false-positive signals to deceive enemy sensors by using decoys and avoiding obvious concentrations of vehicles. A group of three to four vehicles appears like a platoon to most sensors, and there will be many platoons in the battlespace, making identification and targeting much more complicated. On the other hand, eight or more vehicles presents a much more recognisable, and thus tempting, target. Thus, we must network groups of 2–4 vehicles into MC nodes to form a mesh CP structure.

Dispersed: A survivable CP configuration requires new thinking about how CPs operate, communicate, and share information in the battlespace. We can no longer concentrate equipment and operators in easy-to-find-and-destroy target sets. For example, a mesh battalion-level CP configuration could be comprised of three distributed nodes of two C4ISR equipped armoured vehicles per node, dispersed according to the terrain and threat, and using the same common operational picture (COP) to track and synchronise the battle. This mesh arrangement becomes resilient when each node is ready to assume command as required. An ideal mesh CP configuration is a flexible, self-forming, self-healing, and self-organising tactical network arrangement of command nodes. A mesh CP configuration distributes the CP infrastructure into resilient 'functional nodes' that are spread out, and masked throughout the battlespace, yet remain in effective communication. This 'Distributed Mission Command' employs smaller, dispersed command nodes to execute the functions of the CP without staff co-location. The goal is to enhance continuity and survivability of the command function in the modern battlespace.

Visualising the Future

The only constant in leadership and war is change. Leaders need foresight to visualise and prepare for the next fight. The systematic unmasking and attack of CPs in recent conflicts is a wake-up call. If we change our views about CPs to organise them around Distributed Mission Command, using a military internet cloud and hardware, then we can deliver the function of a CP and provide persistent MC as a service, not a geographical location. Imagine if we established CPs in a mesh network of command nodes, each comprising 2–4 networked armoured vehicles, that allowed any commander, from battalion to corps, to operate from any of the nodes. The commander would traverse from node to node to enhance command presence and leadership. If one node is disrupted, another takes over, and the new acting commander seamlessly takes charge of the unit.

To avoid turning CPs into graveyards, commanders must reimagine how they conduct MC and adopt new TTP for CPs. As Gen. James McConville, Chief of Staff of the US Army, said in October 2022: "In the future, the battlefield will be so lethal, and there'll be the ability to gather [targeting] information on where our command posts are, so we're going to have to move them very, very quickly, and they'll have to be dispersed and smaller." The lesson from the Second Nagorno-Karabakh War, the Israel–Hamas War, and the Russia–Ukraine War is clear: in the modern, transparent, lethal battlespace, the target that sticks out gets hammered. Sir Winston Churchill once said: "Want of foresight, unwillingness to act when action would be simple and effective, lack of clear thinking, confusion of counsel until the emergency comes, until self-preservation strikes its jarring gong—these are the features which constitute the endless repetition of history." Lack of foresight to prepare tactical CPs will result in them being quickly targeted and destroyed, with the resulting, irreplaceable loss of experienced commanders and staff. While there has been much discussion of equipping CPs for modern combat, not enough is being done to field new systems and train command-staff teams. Preparing tactical CPs for the next war is a vital task that demands immediate action, lest we fall victim to ignoring the poignant and deadly lessons learned from recent and ongoing conflicts.

The Future of Persistent Ground Surveillance

Tamir Eshel

Ground surveillance consistently monitors ground activities and has historically relied on radar and observational data. This integration of multiple pieces of equipment, such as cameras, radars, and other electronic sensors, results in a single-band or multi-spectral surveillance coverage over a specified area. Unlike conventional systems relying on single sensor feeds inspected by human operators, persistent surveillance enables continuous monitoring by automated means, acting as an 'unblinking eye.' Constantly analysing the sensor feeds, these systems may prevent incidents by early threat detection and even pre-empt potential issues, enabling a swift and timely response.

Digital imagery has revolutionised persistent ground surveillance, introducing significant technological advantages. Unlike traditional methods, modern systems mostly automate operations and can perform constant surveillance without fatigue or attention lapses. These systems cover large areas, including harsh or inaccessible terrain, delivering real-time information to their operators. They automatically detect and track suspicious objects within predefined areas or by analysing the object's activity. Video processing can be done on the camera or at the command centre. Depending on the activity of a detected target, these systems trigger an alert through rule-based or behaviour analysis that can be learned automatically over time.

Credit: USAF/Tech. Sgt. Robert Cloys

US Air Force MQ-9 UAV equipped with Gorgon Stare were operated by the 455th Air Expeditionary Wing in Afghanistan for persistent surveillance and force protection.

The early 2000s saw the development of persistent ground surveillance technology. They played a major role in the US-led 'Global War on Terror,' operating as part of force protection packages on aircraft, aerostats, and unmanned aerial vehicles (UAVs) used by coalition forces in Afghanistan and Iraq. The Israel Defense Forces (IDF) also have utilised these capabilities to secure Israeli borders. Today, persistent surveillance capabilities are already introduced in some 'safe city' programmes despite public concern about the privacy issues they create. This article addresses the technological aspect of persistent surveillance but does not delve into the public debate about the legality of the civilian use of those systems.

A crucial feature of these systems is their ability to integrate live and archived data from various sources. Collecting and analysing data from multiple sources, such as thermal cameras, radar systems, acoustic sensors, and satellite imagery, provides a holistic picture of the surveillance area and deep insight into perpetrators' potential hostile activities and preparations. This allows for more accurate detection and response. These capabilities are further enhanced by advanced video motion analysis algorithms, artificial intelligence (AI), and machine learning (ML). They allow the system to identify patterns, detect anomalies, and predict potential threats.

Persistent ground surveillance utilises various sensors and software tools to gather information and continually monitor vast areas of interest. Each tool offers unique capabilities, from the optronic sensors' passive surveillance and high-resolution imagery to the all-seeing Gorgon Stare Systems' real-time wide-area motion imagery (WAMI) and Multi-INT payloads.

Wide-Area Motion Imagery

Optronic sensors operating in visible (VIS) and near-infrared (NIR) wavebands, are extensively employed by military and security forces for intelligence, surveillance, and reconnaissance (ISR). These sensors act passively, though some utilise infrared light to actively illuminate the scene. Certain active systems deploy pairs of infrared (IR) sources and sensors, functioning as 'optical tripwires' that prompt action when their line of sight is disrupted. There is also the and short-wave infrared (SWIR) band, which is particularly good at highlighting muzzle flashes and is thus employed in hostile fire indicator applications.

Traditional cameras demanded constant human monitoring, however, newer automated systems now leverage real-time image processing technologies, such as video motion detection and object recognition algorithms that can automatically trigger alerts, transforming the operator's role from monitor to analyst. Modern wide-area optronic payloads are explicitly designed to blanket extensive areas with high-resolu-

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Thanks to its expertise, Photonis was the first manufacturer in the world to develop white phosphor image intensifier tubes and is also the only company to offer a 16mm format tube. A new standard which enabled the design of modern, lighter and smaller night vision binoculars. While it is important to maintain the best performance of an image intensifier in all light conditions, it is nearly equally important to make this opto-electronic system as easy and comfortable to use in battlefield conditions allowing effective soldiers to operate safely.

Moreover, with the broader availability of night vision devices, the challenge is to have the best performance image intensifier based equipment that is always more efficient than the one of the opposing forces.

Preferred technology for European Armed Forces

The 4G is perfectly suited to the stringent requirements of night combat operations by providing operators high image quality and long detection ranges in the most challenging light conditions. Following decades of experience with in-service night vision devices using Photonis image intensifiers, the 4G in 16mm format has become the standard in all major European Land Forces programs: Germany, Belgium, United Kingdom, Spain, The Netherlands, Poland notably.

Reducing the load on a soldier is a constant challenge: reduction of SWaP (Size Weight and Power) contributes to enhance the efficiency and effectiveness of armed forces. Night vision devices that are designed around the 16mm offer the tremendous advantage of having the same level of performance as those based upon the 18mm tube, but with significantly reduced weight.

With such advanced technology, Photonis enables soldiers' tactical situational awareness, agility and mobility. And Photonis has not yet said its last word...

tion imagery, facilitating the identification of individuals, vehicles, and other objects without human monitoring.

The US-based company Logos offers a compact wide-area motion imagery (WAMI) payload called Redkite-1, designed explicitly for the Insitu RQ-21 Integrator Group III Tactical UAV. The company also developed the Blackkite-1 pod to accompany the Redkite-1 missions at night. The company extends similar capabilities with its Redkite pod system, which is adaptable for light aircraft or helicopters. This compact system can conduct surveillance of an area equivalent to a small city in near real-time. Its coverage, defined by a circular footprint with a 4 km radius, allows for detecting and tracking multiple targets simultaneously, recording events for subsequent analysis. The system's resolution is tuned to track vehicles and spot moving dismounts within user-designated 'watch boxes' thus enabling automated detection alerts. Redkite-1 employs the Multi-Modal Edge Processor (MMEP), a high-performance processor that transforms gigabytes of data into geotagged imagery, storing up to eight hours of mission data on the platform. This data can be shared with friendly forces while the sensor is airborne over the scene. Ground operators can also use the WAMI system's live and previously-recorded geotagged imagery for intelligence collection and analysis.

Credit: Logos

Logos tested the Redkite-1 WAMI sensor on the RQ-21 UAV in 2017.

3D Mapping Cameras

High-resolution geotagged imagery can be transformed into 3D models, delivering near-real-time information to users and enhancing situational awareness and operational planning. Earlier this year, the Israeli firm BlueBird Aero Systems unveiled the MagiCam, a high-resolution 3D wide-area mapping camera. When deployed on a small drone flying 500 m above ground, it can cover up to 40 km2/hour in 2D or up to 12 km2/hour in 3D. This 1.5 kg camera payload incorporates a 103 MP sensor and an onboard processing computer processing the imagery. With a Ground Sample Distance (GSD) of 3.2cm/pixel, the system generates crisp and detailed images, which can be transformed into actionable intelligence in 3D models, maps, or orthophotos within hours of landing. To compile the data necessary for mapping, MagiCam scans the area, capturing many geotagged, high-resolution images in all directions to ensure precise 3D mapping. The system also processes IR thermal mapping to enrich the model by spotlighting changes in the object's heat signatures indicative of recent human activity.

Through scanning, MagiCam can detect and mark disparities between current and previous sorties, enabling users to track changes in ground surfaces, object dimensions, textures, and more. This information can be vital in identifying potential threats, such as Improvised Explosive Devices (IEDs) or mines, as well as pre-prepared ambush sites.

Credit: Elbit Systems

SupervisIR is a passive, staring IR sensor for covert missions requiring persistent surveillance.

Harnessing Thermal Vision

Optronic thermal imagers are passive devices that transform the infrared radiation emitted by objects into discernible images. Operating in two distinct bands — mid-wave (MWIR), and long-wave IR (LWIR) — these sensors prove especially effective in low-light or night-time scenarios. They excel in detecting heat signatures such as those emitted from a human body or vehicle movement, even without visible light. Both excel at penetrating environmental obscurants such as haze, fog, and rain, with MWIR slightly more suited to warm climates, and LWIR more conducive to colder climates.

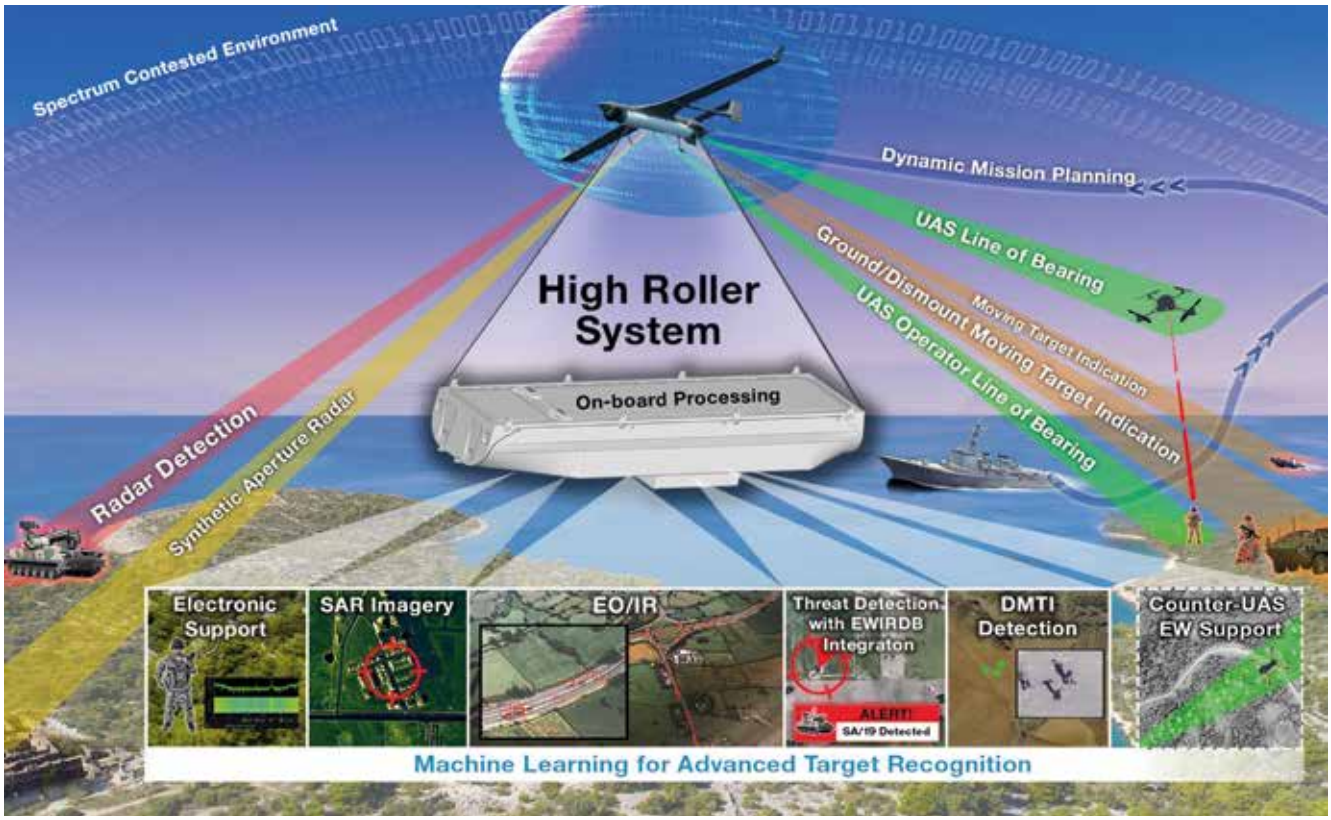
Most thermal imagers are engineered to detect and identify targets at extended ranges, but they need to encompass a broad area for persistent surveillance. Elbit Systems' SupervisIR is specifically designed for this application. It furnishes automatic target detection and tracking with a panoramic field of view spanning 12.5° in elevation by 90° in azimuth. The system automatically detects and tracks multiple targets and displays them in multiple windows specified by the operator to show specific areas of interest. This sensor can function independently or as part of an integrated system, guiding other sensors to observe, identify, and engage targets.

Elbit Systems has also developed an airborne surveillance payload for tactical UAVs, such as the SkyLark 3. Known as MiniSkEye, the system provides day and night persistent surveillance over a wide area. Data and video obtained by the WAMI optronic IR sensor are stored onboard, offering user access via standard interfaces and communication channels in real-time. The system executes WAMI for persistent surveillance or sweeps through a 'push-broom' style aerial survey to cover larger areas, leveraging historical data to detect changes in the currently surveyed scene. With WAMI, the system offers an overview of the entire area, automatically detecting activity and movement in multiple user-defined zones. Images are captured at high resolution, enabling the system to perform target recognition automatically. At the same time, analysts or users can further analyse the target behaviour using one of the system's many high-resolution windows. Although the system primarily uses thermal imagery, it can cross-cue with other cameras onboard the host platform to automatically track operator-specified targets with full-motion video when necessary.

Credit: US DoD

Indiana ANG 181st Intelligence Surveillance Reconnaissance Group (ISRG) employed Gorgon Stare WAMI systems during the aftermath of Hurricane Florence in North Carolina on 19 September 2018.

Credit: SRC Inc.



Applications of the High Roller multi-INT payload.

The Unblinking Eye

In response to a pressing US DOD demand for real-time, wide-area surveillance capabilities during the early 2000s, US-based Sierra Nevada Corporation (SNC) conceived the Gorgon Stare (GS). This transformative technology has drastically expedited intelligence preparation for combat operations from days to hours and minutes on a single mission. GS has been extensively used, so far accumulating over 100,000 flight hours. The system uses an array of 12 cameras to provide uninterrupted surveillance over a city-sized area, round-the-clock. It leverages day and thermal channels, which can be streamed to users in near real-time to offer overwatch footage while simultaneously being archived for further use. An essential feature of the system is this post-mission review of the recorded motion imagery, which allows for forensic analysis following an incident or another significant activity.

Over two decades of operations have seen the Gorgon Stare system evolve significantly. The latest iteration, Gorgon Stare Increment 2, provides more versatile area coverage, improved resolution sensors, and the addition of a broadband Beyond Line-Of-Sight (BLOS) communications data link capable of supporting up to 40 Mbps data backhaul over SATCOM, LINK 16, and MESH networking. The size and weight reduction have enabled SNC to incorporate both sensors into a single pod, allowing the MQ-9 to carry weapons alongside the Gorgon Stare ISR package.Further enhancements include adding day colour imagery, dynamic camera aiming, and adaptable flight pattern manipulation, enabling operators to contract or expand the data collection area while keeping the aircraft's flight path within permissive airspace. In addition to increasing the frame rate and sensor resolution for enhanced image clarity and object characterisation, Gorgon Stare has introduced artificial intelligence (AI) capabilities. This allows for automated target detection, classification, and tracking based on various parameters such as geography and behaviour.

Ground Surveillance Radars

Surveillance radars are crucial in monitoring expansive areas for moving objects on the ground and in the air. Unlike their counterparts employed for airspace surveillance, which often provide 360° coverage, ground surveillance radars are typically static and focus on specific sectors. These systems offer insights into tracked targets' position, velocity, and direction. Modern radars, leveraging electronic scanning, are more compact and lightweight than their predecessors.

For instance, the ELM-2112 V8 radar by IAI Elta is a compelling example. It can detect a person walking at a distance of up to 6.5 km or a vehicle up to 13 km away, ascertaining their range with an accuracy of 3 m. Weighing just 9 kg and equipped with batteries supporting up to 36 hours of operation, this portable unit can be carried in a backpack, mounted on a vehicle's telescopic mast, or deployed on an aerostat. Additionally, the system can be integrated with other sensors, such as observation equipment, launch detection systems, or communication systems, empowering users to monitor areas even without a line of sight.

Another type of airborne radar is the Synthetic Aperture Radar (SAR) and Ground Moving Target Indicator (GMTI), which provides WAMI-like imagery in all weather conditions. Such radars are often mounted on UAVs, and in this vein High Roller was conceived as a multi-intelligence payload for the RQ-21 Integrator. The payload reconciles signals of interest (SOI), synthetic aperture radar (SAR), electro-optical/infrared (EO/IR) imagery, and moving target indicators (MTI). Besides delivering independent streams of ISR data, High Roller enables the host platform's onboard systems to collaborate autonomously, offering multiple-look, geo-registered multi-INT data to friendly forces on the ground.

Surveillance by Signals Intelligence (SIGINT)

Monitoring signals of interest across the radio frequency (RF) spectrum yields real-time intelligence from radio emissions of various sources, including mobile phones, radios, radars, and drones. Comprehensive solutions such as the RFEye from the US-based CRFS company are combined with radar and electro-optical systems, integrating seamlessly into the persistent surveillance mechanisms of aerostats for tasks such as border protection or safeguarding strategic locations.

The unique advantage of these SIGINT systems is the localisation of each signal, which enriches the situational picture by adding more layers of intelligence. These systems meticulously exploit the signals, classifying and geolocating their sources. This information can guide other sensors toward these locations for a more detailed investigation. An in-depth examination of operations, interactions, and shifts in behaviour patterns of these signals could hint at the activity and intentions of the targets. Thus, SIGINT systems are instrumental in detecting and understanding potential threats.

Unlocking the Power of AI

While individual sensors are responsible for collecting video feeds and data, the potent digital processing capabilities using cutting-edge pattern recognition and motion analysis algorithms deliver the analytic processing power. This power enables activities such as triggering rule-based alerts for analysts to study, performing target recognition, tracking targets, and providing comprehensive situational awareness, adding recommended actionable courses for operators, commanders, and forces. These systems are also invaluable for security organisations overseeing large public events, maritime surveillance operations, and military forces. Tapping endless information sources and data points, analytic AI-driven systems can expand the area under surveillance far beyond the visible area covered by the sensors.

One such example of technology deployment is the Halo Drone and Stream technology, used at recent major sporting and cultural events to monitor protester activity, persons of interest, ticket reselling, and crowd safety. The live streaming capability of the Halo (v5) incident and threat management system significantly enhances its utility and provides an important link for building intelligence.

IAI's Elta StarLight system is another significant player in this space, primarily used for military and maritime security. This cloud-based multi-INT analysis system transforms massive amounts of unstructured data from distributed ISR sensors into actionable intelligence. The sensor-agnostic system interfaces with SAR/GMTI radars, SIGINT, EO/IR, Video, WAMI, and Launch Detection Systems. Its innovative AI-based smart operational applications include a situational awareness engine, data mining tools, a threat generator, and more, all interacting to interpret and understand the tactical situation picture and implement responses most efficiently.

Palantir's AIP is another solution leveraging AI to process intelligence data used by all US DOD branches. Currently supporting the Ukrainian Army in its conflict with Russia, this multi-INT system taps thousands of intelligence sources of all modalities, providing alerts on enemy movements, preparations, or potential opportunities on the battlefield. Using AI to analyse the sensor data, analysts can swiftly answer crucial questions such as the enemy's location and intentions. NATO analysts use these procedures to locate Russian troop concentrations, air defence systems, command posts, and supply depots across the war zone. Following the detection and designation of targets for attack, they are transferred directly to the Ukrainian forces over commercial broadband satellite links.

In summary, integrating AI technology is evolving surveillance and reconnaissance operations in both civilian and military contexts. Collecting, processing, and analysing vast amounts of data in real-time enhances situational awareness and enables proactive responses to potential threats. The increasingly sophisticated use of AI, particularly in predictive analytics, signifies a new era in intelligence and security operations. ■

Marketing Report: EVPÚ

LAWAREC – Quality Passive Protection System for Modern Military Vehicles

Let's start with a question: What do the tracked Lynx IFV (a recent Hungarian acquisition) and the wheeled Patria 8x8 AFV (a current Slovak acquisition) have in common? The answer: Both of these sophisticated vehicles are equipped with an advanced passive protection system made in the Czech Republic by optoelectronics specialist EVPÚ Defence.

The LAWAREC laser and radar irradiation detection system is designed to increase the defensive capabilities of military vehicles and vessels. It consists of two types of detection modules, which contain either a laser detector or a combination of laser and microwave detectors. These modules are connected by a daisy-chain with a central unit using a LONWORKS control network, which guarantees the system's reliable operation even in the event of partial damage. LAWAREC detects, analyses and locates radio emissions from radar systems and laser beam sources such as rangefinders, designators and beam riders. Upon detecting a threat, it alerts the crew, indicates the direction of the source and automatically suggests a suitable countermeasure, such as deploying smoke grenades to prevent the enemy from further targeting the vehicle.

"Using LAWAREC brings important benefits to the vehicle crew," says R&D engineer and LAWAREC specialist Jakub Mikel. "With a number of modules proportionate to the size of vehicle, the system provides a threat detection coverage that spans the entire vehicle perimeter. It can be fitted to a broad range of wheeled and tracked vehicles, where it offers effective passive protection against laser aimed and guided weapon systems. Moreover, it can be integrated with various other defence systems. We are delighted that leading European producers are choosing LAWAREC to be part of their solutions in key projects such as the armoured vehicle acquisition in Hungary and Slovakia, and see this as the start of further successful large-scale collaborations in the future."

Credit: EVPÚ Defence

Members of the professional and general public will next be able to see a complete LAWAREC set along with other defence systems produced by EVPÚ Defence at the IDEB exhibition in Bratislava, Slovakia, which takes place from 3-5 October 2023.

Heavens Above!

Thomas Withington

Plans are afoot in the United Kingdom to revitalise the country's dedicated military communications satellites with the latest addition to the Skynet family.

The United Kingdom entered the club of nations possessing dedicated military communications satellites in 1969. That year, the UK Ministry of Defence's (MoD) Skynet-2B satellite reached the heavens. This was not the country's first attempt. Her first two such spacecraft, Skynet-1A/B launched in 1969 and 1970 respectively, suffered problems. Skynet-1A failed after circa 18 months of operation and Skynet-1B experienced the failure of one of its motors. Skynet-2A, launched in 1974, experienced a similar fate when its circuits developed electrical faults. It managed just five days in orbit before being deliberately de-orbited and incinerated in Earth's atmosphere. The MoD finally got things right with Skynet-2B. Also launched in November 1974, this satellite provided coverage over Africa, much of Asia and Europe. Skynet-2B enjoyed over two decades of service. Plans to replace it with the Skynet-3 constellation were scuppered by the British government's decision to withdraw from UK major military bases east of the Suez Canal in the late 1960s/early 1970s.

Net Gains

The Skynet-4 satellites were designed with three X-band (7.9-8.4 GHz uplink; 7.25-7.75 GHz downlink) and two Ultra High Frequency (UHF; 305-315 MHz uplink; 250-260 MHz downlink) transponders. X-band Satellite Communications (SATCOM) are reserved for the military use by the International Telecommunications Union. Known as the ITU, this United Nations body governs global use of the radio spectrum. The Skynet-4 constellation also included an experimental Extremely High Frequency (EHF) transponder working on frequencies of 43 GHz to 45 GHz.

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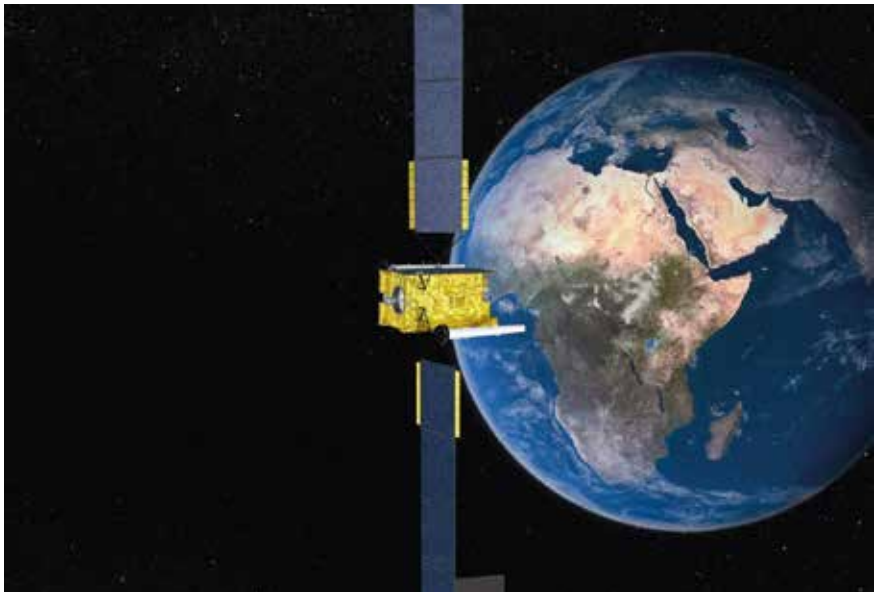
Credit: Airbus



An artist's rendering of the UK's Skynet-5D satellite in orbit. The Skynet-5 family were launched between 2007 and 2012 and included four spacecraft. They could all handle UHF, X-band, Ku-band and Ka-band traffic.

The next launches saw the first member of the Skynet-4 family, Skynet-4B, reach the cosmos in 1988, followed by Skynet-4A/C both in 1990. Of this trio, Skynet-4C remains in operation carrying X-band and UHF traffic. A further three satellites, Skynet-4D/E/F followed between 1998 and 2001 with Skynet-4E/F remaining in service. They can carry C-band (5.925-6.425 GHz uplink/3.7-4.2 GHz downlink) traffic along with UHF and X-band. The Skynet-5 constellation are the latest family members. Four spacecraft, Skynet-5A/B/C/D were launched between 2007 and 2012. Equipped with X-band and UHF transponders, they can also handle Ku-band (14GHz uplink/10.9-12.75GHz downlink) and Ka-band (26.5-40GHz uplink/18-20GHz downlink) traffic. Skynet-5 represented a qualitative and quantitative improvement on its Skynet-4 predecessors. Open sources state that each satellite hosts nine UHF channels and 15 Ka-band transponders.

Skynet-5 was procured using an innovative Private Finance Initiative (PFI) approach. Put simply, two companies, Paradigm Secure Communications and EADS Astrium leased SATCOM services to the MoD. EADS Astrium built and launched the satellites while Paradigm provided the SATCOM services. Both companies have since been absorbed into Airbus. The contact allowed Paradigm to sell spare capacity not being used by the UK to other allied nations for military and government communications. Airbus now manages the MoD Skynet contract. It has partnered with other companies, notably Hughes Network Systems, Inmarsat and SpeedCast, with these companies offering third-party Skynet SATCOM services to other customers.

Airbus was contracted by the MoD in 2020 to provide the next Skynet satellite, dubbed Skynet-6A, which is planned for launch in 2025, according to reports. Airbus is constructing Skynet-6A using its Eurostar Neo bus. The contract was valued at USD 736 M in 2023, and covers the construction and launch of the satellites while providing the appropriate improvements to ground infrastructure to operate the spacecraft. Skynet-6A forms part of the UK's Future Beyond Line-of-Sight (FBLS) SATCOM programme. MoD documents state that FBLS includes the new satellite, in addition to a contract to manage the Skynet constellation supporting elements.

This is known as the Service Delivery Wrap. The Skynet-6 Enduring Capability is a separate contract. This covers satellite's operation and ground infrastructure. The contract also pledges the continued delivery of SATCOM services using the Skynet constellation. The fourth element of FBLS is the MoD's Secure Telemetry, Tracking and Command (STTC) initiative. STTC provides "assured UK control and management of satellites and their payloads," according to these MoD documents.

Six Appeal

Skynet-6 will be a further enhancement in SATCOM capacity for the UK. The satellite "will utilise more of the radio frequency spectrum available for satellite communications and the latest digital processing to provide both more capacity and greater versatility than the Skynet-5 satellites," says Ben Bridge, executive vice president of global business at Airbus' defence and space division. Bridge emphasises that the spacecraft's cost effectiveness will be enhanced by using electric propulsion for orbit raising and station keeping.

Electric propulsion uses electromagnetic or electrostatic fields to generate propulsion. This approach uses much less propellant than conventional chemical-based propulsion. The trade-off is that electric propulsion produces a weaker thrust than its chemical counterpart, but nevertheless produces thrust for a longer duration. Airbus would not be drawn on the frequencies that Skynet-6 will handle, nor its bandwidth capacities. That said, Bridge said the company has "designed and is building a satellite that will provide enough bandwidth for the future shape, size and requirements of the (UK) military around the world for the next 20 years."

Credit: UK MoD

Although the UK is receiving a new military communications satellite in the form of the Skynet-6 system, the arrival of this new spacecraft will not require any major changes for the terrestrial infrastructure used by the UK armed forces for SATCOM.

The absorption of Skynet-6 into the UK's existing Skynet architecture should be relatively painless. The new satellite is designed to "fully support all existing Skynet-5 assured military satellite communications terminals and services, and those already in use by NATO and other allies," said Bridge. He added that Skynet-6 is on track for a planned launch in 2025.

Show Me the Money

The Skynet constellation (comprising the existing satellites and Skynet-6A) could work alongside the UK's OneWeb satellites within the FBLS initiative. In 2020 the British government purchased 45 percent of the OneWeb SATCOM company. The firm had gone bankrupt in 2020 but had aimed to build a constellation of Low Earth Orbit (LEO) satellites to provide global, broadband internet coverage. LEO satellites typically use orbits of below 1,000 km (540 NM) above Earth. In July 2020, the Financial Times reported that there was potential scope to combine OneWeb's and Skynet's services for military and government use.

One major change that FBLS brings is the end of the PFI model hitherto used to provide Skynet SATCOM services to the MoD. Writ large, PFIs were seen as giving bad value for money to British taxpayers. As David Todd, an analyst for Seradata Space Intelligence wrote back in 2017, many long-term PFIs had paradoxically led to increased costs for governments and poor service. Moreover, existing contractors had sometimes sold on the contracts to new contractors netting themselves a handsome profit. This was iron-

Credit: Airbus

One of the UK's Skynet-5 satellites is seen here undergoing preparation before launch. The constellation provides near-global military satellite communications coverage to the British armed forces. The role of the individual in the pressure suit in this endeavour remains unclear.

ic as the logic of PFIs was to reduce government debt and have the private sector share some risk in providing major infrastructure projects. For example, a private company would build and operate a hospital, but the government would pay the company for it to provide services to the public.

"At first PFIs seemed to be a good idea," said Todd in an interview with ESD. "They put the onus of risk onto the manufacturer/service supplier and kept debt off the government's books. However, examination of their costs, effectively a leasing cost, made many PFI contracts look very poor value compared to a straight commercial loan. Worse was that the poorly designed, very costly service contracts were often sold on to third parties, resulting in the quality of service going down." Ironically, "it is said that the only PFI that worked satisfactorily was for Skynet-5 where a good service was apparently delivered to the MoD. It also allowed the then Paradigm service company to sell spare capacity onto other allied militaries."

Nonetheless, Todd underscores the high cost of the PFI compared to a more conventional procurement vehicle: "With respect to the cost-effectiveness of the PFI contract, the overall cost was USD 4.6 Bn compared to a standard purchase contract of say USD 2.5 Bn to USD 3.1 Bn." The latter is his estimate for construction and launch of four specialist communications satellites plus 15 years' operation. "Nevertheless, despite the MoD apparently being over a billion pounds worse off, both sides appeared to be happy, albeit with some concerns that some space specialist MoD staff had been poached for the programme."

"In truth the Skynet-5 PFI contract was never fully tested," Todd argues. "What would have happened if one of the Skynet-5 satellites had failed or been lost on a launch for example? Insurance payouts, which were possible as this was a 'commercial' operation, would have covered the construction and launch costs but probably not any service interruption … Having lost a satellite one suspects that the service provider might have struggled to achieve its service targets for several years."

Although the Skynet PFI was judged to have been well-managed, hiving off the provision of military SATCOM to the private sector led to much of the MoD's internal military SATCOM expertise atrophying. Instead, FBLS will follow a more traditional approach. The ministry will own the satellites and supporting infrastructure, but the private sector operating this on the Ministry's behalf. Instead, the PFI will be replaced by the Service Delivery Wrap. In February 2023 Babcock won this contract, worth USD 497.4 M, which will run from 2024 until 2030, according to the MoD.

LEO Say Yeah!

Where do things go beyond Skynet-6A? A November 2021 report in Battlespace stated that work on the Skynet-7 constellation could begin in the mid-2040s. The report continued that a further three Skynet-6 satellites could join the first of the constellation. One also should not forget the potential role that OneWeb could play. Since SpaceX's StarLink SATCOM network has been deployed to Ukraine, the deployment has underscored the value of LEO SATCOM to militaries and governments. Looking to the future, one can envisage the Skynet constellation being used for the carriage of highly sensitive and secret traffic. OneWeb could be employed for the carriage of less sensitive information. The latter is likely to constitute the bulk of the traffic on any military SATCOM network.

Work continues apace regarding OneWeb. The company said via a January 2021 press release that it planned to have a fleet of 648 satellites in orbit by the end of 2022. As of March 2023, 584 of these satellites were in orbit. The company says that 588 spacecraft can provide global coverage, but that additional satellites are needed for redundancy. By May 2023, OneWeb had confirmed that a total of 648 satellites orbiting. Each weighing 150 kilograms (330 pounds) they provide Ku-band and Ka-band links.

"There is a move away from having a few very vulnerable large satellites to using a LEO-type constellation with lots of spacecraft which have less vulnerability to individual anti-satellite attacks," observes Todd. "OneWeb will probably be independent in its operation/service vis-à-vis the Skynet constellation as there are no intersatellite links with Skynet as such." Nonetheless, LEO satellites have the benefit of a lower latency (signal delay) compared to satellites further away. That said, it is important to remember that "LEO systems might be more prone to debris strikes and could even add to this problem."

Credit: Google Earth

The antennas on top of the structure in the centre of this picture are positioned next to the Old Admiralty Building in Central London. They are believed to be SATCOM antennas that the MoD and UK government uses to provide connectivity from London to Skynet, and hence to UK forces and government installations around the world.

MDI Gets High

The coming years will see the UK MoD needing all the communications bandwidth it can get, and this includes SATCOM bandwidth. As they do now, the United Kingdom's armed forces will continue to deploy around the world. This global footprint requires global, secure communications of the sort that can only realistically be achieved using government-owned military SATCOM. However, the geographical reach is only one driver for this demand, the changing nature of war is the other.

The philosophy of Multi-Domain Operations (MDO) emerged in the United States' defence community in 2019. A US Congressional Research Service report published in 2022 defined MDO as "the combined arms employment of joint and army capabilities to create and exploit relative advantages that achieve objectives, defeat enemy forces, and consolidate gains on behalf of joint force commanders." Why should the US military drink the MDO Kool-Aid? Arguably because, "employing army and joint capabilities makes use of all available combat power from each domain to accomplish missions at least cost."

As the she did with that great US export of rock and roll in the 1950s, the UK has put her own spin on MDO. This has resulted in the emergence of the UK Multi-Domain Integration (MDI) doctrine. This "is about ensuring all of defence (armed forces, government, industry and associated organisations, henceforth known as assets) works seamlessly together, and with government partners and our allies, to deliver a desired outcome," according to the MoD. These two approaches are merged in the author's own combined MDI and MDO definition which stresses the interconnectivity of all assets at all levels of war (tactical, operational and strategic) across all domains (sea, land, air, space and cyber). The point of these MDI and MDO approaches is to facilitate decision-making and action at a faster pace than one's adversary to achieve mission advantage and success.

What does this have to do with the UK's military SATCOM posture? Quite a bit. MDI and MDO places a premium on connectivity because of the need to knit all these assets together. SATCOM, alongside conventional radio and telecommunications, will play a major role. This is a role which will only grow in importance year-on-year, as the UK's appetite for data to make rapid, informed decisions grows. To put matters in perspective during 1991's Operation Desert Storm to evict Iraq from Kuwait, the entire US military deployed into the Kuwait Theatre of Operations had a total of 99 mbps of SATCOM bandwidth available. Ten years later, this provision increased to 3,200 mbps. This increase directly benefitted the US-led operations Enduring/Iraqi Freedom commencing in Afghanistan and Iraq in 2001 and 2003 respectively. A single US Air Force Northrop Grumman RQ-4 Global Hawk series unmanned aerial vehicle needs 500 mbps of bandwidth to perform a mission. This is a 405% increase on the 99 mbps bandwidth available to all US forces during the Persian Gulf War. True, the UK's military is smaller than the US armed forces. However, like the US military, the UK's armed forces embrace technology and defence digitisation as war-winning capabilities. Future SATCOM bandwidth demands are likely to be as proportionally high in the UK as they are in the US. Military SATCOM capabilities like Skynet-6 and OneWeb will have their work cut out. After all, the need to move torrents of data across vast distances shows no signs of abating.

Decontamination and Returning to Service

Dan Kaszeta

Decontamination systems, products, and technologies are an important component of chemical, biological, radiological, and nuclear (CBRN) defence. Yet in a modern military, the threat of contamination threatens warfighting capability more by attacking equipment and systems than by directly causing death or injury to military personnel. The challenge of returning equipment and infrastructure back to duty can be daunting.

CBRN warfare is most often framed as a threat to life and health. This aspect of CBRN warfare is mitigated somewhat. Advances in detection, protection, and medical countermeasures are such that chemical and radiological environments are no longer the threats to military personnel that they once were. Suits, masks/respirators, detection equipment, decontamination for skin and personal equipment, contamination avoidance doctrine, and modern medical care, when combined with good procurement and training, alleviate much of the lethality threat of this category of warfare. Most of the lethal casualties and many of the injuries that were sustained in the First World War would not happen in a modern, well-equipped, and well-trained army.

Instead of people being the primary vulnerability to contamination, materiel and equipment might be the most vulnerable. Some types of persistent CBRN materials can remain present on surfaces or lodge themselves in materials long after an attack. For example, chemical agents, which are mostly liquids in field environments, can absorb into paint, textiles, or rubber. These agents can then desorb for hours, days, or even weeks after contamination. Likewise, radioactive particulates can lodge themselves in cracks or gaps in material. Soil, pavement, and building materials can likewise contain hazards. The residual hazards can make it dangerous for people to operate equipment or vehicles, such as artillery pieces, aircraft, and tanks. It also may make it dangerous to use vital infrastructure like bridges, ports, and runways.

Author

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Credit: US Army/Sgt. 1st Class Brent C. Powell

Army Reserve Spc. Axel Alvarado, a Chemical, Biological, Radiological and Nuclear (CBRN) specialist assigned to the 379th Chemical Company, 472nd Chemical Battalion, 209th Regional Support Group, 76th Operational Response Command waits to spray water on a vehicle during a chemical reconnaissance and decontamination mission at Fort McCoy, Wisconsin, on 14 March 2019.

The prospect of injuries and fatalities from contaminated equipment or infrastructure long after an attack means that the true impact of CBRN warfare might be measured in loss of capability rather than numbers of dead or injured. Compared to the World Wars or even the Cold War, militaries have fewer systems and less infrastructure than they once did. The British Army had about 1,200 main battle tanks (MBTs) in service in 1990. Now, the number is only slightly more than 200. Contamination of 25 tanks in 1990 would have been a far smaller fraction of overall combat power temporarily lost to service than 25 tanks today. The same holds true around NATO, and holds true for things like airfields, aircraft carriers, and artillery systems. Contamination can take vital fighting capability offline, even if only temporarily.

The Nature of the Persistent CBRN Contamination Threat

What is it that we are actually talking about when we talk about contamination? First of all, we must consider that not every CBRN threat poses a serious threat of contamination. Contamination is the long-term presence of a threatening material, in some way that could be harmful to health or the environment. Many CBRN materials pose either no contamination threat, or only a very short-lived one. For example, non-persistent agents such as chlorine and phosgene are true gases which do not contaminate materials. Some other chemical warfare agents are relatively volatile liquids and dissipate quickly. For example, the nerve agent Sarin lasts for minutes or hours, perhaps a day in a very cold environment. Most biologi-

Credit: US ANG/Sgt. Brittany Johnson

Infantrymen with Company C, 2nd Battalion, 198th Armored Regiment, participate in field decontamination of a Bradley infantry fighting vehicle near Doña Ana, New Mexico, on 7 April 2018.

cal threat materials pose no long-term contamination threat, usually through exposure to sunlight. The rare exception is anthrax spores, which could persist for months.

The threats that require deepest consideration are persistent chemical warfare agents, certain radioactive materials with longer half-lives, and those pesky anthrax spores. Many chemical warfare agents are classified as 'persistent agents' – a somewhat sliding definition that covers liquids, powders, gels, and such that last for more than a day. For example, Sulphur Mustard and VX are both oily liquids which can contaminate surfaces for a lengthy period of time. Beyond these, 'Novichok' agents developed by the Soviet Union, are particularly noted for their persistence in the environment. Samples of these agents have turned up in the UK as part of a plot to murder Sergei Skripal. There is also the theoretical possibility of nano-encapsulated agents, wherein liquids are given a protective coating to increase their persistence. In effect, such agents behave as a dust rather than a liquid and could make contamination worse in some ways.

Another issue is the actual surface. Some surfaces absorb materials better than others. Paints, tyres, plastics, some types of armour, and other materials can all be affected by contamination. The rate at which chemical vapours might desorb from such materials depends on a number of factors, including temperature. Higher temperatures aid decontamination by increasing evaporation of chemicals, but have no bearing on radioactive materials. The persistence of radioactive contamination is driven by physics, not chemistry. Short half-lived materials decay quickly, whereas other materials have half-lives denominated in years. For example, Caesium 137, one of the hazards noted in nuclear power plant disasters, has a half-life of 30 years and will stay hazardous until physically removed.

Finally, it is also important to mention contamination in non-CBRN warfare scenarios. Natural disasters can disseminate hazardous materials and could provide contamination of equipment and infrastructure in a similar manner. We are witnessing such a scenario with the flooding in Ukraine following the destruction of the Kakhovka Dam.

How Clean is Clean? How do we Prove it?

The entire issue of decontamination is governed by the question: 'how clean is clean enough?' Nobody has a good answer in every instance. For the non-specialist, the answer might be easy: 'no threat material present.' There is a certain basic logic to such a standard, but it would be impossible to achieve. Proving the presence of zero molecules of a substance is impossible to prove in a laboratory, let alone in a field environment. The technology simply does not exist to verify the presence of a single molecule or single spore. Philosophically, it is also difficult to prove a negative. There are two issues involved here. One is detection threshold and the other is safety.

'Detection threshold' is the minimum amount of material which can be detected by a particular instrument. Every conceivable contaminant has a level below which the available technology simply cannot detect. A nil reading on a detector does not mean there is no threat material. Even laboratory-grade instruments have limitations. With chemical substances, field instruments are usually vapour detectors. Pretty much by definition, persistent chemicals have low vapour pressure and low volatility. In cold weather, some chemicals are difficult or impossible to detect on surfaces given the prevailing military detection methods. Furthermore, chemicals that have absorbed into materials might be impervious to most field detection methods. Detection instruments can still tell us that we have done a bad job decontaminating, but they cannot yet tell us if we have done a good job.

Credit: US ANG/Sgt. Brittany Johnson

Spc. Dustin Warren, an infantryman with Company C, 2nd Battalion, 198th Armored Regiment, conducts field decontamination at Doña Ana, New Mexico, on 7 April 2018.

Credit: USMC/Sgt. Danny Gonzalez

US Marine Corps Cpl. Kasey Dimatteo, a chemical, biological, radiological, and nuclear defense specialist with 31st Marine Expeditionary Unit (MEU), clears an M50 gas mask during a decontamination chamber drill aboard USS Green Bay (LPD 20) in the South China Sea, on 19 February 2022.

The other factor is: 'what level is safe'? Both science and opinion vary greatly on this subject. No substance is so dangerous that a single spore or single molecule is going to pose any kind of threat. We also have reasonable ideas as to what levels of contamination are so acutely dangerous as to pose immediate threats of death or injury. However, there is a wide grey area in the intervening territory between 'nothing here' and 'this level is dangerous.' Much of what we know about the toxicology of chemical warfare agents is based on quite old information. We do not know enough about long-term hazards. Some threats, like the 'Novichok' agents are poorly understood in terms of their toxicity at lower levels. All of this uncertainty means that decisions about what is 'safe' for a few days for a tank crew in full personal protective equipment (PPE) may not be safe for months of peacetime training use or for transport by sea or air. Long-term health threats from low levels of contaminants can be poorly understood, as witnessed by Agent Orange, 'burn pits', and Gulf War Illness. The latter has been closely correlated with exposure to organophosphates in recent studies.

It is only fair to point out that the detection and safety issues are relatively clear-cut with radiological contamination. We have a better understanding of the relationship between radiation dose and harmful effects than we do for most of the chemical threats. Polonium aside (it's an alpha emitter and needs trickier equipment), radioactive contamination is readily detected, and we have a broad understanding of what levels are safe and unsafe. Polonium is a bit trickier, but once you know it's an issue, you can adapt procedures accordingly.

Another aspect of the safety issue is the actual safety of the decontamination process. Some methods of decontamination merely move the contamination from one place to another. While transferring radiological contamination off a tank into a pond of run-off wastewater may return the tank to use, the wastewater pond is now a problem. Many decontamination techniques use reactive chemicals to attempt to neutralise chemical or biological hazards. Yet some of these chemicals themselves might be contamination hazards if residue is left on decontaminated surfaces.

Addressing the Problem

In an ideal world, we would have a chart with curves on it, showing detection thresholds and safety levels of various substances. We could use such charts to guide our selection of decontamination processes. Right now, there is little point in drawing up such charts as, honestly, the detection thresholds are too high, and our understanding of long-term low-level hazards is too low. Military forces are left with an operating assumption that decontamination needs to be thorough, and we cannot rely on detection to tell us if we did a good enough job.

Militaries have understood the decontamination conundrum for some time. For generations, equipment decontamination was driven by an overkill concept. It was basically assumed that heavy-handed caustic chemicals were needed. Hypochlorite bleaches were commonplace and used in quantities and concentrations that would be hazardous in themselves. The US Army's primary decontamination chemical was called DS-2 and was in of itself a dangerous cocktail of three chemicals. It would peel paint and burn skin. While hypochlorite bleaches are still in use, a number of less hazardous decontamination substances are now in use, made by various companies around the world. The general state of this market has been well covered in this magazine, particularly in issues 02/20 and 10/21 and has changed little from the time of writing.

The market has provided good materials for use in decontamination and even the generic ones, such as soap and warm water, generally do work. The issue of thoroughness derives from other factors than the existing decontamination products. It is not that a particular decontamination chemical is ineffective. They are all broadly good at their job, and this author can only foresee

Credit: US Army/Lisa Bistreich-Wolfe

Chemical Agent Disclosure Spray, shows its capability to change colour in the presence of chemical agents.

incremental improvements in efficiency and economy in that sector. Rather, the issue is where and when to use it, how much to use it, how many times a wash might be needed to achieve a safe level, and how to know if you have done a good enough job. This leads back to the issues described above.

The Road to Better Decontamination

Two pathways to improvement become obvious. Better detection is needed. Military personnel need better situational awareness to know when and where decontamination is needed. Detection can also provide better awareness of how much of a particular system is decontaminated. For example, if only the exterior of a tank is contaminated, then much less time, labour, and materiel are needed for decontamination. Additionally, if we can detect lower levels of contaminants, then detection becomes more useful in telling us if decontamination efforts were adequate.

Some of this improvement amounts to greater sensitivity and better selectivity in existing types of chemical agent detection systems. The US Department of Defense (DoD), the biggest spender in military CBRN procurement, is pushing the NGCD – Next Generation Chemical Detector programme. In reality, this program is pursuing four different instruments. One of them is the PCAD – The Proximate Chemical Agent Detector. Smiths Detection (US-UK) and laser firm Block MEMS (US) are known to be working on this project. The PCAD holds forth the prospect of better detection of contamination on surfaces, as it detects liquids or even solids, rather than just vapours emitting from liquids.

Fumigation techniques show much promise, particularly in the tricky business of decontaminating interior spaces and sensitive items like electronics. Companies like Steris (USA) and Cristanini (IT) provide the ability to use hydrogen peroxide or hydroxyl radicals in mist form to neutralise chemical or biological contamination in enclosed spaces. Fogging the interior with reactive mist is a viable method of dealing with environments such as aircraft cockpits and ambulance compartments. If one put the items to be contaminated inside a sealable environment, the entire item can be decontaminated. Traditionally, this has meant cabinets for surgical instruments and the like. However, in theory the technology is scalable. One can envisage a tent big enough for fumigating a tank, or a hangar for a helicopter.

A new frontier in this area is visible contamination indication. If you could spray a tank or a truck with a chemical substance that visibly changed colour in contact with contaminants, it could substantially improve decontamination efforts. The US military funded development of 'Chemical Agent Disclosure Spray.' The product, originally developed by a spinoff from the University of Pittsburgh, uses enzymes to provide a visible colour change when the spray encounters blister and nerve agents. The product, also known as 'Agentase', is now manufactured by Teledyne FLIR (USA). This technical approach is actually superior in many ways to trying to use detection instruments and will yield good results in conditions and scenarios where vapour detection is simply inadequate. Improvements in decontamination are rarely exciting, but this development is an exception, and it merits close observation.

The other pathway is to improvement is capacity. Militaries have, since the cold war, systematically and sometimes even ruinously eroded their force structure in CBRN defence. Dedicated troops and units for decontamination are far rarer than they were at the height of the Cold War. Decontamination as an actual mission often

Credit: US ANG/Master Sgt. Jonathan Duplain

Members of the 101st Air Refueling Wing's emergency management team exit a simulated decontamination unit during the Vigilant Guard exercise held at the University of Maine, Orono, on 5 November 2013.

now resides in reserve units or as an additional duty for other types of units, where it invariably languishes low on the list of priorities. It becomes a serious question in some modern militaries as to exactly which troops are supposed to perform the decontamination task. If the mission itself is not clearly allocated, it is little surprise that training and equipment also get neglected.

All too often, the idea in modern militaries is that, somehow, combat units are going to decontaminate themselves. This is largely an untested hypothesis. Decontamination is not conceptually difficult to grasp. However, it is one of the most physically demanding and annoying missions that you can task soldiers to undertake. If you have soldiers and units whose job it is to do it, then it becomes a priority. If you give the task to soldiers and units that have other important jobs to do, the necessary training and practice for decontamination will lose emphasis. Even if they are reservists, the way forward is for armies to devote at least some force structure to decontamination.

Other Options: Ageing and Abandonment

It is not often discussed, but sometimes there are only bad options. Some operational scenarios have the prospect of widespread contamination of major equipment. Not everything that needs decontamination may get treated in a timely manner. It is possible that resources will be overwhelmed. Some sort of triage is likely to be needed.

One alternative in this scenario is ageing and weathering. If left in open air exposed to the elements, CBRN contamination will degrade on its own due to exposure to the natural environment. Most chemical warfare agents respond, even if gradually, to moisture in the air and from precipitation, and degrade through hydrolysis into compounds that are less hazardous. It should be noted, however, that many chemical agent degradation products are still hazardous to some extent. Biological contamination is susceptible to degradation by sunlight. Radiological contamination will decay according to its half-life. In particular, fallout from actual nuclear weapon explosions has many isotopes with short half-lives. The dose rate (and thus the danger to health) from a vehicle contaminated with nuclear fallout will be far lower after a week of decay time.

Ageing and weathering may not be the perfect solution. In many instances, it is unlikely to be able to replace thorough decontamination. Generally, though, this approach may reduce hazard levels significantly and thus reduce the resources needed for eventual decontamination. Weather obviously varies and not every climate or season will reduce contamination equally. Warm and rainy weather is the best for gradual neutralisation of chemical hazards, whereas dry and sunny is more ideal for biological threats. Returning equipment to service, though, requires awareness with detection instruments and understanding of the properties of the threat material.

The other approach is abandonment. It may be a better use of resources to replace an item rather than decontaminate it. As a practical matter, many items that were potentially contaminated during the Salisbury Novichok nerve agent incident went to landfill rather than be subjected to decontamination. For example, some emergency services vehicles were deemed, not without controversy at the time, to be cheaper to bury forever than decontaminate. Abandonment has also been the course of action in some radiological contamination scenarios involving items dirty with long-half-life materials such as Caesium-137. Abandonment also carries with it the issues of safety. Burying or isolating a contaminated item does not remove a hazard but merely segregates it.

The truth is that military forces have seldom faced the threat of widespread CBRN contamination of equipment since 1918. Armies and potential CBRN threats have evolved considerably since the dawn of chemical warfare. Countermeasures have evolved significantly as well, but for now the challenge of decontamination, as well as returning infrastructure and equipment back to service in CBRN environments remains a hypothetical challenge. ■

Credit: US Army/Sgt. Patrick Eakin

Soldiers from 1st Battalion, 9th Cavalry Regiment, 2nd Armored Brigade Combat Team, 1st Cavalry Division perform decontamination procedures on their vehicles at the Rodriguez Live Fire Complex in South Korea, on 4 August 2017.

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Apache CSP – the UK's Newest Attack Helicopters

Tim Guest

With the first two new aircraft having entered service with the UK's Army Air Corps (AAC) 18 months ago, further deliveries of these latest helicopters are set to take the British Army Apache-64E fleet to 50 in the not-too-distant future.

Described as more lethal, agile and survivable than previous versions of the aircraft, the British Army's new Apache AH-64Es have been steadily filling the hangars of the UK's AAC since 2022 and taking to the skies of the southern and eastern counties of the UK under the British Army's Apache Capability Sustainment Programme (CSP). This article looks at how the programme has unfolded, together with latest developments.

Credit: UK MoD

AH-64E enters service January 2022 with 3 Regiment Army Air Corps.

Setting the Apache CSP Scene

In the UK's Strategic Defence and Security Review 2015, the need to maintain an effective attack helicopter capability was reaffirmed and a holistic approach was set in motion to address what was needed from both the platform itself – the Apache – as well as such needs as the 'strategic interoperability' such an asset would need to offer to allies.

The British Army's Head of Capability for Air Manoeuvre was appointed as the programme's Senior Responsible Owner (SRO) to oversee the Apache CSP, in turn being personally accountable to the Chief of the General Staff (CGS) for delivering the programme. Additionally, within the Defence Equipment & Support (DE&S) unit of the MoD, its Apache Project Team was made responsible for procurement of the aircraft together with support solutions. Once this structure was in place, the Army undertook a cost/benefit analysis of the requirement to eliminate any unnecessary UK-specific 'wants' that might have incurred additional costs and increased delivery times, without adding to the attack helicopter capability in any significant way. As a result, it was decided to acquire the new AH-64E, in an off-the-shelf arrangement, with only two changes from the baseline US Army design – a UK Defensive Aids System in order to maintain operational sovereignty, and a windscreen wash-wipe capability to enable maritime operations.

This off-the-shelf procurement approach not only met all Army requirements, but also enabled the UK to benefit from through-life burden-sharing and the enhanced interoperability with key allies, such as the US, determined as essential in early consideration of the requirement. This approach was fully approved by the MoD in 2016 and it was agreed that 50 new Apache AH-64E helicopters would be acquired, to be built by Boeing via a foreign military sales arrangement worth USD 2.3 Bn through the US Government. The new aircraft would address existing, as well as predicted obsolescence issues that were set to impact operational capabilities of the UK Apache AH Mk1 fleet from that time onwards. But it is the new technologies incorporated into the AH-64E that convinced stakeholders this was the right aircraft and way forward to provide the UK with the advanced operational capabilities its attack helicopters needed to be fit for the battlefields of tomorrow.

The Apache CSP is now at the forefront of British Army programmes and its whole approach is likely to be followed by other capability change programmes; the Chinook CSP currently underway, is one example where this is happening. In terms of strategic benefits, the MoD's defence relationship with the US has been at the heart of the programme. Both interoperability and influence are key tenets of the CSP and a co-operative working arrangement has secured influence on aspects of the US aircraft design, as well as future US Army requirements, including the co-development of a real-time operating system that enables off-the-shelf solutions that better meet a UK requirement.

Programme Underway

It was agreed that the best long-term solution was to adopt the current US Army standard of Apache AH-64E Guardian v6 for a number of reasons, which included being supported by the manufacturer for a longer time. Building an AH-64E has actually been achieved in the US via two tracks:

new-build airframes; or the refurbishment and upgrade of existing airframes, with the route chosen depending on the age and current standard of the existing airframe. In making its decision as to which track to adopt, the UK sent a single airframe to Boeing at Mesa, Arizona to understand if the upgrade/refurbish route was feasible. This proved not to be the case, so it was decided to go for brand new AH-64E airframes as the most cost-effective option, through re-using [and] incorporating as many existing, relevant Apache AH1 components and equipment items as possible.

Having made this choice, old UK Apache AH1s were then selected for the CSP and shipped to the US, based on airframe. For example, in February 2018, airframes ZJ166 and ZJ167 were shipped followed by ZJ182 and ZJ188 in July 2022. Some UK systems and components were removed at Wattisham Airfield in Suffolk, (home to 3 Regiment and 4 Regiment of the Army Air Corps), before being sent to Science and Engineering Solutions (SES) at Huntsville, Alabama, where further stripping of the airframe of remaining, useable components was done. The empty airframe hulks themselves were then discarded. The useable components have then been sent to Boeing at Mesa for integration with the new AH-64Es during the course of the programme. As for the brand-new AH-64E airframes, these have been built on the production line in India, then shipped to Arizona for fitting out and systems integration, including the installation of previously recovered AH1 components. Once test flown, they are then air-freighted to the UK for delivery to the AAC, with the programme proceeding at a rate of roughly one Apache per month.

Credit: UK MoD

Filling the hangars, January 2022, Wattisham Airfield.

First Deliveries

According to schedule, and under the watchful eye of the MoD team instrumental to delivering the programme, led by DE&S Boeing helicopters portfolio manager, Air Commodore Owen Barnes, the first two new Apache AH-64E Version 6 attack helicopters were delivered to the British Army at Wattisham Airfield at the end of November 2020. The aircraft were accompanied by aviation technicians from 7 Aviation Support Battalion, Royal Electrical and Mechanical Engineers (7 Avn Spt Bn REME), to maintain and service the new aircraft. The eventual fleet of 50 AH-64E Version 6 aircraft will fully replace the Apache AH Mk1, which reaches its out-of-service date in 2024, when deliveries of the new aircraft are slated for completion by mid-summer of that year.

Credit: UK MoD

Housed AH-64Es in hangars at Wattisham Airfield.

First UK test flying of the new aircraft commenced in July 2021 and initially focused on trials activity and developing instructional techniques to safely manage aircrew transition from Mark 1 to the E-model. The focus then changed to the full-rate conversion training of 3 Regiment Army Air Corps (3 Regt AAC). Before flying began, however, the full air system safety issues were tested to ensure safe flying was fully supported. This included quality assurance and airworthiness tasks by the REME ground crews, together with certification by the UK Military Aviation Authority, assurance of aircraft documentation, simulators, training and instructors. The new engines, drivetrain, main rotor blades and avionics deliver a significant boost in aircraft performance and embedded system-level diagnostics deliver increased aircraft availability. The aircraft has an extended-range fire control radar, including a maritime mode that ensures the aircraft can operate in the maritime environment. In addition, Link 16, Mode 5 IFF and manned-unmanned teaming (MUM-T) provide theatre entry-standard equipment fits and vastly increase crew battle-space awareness. All these new systems and features have pushed the learning envelope for air and ground crews to their highest levels.

At the time of the first deliveries, Brigadier Steve Hussey, Head of Capability Air Manoeuvre, said in a statement that while there was still some way to go before the Army's modernised attack helicopter capability reached its full operational status, the arrival of the first Apache E Model in the UK was a major programme milestone. His colleague and Commander 1 Aviation Brigade, Brigadier Paul Tedman CBE, added that the AH-64Es would eventually team with Wildcat helicopters to "provide the

Credit: UK MoD

Apaches stationed at Middle Wallop are now operating with 7 Regiment AAC as the instructional platforms. Middle Wallop, July 2022.

backbone of the UK Aviation Brigade's capabilities" as it grows towards its own full operating capability in 2023.

Adding to those voices on the occasion of that first delivery, Maj. Gen. Jez Bennett, Director Capability, said that the arrival of the new aircraft marked the beginning of a significant uplift in capability to enhance the Army's contribution across the spectrum of military operations, from supporting hostage rescue missions, to countering an adversary's anti-access, area denial platforms. He added that the new variant "outstrips" the outgoing Mark 1 aircraft by increased platform digitalisation, improved weapons and avionics, and the ability to use the latest and future technology to enable teaming with semi-autonomous systems, such as UAVs.

Long-term Support

In January 2022, by which time 14 of the eventual 50 new-variant aircraft were already in the UK, the MoD's DE&S signed a Long-Term Training and Support Services (LTTSS) deal with Boeing Defence UK, under which Boeing now provides long-term training, support and sustainment for the new fleet. Valued at GBP 287 M, the LTTSS contract, announced at that time by UK Minister for Defence Procurement, Jeremy Quin MP, during a visit to Wattisham Airfield, sees Boeing working closely with the British Army at Wattisham to provide maintenance and engineering support, supply chain and logistics management. The company is also providing aircrew and maintainer training under the contract from its advanced facility at the Army Aviation Centre/Army Air Corps HQ at Middle Wallop in Wiltshire. [As of July 2022, the Army Aviation HQ at Middle Wallop, also began operating the AH-64E.

BWhilst Wattisham Airfield is home to the new frontline AH-64E regiments, the new Apaches stationed at Middle Wallop are now operating with 7 Regiment AAC as the instructional platforms on which pilots and gunners will train.]

The LTTSS agreement is set to run until 2040 and has created more than 200 jobs in the UK, which will be active during its first four-years, including more than 165 at Middle Wallop, as well as 45 at Wattisham; dozens of related jobs are also ongoing with suppliers in the UK. (Boeing already had more than 40 employees working alongside AAC personnel providing training for the Mk1 Apache).

In addition to the new Boeing roles, the training and support for the new Apache model established new roles and opportunities for Boeing's UK supply chain; Yeovil-based Kuehne & Nagel are providing a warehouse management service at Wattisham with a dispersed store at Middle Wallop, creating 45 new jobs. Meanwhile, H&S Aviation is undertaking repair and overhaul of engines in Portsmouth, subcontracted to GE Aviation, and Cheltenham-based Pennant is providing additional simulated training systems to Boeing as part of the deal, delivering several new and upgraded part task trainers with E-model compatibility, sustaining around 50 skilled jobs.

Jeremy Quin was accompanied at Wattisham by Deputy Chief of the General Staff, Lieutenant General Sir Chris Tickell KBE, and together they met pilots from 3 Regt AAC, plus engineers and groundcrew. The regiment, part of 1st Aviation Brigade Combat Team, is the first UK unit to field the AH-64E, with engineers and aircrew undertaking training courses in the USA as part of the CSP. Throughout the programme, as aircraft have arrived from the US into the unit's hangars at Wattisham, ground crew have made all necessary checks on aircraft delivered. Latest features they've been familiarising themselves with include the aircraft's new drivetrain and rotor blades which boost flying performance, its improved sights and sensors, new communications systems to share data with other helicopters, UAVs and ground forces, as well as embedded maintenance-diagnostic systems to increase aircraft availability.

Simulation, Flying, Performance

In addition, three Longbow Crew Trainers are now in operation with frontline AAC Apache squadrons, playing a key role transitioning the crews to the new variant. The Longbow Crew Trainer is the centrepiece of Boeing's AH-64 Apache training. The high-fidelity flight simulator is used by pilots and other personnel to practice aircraft procedures and rehearse missions. It is containerised and deployable, allowing in-theatre training under a wide range of conditions.

While test flights have been ongoing since July 2021, initial operating capability was achieved in early 2023. The aircraft has a top speed of 300 km/h (186 mph) and with new avionics and sensor suite can detect 256 potential targets at once, prioritising the most urgent threats within seconds, up to a range of 16 km (10 miles). The AH-64E is faster than the Mk 1 and can climb quicker thanks to new composite rotors designed to be more resistant than their predecessors to

Credit: Tim Guest

AH-64E at DVD 2022 latest optical and FLIR sensors.

hits from ground fire; they also allow it to carry a heavier payload of weaponry and thus increase its lethality. Those weapons have their targets acquired and weapons guided by a vastly improved radar and sighting systems' suite, new to the crews. The aircraft also includes an advanced target prioritising system, which helps with rapid reassessment and survivability in countering enemy threats. The UK's Defence Science and Technology Laboratory (Dstl) evaluated the safety of the AH-64E's software and human-machine interface, contributing to the aircraft's release to service in 2022. That said, it did identify potential risks to aircrew as they converted to flying the new helicopter, underlining the need for exhaustive flight training, including on simulators.

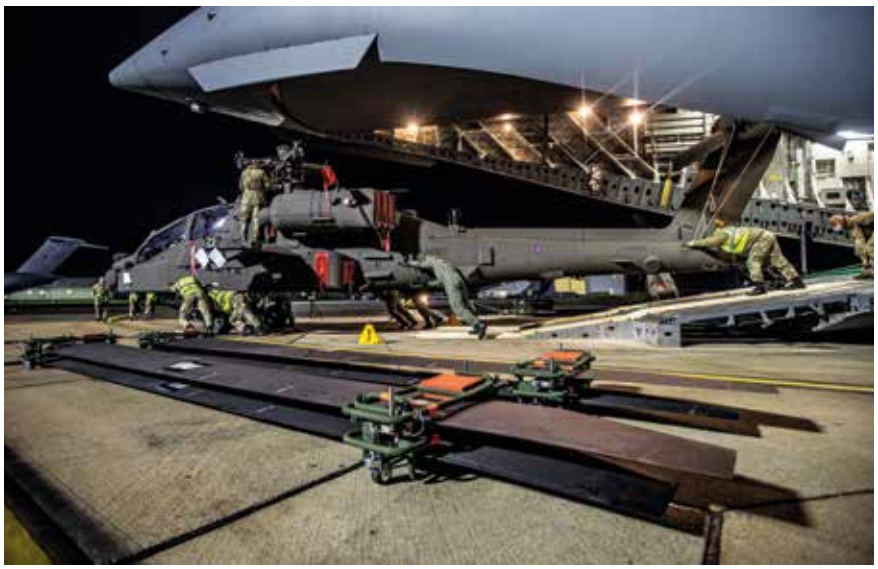
Credit: UK MoD

Aircrew hunted for artillery and armoured vehicles at Otterburn Ranges in Northumberland and for Challenger 2 tanks on Salisbury Plain during Exercise Talon Guardian, October 2022.

Testing Exercise

The new Apache AH-64E made its first full deployment into the field during Exercise Talon Guardian, in October 2022, which saw 3 Regt AAC take a 1,500 km road trip over two weeks, establishing itself at three separate locations to plan and execute attack missions and maintain these state-of-the-art helicopters. The regiment's commanding officer, Lieutenant Colonel Simon Wilsey, said in a statement that the exercise was a "significant step forward" for the new aircraft, with the regiment working hard to learn how to fly and maintain the AH-64E in the field, tackling the additional complexities of living, planning, maintaining and operating in austere environments. He said that with its "vastly improved capabilities", it was not a case of going back to what was done before, but starting to use all the new systems and capabilities, including in the context of lessons from current conflicts, and adapting to ensure relevance and survivability.

The exercise was about basic field craft in the air, as well as on the ground, including dispersing and camouflaging positions to prevent observation by drones, and communicating by data over long range. For aircrew, honing flying skills using natural cover, as well as familiarisation with all aircraft sensors to counter air defence systems and low-tech threats were also part of the deployment. The overall aim was to prepare 3 Regt AAC for its core role, providing an aviation deep attack battlegroup as part of 1st Aviation Brigade Combat Team, to the British Army's warfighting division, 3rd (United Kingdom) Division. During the course of the exercise, aircrew hunted for artillery and armoured vehicles on Otterburn Ranges in Northumberland and for Challenger 2 tanks protected by air defence systems on Salisbury Plain, Wiltshire. One pilot said at the time, that although the exterior looked the same, everything on the inside had changed to deliver improved capabilities in sensors, flying performance, weaponry and communications, and that the switch to the AH-64E from the Apache Mk1 was like changing mobile phones from a Nokia 3310 to an iPhone 14!



Credit: UK MoD

Arriving by air. AH-64Es airfreighted from Arizona to RAF Mildenhall in the UK aboard a USAF C-5M Galaxy.

Up-to-Date

With the programme proceeding at a rate of roughly one Apache per month, over 30 aircraft are now with the AAC in the UK and the full fleet number of 50 aircraft, (down from the original 67 Apache AH1s), is due to be achieved during 2024, which is comfortably on target.

So far in 2023, three new aircraft – ZM728, ZM729 and ZM730 – arrived in March, airfreighted from Arizona to RAF Mildenhall in the UK aboard a USAF C-5M Galaxy, then readied for a road move by REME crews and moved to Wattisham by the UK's Joint Aircraft Recovery and Transportation Squadron (JARTS).

Other aircraft, AH-64E ZM725, and ZM723, made short test flights at Wattisham in March, following re-assembly after delivery by air freight from the manufacturer. April saw AH-64E ZM727 take to the air for the first time at Wattisham, as 'ArmyAir607'. Then, in June, AH-64E ZM726 'Outlaw1' test flew from the air station, followed on 29 June by 4 Regt AAC's 664 Sqn taking to the skies over Suffolk in AH-64E ZM709. ■

Next Generation Rotorcraft Capability: NATO's Joint Helicopter Development Programme

Sidney E. Dean

NATO's Next Generation Rotorcraft Capability (NGRC) programme aims to refresh the aviation fleets of participating member states with an advanced medium-lift multi-role helicopter.

Goal of the Programme

A significant portion of the medium-lift multi-role helicopter fleets of Alliance members will reach the end of their service life in the 2035-2040 timeframe, with additional airframes retiring during the following decade; overall, non-US NATO armed forces are expected to replace up to 1,000 medium-lift rotary aircraft by 2050. Traditionally, nations have pursued individual weapon system acquisition projects, either through domestic development of new aircraft or import of operational foreign systems. Numerous reasons exist for pursuing a joint acquisition programme instead. These include economies of scale, the ability to combine the most advanced design and manufacturing capabilities of the participating states, and the outlook for optimal interoperability of the future fleets.

NGRC was launched on 19 November 2020 with the signing of a non-binding Letter of Intent (LoI) to pursue the multinational development programme. The five signatories – France, Germany, Greece, Italy, and the United Kingdom (as the lead nation) – then proceeded to develop both a statement of requirements to guide the concept development phase, and a long-term multi-phase cooperation plan for realising the full project all the way through fielding. On 16 June 2022, the signatories, now joined by the Netherlands as a sixth partner, signed the binding Memorandum of Understanding (MoU). This formally launched the concept stage of the project, with a combined initial budget commitment of EUR 26.7 M. Canada will join the programme in the summer of 2023, and additional NATO members may also come on board – most likely as observers – as the project progresses.

Credit: NATO

Representatives of six NATO member states signed the NGRC MoU on 16 June 2022 in Brussels.

The NGRC programme will provide participating Alliance members a multinational framework for pooling their resources and efforts to design, develop, and eventually procure the new helicopters. The NGRC is classified as a NATO High Visibility Project (HVP), a term used for multinational initiatives designed to address key capabilities. HVPs are usually launched at the defence minister level, underscoring both the consensus regarding a major requirement, and enhancing the probability that member states are fully committed to the joint project.

The NATO Support and Procurement Agency (NSPA) acts as the contracting authority for the NGRC and is the executive arm of the NATO Support and Procurement Organisation (NSPO), of which all 31 Alliance nations are members. The NSPA is currently organising the concept study phase and providing programme management (procurement and finance); it will also devise and manage the acquisition strategy for upcoming stages. The agency's Cyril Heckel is the official NGRC programme manager.

Roles, Missions, Capabilities

Today's army and air force medium-lift helicopters perform a wide array of missions including assault carrier, special operations transport, battlefield resupply, combat search and rescue, and casualty evacuation/medical evacuation (CASEVAC/MEDEVAC); NGRC must be capable of fulfilling all of these roles. The future helicopter is also supposed to replace medium-lift helicopters in naval service, which means it must be capable of landing on decks and performing such tasks as anti-submarine warfare, maritime reconnaissance and targeting support, and potentially anti-surface warfare. The target aircraft should display significantly improved flight characteristics when compared to current operational systems.

NSPA presented an initial list of 15 system requirements plus another ten desired attributes in May 2021 in preparation of an industry day in September 2021; these requirements and preferences were confirmed in February 2023 by programme manager Cyril Heckel during the IQPC International Military Helicopter (IMH) 2023 conference in London. Whether all requirements survive past the concept study – and the intense review of what is technically feasible – remains to be seen, but for now the agency is seeking an optionally-manned platform with a minimum range of 1667 km (900 NM), a 741 km (400 NM) mission radius, plus 30 minutes of loiter time, and an overall eight-hour mission endurance (with auxiliary tanks fitted). The objective maximum cruise speed is 220 kn or higher, with 407 km/h (180 kn) as the absolute bottom threshold. These baselines would provide NGRC with approximately 50% more speed and double the range of current medium-lift utility helicopters, placing performance parameters closer to the US Army's Future Long-Range Assault Aircraft (FLRAA); the American aircraft is expected to become fully operational at approximately the same time as NGRC. Being able to keep up with one another would of course be advantageous for future NATO operations.

The target take-off weight lies between 10,000 and 17,000 kg, with a 2,500 kg internal payload capacity and a combined internal/external payload of 4,000 kg. The acquisition price per airframe must not exceed EUR 35 M, and the hourly flight cost should lie between EUR 5,000 (objective) and EUR 10,000 (maximum). The aircraft must also have a 75% mission availability rate. As reiterated by Cyril Heckel during the IMH conference, all performance parameters are to be met with minimal differences in aircraft configuration in order to minimise complexity and cost.

Additional required goals are numerous and include: an internal capacity for 12–16 combat equipped soldiers; the ability to perform special operations, anti-surface warfare, electronic warfare (EW), search-and-rescue, personnel recovery and MEDEVAC missions; full-operational capability from frigate/destroyer type vessels; and being able to operate in the face of enemy EW threats. Desired attributes include: a two-minute automated rapid start routine; digital cockpit and avionics; aerial refuelling capacity; the ability to launch and control drones (manned-unmanned teaming); and deployment of advanced crew served weapons including missiles and so-called Air-Launched Effects, a blanket term which includes loitering munitions with a broad capability spectrum ranging from reconnaissance and surveillance to kinetic effects and EW.

Programme Elements

As defined by NATO, NGRC offers a multinational framework under which its participants can combine efforts towards the design, development and eventually the acquisition of the next generation of medium multi-role rotorcraft capabilities. The plan is to create a clean-sheet design rather than adapting a currently operational or developmental aircraft. Working closely with industry, the governments will assess how to sync their operational requirements and desired aircraft characteristics with technological developments, as well as assessments of the future operating and threat environment. "NGRC to me is about transformation capability, delivering an aircraft or an airframe or a system that is an open system architecture based on digital backbones and is aimed for us as soldiers and airmen to be able to modify that aircraft to keep up with the pace of the threat," said British Army Col. Alex Willman, capability sponsor of combat aviation within the UK's futures directorate, after the MoU signing.

The programme's concept study phase commenced in June 2022, and is subdivided into five major areas of interest. Studies are being prepared regarding the concept of operations, novel powerplant solutions (to review the viability of hybrid-electric and other non-traditional propulsion technologies), modular open systems architecture (MOSA), sustainability, and to survey rotorcraft technology innovations which could be applicable to NGRC. A portion of these studies will be contracted out to industry following an open competition, while others – such as the technology review – will be conducted at the government or alliance level for security reasons. The studies should be completed by mid-2024 (some earlier), providing a roughly 18-month period for

Credit: USAF

The French Air Force's optionally armed EC725/H225M multirole helicopter performs the range of missions expected of the future NGRC, namely troop transport, casualty evacuation, combat search and rescue, special operations, maritime surveillance and anti-submarine warfare.

Credit: Royal Navy/Open Government Copyright

The British Royal Navy will retire its ship-based, optionally armed AW101 Merlin helicopters by 2040, and could replace them with the NGCR.

Credit: USAFE

Producing multiple national variants of the NH90 medium helicopter (seen here in the French Army variant) has complicated sustainment and has contributed to reliability issues – a mistake the NGRC programme office hopes to avoid.

exhaustive concept reviews and to adapt the final concept of operations (CONOPS) to the results of the technical studies.
The NSPA hopes to conclude the concept review phase in 2025. A major challenge during this period will consist of harmonising the fundamental – and sometimes contradictory – requirements and priorities of the individual participant nations into one common framework, while avoiding a multiplication of variants which would increase costs and reduce efficiency, NSPA's Heckel added.

Programme Activities to Date

The first formal meeting of the NATO Support and Procurement Organisation NGRC Acquisition Support Partnership took place on 29-30 November 2022 in Luxembourg. All six MoU signatories attended the meeting chaired by the NSPA; Canada attended as an observer prior to achieving full membership. By January 2023, the NSPA was able to announce that the NGRC programme team had been "partially activated."
The first two pre-solicitation conferences for the NGRC were conducted, respectively, in March and May 2023. The first conference held on 30-31 March in Luxembourg was dedicated to the overall concept stage of the project. More than 20 rotorcraft industry firms participated and were briefed on the NSPA's expectations and requirements for the new aircraft. According to the NATO press release, Agency presentations focused on the procurement strategy for the concept stage studies and on the project's special Study Number One. "This first study will analyse and compare novel power plant solutions for rotorcraft based on Strength Weakness Opportunity Threat analysis" to include factors such as capability, availability, cost and logistic footprint, the release noted. The second pre-solicitation conference, held on 22-23 May, focused on the non-proprietary Open System Architecture Study. The 24 companies in attendance received an overview of the open system requirements, and in turn offered their views on the strengths, weaknesses and issues surrounding candidate MOSA concepts in terms of capability and supportability. The comprehensive and formal Request for Proposals is expected to be promulgated in summer 2023, initiating across the board concept development and presentation by industry.

Early Speculation Regarding Aircraft Concepts

Many observers believe that supporting European industry is a secondary goal of the NGRC programme. Early on there were concerns that Britain – which in 2022 signed an information sharing agreement with Washington regarding future rotorcraft lift programmes – might try to steer the NATO programme towards acquisition of the US Army's FLRAA. Specifying that NGRC will be conceived as a clean-sheet programme did much to alleviate those concerns. Presuming that a European firm or consortium will ultimately receive the development contract or contracts, Airbus and Leonardo (either separately or jointly) are the leading contenders going in, with several specialised contractors able to offer propulsion, avionics and other mission systems. However, as a matter of principle, industry partners from any NATO nation remain free to tender their technology, which opens the door for US firms to ultimately participate in some form.
While NGRC is geared toward a clean-sheet design, this could ultimately be interpreted as precluding the acquisition of an upgraded variant of a currently operational military or civilian system. Beyond that restriction, some developmental or conceptual projects could be leveraged as a basis of the future medium multi-role helicopter with several already being proposed by industry. These include the Airbus Racer (Rapid and Cost-Effective Rotorcraft) concept for a high-speed ver-

Credit: Leonardo

Technology from Leonardo's developmental Next Generation Civilian TiltRotor (NGCTR) could flow into the NGRC concept design.

Yugoimport's Journey

Yugoimport Staff

Yugoimport–SDPR was founded in 1949 with the aim of importing technological equipment for the purpose of restoring the war-ravaged military industry of former Yugoslavia, its modernisation and further development. Shortly after its establishment, thanks to its specific geographical location, Yugoimport–SDPR began exporting armaments for the needs of newly liberated countries, primarily in Asia and Africa. With domestic support, as well as a strong political support from neighbouring countries, such business deals developed rapidly and at the same time the military industry became stronger as well. The political conditions of that time contributed to the fact that the production of armaments in our country was based on both Russian and NATO standards which ensured a significant competitive advantage.

Credit: Yugoimport

The Lazanski is fitted with the AU-220M remote turret, the main armament is chambered in the 57 mm × 347SR cartridge, which can overmatch armour beyond STANAG 4569.

After the dissolution of the Socialist Federal Republic of Yugoslavia, Yugoimport–SDPR continued to perform the same activity based on previous experience, tradition and strong relationships with partners, primarily from Africa, Asia and the Middle East. As the manufacturers of complex combat systems remained outside the borders of newly-established state of Serbia, Yugoimport–SDPR decided to replace those capacities and to start the production of these systems independently. That mission is still ongoing. So far, we have mastered the production of armoured combat vehicles and artillery systems, trainer aircraft, and at the same time, we support all foreign trade activities of our defence industry. In this respect, as an integrator of the Serbian defence industry, we participate in numerous exhibitions of armaments and defence equipment around the world. In recent years, we have been intensively equipping the units of the Serbian Armed Forces and Police Forces with systems that we have developed independently. One of the advantages of our industry is the independent development and production (without foreign licences) of a wide range of weapons, and therefore our industry exceeds the average economic and demographic status of Serbia.

Yugoimport–SDPR's offer includes complex combat systems, primarily armoured vehicles. Following global trends, in cooperation with manufacturers of automotive components from the West (primarily engine and transmission), from 2015 until today, we have developed two models of armoured vehicles 4x4 – Milos (14 t) and Milos 2 (18 t), two generations of 8x8 vehicles – Lazar (28 t) and Lazar 3M (28 t), as well as a completely new vehicle model – Lazanski (up to 36 t).

We are particularly proud of the Nora artillery system, the latest generation of which is entering production, and features an increased quantity of projectiles in the automatic loader. The Nora system joined the global players in the field of artillery in the early 2000s, which makes us a completely equal competitor to the world's leading manufacturers.

Credit: Yugoimport

The Nora-B52 M21 is the most modern variant of the Nora Family of self-propelled howitzers (SPHs). Compared to the previous version, the new model uses a more modern base platform and an improved ammunition handling system housing more projectiles.

There are significant investments in development and production of small infantry weapons, unmanned aerial vehicles and trainer aircraft with a tendency of transitioning to more modern aircraft in the future.

A particularly important sector in the Yugoimport–SDPR offer portfolio is ammunition. We develop and produce all types of ammunition, from small- and medium-calibre ammunition of all NATO and Russian calibres, modern ammunition of both standards with 'air-burst', proximity, and impact fuzes, including ammunition with thermobaric explosives, air-dropped munitions, and artillery ammunition of all calibres – from 105 mm to 155 mm. This also includes independent development and production of 155 mm ammunition with an increased range of 40 km, all types of powders – single-base and double-base, propellants, composite propellants, unguided rockets – particularly 122 mm Grad rockets with a range of 40 km, but also development of new rockets 262 mm with a range of 70 and 90 km. In the field of rocket artillery, following modern trends, we have developed modern systems with an extremely short reaction time. We independently integrate fire control systems for rocket and conventional artillery which enables short preparation times for engagement. We develop and produce various other types of armament and defence equipment: personal protective equipment, uniforms, ballistic protection, NBC protection, including the production of activated carbon, etc.

In addition to the production of armament and defence equipment designed for equipping units of the Serbian Armed Forces and Police Forces, Yugoimport–SDPR also deals with import for the needs of armed and police forces. An important element of the offer is the conversion and upgrade of old armoured vehicles, which we successfully perform for both domestic and foreign requirements. The transfer of defence technologies and construction of infrastructure facilities has been a significant part of Yugoimport–SDPR's business activities for decades.

Credit: Airbus

Airbus has proposed considering the firm's conceptual Racer high-speed helicopter as a potential starting point for the NGRC.

tical-lift aircraft, which is currently oriented toward civilian and public safety applications. The Racer design already meets some NGRC baselines including flight speed and inclusion of hybrid-electric power system; first flight of the technology demonstrator is expected in 2023. Another potential starting point could be the Next-Generation Civil TiltRotor (NGCTR) being developed by Leonardo, which is designed for a cruising speed of 519 km/h (280 kn) and range of 1,852 km (1,000 NM), with a (civilian) passenger capacity of 18-25. The first flight of the demonstrator is expected in 2024.

Leonardo is also cooperating with Sikorsky to evaluate the suitability of the American firm's X2 rotorcraft technology for the European market. The technology forms the backbone of several Sikorsky designs including the SB-1 Defiant, which ultimately lost the competition for the US Army's FLRAA contract. Sikorsky is now concentrating on the international utility helicopter market. "We certainly think that the X2 fits very well with a number of the requirements that they [the NGRC programme] have, and we will continue to work that as time goes on," said Sikorsky president Paul Lemmo. All three of the referenced designs would fulfil predictions made by many industry observers and corporate representatives who point out that the high speeds required of the NGRC will require an unconventional design, perhaps including a pusher propeller in addition to the main rotor, or a tiltrotor design.

NGRC - Moving Forward

The concept phase will provide the participating nations with some early design proposals, before tackling the development stage and the preliminary design review post-2025, according to Heckel. The goal is to exit the concept phase with two or three competing designs suitable for further development and evaluation going forward. The preliminary design review will be followed by award of development contracts. The programme office is recommending prototype testing as part of the development phase. NSPA's Heckel estimates that prototype testing could take place around 2030.

Given the early stage of the programme, timelines for future NGRC stages are tentative. Advancing to a full development phase will require a new government-level agreement among the participating nations. Such an agreement would address such – potentially challenging – issues as division of work among the nations, design details, and the possible admission of other NATO members as full partners in the programme. Some points of contention regarding performance requirements – which will in turn impact factors such as size and cost – are already coming to the fore. For example, the priority given by the UK and Italy regarding high flight speeds is not shared by the French Army. Airbus warned early on that the 25 priorities presented by the programme office would require a larger, heavier and potentially more expensive aircraft. Trade-offs must be expected as the programme progresses.

The programme office is adamant that a multitude of national variants should be avoided, as this could lead to sustainment issues and higher costs. Optimally, there should be a single airframe and the modular design should enable aircraft to be refitted for various mission types as needed. Two variants are considered the maximum acceptable outcome if the full spectrum of operations cannot be achieved by a single design.

For the duration of the concept phase, the programme is restricted to the current seven members. After 2025, when a development decision is made, the programme is likely to open up again for additional participants, bringing in additional design and production resources, but potentially complicating decision-making and consensus going forward. Presuming that the programme is not terminated prematurely, and leads to a production decision, Alliance nations not participating in the programme will still be eligible to acquire the NGRC, greatly enhancing interoperability and potentially leading to lower unit costs. Conversely, none of the seven current programme members will be required to procure the NGRC. Should the production schedule be delayed, or the aircraft's profile not meet a nation's specific requirements, other options will be available, including the US military's new FLRAA.

The first operational aircraft are expected to enter service somewhere in the 2035-2040 timeframe, with a target of 2035. Given the large number of helicopters due to retire between 2035 and 2050, an Initial Operational Capability (IOC) later than 2035 would run the risk of creating a capability gap in at least some Alliance fleets. Current expectations foresee production and procurement running through 2059, with at least three major block changes during this timeframe to accommodate major technological developments and operational requirements. Once fully operational, the NGRC aircraft family is expected to dominate non-US medium rotary-lift aviation into the late 21st century. ■

Credit: Lockheed Martin/Sikorsky

Sikorsky X2 architecture, shown here on the S-97 Raider demonstrator aircraft, employs a rigid co-axial main rotor supported by a tail-mounted pusher propeller, which delivers high speed in forward flight while enhancing agility. Aspects of this propulsion concept, regardless of the prime contractor, could be applied to the NGRC.

Global Combat Air Programme: an Update and future perspectives

Guilia Tilenni

Announced at the 2018 Farnborough Air Show with the unveiling of a first full-scale concept model, the programme for a Future Combat Air System (FCAS) is gaining momentum. After a complicated kick-off, mainly due to a limited commitment from Italy, the project, which is intended to deliver a 6th generation aircraft and the related 'system of systems', has gone international in 2022 with the participation of Japan, and is now well on track.

Credit: Leonardo

Rendering of the GCAP fighter's information-sharing capability.

At the DSEI 2019 defence exhibition, Italy and the UK signed a Declaration of Intent to collaborate in the FCAS, followed by a Memorandum of Understanding (MoU) including Sweden in 2020. Rome and Stockholm thus decided to join London's efforts for the development of an "international air project" intended to replace Eurofighter Typhoon from 2040. The UK was already advancing on a national programme for a 6th generation fighter, named Tempest in the UK, to be at the core of the FCAS system.

London has demonstrated its financial and industrial commitment since the beginning, and allocated significant funds over time. In April 2023, London pledged more than EUR 760 M to BAE Systems a part of a contract extension to progress in the "concepting and technology of the next-generation combat aircraft", as the Ministry of Defence declared. This is part of a broader investment announced in the 2021 Defence Command Paper, consisting of more than EUR 2 Bn in funds to be pledged up to May 2025.

The programme progressed slowly in the initial phases, mainly due to the low financial participation of partners. Sweden signed up for the FCAS programme in July 2019 but was not formally included into the Tempest programme. In July 2020, Saab was awarded a contract for a preparatory study concerning the development of future fighter jet technologies. However, the government set 2025 as deadline to prepare its future combat aviation plans, thus putting the Swedish involvement in the FCAS programme "in hibernation", as Saab's President and CEO Micael Johansson said in August 2022.

Concerning Italy, the Defence Policy Document (Documento Programmatico Pluriennale, DPP) for 2020-2022 did not allocate any funds to the Tempest programme, but did so for the transition from Typhoon to Tempest fighters. However, the situation has slightly changed in 2021, when Italy openly affirmed its financial commitment to the programme. The DPP for 2021-2023 allocated EUR 20 M per year to the programme, likely to become EUR 30 M per year between 2024 and 2026. Concerning R&D funding, Rome firstly committed to EUR 2 Bn in funding over 15 years. This amount was revised upwards at the end of 2022, to almost EUR 4 Bn, a figure suggesting that the final R&D budget might be revised upwards.

The date of 9 December 2022 marked a key milestone with the launch of the Global Combat Air Programme (GCAP). With this partnership of equals, Japan aligned its requirements and schedule for its F-X programme with those of the UK and Italy's Tempest. In the joint statement following the launch, the three prime ministers stressed the benefits of sharing the costs of investments in peoples and technologies, which will enable participants to support their sovereign capabilities. British PM Sunak stressed that the GCAP will allow the UK to "stay at the cutting-edge of advancements in defence technology – outpacing and out-manoeuvring those who seek to do us harm".

Partners set 2035 as key official date for the entry into service. At DSEI Japan 2023, UK Defence Secretary Wallace, noted that all designs should be shared by 2025, thus kick-starting the development of the GCAP. The R&D phase has an estimated cost of EUR 6 Bn with the first flight of the fighter scheduled to take place in 2029.

Main Features

The GCAP, known as Tempest in the UK but still unnamed in Italy and Japan, will be a manned/optionally-manned, 6th generation fighter. For the UK and

Italy, it will remain at the core of the FCAS technology system, which mirrors the approach brought by 5th generation aircraft. The cutting-edge F-35 flies further than its predecessors, and its remarkable features, namely fully fused sensor information, transform the pilot into a unitary decision-maker focusing on limited, yet essential decisions. Pilots receive comprehensive intelligence from the battlefield, rather than rough information to be aggregated and analysed, and are thus in charge of choosing the best solution among those automatically proposed by the system. The Multifunction Advanced Data Link allows for data sharing with the other platforms involved in the missions, such as modern and legacy strike aircraft, and aerial and ground-based platforms.

The fighter will likely incorporate most of the features outlined for the original Tempest programme, namely:

- A flexible, software-driven flight control system;
- An adaptable physical architecture with changeable software and hardware;
- A survivability design that provides a good balance among comprehensive situational awareness, low observability and significant payload;
- Scalable autonomy that includes manned-unmanned teaming;
- An efficient, electrical power system allowing for optimising the aircraft's performance while limiting its thermal signature;
- A 'wearable cockpit' that controls pilot workload;
- Advanced integrated sensors, communications and effects;
- Advanced manufacturing with automated support options.

Credit: Leonardo

Schematic representation of the GCAP fighter's capabilities.

Leonardo, BAE Systems and Mitsubishi Heavy Industries (MHI) will work as 'Lead System Integrators'. This means they will oversee all the airframe development and lead the programme in Italy, Japan, and the UK, respectively.

Current status

The GCAP programme took centre stage at the Japanese edition of DSEI exhibition, held in March 2023. On the government side, the three defence ministers held a meeting to reaffirm their commitments. For the next two years, the British, Italian and Japanese governments will focus on defining cost-sharing arrangements and to build up the programme's governance. As of 2025, the GCAP is expected to enter its full development phase under a unique joint entity and common funding stream.

During the exhibition, Leonardo UK, ELT (formerly known as Elettronica) and Mitsubishi Electric Corporation signed their collaborative agreement for the development of the Integrated Sensing and Non-Kinetic Effects (ISANKE) and Integrated Communications System (ICS) suites for Tempest. Thanks to these advanced electronics on board, the GCAP core platform will be able to rapidly manage a large volume of data. By providing the aircrew with increased information and advanced self-protection capabilities, the system will enable "6th generation tactical sensing", according to the official press release. Integrated across all the operational domains, including space and cyber, ICS will allow ISANKE to operate as a network across a formation of manned and unmanned aircraft. During the exhibition, Masahiko Arai, Senior General Manager, Defense Systems Division, at Mitsubishi Electric, said that ISANKE & ICS will account for 25% of the GCAP budget, but provide more than 50% of the solution's overall capabilities. The ratio is significantly different compared to legacy aircraft, were the electronics usually account for 10-15% of costs and capabilities.

Rolls-Royce, IHI and Avio Aero agreed to pool their respective expertise to advance the design, manufacturing and testing of the future engine. In fact, the programme is revamping an existing collaboration between IHI and Rolls-Royce, which have been sharing defence equipment and technologies since 2013. In 2021, Rolls-Royce declared that the British Government had invested EUR 35 M in planning, digital designs, and manufacturing developments.

BAE Systems unveiled the latest version of its augmented reality cockpit concept for the GCAP during the Future Combat Air & Space Capabilities Summit held in London during May 2023. This latest update features a map that can be toggled from a 2D to a 3D perspective in Augmented Reality (AR). On that occasion, the company explained that the cockpit, which is to be personalised for each individual, will include biometrics, eye tracking and stress monitoring to sense whether the pilot is overwhelmed.

In an update published on social media on 14 July 2023, BAE Systems illustrated the main advancements of the programme on the Brit-

Credit: Giulia Tilenni

The mock-up of the SCAF fighter unveiled at the 2019 Paris Air Show. This programme is being developed by France, Germany and Spain. It also looks set to compete with the GCAP at the European level.

ish side. Test pilots from the company, Rolls-Royce and the Royal Air Force have already flown 150 hours on a bespoke simulator, to provide evidence that will support flight trials. BAE's engineers have already created safety-critical systems software, thus enabling a rapid assessment of the flight control systems during the flight in the simulator. This allows crucial data to be collected on how the jet will handle and perform in complex manoeuvres. Aerodynamic engine testing is also ongoing, as well as ejection seat trials, held in cooperation with Martin Baker.

New Industrial Approach

Partner companies are working extensively to maximise investments while keeping the deadline and the programme's ambitions unchanged. A difficult balance considering the complexity of the programme they are working on, but that might finally be managed thanks to a profound transformation of the working environment and a new approach to management.

During an event organised by the Royal United Services Institute (RUSI) in January 2023, the UK Future Combat Air Director at the MoD, Richard Burton, reaffirmed that the partners were building on the lessons learned from previous multinational cooperative programmes, such as the Lockheed Martin F-35 Lightning II Joint Strike Fighter project and the Eurofighter consortium. For instance, the involvement of the NATO Eurofighter and Tornado Management Agency (NETMA) has slowed down the pace at which the Eurofighter was developed, and reduced the programme's flexibility. Since NETMA was not powerful enough to manage the programme autonomously, companies and partner nations took over, but still needed NETMA to validate the different steps.

To remain on schedule, GCAP partners are seeking to establish deep synergies between government and industry to provide a fully joint international basis to the development contracts, set to be awarded in 2025.

According to Herman Claesen, FCAS managing director at BAE Systems, the structure might take the form of a joint venture with the capacity to act on behalf of the three governments involved. This means that, once any of the governments and industry partners have fixed requirements and priorities together, industrial partners will have a certain 'freedom of action' and 'freedom of modification' on the technical aspects of the programme.

GCAP will not only be managed according to a new structure but will also follow an innovative product design cycle. In 2020, Michael Christie, BAE Systems Director of FCAS said that the relevant stakeholders were in no rush to lock down a design or fly a demonstrator. Conversely, the focus was more on developing the relevant technologies and capabilities through model-based system engineering and design.

Tapping into the know-how of companies of all sizes, research centres, universities and start-ups, the development will try to apply the most innovative approaches available, such as the use of 'digital twins' or a 'common working environment'. Thanks to digital design and model-based system engineering, 'digital twins' will make testing faster and cheaper. Savings are currently estimated at 50-70% on schedule and 25-35% of costs compared to legacy projects. The 'common working environment', currently under testing in three Leonardo facilities (two in Italy, one in the UK), means significantly less time is needed for data analysis. Once fully operational, the system will ease the collaboration among the different experts involved, even when working in different time zones.

The launch of the GCAP Acceleration Initiative launched by the Italian Ministry of Defence in collaboration with the Milan Polytechnic University, the National Organisation of Italian Companies for Aerospace, Defence and Security (AIAD), Leonardo, Avio Aero, Elettronica and MBDA, is another example of how the programme's development might be sped up. Following an open innovation approach, the initiative launched over 40 technology exploration calls to propose solutions for the various components of the GCAP programme.

Effectors and Possible Commonalities with SCAF

As collaboration is a crucial characteristic of systems of systems, effectors play an important role in the programme's architecture. Numerous countries are therefore working on the development of the so-called 'loyal wingman' (also known as 'remote carriers') to be integrated in manned-unmanned teaming projects. These transonic, unmanned aerial vehicles (UAVs) are aimed at providing increased capability, protection, survivability, and information to combat aircraft, mainly thanks to artificial intelligence (AI). To this end, they should be able to perform a range of reconnaissance or Suppression of Enemy Air Defences (SEAD) missions, autonomously (alone or in swarms) or playing a supporting role to manned aircraft.

The UK has been working on the development of 'loyal wingman' since 2015, with the Lightweight Affordable Novel Combat Aircraft (LANCA) programme. Launched in 2019, Project Mosquito was intended to develop a technology demonstrator of a UAV able to provide "additive capabilities" to manned combat aircraft. However, the Royal Air Force's Rapid Capabilities Office (RCO) announced its end "beyond the design phase" in June 2022. The RCO and the Defence Science and Technology Laboratory (Dstl) preferred to explore smaller and less costly "additive" capabilities.

Credit: MBDA

Artist's impression of Future Air Systems launched from a 6th Generation Platform. MBDA is working on a new family of effectors, that will be part of the GCAP and the SCAF programmes.

At time of writing, no details have been provided on GCAP's effectors, and Japan has not identified which company will partner with MBDA UK and MBDA Italy on this part of the programme. However, this might be an area of commonality with the Système de Combat Aérien du Futur (SCAF) programme developed by France, Germany and Spain, considering that the contract concerning effectors has been awarded to MBDA France and MBDA Germany. The two branches are currently working on the development of an Expendable Remote Carrier (ERC) as part of the Phase 1B of the SCAF programme. Speaking to journalists during the Paris Air Show 2023, Grégoire Faron, MBDA's programme manager for the SCAF programme, explained that the company is focusing on the development of a full-scale demonstrator ERC with a compact and modular design, possessing a very large subsonic operating envelope and equipped with a datalink and collaborative functions. The aerial vehicle will likely be around 4 m long, with a 400 kg weight and a 1-hour endurance.

Questioned on the possible commonalities between the GCAP and the SCAF programmes, MBDA's representatives confirmed that this option was feasible from an industrial point of view.

Credit: USMC/Sgt. Kyle C. Talbot

An Italian Air Force Eurofighter Typhoon manoeuvres during a joint close air support (CAS) exercise with US Marines in 2019. Rome seeks to replace its fleet with 6th generation fighters

Looking Ahead

According to Defence Secretary Ben Wallace, the GCAP programme will "bridge" Europe and the Pacific, opening new technological and export opportunities expected to last for decades.

Indeed, the companies involved are using the programme as a testbed to develop numerous technologies and development processes. This will allow them to increase their respective know-how in the defence sector, with an interesting spillover effect on the global knowledge and the workflow's optimisation for hundreds of companies in the three countries. Looking at the UK only, the whole programme involves

almost 600 organisations and 2,800 people, and Team Tempest (BAE Systems, Leonardo UK, MBDA UK and Rolls-Royce) is working on the maturity of about 60 technology demonstrations, digital concepts, and new technologies.

GCAP is also a great technical challenge: this is the first time that partner companies are working on a 6th generation fighter, and an aircraft that will be part of a system of systems. European companies, as well as Japanese ones, have not worked on 5th generation fighters. However, the UK, Italy and Japan are familiar with the F-35 and the new approach that this fighter brings to the battlefield. This might bring them a competitive advantage compared to France, which flies an upgraded version of 4th generation fighters, and Germany, which should reach its initial operational capability (IOC) on the F-35 in 2028.

Considering the status of the two programmes, GCAP might end up more successful than its European competitor. However, keeping a consistent political commitment to the programme will be the key for its completion. The programme is currently on schedule after difficult debuts, and the three countries have officially reaffirmed their engagement several times in the last months – the last time in Rome during June 2023. Working on several defence programmes at the same time might prove difficult, especially for Italy – which, according to speculation, might fund only one fifth of development costs. Similarly, the UK's National Audit Office (NAO) in its 'The Equipment Plan 2021 to 2031' report published in February 2022 cautioned that the budget for FCAS "is considerably less than the project team's estimate of the cost needed over the next 10 years" and that "affordability of the Department's plans will depend on the extent it is able to share development costs with international partners". Yet the potential economic benefits of GCAP should convince the three capitals to remain on track.

The innovative governance of the programme might be another wildcard. The establishment of a joint structure with joint funding but leaving a certain degree of autonomy to industrial partners seems a convincing management model. It might effectively help the programme remain on schedule, but its effectiveness will have to be tested. Moreover, the number of partners might still change, as preliminary conversations are ongoing with Saudi Arabia to eventually cooperate on GCAP.

The market outlook might also be a challenge for GCAP. The programme is intended to replace the British and Italian Eurofighter Typhoon fleets, as well as the Japanese Mitsubishi F-2 fleet. However, no procurement estimates have been disclosed yet, and export perspectives remain unclear.

In Europe, the number of countries seeking a medium-term solution to replace their fleet of fighters is limited: Finland, Switzerland and the Czech Republic procured the F-35 in 2022, while Croatia and Greece chose Dassault Rafale. A lot will therefore depend on the completion of the SCAF and on Sweden's decision regarding the eventual development of an indigenous fighter.

During a meeting with the media at BAE Systems' assembly plant in Warton at the beginning of July 2023, Claesen said that an export analysis is ongoing. Considering the possibility to adapt solutions for export customers, BAE Systems expects orders for several hundred platforms. In the meantime, Japan's ruling parties are working to review the restrictive national regulation on weapons exports. ■

Protector RG Mk1: Royal Air Force Gains New MALE UAV

Sidney E. Dean

The UK's Royal Air Force accepted the first of 16 planned Protector RG Mk1 unmanned aerial vehicles (UAV) on 6 October 2022. The new long-endurance aircraft will offer a significant capability upgrade over previous UAVs and is expected to make a major contribution to securing the North Atlantic sea lanes and to global deployments.

The Protector RG Mk1 (or simply RG1) is a Medium-Altitude, Long-Endurance (MALE) UAV derived from the General Atomics Aeronautical Systems Inc. (GA-ASI) MQ-9B SkyGuardian/SeaGuardian, and is considered the next generation of MALE UAV technology. The new aircraft was specifically configured to meet Britain's operational requirements, and will replace the RAF's MQ-9A Reapers, which are being retired. The Protector is expected to exceed the Reaper in all relevant attributes and performance parameters. The new UAVs will be stationed at and operate from RAF Waddington, current home of the MQ-9A. The air base, located in Lincolnshire in eastern England, will receive upgrades and infrastructure valued at GBP 94 M to accommodate the Protector.

The 'RG' portion of the RG Mk1 designator stands for reconnaissance/ground-attack, reflecting the Protector's ability to conduct intelligence and surveillance missions, as well as engage surface targets on land or sea. The RG Mk1 is built in California by GA-ASI, with input from 12 UK firms. The British partners are contributing to every part of the aircraft system, from computer modules to engine development and logistical support. Particular notice has been paid to the V-tail assembly, which is being produced by GKN Aerospace on the Isle of Wight. In addition to the RAF's Protectors, the GKN tail assembly will be utilised on all MQ-9B aircraft sold worldwide.

Credit: GA-ASI

Testing the Protector RG Mk1 prototype.

Mission Profile

"Protector represents a giant leap forward in technology and aircraft performance over its predecessor Reaper," said Chief of the Air Staff Air Chief Marshal (ACM) Sir Mike Wigston in September 2021. "This aircraft will enable our government to act on a world stage within hours, at range, and precisely," added Wigston, who retired in June 2023.

According to the RAF, the Protector will be deployed globally for wide-ranging intelligence, surveillance, target acquisition and reconnaissance (ISTAR) operations. ISTAR missions will include wide-area surveillance, as well as targeted reconnaissance missions. Operations will be conducted over land and over sea. The aircraft's long endurance make it particularly suitable for patrol of strategic waterways such as the Greenland - Iceland - United Kingdom (GIUK) Gap. Recent advances in satellite communications (SATCOM) and high-performance datalinks will even permit Arctic patrols. GA-ASI demonstrated such capabilities in 2021 by deploying an MQ-9A UAV to the 78th parallel North, where the aircraft received communications support via Inmarsat's L-band airborne ISR service. The capability for long-endurance missions over northern waters will support the UK's intention to boost surveillance and data-gathering capabilities in the Arctic as defined in the MoD's 2022 document 'Defence Contribution in the High North' as well as in the 2021 Defence Command Paper. The Protector will furthermore be well suited to augmenting the RAF's P-8 Poseidon maritime patrol aircraft over the greater North Atlantic and other waters.

Armed missions for the RG1 will include targeted attacks on static and moving targets (including targets of opportunity) on land and at sea, as well as close-air-support for ground forces. Humanitarian missions in support of civilian agencies' disaster relief or search and rescue operations are also planned.

Technology and Capabilities Profile

The UAV is equipped with GA-ASI's state-of-the-art detect-and-avoid technology, which employs radar and transponder data to safely fly alongside civilian aircraft in unsegregated and crowded airspace. This

enables Protector to meet NATO and UK safety certification standards and become the first MALE UAV certified to operate in civilian airspace. This not only enhances safety but simplifies deployment as the operator merely needs to file a standard flight plan rather than reserve a special air corridor for transit flights.

The UAV has a length of 11.4 m, a wingspan of 24 m and a maximum take-off weight of 5,680 kg. The single Honeywell TPE331-10 turboprop engine enables a maximum altitude of 12,300 m and an airspeed of 108 m/s (210 kn). Like the Reaper, the Protector has an aft-mounted pusher-propellor. The new aircraft's longer wingspan enhances range and payload capacity, and permits operations from shorter airfields. Mission endurance exceeds 40 hours, a significant improvement over the RAF's Reapers, which can fly 20 hours unarmed or 12 hours with a full weapons load. The aircraft has advanced anti-icing and lightning protection features which permit operations in extreme weather conditions, as well as a fire-protected engine bay. The Protector's maximum range exceeds 11,112 km (6,000 NM) and its damage-tolerant airframe is designed for a 40,000 flight-hour service life.

The aircraft is equipped with an X-band satellite communications system. Take-off and landing are conducted automatically. To enable this, the aircrew uploads GPS coordinates of the runway to the aircraft. The system then devises a navigation plan (in accordance with local air traffic control guidelines or airspace limitations) for the take-off or landing procedure. The aircraft will automatically abort a take-off run or landing approach if necessary; the Protector pilot can also assume control remotely at any time during the take-off or landing phase.

The UAV will be operated by a three-person crew consisting of two pilots and a weapon system/sensor operator. Aside from the take-off and landing phases, the Protector will be remotely controlled at all times. Pilots and systems operators will remain at RAF Waddington, regardless of the theatre of operations where the aircraft are deployed; only ground crews will deploy with the aircraft. This reduces the logistics footprint of the deployed unit, and permits operations to begin comparatively soon after arrival in theatre.

Credit: RAF

Front view of the Protector with the optical sensor gimbal mount clearly visible.

Payload Options

Payload capacity is 2,177 kg. The Protector's standard integrated sensor suite includes a gimbal-mounted high-definition, large-aperture optoelectronic infrared (IR) video camera for long-range persistent day and night surveillance capability. GA-ASI's proprietary Lynx synthetic aperture radar is permanently mounted inside the aircraft's forward avionics payload bay. It can penetrate cloud cover, smoke, dust storms or blizzards to perform air-to-surface and air-to-air reconnaissance.

The airframe has nine hardpoints (eight underwing and one centreline) for external payloads. According to the British MoD, the RG Mk1 will carry a mixed load out, including MBDA's Brimstone precision strike missile and Raytheon's Paveway IV guided bombs on six of the underwing hardpoints. Each of these hardpoints can accommodate three Brimstone or one Paveway IV. The two outboard hardpoints are not intended for weapons, and can assume lighter loads.

The hull's centreline can be used for additional sensor payloads as well as for defensive and offensive electronic warfare (EW) suites. One option is the Leonardo Seaspray 7500E V2 multimode maritime search radar (manufactured in Scotland). This Active Electronically Scanned Array (AESA) radar can observe large ocean swaths, tracking hundreds of large and small maritime contacts in high clutter environments. The Seaspray radar can also perform ground-mapping missions, conduct reconnaissance overland or monitor airspace via moving target detection; the latter capability enables deployment in an airborne early warning role.

Optional external EW payloads include the L3Harris Sledgehammer electronic attack pod, designed to deny enemy communication networks, disrupt command and control, and deliver information operations (Info Ops) messaging. The UAV can also be equipped with an internally carried Leonardo SAGE signals intelligence (SIGINT) suite capable of gathering intelligence on maritime and land-based radar emitters over a wide area.

Credit: UK MoD

The Protector will carry ordnance on its underwing hardpoints.

Credit: UK MoD

The first production airframe of the Protector series at GA-ASI's Desert Horizons facility in California.

Programme Milestones

The Protector programme was initiated in 2015. Selection of the MQ-9B airframe as the basis for the UAV was announced in April 2016. The initial development contact with GA-ASI announced in December 2016 was valued at GBP 100 M. In July 2020, the MoD and GA-ASI signed the formal procurement contract for the first three aircraft (plus three ground control stations and auxiliary equipment), with an option to acquire 13 more aircraft and an additional four control stations. The MoD exercised that option in July 2021, bringing the standing order to 16 aircraft. Both contracts together are valued at GBP 260 M.

Ground and air testing have progressed steadily. In July 2018, the first Protector prototype conducted a transatlantic flight from the US to the UK to participate in the Royal International Air Tattoo (RIAT) at RAF Fairford. The automated taxi, take-off and landing capability was demonstrated in 2019. In July 2021, the Protector prototype returned to RAF Waddington for airspace integration flights and to conduct capability demonstrations before participating in the multinational Joint Warrior exercise in Scotland. The aircraft returned to the US in September 2021. All of these prototype demonstrations were conducted by GA-ASI personnel.

The UK's first operational Protector aircraft conducted its maiden flight in September 2020. The Acceptance Test Procedure (ATP) was completed on 26 August 2022 following a two-month series of inspections and tests conducted at GA-ASI's Desert Horizon flight operations facility in El Mirage, California. The two-hour culmination flight was jointly conducted by UK MoD personnel and GA-ASI employees. In addition to the aircraft, the evaluation also included vital ground equipment designated as 'Portable Pre-flight and Post-flight Equipment', or P3E. According to a FA-ASI press release, P3E is laptop-sized piece of ground support equipment that enables SATCOM automatic taxi, take-off and landing capability from anywhere in the world, allowing a small personnel and equipment footprint during deployments. The P3E doubles as ground support equipment when directly connected to the aircraft.

Successful completion of the ATP paved the way for the official handover of the first operational aircraft to the RAF on 7 September 2022, receiving the RAF tail number PR005. For the time being, it has remained in the US to support aircrew training, but is due to be transferred to its operational home at RAF Waddington later in 2023.

Crew Training

The first Protector ground crews graduated from training on 1 March 2023 at the GA-ASI facility in El Mirage. The initial training phase consisted of a blend of classroom-based theory and practical assessment, and was conducted from October through December 2022. It was followed by a six-week period which included live operation of the air system. The 20 engineering personnel of the first cohort successfully qualified as dedicated cross-skilled technicians. The individual personnel combine skills as avionics technician, mechanical technician and ordnance technician. Cross-qualification of personnel will be particularly valuable overseas, where small engineering detachments will be responsible for maintaining and preparing the aircraft between flights.

Training of the first Protector flight crews began on 1 May 2023, conducted by the RAF's 54 Sqn at GA-ASI's Flight Test & Training Center (FTTC) in Grand Forks, North Dakota. The first cohort includes eight complete crews consisting of pilots, sensor operators (SOs) and

Credit: UK MoD

Assembly of the Protector's tail unit at the GA-ASI plant in California.

mission intelligence coordinators (MICs). The curriculum for pilots and sensor operators runs for 12 weeks; mission intelligence coordinators complete their portion of the programme after six weeks. The programme includes both simulator and live flying sessions. As reported in May 2023 by ESD's Peter Falstead, the scope of the training is focused on the foundational skills required to operate the Protector and its equipment, including its multi-spectral targeting system, synthetic aperture radar, mission intelligence station, and system for tasking and real-time exploitation (STARE). Training involves building solid foundations for both normal and emergency operations in ISR systems, instrument flying, and automatic take-off and landing. The mission intelligence coordinators train on the system's mission intelligence station, learning to conduct real-time exploitation of intelligence gathered by the aircraft's multi-spectral targeting system and synthetic aperture radar. After the first group of pilots, SOs and MICs graduates, GA-ASI will train another three cohorts, each consisting of eight complete crews. The RAF will assume the training of aircrews and technicians once the Protector International Training Centre opens at RAF Waddington in 2024.

Preparing for Service

The RAF's 31 Sqn, a former Tornado GR4 squadron deactivated in 2019, will formally reconstitute in October 2023 to become the first Protector RG Mk1 operational unit. A cadre of personnel has been preparing the transition. Standing up the squadron will mark the Protector's official service debut with the RAF, but considerable training and integration work will still be required. The GR Mk 1 is scheduled to achieve Initial Operating Capability (IOC) in 2024. Full Operating Capability (FOC) is expected in 2026. To earn that designation the RAF must be capable of conducting three separate missions simultaneously, each with 24/7 coverage.

In addition to 31 Sqn, the UAVs will also be operated by 13 Sqn (which currently operates the MQ-9A Reaper). Both units are subordinate to the RAF's No. 1 ISR Wing which was established in May 2021 at RAF Waddington. The wing also includes squadrons operating the RC-135W Rivet Joint and Shadow R1 fixed-wing ISR aircraft. Other units of No. 1 ISR Wing include 1 ISR Sqn which analyses video obtained by the Protector (and other ISR aircraft), as well as 54 Sqn (the conversion unit responsible for personnel training on airborne ISTAR systems).

Credit: GA-ASI

The Protector International Training Centre will include simulator stations developed by CAE Defence.

As ACM Wigston pointed out in 2021, the Protector will be a fully UK-owned sovereign capability, in contrast to the Reaper drones which were operated by the RAF but which (as the former Chief of Air Staff stated) were an urgent operational requirement for Afghanistan that was largely controlled by the US. Other nations are interested in acquiring the Protector variant of the MQ-9B. The UK will act as the lead nation for training and integration support, utilising the Protector International Training Centre at RAF Waddington to support partner nations acquiring the RG Mk1. Belgium has already contracted to procure four Protectors, with Brussels and London signing a statement of intent to cooperate on agreement in August 2020 covering collaboration in training, maintenance, logistics support, and interoperability. This was followed up by the two sides signing a memorandum of understanding in April 2023, allowing the two countries to work together on all programme areas, including certification, airworthiness, training, sustainment, and future capability enhancements. ■

Credit: RAF

The first four Protector technician cohorts are being trained in the USA until the Protector International Training Centre opens at RAF Waddington in 2024.

Upwardly Mobile: VTOL and Tiltrotor Technology Developments

Sidney E. Dean

While conventional fixed-wing aircraft and traditional helicopters continue to dominate military aviation, VTOL and tiltrotor aircraft are becoming increasingly interesting for both mainstream and niche applications.

Although helicopters or 'rotary-lift' aircraft take off and land vertically, the term Vertical Take-Off and Landing (VTOL) is generally not applied to them. A rotary-lift aircraft's propulsion system centres around one or more fixed vertical masts topped by horizontally-aligned rotors. To transition from vertical to horizontal flight, the rotor disk is pitched slightly forward, but continues to rotate around the mast's central axis with the main thrust directed downward. By contrast, VTOL refers to aircraft which produce vertical thrust for take-off and landing and are capable of hovering, but which transition to horizontal thrust for flight operations. Some aircraft are also defined as Short/Vertical Take-Off and Landing (S/VTOL) when the standard operating procedure calls for a short rolling take-off – often utilising a ski-ramp style aid – and a vertical landing. Usually such aircraft will be capable of a fully vertical take-off when necessary, albeit with a reduced payload.

The primary advantage of VTOL aircraft lies in their flexibility. They operate independent of runways and can take-off/land from relatively confined spaces, including parking lots, clearings, ship decks, and unprepared terrain. High-end VTOL which have been designed for purely military applications have comparable payload capacity, speed and mission-range as conventional take-off aircraft, and generally exceed helicopters in all of these parameters. On the other hand, numerous experimental and developmental VTOL aircraft currently being devised for civilian or dual-use applications have yet to outperform dedicated military helicopters.

There are numerous technical options for the design of VTOL fuselages and for the number and arrangement of propulsion units. Aircraft can be manned, optionally manned or unmanned. The fuselage design can mimic a conventional fixed-wing aircraft, resemble a helicopter, or be completely unconventional. Propulsion options include multiple rotors, propellers, fans or jets, which can be distributed along the wings or embedded in the fuselage. Vertical lift can be achieved in multiple ways, including fixed rotors, dedicated lift fans (in addition to the primary propulsion system), rotating fans, ducted fans, tiltrotors or tilting wings. Three options currently exist for the actual propulsion system: traditional aviation fuel-powered engines, electric propulsion, and hybrid systems using both. Electric and hybrid systems, known as eVTOL, are particularly popular for civilian applications. These are frequently conceived as 'air taxis' for urban environments, which makes the low-decibel and environmentally friendly propulsion the system of choice. However, certain military and security applications – such as special operations insertion, SWAT transport, or even assault carrier – could also benefit from a quieter and stealthier approach capability.

There are many civilian VTOL (and especially eVTOL) development programmes underway in North America, Europe and Asia. Regarding military developments, the vast majority are being conducted in the United States.

Credit: USMC

The aft-mounted swivel duct and the forward mounted lift fan provide vertical thrust for the F-35B.

VTOL Combat Aircraft

High-performance VTOL aircraft include the Harrier AV-8 and the F-35B Lightning II. The AV-8 achieves vertical lift through four rotating vectoring nozzles integrated into the flanks of the fuselage and which direct energy from the main propulsion system downward. The Harrier, which entered service in 1969, has been or is being retired by most operators. By contrast, the F-35B entered service in 2015, and constitutes the most modern and powerful VTOL-capable combat aircraft. The fifth-generation stealth aircraft's characteristics include powerful long-range multi-spectral sensors, a potent electronic warfare (EW) suite, and the ability to carry a limited number of sophisticated air-to-air and air-to-ground weapons internally. It has the performance capabilities (450 NM (833 km)

combat radius, Mach 1.6 airspeed, 6,800 kg weapons payload, and 7.0 g-rating) of conventional take-off and landing combat aircraft. Procurement by the US Marine Corps (USMC), the Italian Navy, the British Royal Navy and Royal Air Force, and the Republic of Singapore Air Force is ongoing.
The F-35B is technically an S/VTOL aircraft. When configured for a mission it requires a short runway or flight deck, optimally enhanced with a ski--ramp. However, a plane with minimal payload and a light fuel load can execute a fully vertical take-off, as demonstrated by Lockheed Martin on 10 May 2013. This capability permits relocating the aircraft to a different staging area. Once in the air, the plane – even when fully armed and fuelled – can hover in place or perform a vertical landing. The S/VTOL characteristics make this F-35 model ideal for deployment on amphibious warships and smaller to medium-sized aircraft carriers. The ability to operate from clearings and challenging landing zones will also enable Marines to establish roving refuelling and rearming points on islands or in coastal zones, enhancing operational flexibility and operational tempo.
The F-35B uses the same Pratt & Whitney F-135 engine as the conventional take-off F-35 variants. The Rolls-Royce designed VTOL system consists of three main components. The engine cowling opens to expose the lift fan which is mounted directly behind the cockpit and which directs 9,072 kgf (20,000 lbf) of thrust at a 90° angle to the fuselage. This downward thrust near the aircraft's forward section is matched by another 8,165 kgf (18,000 lbf) of exhaust thrust directed downward by a 3 Bearing Swivel Module (3BSM) located at the engine's rear. Together, the lift fan and the swivel duct divert the engine's entire maximum thrust capacity into the vertical flight manoeuvre. These two components are augmented by two downward pointing ducts located at the root of each wing, which help stabilise the aircraft during vertical flight and together provide a further 885 kgf (1,950 lbf) of thrust. Once the pilot is ready to transition to horizontal flight mode, the engine cowling closes and the aft swivel duct returns to its normal position, a manoeuvre which can be completed within 2.5 seconds.

Credit: US Navy/Spc. 1st Class Peter Burghart

The F-35B's Rolls-Royce designed lift fan provides 9,072 kgf of thrust for vertical flight.

Tiltrotor Multi-mission Aircraft

Tiltrotors constitute a special category of VTOL aircraft. The engines are housed in nacelles located at the ends of a fixed wing. Rotors are mounted at the tip of the nacelles. Rotating shafts permit the nacelles to tilt by 90°, enabling the aircraft to take off and land vertically in 'helicopter mode.' Airborne, the nacelles rotate back to the horizontal position, permitting the aircraft to fly like a conventional turboprop. Tiltrotor technology thus combines the flexibility of the helicopter with the speed, range and fuel efficiency of conventional planes. These attributes make tiltrotors well-suited to a variety of military missions including general cargo and personnel transport, search and rescue, medical/casualty evacuation (medevac/casevac), special operations forces (SOF) transport, and assault carrier.
While military tiltrotor concepts were first introduced during World War II, the first successful operational aircraft is the medium-lift, multi-mission V-22 Osprey which entered service in 2007. The aircraft's highly responsive engines can pivot by 90°

Credit: USAF

The Air Force Special Operations Command CV-22 Osprey features an aerial refuelling probe.

Credit: US Army

The Bell V-280s depicted in this concept image have more than twice the speed and range of current helicopter platforms. The image shows the FLRAA in the background, escorted by a notional tiltrotor configured Future Attack and Reconnaissance Aircraft.

Credit: Joby Aviation

USAF pilots inspect the Joby S4 demonstrator.

within 12 seconds, supporting operations in high-intensity scenarios. Built by Boeing and Bell Helicopters, the Osprey comes in several variants, including: the USMC's MV-22 optimised for airborne assault; the US Air Force (USAF) CV-22, equipped with extra fuel tanks, aerial refuelling capacity, and a special avionics and sensor package to support SOF missions; and the US Navy's CVM-22 utilised for seaborne logistic support, with a range of 2,130 km (1,150 NM). The Japanese Self-Defence Forces received their first Ospreys in 2020, a portion of which will be deployed aboard the Izumo class aircraft carriers. The V-22 in all its variants is expected to serve through 2055.

In 2022, the US Army opted for the V-280 Valor tiltrotor for the service's Future Long-Range Air Assault (FLRAA) aircraft. Built by Bell-Textron, the Valor externally resembles the larger Osprey, although it incorporates numerous enhancements and is considerably more agile. A V-shaped tail was chosen over the Osprey's H-shaped tail to enhance manoeuvrability. The propulsion system has been simplified and employs pylon rotation rather than nacelle rotation; this promises to reduce heat development and simplify maintenance. It will be capable of transporting 12 combat-equipped soldiers. The 144 m/s (280 kn) airspeed and (configuration dependent) mission radius of 926-1,482 km (500–800 NM) offers twice the performance of today's assault carrier helicopters, making it a viable platform even for conflicts in the Indo-Pacific region, where large distances between landmasses can be a major factor.

In addition to the combat role, the Valor will also perform utility/logistic support, medevac, and humanitarian/disaster relief missions. In 2018, Bell also proposed gunship variants of the V-280. The firm presented two different concept models. A purported Army variant showed air-to-ground missile racks extending from the passenger cabin. A maritime variant – suitable for either USMC or Navy applications (including anti-submarine warfare) – displayed greater modification, including a reduced radar cross-section, an internal weapons bay, and folding wings which would allow the aircraft to fit inside the hangar of a guided missile destroyer. While the services are currently not publicly contemplating a gunship version of the V-280, these concept displays demonstrate the versatility of tiltrotor technology.

Agility Prime

The United States Air Force is pursuing acquisition of small eVTOL systems. To this end, the service is evaluating civilian-developed or developmental 'air taxi' designs. The evaluation programme initiated in 2020 is called Agility Prime and is managed by AFWERX, a USAF technology incubator designed to support innovative development projects. The eVTOL concept is considered particularly suitable for urban military operations due to the reduced noise and heat signature. Such aircraft utilise smaller rotor systems than conventional helicopters, enhancing mobility and safety in urban terrain. Potential applications include Special Operations Forces (SOF) and urban assault, short-range cargo transport/battlefield resupply, search and rescue, medevac, installation security, and reconnaissance.

After reviewing 27 competing models, the Air Force selected seven for serious consideration in 2021. Since then the field has narrowed further. On 25 April 2023, the USAF and Joby Aviation announced a rapid acquisition contract award for up to nine of the firm's S4 eVTOL aircraft. The S4 operates in tiltrotor mode to transition between vertical and horizontal flight. Four of the aircraft's six electric motors are mounted on the wings, and two on the edges of the forward-swept V tail. Each rotor-equipped nacelle has an isolated battery pack to prevent a single point of failure preventing flight operations.

Credit: Bell Textron

Bell helicopter offers HSVTOL in various sizes and configurations.

This is the first acquisition contract to be placed under the Agility Prime programme. The first two aircraft are to be delivered to Edwards Air Force Base by March 2024 for in-depth testing. The remaining aircraft could be evaluated at other military facilities; all service branches have expressed interest in eVTOL technology, with the USMC expressly planning to test the S4's suitability for resupply, personnel transport, and emergency medical response applications. According to a USAF press release, testing at Edwards AFB will focus on the suitability for "short- to mid-range cargo operations at low operating costs and just-in-time delivery constructs." USAF is also interested in the potential for transporting personnel between Edwards' far-flung test ranges.

The optionally-manned S4 aircraft can carry up to five people (including a pilot) or a 450 kg payload. The aircraft's proven 3,400 m service ceiling, 103 m/s (200 kn) maximum speed, and a stated range of 275 km – together with a 45 dB level in forward flight – would also favour SOF tactical operations should the military choose to utilise the aircraft beyond logistics missions. The Agility Prime programme office stresses that the S4 is not the sole aircraft of interest. The USAF plans to transition additional eVTOL systems into field-testing during 2023.

'Next Generation' High Speed VTOL

In addition to Agility Prime, AFWERX is also pursuing a High-Speed VTOL (HSVTOL) programme to meet a requirement by the US Special Operations Command (SOCOM). The goal is to acquire high-end, runway independent and air-refuellable aircraft capable of 400-kn flight speed to perform personnel infiltration, weapons and supply transport, tactical mobility and aeromedical evacuation. The target aircraft would eventually replace the CV-22 Osprey (which achieves 280 kn).

The initial call for ideas published in 2021 resulted in 218 proposals for aircraft and propulsion designs. In January 2022, the USAF selected 11 of these for Phase 1 contracts (concept development). The majority of the designs feature conventional turbine propulsion in order to achieve the required jet-like airspeed; a few include hybrid propulsion, but none are purely electric. Phase 1 ended on 30 June 2022. An indeterminate number of firms were to be carried over to the programme's Phase 2 (risk reduction and design), followed by another down-select for Phase 3 (full-scale prototyping). The Request for Information (RFI) for Phase 2 was originally expected to be issued in autumn 2022, with work on this phase beginning in early 2023. The Air Force has not published additional information regarding the programme timeline, although AFWERX has previously stated an interest in accelerating HSVTOL development.

Several firms have publicly presented information about their concepts. Jetoptera has patented the fluidic propulsion system (FPS) which utilises rotorless and bladeless fan technology. A small flow of compressed air is used to draw in ambient air which becomes disproportionally accelerated to provide thrust. The firm touts the system's greater fuel efficiency and lower decibel levels when compared to conventional turbine systems, and its greatly improved speed and range versus electric propulsion. Jetoptera predicts a prototype could be ready for testing by 2025.

Bell, which has partnered with Pratt & Whitney for propulsion, has presented a family of tiltrotor aircraft with – in the company's words – "the hover capability of a helicopter [and] the speed, range and survivability features of a fighter aircraft." Vertical flight is accomplished via wingtip-mounted turboshaft nacelles topped by rotor blades. For forward flight, the nacelles rotate to the horizontal position and the rotors fold back for improved aerodynamics, while the aft-mounted primary engines provide high-speed turbofan propulsion. Bell has spoken of "emerging propulsion technologies" which could indicate plans to ultimately use a single convertible engine capable of alternating between turboshaft and turbofan modes for lift and cruise flight, respectively. Piasecki Aircraft Corporation entered the PA-1459 HSVTOL concept air vehicle into the competition. Graphics show two large aft-mounted turbofan engines equipped with vectoring thrusters, and two tilting ducted propellers amidship. The vectoring thrusters and the ducted propellers work together to provide full vertical thrust for take-off and landing. Another competitor, Valkyrie Systems Aerospace, is basing its proposal on the firm's conceptual Guardian HoverJet, which is designed to achieve an airspeed of 201 m/s (390 kn) and a 15-hour mission endurance.

These and the other proposals constitute what Col. Kenneth Kuebler, SOCOM's Program Executive Officer for Fixed Wing Programs, has dubbed "the next generation of high-speed vertical take-off and landing." While developing operational systems that meet the programme's performance parameters is the ultimate goal, AFWERX has acknowledged that considerable technological challenges exist. The office's self-proclaimed near-term goal is developing a conceptual framework that can assess realistic and optimal trade-offs between such factors as speed, range, payload, and mission spectrum. ■

Credit: Piasecki Aircraft Corp.

Piasecki's PA-1459 concept features extra-large propulsion elements.

Sniper Rifles – Scoping the Field

David Saw

There has never been a consistent approach towards sniping. Is it an essential capability worthy of significant investment, or is it just useful to have, but not particularly influential? What is clear is that developments in weapons, ammunition and sighting systems have given the modern sniper the ability to acquire and engage targets at extended ranges day and night. In addition, the mission parameters of the modern sniper have increased, and the anti-materiel mission has now joined the anti-personnel mission. The march of technology has provided all sorts of possibilities to be included into the mission of the sniper.

The question of how much to invest in a high quality sniper capability is not a new one, with the question of performance and utility versus price always an issue. The Whitworth rifle of the 1860s had many of the characteristics of a modern sniper system. It was accurate, allowed extended range engagements, and was fitted with a telescopic sight. On the other hand, it was craftsman-built, expensive and used non-standard ammunition. Even though it was demonstrably effective in the American Civil War, when used by the 'sharpshooters' of the day, it was never acquired in significant numbers. It should be thought of as the genesis of the modern sniper rifle, but it never established a trend towards a calculated and resourced sniping capability.

The re-emergence of sniping would come many years later, but would not see the acquisition of specific sniper systems, as it was usually a case of adapting existing equipment for the sniper role. The starting point was the human factor, and in this case, selecting the sniper. Fundamental to the basic training of the soldier was marksmanship; those who excelled in this area provided the pool of candidates for role-specific sniper training and those who made it through sniper selection were high-quality shooters. With the people side of the equation resolved, what of the equipment to be used? The weapon would be the standard infantry rifle, with the most accurate rifles put to one side for the sniper role. These would be worked on to improve shooting characteristics and accuracy, and then paired with a telescopic sight, before match-grade ammunition was finally issued.

The Need for Change

Ironically, the next stage in sniping evolution could well be seen as a case of history repeating itself. The aforementioned Whitworth rifle was equally at home as a rifle for competition shooting as it was for military applications. The British Army would replace its elderly L42A1 sniper rifle with the Accuracy International (AI) L96A1 in 7.62 × 51 mm, equipped with a Schmidt & Bender PM 6×42 (L13A1) telescopic sight. The basis of the AI design came from the world of competition shooting and, as time went on, AI would become one of the most influential forces in sniper rifle design and evolution.

Advanced designs, new materials and, arguably, a greater understanding of the operational possibilities that could be obtained from developments in sniper rifles triggered a wave of advances. Amongst these were that sniper systems were no longer limited to the 7.62 × 51 mm calibre, as new mission requirements arose and to meet those, new calibres emerged.

An understanding of the current state of the sniping environment, at least in Europe, can be gained from a recent set of acquisition programmes in two NATO member countries and Sweden, soon due to be a NATO member. Sweden, has increasingly been coordinating defence acquisition programmes with Finland. In late March 2023, the Finnish Defence Forces Logistics Command, the Swedish Defence Materiel Administration (FMV) and Finnish small arms company Sako Ltd, part of the Beretta Group, signed a framework agreement, under which Sweden will acquire a range of small arms from Sako.

The existing Automatkarbin 4 (AK4) 7.62 × 51 mm battle rifle, a locally manufactured Heckler & Koch G3, is to be replaced by a Sako assault rifle in 7.62 × 51 mm, while the Automatkarbin 5, a locally manufactured FN FNC in 5.56 × 45 mm, is to be replaced by a Sako weapon in the same calibre. Both Sako weapons are based on the M23 platform, utilising the AR operating system. The Prickskyttegevär (Psg 90) is the AI Arctic Warfare (AW) sniper rifle in 7.62 × 51 mm; over 1,000 weapons were acquired since the start of the 1990s. This weapon is set to be replaced by the Sako TRG M10, a modular multi-calibre system, with the operator able to change the barrel rapidly and utilise a new calibre within minutes. Sweden is acquiring the system in 7.62 × 51 mm and in .338 Lapua Magnum (8.6 × 70 mm). The M10 will be delivered in 2024 and the AK5 replacement in 2025, with the AK4 replacement to arrive thereafter.

Credit: Sako

The Sako TRG M10 has been selected by the Estonian Defence Forces and the Defence League as their future sniper rifle, with first deliveries due in 2024. The M10 for Estonia will be in .338 Lapua Magnum calibre. Both Finland and Sweden have selected the M10 in 2023.

How will optics help allied forces win in the future battlespace?

Optics are ubiquitous in modern society. From smartphone displays to fibre optics carrying information, optics drive modern manufacturing, medical devices, and defence technology. In the connected battlespace, optics are the unseen enabler, helping allied commanders detect, analyze, and make decisions faster. It's not surprising, then, that they are undergoing a rapid evolution.

DRIVING INNOVATION

"The biggest shift will be leveraging more than just IR systems," says Kristy Dalzell, associate director of engineering for Raytheon ELCAN. "Multispectral and hyperspectral systems will be important technologies and are therefore key IRAD focus areas for Raytheon ELCAN. With the increased focus on unmanned systems, leveraging our experience in other sensing modalities, like LiDAR, will also be critical in modern battlefields."

HELPING CUSTOMERS SEE FASTER AND FARTHER

The short range of organic sensors poses a major constraint. In the future battlefield, faster, more distant threats will require swift detection and response.

We asked Dalzell about Raytheon ELCAN and the role of optics in the future battlespace.

Q Amid increased interconnectivity — humans, vehicles, air, and artillery — how do Raytheon ELCAN's solutions address vital vehicle connections in the battlespace?

Kristy Dalzell: Raytheon ELCAN doesn't define the connection but we are ready and able to work with whichever protocols our customers specify. For our Specter DFCS digital fire control sight, our electronic design department has a robust tech road map that will ensure we have the capabilities to integrate communications and wireless telemetry, as well as other advanced technologies, into the platform, driving the soldier as a sensor in multi-domain operations.

For larger platforms, like vehicles, sensor developments will drive requirements. Faster sensors will need higher resolution optics and multi-band sensors will need multi-band optics. We have the technology and capability to meet these needs.

Q Vehicle tech is advancing, partly due to modern battlefield armour challenges. How do you see the future of countermeasures and search and track?

Dalzell: Raytheon ELCAN has extensive experience designing and manufacturing vision systems on airborne systems, including infrared search and track and countermeasures. This, combined with our experience delivering ruggedized, battle-proven solutions for land vehicles, sets the stage for reliable systems to help protect drivers like we continue to do for pilots.

Q The second area of this push in technology is targeting systems. How are systems keeping up?

Dalzell: As targets get faster and smaller, resolution and field-of-view become important considerations, in combination with response time. Raytheon ELCAN has expertise in the design and manufacture of wide field-of-view (WFOV), multi-FOV, and zoom.

Q The future battlefield will have additional weaponry that is coming to fruition now. How are you looking to provide solutions in areas such as high-energy laser optics?

Dalzell: Raytheon ELCAN is well positioned to manufacture optics for high-energy laser systems because of our vertical integration and process controls. There are approximately 300 ways to process an optic. We know how to map backward to determine the optimised process chain to meet desired results and tolerances, based on our experience.

High-energy laser systems must minimize energy loss to prevent catastrophic failure. We begin by using top-quality substrates to create low surface damage optics. Our optimised process chain eliminates sub-surface damage, maintains low-foreign object debris (FOD) conditions in dedicated cleanrooms, and enhances optical coatings for enduring high energy densities.

Our multiband optical research and fine stabilization mirrors aid here. Raytheon ELCAN's broad experience and ongoing investments in weapon guidance and optical technologies, encompassing intricate structures like domes and coatings, enhance capability in the connected battlespace.

As part of RTX – the world's largest aerospace & defence company – Raytheon ELCAN is an optical centre of excellence in Canada. Raytheon ELCAN designs and manufactures high-precision, platform-and-sensor-agnostic optical systems to help our global customers see faster and further across the spectrum.

Raytheon ELCAN

Other sniper systems in service with Sweden include the Automatgevär 90 (Ag 90), which is the Barrett M82A1 in .50 BMG (12.7 × 99 mm NATO), with the first order for 100 weapons being placed already in 1989. In early June, it was announced that Sweden would supply an unspecified number of Ag 90 rifles and associated ammunition to Ukraine. Sweden intends to field a replacement for the Ag 90 in 12.7 × 99 mm calibre. Swedish Special Forces also currently operate the Sako TRG-42 sniper system.

Credit: Maavoimat

Finland uses the Sako M23 7.62 × 51 mm rifle for sniping (TKIV 23) and as a Designated Marksman Rifle (KIV 23). The TKIV 23 variant shown here has a Steiner M7XI 2.9-20×50 scope on a Spuhr mount and a suppressor from Ase Utra.

Baltic Sniping

In February, Finland announced that it was refreshing its own sniper capabilities, placing an EUR 11 M order with Sako for TRG M10 rifles in .338 Lapua Magnum (8.6 × 70 mm) and 7.62 × 51 mm, spare parts and associated equipment. Prior to that, they had selected the Sako M23 in 7.62 × 51 mm to meet Designated Marksman Rifle (DMR) requirements as the KIV 23 and sniper requirements as the TKIV 23. These weapons will replace the SVD Dragunov and the TRG-85, both of which are chambered in 7.62 × 54R mmR. The TKIV 23 has a Steiner M7XI 2.9-20×50 scope on a Spuhr mount and a suppressor from Ase Utra in Finland. By contrast, the KIV 23 DMR, mounts a Trijicon VCOG 1-6×24 optic. Canada adopted the TRG M10 in .338 Lapua Magnum/7.62 × 51 mm in 2022 for its multi-calibre sniper weapon (MCSW) programme, with 224 rifles to be acquired.

Elsewhere in the Baltics, there have been more sniper capability acquisitions. In late April 2023, the Estonian Centre for Defence Investments (ECDI) signed a framework contract for the acquisition of the TRG M10 in .338 Lapua Magnum for the Estonian Defence Forces and Defence League. The framework contract will run for seven years and is valued at EUR 40 M, with deliveries due in 2024. The ECDI noted that their evaluation included sniper systems from Sako, Haenel, Unique Alpine, and Desert Tech. The M10 will replace the Sako TRG-42 in .338 Lapua Magnum in Estonian service.

Lithuania selected its future sniper rifle in 2016 opting for the AXMC multi-calibre rifle from AI. The weapon can operate with .338 Lapua Magnum, 7.62 × 67 mm (.300 Winchester Magnum) or 7.62 × 51 mm; Lithuania chose the .338 Lapua Magnum for its application. The sight chosen for the Lithuanian AXMC was sourced from Kahles in Austria. Latvia also has the AXMC and other AI weapons, and they have also purchased the PGM Hécate II in 12.7 × 99 mm from France for anti-materiel applications.

This quick description of the sniping situation around the Baltics shows a number of important trends. The .338 Lapua Magnum round continues to be highly successful in anti-personnel applications; multi-calibre weapons back up that round with the 7.62 × 51 mm for less demanding environments and as a lower cost solution for training, while the 12.7 × 99 mm round is still dominant in the anti-materiel domain.

Within the overall sniping environment, one should not forget the growing importance of the DMR. The crux of the matter is the performance level that operators are prepared to demand from their DMR. For example, in 2013 Lithuania adopted the FN SCAR-H PR in 7.62 × 51 mm as their DMR with a Schmidt & Bender optic. In 2019, France also adopted the SCAR-H PR as their DMR weapon; the sight is a Schmidt & Bender 1-8×24 PMII, with a PGM Precision bipod and a B&T suppressor from Switzerland.

If you compare what France has specified on its DMR compared to the situation in Finland, the French capability is much closer to the TKIV 23 sniper system than the KIV 23 DMR. However, the solution adopted by Finland is similar to that chosen by the British Army for its DMR, the L129A1, a version of the LM Defense LW308 Modular Weapon System (MWS); for the DMR role, it is fitted with the Trijicon 6×48 ACOG. Then another more challenging requirement emerged, known as the Sniper Support Weapon (SSW), designed to equip the spotter in the two-person sniper team. Britain's solution for SSW was the L129A1 mounting a Schmidt & Bender L17A2 3-12×50 scope, with a SureFire SOCOM suppressor.

Competition shooting, hunting and specialised sniping requirements, often from Special Forces, have created a situation where a military user can look to acquire a whole host of sniper rifle solutions. On the ammunition front, as discussed, there are plenty of different rounds to consider. Indeed, more exotic options could even be considered, for example the .408 Cheyenne Tactical (Cheytac; 10.36 × 77 mm) round. It is larger than the Lapua Magnum round, with far higher muzzle velocity and muzzle energy. To add to the exotica, the Russian Lobaev SVLK-14S Twilight sniper rifle can be chambered in either .408 Cheytac or .375 Cheytac (9.5 × 77mm). Lobaev is a small private company, and its rifles has been acquired by the Russian Armed Forces, with the aforementioned SVLK-14S, as well as the TSVL-8 M1 Stalingrad (offered in .338 Lapua Magnum or .300 Winchester Magnum), and DXL-4 Sevastopol (offered in .408 Cheytac or .375 Cheytac) having reportedly been used in Ukraine. In the final analysis, there remains an abundance of choice in terms of weapons, ammunition and sights for sniping requirements. ■

Credit: UK MoD

At the end of May 2023, Exercise Northern Forest saw a British Army Company Group exercise with the Finnish Defence Forces in Rovaniemi, Finland. The L129A1 Designated Marksman Rifle (DMR) in use here has a Trijicon ACOG 6×48 optic, the L129A1 Sniper Support Weapon (SSW) is comparatively better-equipped.

Creating a Unique Product

P1G Staff

The P1G brand was founded in Kyiv in 2012. We specialise in the development, testing and production of military equipment, and military and outdoor clothing. Initially, the company began with the development and production of Ukrainian camouflage in three variants: 'Zhaba Poliova', 'Zhaba Stepova' and 'Varan'. P1G products are directly comparable, in terms of the quality of the tailoring, materials, and accessories to their European and American counterparts. P1G uses wear-resistant materials and fittings from world-renowned suppliers, and now the company has completed several contracts for the delivery of materiel to several military formations of the Armed Forces of Ukraine, all of which were tested to meet requirements and accepted.

Since 2014, after the annexation of Crimea, the leading specialists of P1G began working under contract for the Ministry of Defence of Ukraine, being engaged in the development of uniforms for military personnel, the system of developing equipment acquisition and provision, and the quality control system. According to Pavel Parkhomenko, Head of Marketing for P1G "We can proudly say that most of the uniforms, individual equipment and other similar items for the Armed Forces of Ukraine were developed in the period from 2014 to 2016 by employees of our company." With the efforts of P1G specialists, within two years it was possible to bring the system of material provision of the Armed Forces of Ukraine to a new European level.

Credit: P1G

In particular, a new unit was created as the "Main Department of Development and Support of Material Provision of the Armed Forces of Ukraine".

After finishing work at the Ukrainian Ministry of Defence, the P1G employees returned to the company and a new stage of development of the brand began. Parkhomenko stated: "The most important things that distinguish us from many global brands are not only our development, but also our own manufacture, which produces a full range of goods." P1G's production specialises in three branches – outerwear, knitwear, and haberdashery (nylon equipment), which require the availability of various manufacturing assets and expert personnel, allowing the company to integrate development, production, and quality control of each product.

The main development principle for P1G is to look to create new products without relying on developments by competitors under other brands: to create a unique product. It is as a direct result of this principle that the company won contracts from the Ukrainian Ministry of Defence of Ukraine, on behalf of operational units of the Ukrainian Armed Forces, to develop, manufacture and deliver a sniper kit and an assault rifle transport case. These contracts were successfully executed, and the resulting products accepted into service. Supply of these items of equipment to the Armed Forces of Ukraine has been exclusively in the hands of P1G since 2016.

Despite the full-scale invasion of Ukraine by the Russian Federation, the company has continued its work. Active warfare on the territory of Ukraine has shown that military personnel need equipment with good operational characteristics. In the spring of 2022, the 'BASE' product line was launched, which completely covers these needs. In general, we focus not only on government orders, but also pay attention to our portfolio, so that both the military and the outdoorsman can purchase a complete set of clothing or equipment from summer to winter.

Towards a New UK Weapon-Locating Capability

Tim Guest

An effective and comprehensive new weapon-locating radar capability has been in UK MoD sights for some time. Until operational though, extending existing systems to sustain present capabilities is the order of the day.

This article looks at the UK MoD's roadmap on introducing a new battlefield weapon-locating capability through its SERPENS programme, whilst maintaining an effective existing capability until a new system becomes operational.

The Need Underlined in Ukraine

The UK MoD introduced its quest for a next-generation weapon locating system (NGWLS) in 2018 at a time when fighting between Russia and Ukraine had already been ongoing for four years in the east of the country with Crimea in Russian hands during that time. Mention of these early years of conflict is relevant as they highlight, with terrible ferocity, Russia's ability at that time to locate Ukrainian artillery fire and respond with devastating counter-battery fire to destroy whole units within minutes of first rounds fired. The world was watching. And while many Western eyes remained blinkered to the prospect of a wider conflict in Europe and the need to quickly bolster and upgrade aging inventories, there was at least recognition in the UK MoD for the need to procure a newer and more comprehensive capability, since the existing system had been in service for some 15 years.

Then, in 2019, the NGWLS was renamed Project SERPENS under the control of the MoD's DE&S organisation. SERPENS would also, according to the MoD, become part of the ZODIAC future Land ISTAR system, designed to gather information from all battlefield sensors to deliver comprehensive, effective and actionable intelligence for friendly forces. SERPENS was laid down to replace not only the current artillery locating radar asset, the Mobile Artillery Monitoring Battlefield Asset (MAMBA, of which more below), but also the Hostile Artillery Locating (HALO) system – the artillery's advanced sound-ranging programme (ASP) – as well as the AN/TPQ-49 lightweight counter-mortar radar (LCMR), all three scheduled to retire by 2026.

Credit: Roke

In February 2022, a contract worth GBP 6.7 M was awarded to Roke, the delivery partner for ZODIAC, which marked an alpha-development phase to de-risk the delivery of the Land ISTAR programme. The SERPENS solution will be an integral component of the overall Land ISTAR ecosystem.

Land ISTAR, into which any new weapon-locating asset will become a part, will deliver an integrated and distributed system of sensors, applications and underlying system architecture that will enable the Army to act with greater precision and speed. Enhancing FIND to UNDERSTAND and FIND to EFFECT is critical to the generation of a competitive advantage in the modern, hostile, operating environment. As the core project for the Land ISTAR programme, ZODIAC must provide the systems required to collate data from all battlefield sensors and combined, joint, inter-agency, intra-governmental and multinational (CJIIM) intelligence feeds. It will need to fuse, analyse and distribute the resulting intelligence to battlefield users, integrating across land, sea, air, space and cyber, as well as with allies.

In February 2022, a GBP 6.7-Mn contract was awarded to Roke, the delivery partner for ZODIAC, which marked an alpha-development phase to de-risk the delivery of the Land ISTAR programme. The SERPENS solution will be an integral component of the overall Land ISTAR ecosystem. ZODIAC will act as the central nervous system for Land ISTAR to transform how the British Army operates, integrates and sustains a persistent and decisive global presence. ZODIAC will pioneer the use of next-generation technologies, empowering and better protecting the British Army to think and act faster than its adversaries.]

SERPENS RFI

The MoD's RFI 2 for SERPENS was issued in March 2020 as a land equipment, armoured vehicle/artillery systems programme, with a closing date almost six weeks later. It stated that SERPENS was a Category A equipment procurement project, taking into account through-life costs, and with the main, eventual users being 1 Artillery Brigade and 1st Intelligence, Surveillance and Reconnaissance Brigade (1 ISR Bde). The equipment's envisaged roles in the Land ISTAR ecosystem is performing intelligence, surveillance, target acquisition and reconnaissance roles out to vastly greater ranges than current systems. At the time of the RFI, the in-service date for SERPENS was slated for 2026 with an anticipated out-of-service date of 2057. The duration of the programme to decision time was two years and 1.5 months, with the budgetary value detailed in the RFI being GBP 400 M.

Credit: DE&S

MAMBA will remain the mainstay of the UK's WLR capability until 2026.

Meanwhile Maintaining a Capability

Having laid down an in-service date for a new, yet-to-be-selected weapon-locating system, the MoD announced in April 2020 (while the RFI for the new system still had ten days to run) its decision to extend the life of MAMBA, its existing weapon-locating radar (WLR) asset. Accordingly, DE&S announced that it had awarded Saab with a GBP 46 M contract to extend the British Army's use of the WLR system. The contract secured the continued use of what DE&S described as a "life-saving, critical-operational, counter-fire capability" that had been in service since 2003, when it had successfully supported operations in both Iraq and Afghanistan.

MAMBA has proven itself to be a highly mobile weapon-locating system over the years, one that can be tactically deployed close to the forward line of troops where it can act in a fire-control capacity. Its hostile fire-detection capabilities allow it to provide advanced warning to troops on the front line of any incoming hostile fire. Moreover, it provides coordinates to own artillery batteries of enemy locations to enable effective and timely counter-battery missions. Within battlefield sectors, or other areas of interest, MAMBA rapidly detects and tracks artillery projectiles through their trajectories and calculates points of origin and points of impact. Based on calculations produced by MAMBA, priorities are made and directions are provided for effective counter-battery fire. In fire control mode, MAMBA tracks the projectiles of own fire and extrapolates points of impact, offering adjustments, as necessary. In 'sense-and-warn' mode, extrapolation of points of impact of incoming fire triggers a timely warning to the system's own operators.

Saab itself had announced the previous month that it was to provide a mid-life extension for its Arthur systems in use with the UK, (Arthur being Saab's name for MAMBA), and that the order had already been booked in Q4 2019. Saab and the Artillery Systems Team at DE&S, which awarded the contract to Saab, have now been working with the Royal Artillery's 5th Regiment based in Catterick, UK, to ensure the capability remains until 2026 – the in-service date for the SERPENS winner. Saab said that the mid-life extension represents a major programme of obsolescence management by 'the insertion of modern technology, ensuring that this critical operational counter-fire capability can be sustained on a cost-effective basis through to its extended out-of-service date'. Deliveries of the MAMBA mid-life extension began last year and have been continuing in 2023, with the support contract covering the full six years to 2026. Saab has been carrying out the work in Gothenburg, Sweden, with ongoing support continuing at Catterick.

At the time of the MAMBA mid-life extension award, Anders Carp, Senior Vice President and Head of Saab's business area Surveillance, said that with Saab's systems having contributed to protecting UK forces for more than 15 years, the company was looking forward to continuing to strengthen the UK's weapon-locating capability for years to come. With work already underway to explore which capability would replace MAMBA, however, any continuing weapon-locating relationship beyond 2026, was not a foregone conclusion.

For its part, DE&S said at the time that the Army was already considering SERPENS and what it called 'a next-generation weapon-locating system with a digitally-networked suite of sensor systems to detect hostile mortars, artillery and rockets, which was, however, still in the early stages of its concept phase and subject to further research and development'.

Enter SERPENS

It is clear that this further research and development bore fruit, when, in August 2022, more than two years after the RFI, it was announced that Israel Aerospace Industries (IAI), its subsidiary ELTA, and Babcock International, would collaborate on the new radar solution for the UK MoD's next-generation weapon-locating system for the SERPENS programme. The main sensor chosen was IAI-ELTA's capable and proven ELM-2311 compact multi-mission (C-MMR) radar, to be partly produced and integrated in the UK. An MoU signed between the three companies would bolster Babcock's systems integration and through-life support capabilities, for one, while also honing its expertise in radar assembly and maintenance service support.

Babcock's Chief Technology Officer, Dr. Richard Drake, and IAI UK MD, Ronald Cook, expressed their enthusiasm to collaborate on this 'deep-find radar solution' partnership for SERPENS, particularly with the C-MMR being what they described as 'battle-proven', 'cutting edge', 'affordable' and, importantly, 'available' technology.

The ELM-2311 C-MMR is designed for air defence (AD) and artillery weapon-locating missions. The radar operates in the C-band, and offers an 3D multi-beam operation through the use of active electronically-steered array (AESA) antenna

Credit: Elta

SERPENS has settled for the vehicle-mounted ELM-2133 C-MMR from IAI-Elta, an active electronically scanned array system.

technology. It can be operated remotely and is carried, containerised, on a single vehicle with just two operators/crew. It has advanced ECCM and signal processing capabilities, enabling it to handle a variety of targets and environmental conditions. According to IAI, it also has high redundancy, graceful degradation, high reliability and high availability characteristics. Through SERPENS, the C-MMR will provide the British Army with a highly mobile and transportable, all-in-one radar on a single vehicle for forces on the move.

The main components of the radar are the AESA antenna, cooling unit, power unit and operator consoles, including communication equipment. In AD mode, the radar detects and classifies all types of airborne targets and generates a real-time air situation picture. In WLR mode, it provides detection of incoming mortar and artillery rounds, rockets and missiles for stationary or deployed forces. The radar locates hostile weapon locations and calculates impact and launching points – point of impact and point of origin in real-time, and provides friendly fire ranging simultaneously. The radar also provides fire control support for counter-RAM (rockets, artillery and mortars) weapon system missions.

In staring mode, used for terrestrial weapon location, the C-MMR has a field of view covering 120° in azimuth and 50° in elevation, and is capable of detecting artillery rounds out to 70 km. In air surveillance mode, used for air defence, the antenna is rotated through 360° to extend coverage in azimuth, and it is capable of detecting common aerial targets out to 250 km. Within those parameters, the C-MMR is capable of handling up to 100 targets/min for both air surveillance and weapon-location purposes, incorporating a fast refresh rate for tracking manoeuvring targets.

With the current state of play in Europe, the year 2026 cannot come soon enough for the Royal Artillery, as it awaits this new capability.

Credit: Elta

The ELM-2133 C-MMR is carried and containerised on a single vehicle with just two operators/crew. It has advanced ECCM and signal processing capabilities, enabling it to handle a variety of targets and environmental conditions.

Alliance Interoperability

Interestingly, in the not-too-distant future, the British Army and Finnish Defence Forces will be able to interoperate in this space, as the decision to adopt the ELM-2311 C-MMR was previously taken by Finland, and announced in early 2019. This came about following trials by the Finnish Army with a number of competitive solutions in the spring of 2018. The new C-MMR equipment chosen(with Saab eliminated as the final competitor), was delivered to the Finns in 2021 to provide the ability to locate and track incoming rockets, artillery shells and mortars, as well as to act as an interface to alert the Army's counter-weapons systems to enable effective and timely counter-battery fire.

A spokesperson for IAI at the time of the Finnish deal said that with the modern battlefield having drastically evolved in recent decades as aerial threats have become more versatile, the need to take preventive measures had become a greater and more serious challenge. This relates to radar systems, which can no longer specialise, or focus, on a single-mission capability, but instead must display the ability to handle different missions in parallel.

Underpinning those sentiments, IAI VP and CEO of ELTA, Yoav Tourgeman, said that the company's "MMR family responds to a broad range of needs, by locating and tracking incoming rockets and artillery shells and by creating a comprehensive situational air picture." He added that, "the demand for mobile MMR systems is on the rise, with ELTA's operationally-proven radars well known and active across the globe."

HALO for SERPENS?

SERPENS's C-MMR will replace three standalone systems, including the current iteration of HALO, with a single system. Leonardo, the HALO producer, is investing heavily in the next generation of its solution and considering how it might eventually have a role within the SERPENS programme. The company is looking at how HALO would use short-range and deep-firing radar, as and when needed, rather than those sensors being permanently switched on. Leonardo's Rob Motherwell said, "We would have a capability to be operational 24/7, although our big heavy radars would only be switched on for a maximum of two minutes at a time, before being redeployed to another location, so avoiding enemy fire. Just by looking at the Ukraine situation, it is clear that there's a real requirement to identify where artillery is coming from." Time will tell, but, certainly, 2026 is coming. ■

AFCEA Europe Interview

In July 2023, *ESD* interviewed Erich Staudacher, General Manager AFCEA Europe, on the events being run by the AFCEA Europe organisation.

Credit: TechNet Europe

Q: How has AFCEA evolved since previous years?
A: Being part of AFCEA International as the branch office for Europe, AFCEA Europe has thrived alongside the entire AFCEA organization. After the pandemic, our constituency from the military, industry, and academia flocked back to AFCEA events in big numbers, eager to network and communicate. This interest to meet in person persists until today. But the interest in virtual elements such as webinars remains also at a significant level.
In Europe, developments originating in NATO's strategic concept, the Ukraine war, the EU's intention to strengthen defence and security, and emerging and disruptive technologies drove the spotlight onto a large number of new subjects to be discussed and covered in our work.

Q: What focus do this year's AFCEA Europe conferences have? Which information is provided by this selection, and what are the newest topics?
A: Through a mix of traditional elements of AFCEA Europe activities, such as TechNet International and TechNet Europe, webinars, and a new transatlantic conference, we want to serve our customers' interest for relevant information, and exchanges with their peers.
TechNet International featured the newest developments in NATO's DIANA and EDA's HEDI hub projects and related technology fields, and networking of the Brussels-based C5ISR community. TechNet Europe in London will identify the lessons of the Ukraine War and C5ISR technology on refreshing the digitalisation efforts in defence, and the need for a more adaptive and agile procurement system. Finally, TechNet Transatlantic in December will give warfighters from US forces in Europe and their partners a platform on how to better integrate and collaborate on the theatre battlefield and beyond. Supplementing these will be webinars to showcase select technology challenges for the European audience.

Q: In terms of first-time exhibitors and attendees at AFCEA's conferences, are most of them coming from a specific region or sector?
A: No, there is a wide geographical range of 'first-timers' from both sides of the Atlantic and within Europe. Their interest of course is related to C5ISR technology in one way or the other. There are cyber experts as well as communication specialists as well as software providers – and users. We are happy to have this diversity of interest, it stimulates interesting discussions, which is our goal.

Q: Are there any key highlights of the AFCEA events that you would be interested in pointing out to our readers?
A: A notable aspect of all our conferences is the consistent participation of high-ranking and exceptionally experienced speakers, both from government, industry, and academia. These influential persons bring valuable insights, enhancing the overall experience for attendees. Their presence adds strategists' and practitioners' views to our events, underscoring our commitment to delivering high-quality content and fostering meaningful discussions.
In addition, a highlight this year will be the Black-Tie Conference Dinner on 3 October at TechNet Europe 2023. Taking place at the end of Day 1 of the conference, this exclusive event offers an evening of networking in a prestigious central London venue. It's an occasion not to be missed, adding a touch of charm to our conference experience.

Q: AFCEA expanded their portfolio of conferences, including virtual events. How did the concept turn out?
A: Partially, the expansion was a result of the pandemic, when in-person events became rather difficult. Also, the social distancing rules forced by Covid did not provide the exciting mingling and networking feeling. Partially it was introduced because virtual presentation technologies allowed us to satisfy a growing demand for such types of conferences.
From a temporary replacement of in-person events, such virtual presentations developed into a useful addition to the overall portfolio. It enables us to focus on special interest groups or can be designed as 'ramp-up' events to larger conferences. Only the virtual exhibitions and walk-throughs vanished almost entirely, as far as I can see. They are too artificial and miss the interactive component.

Q: The current situation of worldwide conflicts is followed by a higher interest in Defence and Security. What impact does this have on AFCEA International's role?
A: Indeed, the rising number of conflicts and imminent threats to peace and security leads to a great demand for information and exchange on Defence and Security related technologies and topics. It also widens the interest in topics like Cyber security for critical infrastructure. This should boost interest in our events and AFCEA publications. AFCEA tries to satisfy the demand for discussions on wider subjects such as information warfare, space as critical infrastructure, as well as emerging and disruptive technologies.
On the other hand, military and defence-related government officials are busier than ever. Exercises and deployments take them away from meetings at home. Furthermore, since readiness is the dominant term in NATO right now, discussion of future capabilities and relevant technologies beyond today's readiness posture sometimes seems to be pushed into the background.

Sky Sabre: A Landmark in UK GBAD Capability

Doug Richardson

Given the high cost of developing high-technology weaponry, any approach that promises to save time and money is of potential value. When the British Army took its latest surface-to-air missile into service at the end of 2021, it was not only fielding a replacement for the ageing Rapier system, but was also showing how an effective weapon can be developed by exploiting existing technology, and combining this with carefully-selected new developments.

The' all-new' approach to developing military hardware has traditionally been favoured by the UK, but has often resulted in programmes that ran over-budget and well behind schedule. However, reusing technology from MBDA's Advanced Short Range Air-to-Air Missile (ASRAAM) short-range air-to-air missile and combining this with state-of-the-art developments has allowed the UK to develop two short-range SAM systems based on a common missile – the Sea Ceptor system for the UK's Royal Navy, and the Sky Sabre for the British Army.

The Emerging Requirement

Creation of a radar-guided short-range SAM system able to operate by day or night in all weather conditions was not practical during the second half of the 20th century. Semi-automatic command to line-of-sight (SACLOS) guidance offered a simpler solution, and was used by the UK for the Rapier, which used optical SACLOS, with a later add-on radar automatic command to line-of-sight (ACLOS) capability, and Seawolf, which used optical SACLOS and radar-based and ACLOS modes.

By the early years of the 21st century the UK faced the problem that Rapier and Seawolf would both need to be replaced around 2020 when these were expected to reach the end of their respective service lives. Replacement systems would have to cope with a target set that included fast jets, helicopters, cruise missiles, and unmanned aerial vehicles. MBDA described potential future targets as being "typified by high speed, rapid evasive manoeuvres, low signatures and advanced countermeasures".

By that time, radar guidance technology had progressed to the point where it seemed possible to use this in a new lightweight missile able to deliver all-weather day and night capability. MBDA (then MBD) and the UK MoD's Defence Evaluation and Research Agency (DERA; now succeeded by Dstl) jointly funded a first-phase CAMM technology development programme (TDP) to work on several critical technologies including a soft vertical launch (SVL) demonstrator, a low-cost active radar seeker, and a dual-band two-way datalink.

Author

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

Credit: MBDA

The Sky Sabre TEL on display at DSEI 2017.

The Quest for Soft-Launch

Previous UK-designed SAM systems had relied on traversable launchers, a solution retained for Rapier and the original GWS-25 version of Seawolf, but the GWS-26 version of Seawolf first fielded in the 1980s marked the first use by the UK of the hot vertical launch technique. It teamed the basic Seawolf missile with a booster motor and turnover pack that separated after use. This configuration increased the range of the system from 6.5 km to 10 km. However its use against short-range targets is reported to have sometimes involved the missile and booster making a post-launch manoeuvre of more than 180° in elevation, which briefly resulted in these heading back towards the launch ship before executing a sharp turn that brought the combination onto a low-level trajectory heading away from the ship and towards the target.

Although vertical launching was adopted for many SAM systems, the hot-launch technique that these used posed several problems. One was the need to cope with the efflux generated if the rocket motor of the missile or booster was ignited in the

Credit: MBDA

Rear view of the CAMM, with the main thrust nozzle and turnover nozzles visible at the rear.

launch cell. Another was the need to expend a portion of the boost-phase energy on the task of orienting the missile in the required direction. There was also the possibility that a malfunctioning missile which has failed to leave the launcher could destroy its launch cell and damage neighbouring cells.

Cold vertical launch is an alternative technique in which the missile is ejected from its storage container by a mechanism such a telescoping rod or captive piston driven by the efflux from a gas generator. Once the missile is clear of the launch container, an orientation system such as sideways-firing thrusters turns the weapon in the direction of the target. Once this has been done, the missile's rocket motor is ignited, and powered flight begins. The entire burn time is used to power the missile toward the target. Since the missile has been vertically launched, the system has a full 360° coverage. This avoids the need to fly energy-bleeding 'over-the-shoulder' manoeuvres that would decrease the range performance of a missile launched to engage a rear-sector target.

It should be noted that cold vertical launch technology is not altogether new, having been used by the Soviets starting in the late-1970s on the S-300P family, and subsequently implemented on the Tor, S-300V, S-400, S-350, and S-500 air defence system families. However, it has been a comparatively rare sight on Western air defence systems, which have tended toward either hot vertical launch or traversable launchers.

Between 2002 and 2005, MBDA conducted a series of demonstration firings in order to demonstrate the planned soft-launch scheme. These trials used a missile about 3 m long, whose all-up weight was about 100 kg, slightly more than the 87 kg of the ASRAAM. If a standard ASRAAM motor had been used, this would have created a range-safety problem.

Before conducting a missile test, engineers the need to define the area of terrain that a missile flight will place at risk. The 'worst case' from the point of view of safety is that a newly launched missile will turn to face the worst-possible direction, then make no further manoeuvres but fly until it runs out of energy. The resulting distance from the launch point may be inconveniently long, but any location closer to the launch point could be at risk from a malfunctioning missile. In the event of a guidance failure, the missile used for these early cold vertical launch trials could have landed up to 60 km from the launch point if powered by an off-the-shelf ASRAAM rocket motor. So, in order to meet range-safety requirements, a short-burn version of the ASRAAM motor was used for these test firings.

One interesting feature of the chosen configuration was that the eight side-firing thrusters (arranged as four pairs located directly below the control fins) were a permanent part of the missile, rather than being located in a tail-mounted subunit that could be jettisoned after use. Although releasing the spent thruster unit would have reduced the weight of the missile before beginning powered flight, the resulting weight saving would be offset by the weight of the missile-mounted hardware needed to conduct the jettisoning. The latter would also have added a potential failure mode to the weapon.

Developing the Technology

A joint MoD/MBDA initiative into multi-role modular seekers was begun in 2001. The goal was to create hardware that would allow excellent target discrimination plus good resistance to the effects of clutter, glint, and jamming. Speaking at the DSEI 2013 exhibition in London, Steve Wadey, executive group director technical and managing director UK of MBDA, described gallium nitride (GaN) solid-state power amplifier technology as being a key feature of the new seeker. To minimise the cost, the transmitter section of the prototype hardware operated at a lower power level that that planned for an operational version.

Credit: UK MoD

The Image shows the key combat components of a Sky Sabre battery, comprising the Giraffe AMB radar (left), SAMOC (middle), and TEL (right).

By 2005, MBDA envisaged the creation of a single multi-role missile able to replace the AIM-9M Sidewinder and ASRAAM air-to-air missiles, as well as the Starstreak, Rapier and Seawolf surface-to-air missiles. A second phase TDP launched in 2008 included the manufacture of flightworthy subsystems, mid-course guidance firings, further soft vertical launch trials, and captive airborne trials of the seeker.

The Naval Requirement Takes Priority

By 2009 the CAMM programme was in the Assessment Phase of the UK procurement cycle, with development of what was now termed the Future Local Area Air Defence System (FLAADS) due to begin in 2010. The initial application envisaged was for a naval SAM variant designated Sea Ceptor. This was planned as a retrofit to the Royal Navy's Type 23 frigates from 2016 onwards in order to replace the aging Seawolf surface-to-air missile system, then as the primary air-defence system for what were then the planned Type 26 frigates. In January 2012 the MoD awarded MBDA a GBP 483 million contract to develop FLAADS (Maritime), and the system entered service in 2018 under the designation 'Sea Ceptor'.

The assessment phase for the land-based version (then known as FLAADS Land) began with a GBP 36 M contract from the UK Ministry of Defence (MOD) in 2014. This would study integration of the CAMM missile into a land-based launcher, as well as the command and control facilities needed for the new role, and interfacing with suitable radar systems that were either already in UK service or planned for future service.

The Land-Based Solution

Sky Sabre combines the MBDA launcher and its associated missiles with a SAAB Giraffe Agile Multibeam (AMB) radar and a Rafael Surface to Air Missile Operational Centre (SAMOC; also referred to as the Tactical Operations Centre (TOC), which serves as the command post. A battery will typically consist of a command post, a multifunctional radar, four to six transporter, erector, launchers (TELs), plus associated supporting assets.

The system was not designed to launch missiles whilst on the move. Before an engagement can begin, the radar, command post, and the associated launchers must be emplaced and set up. The use of RF links avoids the need to deploy, connect, and restow conventional cables. This greatly reduces setup and teardown time, but could make the system potentially more vulnerable to enemy EW measures.

Rafael Meets the Command Post Requirement

The command post is based on a Rafael Advanced Defense Systems Modular Integrated C4I Air & Missile Defense System (MIC4AD). Designed for use with a range of possible air and missile defence systems, this is able to correlate data from distributed sensors such as radars, IFF systems, and information available via data links in order to create a real-time, coherent national air situation picture, and also incorporates a mission planning system. The operators are able to carry out threat assessment and classify hostile targets, and generate interception plans. MIC4AD links the radar with the missiles, guiding the latter towards their individual targets.

Sweden Provides the Radar

Giraffe AMB is a C-band (4–8 GHz) passive electronically scanned array radar able to provide full 360-degree situational awareness out to a range of 120 km, and with an elevation coverage of up to 70° in elevation, and an update rate of 60 times per minute. Developed by Saab,

Credit: UK MoD

Prior to being ready for engagement, Sky Sabre's components need to set up for operation, lowering their stabilisers and raising radar or communications masts, as well as elevating the launch assembly to the vertical launch position.

it was designed to cope with coastal or mountainous terrain, and to reject radar clutter from birds or wind farms. An extending mast allows the antenna unit to be elevated above tree lines and other obstructions in order to maximise performance against low-flying intruders.
Once the radar vehicle has reached its planned operating location, stabilisers are lowered, and the radar antenna is raised from its transport location flat against the shelter roof up to its full height of 12 m above the shelter structure. An extending telescopic mast that houses the AMB's communications antenna is also raised.

An Agile Launcher Takes Shape

In developing the launcher, MBDA was able to take advantage of the experience it had gained having used a truck-mounted missile launcher for early CAMM test launches. First displayed at the 2011 DSEI exhibition in London, this trials unit was based on a MAN 6×6 truck, and carried two packs of six missiles. Three or six canisters from each pack could be raised and lowered independently for reloading, while the others remained ready for use.
For the purposes of Sky Sabre, a launcher module is installed on a Rheinmetall MAN HX77 8×8 heavy utility truck, a vehicle already in British Army service. Like the radar vehicle, the launch vehicle is fitted with stabilisers which allow the vehicle to raise two telescoping masts, one for a communications mast that provides a high-bitrate datalink for wireless communication with the other battery components, and the other for an optoelectronic sight thought to incorporate an IR camera. This probably allows the vehicle to passively acquire and track targets in cases where the multifunctional radar may not be able to detect the target or has been forced to shut down due to the threat posed by enemy anti-radiation missiles. Although the optoelectronic sight is thought to be capable of tracking a missile and its target, and generating mid-course guidance corrections for the missile, this has not been officially confirmed.
The launch assembly consists of a frame on which two packs of four containers for ready-to-launch missiles are mounted. The containers are angled slightly away from vertical, in order to prevent a newly-launched missile from falling back onto the launcher should its rocket motor fail to ignite. An electro-hydraulic mechanism is used to elevate or depress the entire assembly, while a second mechanism is available to extend and retract a hook arm. This arrangement allows the vehicle to self-load and unload the complete frame with missiles to and from a nearby missile transporter truck. There is no need for a separate loader or transloader vehicle. The individual launch containers are sealed, and should give the missile an estimated storage life of at least 20 years.
In terms of launching the missile, when launch is initiated, hot gas created by a pyrotechnic generator drives a piston located below the missile up the length of the container. This process expels the missile, which breaks through a frangible a lid at the top of the container. Once the missile is clear of the launch container, its four cropped-delta control fins unfold ready for use, but the piston remains trapped at the top of the tube, so that the efflux from the gas generator does not escape. This reduces the launcher's thermal signature, and prevents the efflux from damaging the launcher hardware.

Ground-Controlled then Autonomous

Once a missile has been launched and has competed its boost phase, it flies under the control of its INS-based autopilot. Mid-course guidance corrections transmitted by the radar are received by the missile, but the location of the missile-mounted antennas used to receive these updates has never been revealed by MBDA or the UK MoD. One possible location is within the inboard section of missile's cruciform steering fins. This would require an RF connection able to pass signals through the fin's pivots, then use the same route past the missile's solid-propellant rocket motor as the electronic connections used to carry commands to the actuators that move the steering fins.
Guidance corrections are provided until the missile's seeker is able to independently acquire the target – the technique known as lock-on after launch (LOAL). The missile seeker then tracks the target, and an on-board processor calculates the course corrections required to achieve intercept, then passes steering commands to the flight-control surfaces. A laser proximity fuze is used to activate a warhead thought to weigh about 10 kg.
It is worth noting that the guidance system may be more complex than the above description implies. Since the initial CAMM technology development programme was reported to have studied a dual-band two-way datalink, it is possible that the missile may have a downlink capability able to pass data back to the ground systems. This could allow several guidance-related functions. For example, ground-based monitoring of the performance of the seeker during its active phase might allow the sending of a command to change seeker parameters, in order to optimise its end-game performance, or to blunt the effects of enemy countermeasures.

Entry into Service

By October 2021, Britain had already sent a Sky Sabre battery to the Falkland Islands. Following this, on 6 December 2021, the UK's Defence Equipment & Support (DE&S) organisation announced that it had delivered the first Sky Sabre system to the British

Credit: MBDA

A closeup of the CAMM, showing the key external features of the missile. The optical windows for the laser proximity fuze are visible forward of the warhead section.

Army. The first unit to be equipped was 16 Regiment Royal Artillery, part of the British Army's 7 Air Defence Group.

During the July 2022 NATO summit meeting held in the Lithuania city of Vilnius, the alliance agreed to enhancements of its Integrated Air and Missile Defence posture, including the rotational deployment of modern air defence systems across the eastern flank.

On 17 March 2023 UK Secretary of State for Defence Ben Wallace announced the planned deployment of British Army Sky Sabre units to Poland. Although unannounced, the first hardware and personnel from the Royal Artillery's 11 (Sphinx) Battery probably reached Poland in late-April. Initial operating capability (IOC) of what was termed the Medium Range Air Defence Contingency Force was announced on 23 May 2023.

Sky Sabre Assessed

Although the CAMM missile inherited much of its technology from ASRAAM, and uses many components from latter, including the main fuselage, rocket motor, laser proximity fuze, and warhead, it represents a major step forward in short-range SAM capability. While the US attempt to combine two different guidance systems in the General Dynamics Mauler short-range SAM some 60 years ago was unsuccessful, MDBA engineers were now able to do this with great success, and in a missile weighing 99 kg, just over twice the weight of the 43 kg Rapier Mk2B that it would replace, and less than two-thirds the weight of the 165 kg 9M331 vertically-launched missiles used by Russia's 9K331 Tor-M1 (SA-15 'Gauntlet') short-range SAM system.

No details have been released concerning the missile's accuracy, but according to Major Tim Oakes, the senior training officer for the 16 Regiment Royal Artillery unit's training programme, "Sky Sabre is so accurate and agile that it is capable of hitting a tennis ball-sized object travelling at the speed of sound...it can control the flight of 24 missiles simultaneously whilst in flight, guiding them to intercept 24 separate targets."

In terms of maximum range, it eclipses older systems such as Rapier and Tor. While the Rapier could manage only 8.2 km, and Tor (depending on the variant) has a range of up to 12 km (using 9M331), 15 km (using 9M331D), or 16 km (using the newest 9M338K). By contrast, CAMM can be used against targets over 25 km away, and as such the British Army considers it to be a medium-range system.

It is worth noting that the 25 km figure for CAMM represents useable range against a realistic target, rather than a theoretical maximum range. As described earlier, the hardware used for early flight tests would have imposed a safety distance of 60 km had a standard ASRAAM rocket motor been used. However, this does not imply that CAMM has anything like this as its maximum range. In combat, the target is unlikely to be flying straight and level, but could well be manoeuvring either to avoid an incoming missile, or to accomplish its own mission. Wayward SAMs can impact the ground many times further than their practical range against aerial targets, as was the case in 2019, when a stray Syrian S-200VE landed in Cyprus, over 220 km from its launch point.

Like any other missile fired against an air target, CAMM is subject to the missile engineer's 'rule of thumb' that it needs to be able to pull a manoeuvre involving five times the 'g' of any defensive manoeuvre executed by the target. The resulting expenditure of energy by the missile will reduce its range to well below the safety distance used during missile trials. So that figure of over 25 km for the maximum range of CAMM represents a real-world value for a tactical engagement. That said, a hostile aircraft unable or unwilling to conduct hard anti-missile manoeuvres might find it advisable to keep a slightly greater distance from a Sky Sabre battery. ■

Credit: UK MoD

The Sky Sabre represents a major leap forward for the UK's ground-based air defence capabilities.

A Recipe for Networked, Integrated Air Defence

Adapting to the rapidly changing challenges of modern air warfare, air defence systems leverage open architecture, modular design, and software-based agility to transform into agile and advanced network-centric Integrated Air Defence System (IADS).

Legacy air defences built in the 1990s and early 2000 were bound to rigid and hierarchical formations and centralized command and control to achieve their mission. The proliferation of such weapons creates an operational paradigm shift of the threat. For legacy systems designed to defeat aircraft, meeting such capabilities requires massive investment in new strategies and expensive upgrades of existing hardware. To remain effective and potent, the IADS must maintain its effectiveness against electronic attack and suppression.

Photos: IAI

Modern IADS such as the BARAK MX are required to flexibly deploy and provide optimized coverage against all known threats, whether fixed-wing or rotary-wing manned aircraft, unmanned aircraft, ballistic, cruise, and anti-ship missiles, and loitering weapons. Modern IADS are integrated via networks, allowing for seamless data sharing, limited only by commanders' decisions to delegate roles, responsibilities, and decision-making. By delegating defensive actions to different elements distributed throughout the defended area, the networked IADS can simultaneously execute multiple kill chains, thus mitigate uncertainties in battle. Moreover, the networked systems can easily delegate tasks for complex threat mitigation, thus overcome the destruction or isolation of particular nodes.

IAI offers the BARAK MX system as a modern IADS and as part of multi-layered air and missile defence system. The system relies on the network-enabled architecture, featuring centralized battle management and independent operation, utilizing the smart-launcher concept. As such, the modular and customized BARAK-MX fire unit can be networked to a central battle management node, operate as a classic battery Fire Unit (FU), or act in a stand-alone mode. It can also merge those modes of operation into a hybrid model.

The system's agility is reflected by the fire unit (FU) design. The system consists of a Smart Launcher designed for land-based or naval applications. The unit can load a mix of BARAK interceptors – The Medium Range Air Defence Missile (BARAK MRAD), effective up to 35 km, the Long-Range variant (BARAK LRAD) effective at up to 70 km, and the BARAK ER, effective up to 150 km and with additional anti-ballistic missile capabilities. The three missiles maintain a high level of commonality, differing from each other only in elements related to the specific performance of each variant. The Battle Management System (BMS) provided as part of the system or by the customer, manages all smart launchers and interceptors associated with the system, whether local or remote, thus achieving the highest success rate while maintaining the most efficient battle economy.

Network-Centric operation enables each node to generate and share a situational picture, receive target allocations and tracks from the battle management center and perform intercepts in a network-centric operation. The sky picture and early warnings are processed and synthesized by the battle manager by fusing all available sensors. This common picture is constantly updated and distributed to each node. When threats are detected, the battle manager allocates targets to each fire unit to pursue, based on tracks provided by local or remote sensors, and according to a battle plan that considers each target data, the location of fire units, state of ammunition and the probability of kill. This coordination ensures optimal use

of interceptors, eliminates 'double booking' of targets, and ensures all fire units remain loaded to continue the mission. The battle manager function can be distributed and reallocated to different elements, as the situation requires.

BARAK MX leverage the radars developed by Elta Systems, or other radars, including the land-based ELM-2084 MMR or naval MF-STAR. However, to better integrate with existing air defence systems, IAI has streamlined connections with command and control and radar systems the user provides. The ability to fuse sensors and interceptors into a single system lies at the heart of Barak MX architecture and is a significant element in its attractiveness to clients. As a modular, software configurable system, Barak MX can be upgraded and enhanced to cover more options by software changes, enabling customers to tailor the plan to meet different challenges.

Such a layout enables air defenders to face attacks from different directions, heights, and trajectories, posing a complex multi-dimensional Anti-Access Area Denial (A2AD) defence capability.

As reflected by current tenders issued by advanced militaries, net-centric IADS systems are becoming the go-to concept, as they provide the highest operational advantage and cost and benefit, becoming a profound safeguard against evolving threats. But nations are not satisfied with owning such systems; they want to become sovereign in this critical capability.

Solving the British Artillery Capability Gap – the Mobile Fires Platform

David Saw

The British Army has suffered from significant capability decline in a number of critical areas in recent years, including armoured vehicles and artillery. This is not to suggest that deficiencies in these critical areas have remained unknown or deliberately ignored. On the contrary, there have been numerous statements by government and military figures that steps were being taken to correct these problems and that solutions would soon be fielded. Yet time has passed, and for all the statements made and the good intentions expressed, very little has changed.

Before venturing further, it might be useful to pose the question: after the end of the Cold War, what was the primary mission of the British Army? If it were to confront a peer or near-peer competitor, then it would need the appropriate conventional weapons for high intensity mechanised conflicts. In these circumstances, effective armour and artillery capabilities were essential and that is where you would invest your procurement funding. The important point to note is that for much of the post-1990s, there was never any intention of confronting a peer/near-peer competitor in a conventional conflict.

Security threats were plentiful, as it was an era of asymmetric conflicts in multiple locations around the globe. Consequently, the military assets required would have to be lighter, more mobile and easily deployable. Anti-air threats were minimal. As such, it was thought that this was not the environment for a heavy armoured force supported with numerous artillery assets. If these systems were not really required, then they would be low down the priority list for funding for replacement or upgrade programmes.

The other problem confronting the British Army was the dysfunctional British procurement system, a system in which efficient programme management and sound financial management appeared to be very difficult to achieve. The other two services, the Royal Navy (RN) and the Royal Air Force (RAF), seemed to be far more effective in turning their equipment requirements into functioning procurement programmes than the Army could manage. Might the success of the RN and the RAF in playing the procurement system also be a function of the British Army being unable to articulate what its role was within an uncertain international political and strategic environment?

Credit: JCCC/Spc. Rhonda Roth-Cameron

British soldiers of J (Sidi Rezegh) Battery, 3rd Regiment, Royal Horse Artillery spend the early evening hours calibrating the AS90, 155 mm SPH in Multi-National Division Southeast, Basra, Iraq, on 28 August 2008.

Responding Slowly

With the War in Ukraine this security environment represents a conventional and clearly understandable threat that would obviously see NATO ground forces respond by upgrading their conventional combat capabilities. Unfortunately, although the threat might have been clear, the reaction was somewhat anaemic. Rebuilding conventional capabilities was going to take time, despite the fact that the British Army was starting to make progress on confronting its conventional credibility gaps. There were real procurement programmes in progress in terms of armoured vehicles and plenty of ideas on how to regenerate artillery capabilities.

As far as artillery capabilities were concerned, there were a number of programmes grouped under the overall rubric of Long-Range Fires. These were classified as Close Support and Deep Fires efforts, with the first programme to become a reality based on M270 Multiple Launch Rocket System recapitalisation and range extension for Land Deep Fires. MLRS will be upgraded to the M270B1 configuration and utilise the Guided MLRS Extended Range (GMLRS-ER) rocket which would boost engagement ranges from 84 km out to 150 km.

Other artillery programmes are the Dismounted Joint Fires Integrator (D-JFI) and fire control systems, that will "deliver enhancements in the integration of Joint Fires producing target effect in the land environment." This programme is currently in the

Credit: UK MoD

British Army AS90 in Estonia, part of the NATO Enhanced Forward Presence (eFP) Battlegroup in 2018. The AS90 is to be replaced by the future Mobile Fires Platform (MFP), meanwhile 20 workable AS90s and 12 more that could be refurbished or broken up for spares have been supplied to Ukraine.

assessment phase. Then comes the Close Support Fires Programme (CSFP), which included the Mobile Fires Platform (MFP) and the Tactical Guided Munitions Indirect (TGMI) programmes. The latter vision was officially described as such: "Guided munitions with increased range and accuracy that can be fired by current and future Close Support Fires platforms." The programme is in the concept phase, transitioning to being funded. Mention should also be made of an outline programme to replace the L118 105 mm Light Gun. Currently 129 guns are in service, with the out-of-service Date (OSD) being 2030; the successor requirement is known as the Lightweight Fires Programme (LFP).

MFP, the second component of CSFP, is described as "a Close Support Fires platform to replace AS90." MFP has reached the concept stage, but the poor state of the British Army's 155 mm artillery capability has seen this programme gain significant momentum and it is on the verge of becoming a fully live competitive procurement effort.

Declining Capability

AS90 was designed in the 1980s as a replacement for the British Army M109 fleet in the 1990s, hence the name 'Artillery System for the 1990s' or AS90. In total, 179 of these 155 mm L39 self-propelled howitzers (SPHs) were acquired, though the downside was that they arrived in the 1990s once the Cold War was over, at the point when the British Army was really getting out of the business of operating large numbers of SPHs. With the long-awaited conflict on the North German Plain disappearing from the British threat calculus, the British Army shrinking and the continental commitment evaporating, active AS90 numbers declined rapidly. According to official Ministry of Defence (MoD) figures, by 2016 the number of active AS90 systems had declined to 89.

Even though AS90 numbers were massively reduced and the sort of conventional capability they represented had lost emphasis, there were still efforts to further develop AS90. Artillery developments elsewhere and an understandable desire to enhance the AS90 led to a number of upgrade proposals; the most obvious proposed change was the replacement of the L39 gun with a longer L52 gun to greatly increase engagement ranges. As time went on, there were also proposals to replace systems within the AS90 that were becoming difficult to support, or needed to be replaced as part of an improvement effort. An AS90 upgrade was certainly viable and would have resulted in real capability growth, though sadly the money was never found for progressing an upgrade effort.

Eventually though, as AS90 numbers continued to decline, the first steps were taken to resurrect the 155 mm artillery capability, and this was the genesis of MFP. Fundamental to the selection of any NATO 155 mm artillery system is that it complies with the Joint Ballistic Memorandum of Understanding (JBMoU), whereby NATO nations adopted standards for 155 mm artillery systems and ammunition to ensure that they are interchangeable between the signatory nations. However, in the context of MFP, the required range of 80 km was, at least at that time, not likely when compliant with the 23 litre chamber volume specified in the JBMoU.

At this point, MFP seemed to be reflecting the direction that Germany was heading in as regards artillery. They also wanted extended range, and this saw interest in a Rheinmetall proposal of 155 mm L60 gun.

Credit: DE&S

In March 2023, to fill its 155 mm artillery capability gap, Britain announced that it would procure 14 BAE Systems Archer SPHs from Sweden. These will become operational with the British Army in April 2024.

There was also a suggestion of an artillery system with a much larger, and therefore non-JBMoU compliant, chamber volume. Many recent artillery developments from Rheinmetall in terms of gun technology, ammunition and charges could yet play a significant role in the MFP programme, especially since extended ranges are being reached with JBMoU-compliant artillery.

According to Rheinmetall, their current 155 mm Base Bleed (BB) round reaches 40 km with current modular charges, out of a 52 calibre barrel, with the Extended Range Charge (ERC) that they intend to introduce, range increases out to 46 km and will reach 52 km in the medium term. They also have a Velocity enhanced – Long-range Artillery Projectile (V-LAP) round that currently reaches a range of 54 km, increasing to 63 km with the ERC; the objective is to reach 68 km in the medium term.

The ideas floated at the start of the MFP process in terms of range, rate of fire and system weight all turned out to be too ambitious at that time, hence the programme pivoted towards something more achievable. There was also the suggestion that an 80 km range for MFP was unnecessary, as extended ranges out to 80 km and beyond would be covered by GMLRS and there was therefore no need to duplicate capability. On the other hand, with the envisaged service life of MFP being 30 years, the system must be capable of 'Forward Capability Insertion' to upgrade capability throughout its service life. Such upgrades could include new ammunition, enhanced automatic loading, improved ordnance, automotive upgrades such as hybrid propulsion and autonomous operation.

A re-focused MFP effort was then based upon a 155 mm L52 gun on either a wheeled or tracked platform, with the acquisition of a new range of ammunition options under the TGMI programme and an advanced modular charge system. The idea was that the AS90 would have an out-of-service date of 2030 and that MFP would be available at some point 'later this decade.'

New Factors

That the AS90 was being discussed as having a 2030 out-of-service date seemed delusionally optimistic – while the officially stated AS90 fleet size was 89 systems (as of September 2022), the reality was that at best less than 30% of this fleet was actually usable. As for the rest, it was in store, some systems were salvageable, many more were only fit for cannibalisation. Effectively the British Army was on the road to having zero 155 mm artillery capability, and most likely this would come long before 2030.

Russia's invasion of Ukraine in February 2022 made it impossible to ignore the poor state of 155 mm artillery in Britain. The course of military operations in Ukraine provided conclusive proof of the importance of tube artillery and, as a result, there started to be more emphasis on improving Britain's capability. However, other factors would complicate the British artillery picture.

Britain has made major efforts to supply Ukraine with weapons and ammunition. In response to Ukrainian requests for more artillery, in January 2023 the British Government agreed to supply 20 operationally capable AS90, plus 12 more that could be refurbished or broken up for spares. The first AS90s entered combat in Ukraine in late June the same year. Given that it had donated the majority of its usable systems, this effectively left the British Army without a credible 155 mm artillery capability.

As a result, Britain embarked on a programme to acquire an interim artillery capability that would fill the gap until the MFP eventually comes online. In January 2023, they commenced talks with Sweden on the acquisition of 14 BAE Systems Archer 155 mm L52 mm truck-mounted artillery systems and on 16 March, Defence Equipment & Support (DE&S) announced that

Credit: armasuisse

The KNDS RCH 155 (Remote Controlled Howitzer 155 mm) is to be evaluated by armasuisse on both the Boxer and the Piranha 8×8 platforms for the Swiss M109 KAWEST replacement programme, where it will compete against the BAE Systems Archer.

Credit: Rheinmetall

In 2019, the Israeli Ministry of Defence awarded Elbit a contract to develop a fully automatic truck-mounted artillery system. In 2022, Rheinmetall and Elbit signed a collaborative agreement to develop a 'European' 155 mm L52 mm SPH based on an Israeli design, this is being proposed for future German and British requirements.

14 artillery systems would be transferred to Britain later that month and the systems would become operational with the British Army in April 2024. In a related development, DE&S announced a major 155 mm ammunition contract with BAE Systems in July 2023, which they said: "will increase the UK's stockpile and deliver an eight-fold increase in production capacity."

Sweden had originally ordered 48 Archer systems and the 14 systems for Britain will be drawn from this source. Additionally, eight systems from Sweden's fleet were supplied to Ukraine. In June 2022, it was announced that Sweden would purchase an additional 24 systems.

In August 2022, armasuisse, the Swiss Federal procurement authority, announced that it had established a shortlist for the replacement of their existing M109 KAWEST artillery systems, which are to be withdrawn from service by 2030. They will compete the Archer against the KNDS RCH 155 (Remote Controlled Howitzer 155 mm), with the latter system to be evaluated mounted on both the Boxer and the Piranha 8×8 platforms. Ukraine is on course to receive 18 RCH 155 systems.

It is significant that the UK MoD chose to talk to BAE Systems in order to acquire an interim artillery solution, especially since relations between the British Army and the company have been troubled. Equally significant is that the MoD apparently chose not to talk to Hanwha in any depth about the interim requirement, especially since the Korean company had demonstrated its ability to rapidly supply artillery systems. In July 2022, Poland announced that they would purchase 48 K9PL artillery systems, with contracts already signed in August 2022, and the first 24 guns ready for delivery in October and arriving in Poland on 5 December that same year.

The Archer will fill Britain's 155 mm artillery gap from 2024, yet even so, it is problematic that the British Army will only have 14 modern SPHs in this category until MFP arrives. This had led to speculation that more Archer systems might be purchased, and there is clearly a need for more guns. However, thus far there has been a clear effort to treat the Archer as an interim purchase and MFP as the future artillery solution that has yet to be competed.

Stiff Competition

Assuming that MFP becomes an active acquisition programme, there are obvious contenders that will have to be evaluated. BAE Systems' Archer, Hanwha and Team Thunder with the K9A2, Elbit and Rheinmetall's yet-to-be-named 'Automated 155 mm L52 wheeled self-propelled howitzer', KNDS with either the RCH 155 on Boxer or the CAESAR system. Other 155 mm L52 proposals might yet emerge, but it is obvious that there are a substantial number of serious competitors that will have to be evaluated.

System performance will not be the only metric for evaluation, since inevitably price will be an issue as will British industrial involvement for production and sustainment. Another important factor is 'Social Value,' as this has been a major factor in how policies, programmes and projects are evaluated since January 2021. Social Value aims to "make the delivery of wider economic, environmental and social goals an integral part of the procurement process," according to Lexington, a major corporate consultancy.

The UK Government wants procurement programmes to strengthen the defence industry by creating new skills and capabilities, along with supply chain resilience. Other factors that could come into play might include "tackling economic inequality, fighting climate change, equal opportunities and general social well-being," Lexington suggests. In terms of a defence procurement proposal, Social Value could account for at least 10% of decisive factors in influencing a 'yes or no' decision. The concept of Social Value in defence procurement has also been supported by the opposition Labour Party, as such will likely play an important role in how MFP evolves.

There will most probably be a general election in the UK in late-2024, with the current government expected to be defeated. Assuming that the Labour Party forms the next government, there will very likely be a defence review and that this might lead to a change of emphasis in programmes and procurement. At this point in time, it is thought that the MFP programme will survive any projected defence review. ■

Arquus Proposes Hybrid Tank Engine Upgrade Solutions

David Saw

Arquus has been developing a range of options to allow existing armoured fighting vehicles to be upgraded with hybrid propulsion systems. Recently, this work has begun to gain momentum, with the company proposing a range of upgrade paths targeted at different sectors of the vehicle market.

Arquus started working on alternative mobility solutions more than a decade ago. At that time, they developed a hybrid drive system for the Véhicule de l'Avant Blindé (VAB) armoured vehicle, replacing the Internal Combustion Engine (ICE) originally installed. The objective was having the autonomy for a three-day mission, but it was found that the state of the technology at the time meant a 25 tonne vehicle would be required, with 11 tonnes of that accounted for by the battery system, and even then, the mission requirement would be beyond its capabilities.

Work on non-ICE mobility solutions continued, and in 2018 Arquus unveiled the Scarabee vehicle at Eurosatory. The hybrid Scarabee represented Arquus' solution to meet the French Army Véhicule Blindé d'Aide à l'Engagement (VBAE) requirement to replace the legacy Panhard Véhicule Blindé Léger (VBL) 4×4 protected patrol vehicle. In a reconnaissance mission, the ability to utilise electric drive to reduce vehicle noise signature offers substantial operational advantages.

This work on hybrid propulsion led to the then French defence minister, Florence Parly, to announce in September 2020, that Arquus would conduct a study with the DGA on a hybrid electric vehicle (HEV) solution for the Véhicule Blindé Multi-Rôles (VBMR) Griffon, with the intention to develop a functional hybrid propulsion system for the vehicle. Successful implementation of an HEV solution for the Griffon would also provide the basis for Véhicule Blindé de Combat d'Infanterie (VBCI) and Engin Blindé de Reconnaissance et de Combat (EBRC) Jaguar vehicles to have hybrid solutions as well. Armoured vehicles in this category have extremely high electrical power demands, something that HEV solutions are better-suited to meeting than Battery Electric Vehicles (BEVs).

Credit: Armée de Terre

VBMR Griffon armoured vehicles of the 21e régiment d'infanterie de Marine based at Fréjus. Arquus is responsible for the complete powertrain of the Griffon. The company is working on a hybrid propulsion package for the Griffon for the DGA.

The HEV option to power armoured vehicles gained serious momentum once the Griffon hybrid study commenced, especially since improvements in battery and associated technologies promised ongoing performance growth. At a technical level, thought was given to the implications of HEV solutions for tanks. In the case of France, HEVs could have applications in both current and future tank programmes, but it is a matter of timing and convincing the user that an HEV solution is practical and offers performance advantages.

In the case of the French Army's Leclerc main battle tank, 200 vehicles are being upgraded under the Leclerc XLR programme, with all tanks to be delivered by 2029. From 2035 onwards, the tank needs of the French Army are due to be met by the Main Ground Combat System (MGCS), a collaborative programme with Germany. If, for whatever reason, MGCS is delayed, that would likely result in the service life of the Leclerc being extended further. In turn, this could lead the French Army and the DGA to consider further upgrades, with the engine being a likely candidate. The current Wärtsilä V8X 1,500 hp engine is said to be becoming difficult and expensive to support, with reliability and fuel consumption also being areas of concern, as the engine confronts obsolescence issues.

Next Steps

It should be stressed that an HEV solution for Leclerc is only being discussed, and is not at present a real programme. However, Arquus sees the HEV option as one possible path for future tank propulsion and as a valid upgrade solution. The problem is that at present it can be dif-

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Credit: Etat-major des armées

French Army Leclerc participating in a live fire exercise in Romania. France is upgrading 200 Leclerc tanks to the XLR configuration with all to be delivered by 2029. Vehicles in the 60 tonne category, such as Leclerc, are seen as a potential market for powerpack upgrades by Arquus

ficult to persuade end-users that HEV is the way forward. Equally, the other non-ICE mobility solution in the form of BEV electric solution is not practicable at this point due to weight, space constraints and performance limitations.

This led Arquus to consider another approach to tank engine requirements; their enthusiasm for hybrid solutions remained, but they also came to the conclusion that more modern ICE solutions could offer considerable performance advantages over current in-service systems. It was therefore decided to develop a range of tank engine upgrade proposals based on these new ICE solutions. They then developed a path that would allow the user to undertake a further upgrade to a hybrid solution if so desired. As such, there are three upgrade paths available:

- Upgrade with a modern, more efficient, lower-emission ICE;
- Upgrade from the modern ICE to hybrid electric drive;
- Opt for an HEV solution from the start.

Powerpack solutions would be geared towards two vehicle categories: heavier tanks with a combat weight of 60-70 tonnes, and lighter tanks or other armoured vehicles with a combat weight of 40-60 tonnes. In the lower of the two weight categories, the intention is to target export markets.

Central to these upgrades is a new range of engines from Volvo Penta such as the D13 and the D16, which were designed to offer high reliability, plus low fuel consumption and low emissions, while being compact enough for a wide range of vehicle installations. Another Volvo Penta engine, the D17, derived from the D16, is designed for Auxiliary Power Unit (APU) applications and this could also be offered as a part of the tank upgrade package. With these engines in a hybrid solution, the tank ICE engine can be switched off, but power would be provided to the tank's systems while reducing the vehicle's heat and acoustic signature, as well as decreasing fuel consumption.

Looking to wider industrial trends, Arquus' parent company Volvo Group is aiming to move beyond conventional ICEs in their truck business, since they believe the future will be based on BEV trucks. Volvo wanted to secure a strong position in this area before governments mandate BEVs, so it invested heavily in BEV technologies. BEV trucks are set to make up some 35% of the Volvo range by 2030, increasing to 80% by 2040. Volvo Group has strong incentives to take a lead in producing this technology, as along with Volvo Trucks, the group owns Renault Trucks and Mack, while also having a 45% stake in Dongfeng Commercial Vehicles, together representing a substantial segment of the logistics vehicle market. Volvo Group's investment in BEVs and other technologies is also available to Arquus, allowing them to reap the benefits of the group's investments in ICE, HEV, and BEV solutions.

Developing a tank powerpack solution is no easy business, hence many in-service tanks find their performance compromised by their existing engine. As such, the relatively flexible upgrade path presented by Arquus provides a range of options which would allow a user to flexibly upgrade sections of their vehicle fleet as required. As emissions targets loom ever larger in the political landscape, and with the existence of viable hybrid alternatives presenting operational advantages, even militaries are likely to begin feeling the pressure to reduce their emissions. ■

Credit: Volvo Penta

Rear view of the D17 engine from Volvo Penta.


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New Guns, Missiles and Laser Systems for Naval Inner Layer Defence

Luca Peruzzi

In recent years, naval forces worldwide have dealt with the spread of challenging threats, from supersonic, high-diving or low-level and highly manoeuvrable anti-ship cruise missiles (ASCM) to swarms of asymmetric threats such as unmanned systems and fast attack craft, in addition to even more demanding hypersonic weapon systems in congested and contested littoral waters. This has required the industry and naval operators to move towards inner-layer defence systems (ILDS) with longer-range and networked capabilities alongside innovative solutions such as the laser-based systems.

Guns

The Raytheon Mk 15 Phalanx with its 20 mm M61A1 six-barrel Gatling gun system continues to be the most widely-used self-contained all-weather, fully automatic CIWS (close-in weapon system). The aforementioned threats, which emerged during its service life, alongside new fire control and weapon technologies, have influenced the development and use of longer-range gun and missile systems.

In July 2021, the South Korean Defense Acquisition Program Administration (DAPA) selected and awarded LIG Nex1 the CIWS-II programme for the Republic of Korea (ROK) Navy. It aims to develop a next generation 'last line of defence' system for ships such as the FFX Batch III (Ulsan class) frigates, the future KDDX destroyers and the CVX aircraft carrier programmes. Scheduled to complete development in 2027, the CIWS-II is a standalone and over-deck system equipped with a 30 mm Gatling gun and a turret system with reduced radar cross-section (RCS) shape, incorporating a search and fire control system. The latter includes an AESA (active electronically scanned antenna) search radar with four fixed antennas offering a 360° coverage and a fire control system (FCS) with an AESA tracking radar and an optronic sight with day camera and short-wave infrared (SWIR) imager. Thanks to an advanced fire control and automation, the CIWS-II is expected to be more capable, accurate and easy-to-maintain compared to the current Phalanx, though high procurement costs and 30 mm weapon effectiveness against modern anti-ship threats have raised questions.

Credit: Aselsan

The Gökdeniz 35 mm twin cannon naval ILDS developed by Turkish companies Aselsan and MKEK has found international and domestic success. In addition to Turkey, it has been acquired by Turkmenistan and Pakistan, and selected by the Philippines, according to Aselsan.

Turkish company MKEK has also developed an indigenous 20 mm CIWS known as YHSS (Yakin Hava Savunma Sistemi), unveiled for the first time during the IDEF 2021 exhibition. Developed to reduce the dependence on foreign systems and to increase export potential, the system architecture resembles the Phalanx CIWS, but it features a six-barrel 20 mm Gatling gun produced by MKEK itself. With a total weight without ammunition under 3,500 kg and a drum for 1,500 rounds (20 mm), the YHSS rate of fire is 3,000-4,000 rounds per minute. The gun system is currently equipped with an FCS with optronic sight including day and night sensors alongside a laser rangefinder, which receives target data from the ship's Combat Management System (CMS). However, it is expected to receive a locally developed search radar in the future. In 4Q 2022, the YHSS was subjected to live-firing trials and qualification, after which it was to be delivered by year-end to the Turkish MoD.

Rheinmetall Air Defence continues to expand the club of customers using the Oerlikon Millennium naval gun system including on board the Danish Navy's Iver Huitfeldt and Absalon class frigates. The system is in service with the Indonesian Navy on its new OPVs and is also mounted on board the Royal Saudi Navy's Al Jubail class corvettes, the Venezuelan Navy and more recently the Colombian Navy on the new Damen/Cotecmar SIGMA 10514 frigates, making the latter service the first customer in Latin America. The Oerlikon Millennium matches the 1,000 rounds/min fire rate of the Rheinmetall 35 mm 35/1,000 revolver gun system with the AHEAD (advanced hit efficiency and destruction) 35 × 228 mm air-burst ammunition, each round containing 152 tungsten sub-projectiles forming a lethal cone-shaped cloud ahead of the incom-

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cta-international.com is a joint venture between BAE SYSTEMS and nexter, a company of KNDS

Credit: Nexter/Thales

The T40 RapidFire developed by Nexter and Thales is equipped with the CTA International 40 mm CT40 automatic cannon, firing case telescoped ammunition.

ing target. On the basis of hit probability, the Millennium can defeat ASCM at ranges between 1-3 km and asymmetric threats such as multiple-axis swarms of fast attack craft up to 4.5 km. The Millennium doesn't require through-deck penetration and is available in both standard and ISO-mount installation, the latter being a container shaped mechanical structure for rapid mounting and dismounting with an additional 252 round magazine.

Credit Luca Peruzzi

Leonardo's 'Single Deck' (Sovraponte) is a completely new light and low footprint 76/62 mm gun mount with the same capabilities as the SRGM/Strales. The Netherlands and Belgium are the first international customers.

Turkish companies Aselsan and MKEK jointly developed the Gökdeniz 35 mm twin cannon naval ILDS which has found both international and domestic success. Derived from the Korkut tracked SP anti-aircraft land system, the Gökdeniz is characterised by a variant of the Oerlikon 35 mm twin cannon manufactured under licence by MKEK and an FCS including tracking radar and ETOS for engagements based on CMS-provided target data while full autonomous engagement will be assured by a 3D search radar addition. Thanks to its 35 mm twin gun system with a 1,100 rounds/min rate of fire for each gun and airburst ammunition (ATOM) developed by Aselsan, the system yields ship defence at an effective range of 4 km. The automatic linkless ammunition feed mechanism allows loading of both airburst and high-explosive incendiary ammunition at the same time, switching between 35 × 228 mm NATO-standard ammunition types as needed during operations. In addition to anti-ship missiles, Gökdeniz is also effective against helicopters, fighters, UAVs and asymmetric naval surface threats, capable of being installed on OPVs and medium-size vessels, according to MKEK. In addition to service with the Turkish Naval Forces, which qualified the system in May 2022, Gökdeniz initially found international success with the Turkmenistan and Pakistan navies followed by the Philippines according to Aselsan.

Guided Munitions and Medium-Calibre Guns

With the most widespread and versatile medium-calibre model, represented by the 76/62 mm Super Rapid (SR) gun mount and the new non-deck penetrating variant, the 'Sovraponte' 76/62 mm gun mount, Leonardo and the Italian Navy have been frontrunners in developing guided ammunition and directors. They achieved this initially with the SRGM in the Strales configuration and later with the long-range guided/unguided Vulcano family of 127 mm, 155 mm, and 76 mm ammunition. Centred on the high-speed (muzzle velocity of ~1,100 m/s) Driven Ammunition with Reduced Time of flight (DART) guided round with an effective range of over 8 km and equipped with a Ka-band antenna to provide semi-active guidance mounted on the gun, the SRGM Strales has attracted the interest of operators worldwide. Along with Colombia, the SRGM Strales is in service in the Middle East with Egypt and soon with the UAE, while in the Asia-Pacific region, India will join the userbase alongside Singapore which hasn't released any information but has shown renderings of the new equipped MRCVs (multi-role combat vessels). Taiwan also requested funding in its FY 2023 budget to arm its fleet of combatant vessels with SRGM Strales.

This capability is at the heart of the new Sovraponte 76/62 mm gun system, a new light gun mount, with almost 40% weight reduction compared to the SRGM, and lower footprint, along with no deck penetration. Characterised by a low-observable design extended to the air-cooled low-profile barrel and the Strales guidance package, the Sovraponte has the same rate of fire, number of ready-to-fire rounds, and capability to fire DART and Vulcano rounds as the SRGM.

In late June 2023, the Dutch MoD, being responsible for the ASW frigate joint programme on behalf of Belgium and the Netherlands, awarded Damen and Thales the contract for the design, construction and delivery of four ASW frigates (two each for respectively the Netherlands and Belgium). Following this, in July 2023, the Dutch MoD awarded Leonardo the contract for the supply of the 76/62 Sovraponte gun mounts to equip these ships, making the two Navies the first known international launch customers for this mount. Deliveries are planned from 2027, and the contract also include a spare gun, as well as options for additional three Sovraponte systems to equip the Karel Doorman and John de Witt

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Credit US Navy

Thanks to the enhancements introduced with the RAM Block 2B version and the delivery of critical missile software-based capability package, the missile will be able to counter emerging threats, such as hypersonic weapons.

amphibious ships, and the new supply ship Den Helder, to be commissioned in 2025. These are expected to be followed by additional systems alongside the Raytheon RAM Mk 31 system for the Dutch Goalkeeper replacement.

The US Navy is also evaluating advanced technologies for medium-calibre ammunition under the Defense Advanced Research Projects Agency's (DARPA) Multi-Azimuth Defense Fast Intercept Round Engagement System (MAD-FIRES) demonstration programme. It advances fire control and medium-calibre projectile technologies, and guided hit-to-kill technology enabling the multiple, simultaneous target, kinetic engagement mission at greatly expanded raid sizes. MAD-FIRES was developed by Raytheon Missiles & Defense, along with together with its target illuminator and engagement management system. The munition itself is a hit-to-kill 57 mm round, which is understood to use a semi-active radar guidance system along with rocket-assisted propulsion to extend range. According to the US FY2024 presidential budget request documentation, the last phase of the programme, is focused on demonstrating end-to-end system performance against surrogate supersonic targets, and is expected to conclude in FY 2023

Missiles

In October 2022, German Defence procurement agency (BAAINBw) awarded the RAM-System (RAMSYS) consortium a contract for supplying 600 rolling airframe missiles (RAM) Block 2B (RIM-116C), with deliveries to the German Navy starting in 2024. Developed under US/German co-operation by Raytheon and German RAMSYS consortium (MBDA Deutschland and Diehl Group's companies), the RAM MK 31 guided missile weapon system is an all-weather missile-based ILDS with an integral dual-mode (passive RF/IR) guidance, which switches to passive RF seeker after launch for acquisition lock/mid-course guidance and passing to IR seeker head for terminal phase. Fired by a 21-round MK 49 RAM GMLS launcher and Mk 15 Mod 32 SeaRAM system, the RAM munitions in both Block 1 and 2 versions are operational or under delivery with Egypt, Greece, Japan, South Korea, Turkey, UAE and more recently Qatar, Mexico and soon Saudi Arabia, in addition to the US and Germany. The Dutch MoD's selection of the RAM system in tandem with Leonardo's Single Deck gun to replace the Goalkeeper and the recent award of the Netherlands/Belgium contract for the new ASW frigates, the club of RAM customers will soon be enlarged.

The Block 2 version adopts a larger and more powerful motor and independent four-canard control actuators to increase effective range by about 50% and deliver a three-fold improvement in manoeuvrability, a digital autopilot and an enhanced passive RF seeker to defeat the latest classes of ASCM, while maintaining the proven capabilities of the RAM Block 0/1/1A. Today, the production and qualification activities are focused on the Block 2B, which, in addition to improved performance against multi-threat raid attacks (Block 2A), adds an upgraded IR seeker and missile-to-missile Link (MML) capability to allow communications between in-flight missiles for target prioritisation/allocation against complex raid threats.

According to the US FY2024 PB request, in the upcoming four fiscal years, the US Navy will focus on integration efforts with the new Combat System baselines for aircraft carriers and amphibious platforms under the Ship Self-Defense System (SSDS) Baseline 12 – RAM integration activities. The service will also correct issues found during Block 2B development flight tests and will launch agile development efforts to deliver critical missile software-based capability packages to counter emerging threats, such as hypersonic weapons. Preliminary investigations to support RAM integration on AEGIS destroyers will also be conducted. In Europe, Thales will be focused on in-

Credit Israeli MoD

Live firing trials conducted successfully by the C-Dome system on board the Oz Sa'ar 6 class corvette mark a significant step towards achieving the final operational capability of the system on Israeli Navy platforms.

tegrating RAM within the Above Water Warfare System (AWWS) fire control suite selected for both the German F126 and the joint Dutch/Belgian ASW frigate programmes.

In early June 2023, the Israel Missile Defense Organization (IMDO), in collaboration with the Israeli Navy and Rafael Advanced Defense Systems, announced the successful completion of a series of comprehensive tests for the Iron Dome naval version, called C-Dome. These tests, according to the press statement, mark a significant step towards achieving the final operational capability of the C-Dome system on the Israeli Navy's Sa'ar 6 class corvettes. The live fire test series conducted by the involved ship's crew included simulations of both existing and future threats that the Magen class ships may encounter in times of conflict, including rockets, cruise missiles, and UAVs.

Enabling hemispheric protection against saturation attacks, the C-Dome consists of one or more 10- round modular vertical launcher assemblies loaded with the same Tamir missiles as used in Iron Dome, possessing a maximum range of 10 km. C-Dome uses the host ship's surveillance radar, without requiring a dedicated fire control radar, while the weapon command and control unit is integrated with the ship's CMS. C-Dome is sufficiently compact to allow installation on smaller vessels such as the future Israeli Navy's Reshef class corvettes. During IMDEX 2023 Rafael unveiled the C-Dome Mission Module solution for naval platforms. This is effectively a platform-agnostic, modular variant of C-Dome intended to both allow retrofitting to older vessels, or mounting on ships which do not possess an organic self-defence capability, such as logistics support vessels. It includes a radar-equipped command and control (C2) shelter which carries out

Credit MBDA

In addition to France, the MBDA weapon system, together with its naval launchers including SIMBAD, SADRAL and SIMBAD-RC systems, are in service with Indonesia, Norway, Saudi Arabia, the Philippines and more recently Turkmenistan and Senegal.

Credit: BAAINBw

On 30 August 2022, the German frigate Sachsen successfully engaged drones at short and very short-range in the Baltic Sea test range. This was a German Armed Forces' first shipboard laser weapon firing, which was developed together by MBDA Deutschland and Rheinmetall Waffe Munition GmbH with BAAINBw.

target detection and fire control, as well as a launcher module which can accommodate two 10-round vertical launchers, with both shelter and launcher fitting within the floor space taken up by a 20 ft ISO container.

During IDEF 2021, Turkish Roketsan unveiled a one-third size scale model of its Levent naval short-range missile defence system set to be embarked on light vessels for domestic and international markets and capable of countering different threats. The system can be armed with two different types of missiles, depending on the target and intercept range – the Sungur and the Levent missiles. The Sungur is a very short-range air defence (VSHORAD) missile with a minimum range of 500 m, a maximum range of 8 km and capable of attaining a maximum altitude of 4 km. In terms of guidance, it is equipped with an imaging infra-red (IIR) seeker, and operates in lock-on-before-launch (LOBL) mode only. Powered by a dual-thrust solid propellant rocket motor, and is understood to be fitted with an HE-FRAG warhead with programmable fuze delay modes. Levant was in the concept design phase in mid-2021, with the missile envisioned to be is larger than the Sungur. Preliminary specifications state that the missile will weigh 70 kg, with a main body diameter of 128 mm and a maximum range of 11 km. Guidance is due to be based on a passive RF and IIR seeker. According to information released by Roketsan in May 2023, the first firing trials will be carried out at the end of 2023.

The expansion of the MBDA Mistral 3 userbase by ground forces is expected to foster the missile's selection by new naval operators. The Mistral 3 is the latest variant of the missile family, and is equipped with new guidance and electronics, and improved range out to approximately 7 km. The missile is equipped with an IIR seeker developed by Safran which possesses sophisticated image processing capabilities, enabling the engagement of surface and aerial asymmetric threats with low-thermal signature such as small UAVs and turbojet-powered missiles in addition to resistance to countermeasures. In addition to France, the Mistral family, including naval launchers in single or dual-launcher configurations, as well as SIMBAD, SADRAL and SIMBAD-RC systems, are in service with Indonesia, Norway, Saudi Arabia, the Philippines, and more recently Turkmenistan and Senegal.

Credit DGA

The French DGA agency, CILAS and the French Navy successfully conducted the first test campaign in June 2023 for the HELMA-P anti-drone laser effector from a service vessel.

The Advent of Naval Laser Weapons?

In February 2022, the US Navy completed the first test where an all-electric, high-energy laser (HEL) weapon was used to defeat a target representing a subsonic cruise missile in flight. Known as the Layered Laser Defense (LLD), the weapon was designed and built by Lockheed Martin to serve as a demonstrator. The drone shoot-down by the LLD was part of an Office of Naval Research (ONR) demonstration at the US Army's High Energy Laser Systems Test Facility at White Sands Missile Range in New Mexico in partnership with Lockheed Martin and the Office of the Under Secretary of Defense (Research and Engineering). Lockheed Martin has been working together with ONR to provide an embarked directed energy weapon (DEW) capability based on the LLD system to potentially be inserted into Phase two of the 'Littoral Combat Ship (LCS) lethality and survivability' upgrade programme, which will be defined in 2024.

As part of the US Navy Laser Family of Systems (NLFoS), the Navy is working on the High Energy Laser Counter ASCM Project (HELCAP) to develop and demon-

strate various laser weapon technologies and methods of implementation required to defeat ASCMs in a crossing target engagement. A 'detect to defeat' demonstration of surrogate ASCMs, including static and dynamic ground targets and low-cost unmanned aerial targets, is planned to be conducted between 2Q FY 2023 and 4Q FY 2024.

Exploiting the testing and live firing campaigns already conducted on the land-based Iron Beam HEL, during IMDEX Asia 2023, Rafael announced the development of the Naval Iron Beam version, meant to be installed also on smaller platforms with the first planned application being the future Israeli Navy's Reshef class corvettes. According to Rafael, the naval version will take four to five years to reach operational availability, and will be available in two configurations: integrated or modular standalone.

European industry has conducted a series of live tests on small drones, but in most cases the ultimate goal of these activities is expected to be the capability to engage and neutralise the threat coming from missiles as well as artillery shells and rockets in joint armed forces efforts.

On 30 August 2022, the German frigate Sachsen successfully engaged drones at short and very short-range in the Baltic Sea test range. This was a German Armed Forces' first shipboard laser weapon firing, which was developed together by MBDA Deutschland and Rheinmetall Waffe Munition GmbH. Although future DEW will be deployed to defeat asymmetric threats, the system can also be designed for greater output, enabling it to destroy guided missiles and mortar rounds. Expected to run until mid-2023, these tests lay the foundation for the possible development of an operational laser weapon system for the German Navy, according to managing agency BAAINBw.

About two months later, MBDA and its partners in the UK MoD's DragonFire consortium have successfully carried out the first static high-power laser firing of a domestic UK capability at the Defence Science and Technology Laboratory (Dstl) range in Porton Down. Using QinetiQ's phase-combined laser demonstrator, generating power in the order of 50 kW, focused by Leonardo's beam director and delivered using MBDA's advanced image processing and command and control system, the trials showed that DragonFire could safely control and focus a high-power laser onto a precise point at long range.

In September 2021, the UK MoD awarded the contract to a national industrial team led by Thales UK, which includes BAE Systems, Chess Dynamics, Vision4CE and IPG, for the development and delivery of a direct laser energy weapon demonstrator for user experimentation on a Royal Navy Type 23 frigate starting in 2023.

In mid-June 2023, the French DGA agency, CILAS and the French Navy conducted a test campaign for the High Energy Laser for Multiple Applications-Power (HELMA-P) counter-UAV laser effector on board the French Navy's Forbin air defence destroyer in the Mediterranean Sea. These tests open the door for further development of the prototype with a view to its long-term integration into French Navy ships. During the follow-on Paris Air Show 2023 edition, CILAS revealed the new system design which they had developed in co-operation with Ariane Group. According to CILAS, French industry is also working on the higher-power HELMA XP model to be available in 2027, and aims to be capable of defeating UAVs at longer ranges, but also combat the rocket, artillery, and mortar (RAM) threat.

Offshore Patrol Vessels: The Swiss Army Knife of Modern Navies

Jean Auran

Hundreds of Offshore Patrol Vessels (OPVs) are already widely operated worldwide, and more than 200 will be launched in the coming years. These small vessels now form the backbone of many countries' coastal maritime operations, protecting against various threats, including terrorism, smuggling, drug and human trafficking, illegal fishing, and illegal immigration.

The roles taken up by OPVs are highly varied – alongside the aforementioned tasks, they also play a key role in search and rescue, environmental protection and securing critical maritime infrastructure such as offshore oil rigs. They patrol from the Arctic regions to the vastness of the Pacific Ocean, particularly in exclusive economic zones (EEZs). Shipyards compete to improve the capabilities of their ships, concentrating a maximum amount of equipment on platforms with limited space available. This article looks at OPVs ranging from the smaller end at 500 tonnes to significantly larger vessels over 2,500 tonnes.

OPV Characteristics in 2023

Current patrol vessels have evolved to increase their capabilities and scope of missions. Offshore service (supply) vessels, renowned for their robustness and endurance, have inspired modern designs; some hulls have been designed to obtain better performance at low speeds, which reduces the wake, eddies, and vertical acceleration on the rear. French shipyard Kership adopted C-SHARP (Combined-Speeds Hull with All-Round Performances), an innovative hull design developed with the Nantes Research Laboratory in Hydrodynamics, Energetics and Atmospheric Environment (LHEEA); C-SHARP offers high performance at both high and low speeds.

In terms of weaponry, this varies depending on the OPV's intended use. While some patrol vessels have only light arma-

Author

Jean François Auran is a retired French Armed Forces officer and a Defence and Security Analyst.

Credit: Spanish Navy

OPVs can be heavily armed like the Egyptian Navy's ENS S. Ezzat.

Credit: Spanish Navy

Most ships carry remote weapon stations, which are useful against sea targets, but also against air or missile threats.


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Credit: Liteye System Inc.

Most patrol vessels have sophisticated sensors for identifying threats.

Credit: Spanish Navy

Seahawk aboard the Spanish Navy patrol boat Relampago.

ments, others have a 76 mm gun. The lightest vessels are equipped with 20 mm and 30 mm remote weapon stations (RWSs). In this category, we can mention Leonardo's Lionfish 20 mm RWS with 250 ready to fire rounds and the Oerlikon KAE cannon, which has a cyclic rate of fire of 1,000 rds/min and an effective range of up to 2,000 m. Nexter/KNDS markets the NARWHAL (NAval Remote Weapon, Highly Accurate, Lightweight) incorporating the Nexter M621 chambered in 20 × 102 mm, or the more powerful M693 which is chambered in 20 × 139 mm and has an effective range of approximately 1,500 m. The US uses the Mk44 Bushmaster II 30 mm automatic cannon,, and is now offered on various stabilised RWSs, including the Aselsan SMASH. The lighter units suit 12.7 mm solutions such as the Belgian Sea Defender, Swedish Trackfire and Israeli Wave 350 from Elbit Systems. This type of weapon is appropriate for most operations.

OPVs can also carry anti-ship missiles such as the MM40 Block 3 Exocet or the RGM-84L Harpoon. Philippine Navy ships receive the Korean-built SSM-700K C-Star missile with a maximum range of 180 km. The Senegalese Navy's three Walo class (OPV 58 S) vessels will receive the MARTE Mk2/N missile from MBDA, a light missile weighing 310 kg with a range greater than 30 km. Another possibility is to mount the Brimstone maritime missile, which weighs only 50 kg, and range is understood to be approximately 12 km for the Brimstone 3B variant when surface-launched. All OPVs have one or more Rigid Hulled Inflatable Boat (RHIB), allowing for onboard inspection teams, thereby accelerating their action when necessary. Most have a rear ramp for quick boat deployment while another RHIB is commonly positioned under the davit on the deck.

Most OPVs implement aerial and maritime surveillance drones. Here we can mention the SMDM mini-drone capable of operating within a limited range of 50 km, in service with the French Navy. On its River class, the Royal Navy deploys the Puma 3 AE drone, which is 1.4 m long, has a wingspan of 2.8 m, and can fly for two hours. Some OPVs accommodate helicopters such as the AS.365 Dauphin, Seahawk and NH90. The majority can perform a vertical replenishment, or VERTREP, to bring supplies or conduct medical evacuations.

Some OPVs have surface-to-air defences, such as the VL Mica missiles, installed on the OPV Al Shamikh of the Royal Navy of Oman. Pakistan is willing to acquire the RIM-116 surface-to-air missile for its new OPV from Damen shipyard. Vessels are fitted with navigation radars, marine and air surveillance. Multiple models, such as the Kelvin Hughes Mk11 SharpEye air and surface surveillance radar, are available on the market. Thales offers the NS50 with associated air/surface surveillance and fire control functionalities. The Dutch Navy's OPV Holland was the first to receive the Thales integrated mast IM 400, incorporating the Thales Sea Watcher 100, and Sea Master 400 radars, as well as observation and communication systems.

Terma's Scanter 6000 radar is also widely deployed for new-generation OPVs, which are all equipped with optronic turrets. We can also mention the installation of a three-sensor gyroscopically stabilised optronic system Argos-15HD on certain units or the Sea Eagle optronic system from US company Liteye or Gatekeeper from Thales. Most are equipped with an information management system and Link-11 and Link-22 data link systems for NATO countries. The 12 Australian Arafura class vessels will receive an iXblue Inertial Navigation System (INS), providing them with highly accurate and reliable navigation capabilities in all environments, including within Global Navigation Satellite System (GNSS)-denied operational areas.

Current Acquisition Programmes

Demand is strong for OPVs and there is an increasingly diversified offer. If Western navies lightly arm their OPVs because they have frigates and destroyers, emerging countries' navies tend to equip them more robustly because they constitute

Credit: French Navy

The OPV Auguste Bénébig (P779) has reached her base at New Caledonia.

their main naval assets. Nevertheless, the broad trend is toward increasing the size of patrol vessels to take on a wider range of missions.

Strong Demand in the Gulf of Guinea

African countries have long neglected the protection of their maritime access and their EEZ. That lack of investment has enabled the development of maritime piracy and illegal, unreported, and unregulated (IUU) fishing. Recently, countries in the Gulf of Guinea have been acquiring new units. Even if the units remain modest because of ownership costs, there is an increase in their size and their capacities. In North Africa, the Royal Moroccan Navy ordered the Avante 1800 Patrol from Navantia. The vessel is 89 m long, 13.3 m wide, with a complement of 46. The ship will receive a 76 mm gun, a missile launcher, modern sensors, and radars and can accommodate a helicopter. The country already operates five OPV 64 vessels and one OPV 70 built by STX and Raidco Marine.

The Piriou shipyard in Concarneau delivered the Walo to the Senegalese Navy on 2 June 2023. This is the first of three missile patrol vessels ordered in 2019 from the French manufacturer. This 62.2-m-long ship with a draft of about 3 m will be the most heavily armed of the Senegalese vessels with a 76 mm OTO-Melara turret and two remotely operated guns. The Polaris mission system from Naval Group will manage all armament and sensors. The OPV 58S will be able to implement aerial or underwater drones suitable for deploying commandos, including combat swimmers. The country also has the OPV Fouladou made by manufacturer OCEA. It is the largest aluminium OPV in Europe, 58 m long and 9.4 m wide. The platform's stability and noise levels are excellent, even without including its pair of Naiad Dynamics fin stabilisers. No less than 27 shapes of hulls have been evaluated to find the best design. In addition to its navigation and surveillance radars, the Fouladou is equipped with a Vigy observer optronic system in its mast. It has a RWS from MSI Defence Systems armed with a 30 mm cannon installed on the foredeck. The ship has FRSQ 700-type aluminium-hulled RHIBs, which can exceed 35 kn and carry about 15 people.

The Ivory Coast has also significantly strengthened its fleet by acquiring the RPB 33-type OPV. Ufast shipyard in Quimper built the Ivorian units based on a design provided by Camarc Design, a small British company. With a composite hull 33 m in length, these OPVs have a 6 m RHIB, and can be armed with a 20 mm cannon and two 12.7 mm machine guns. In March 2023, Ivory Coast received the high seas OPV 45 type patrol vessel Espérance (46.7 m long and 8 m wide), manufactured in Israel. This ship is armed with a Rafael Typhoon weapon station, which is understood to be equipped with a 30 mm automatic cannon, and two 12.7 mm machine guns. The vessel has a crew of 32 and range of 3,500 NM at 12 kn (22 km/h).

On 17 June, the Ghana Navy took delivery of two ex-US Coast Guard Marine Protector patrol boats supplied by the US. The Marine Protector class is 27 m long, with a displacement of over 90 tonnes. Two MTU diesel engines provide a top speed

Credit: OMT

First impression of the future Danish OPV.

Credit: Royal Navy

The River Class is in service with the UK, Bahrain, Thailand, and Brazil.

of 25 kn (46 km/h), providing a range of 1,700 km (and the capability to remain operational for up to three days). Nigeria, long decried for its maritime inaction, has strengthened its intervention capacities. We can mention the acquisition of several 32 m Ocea FPB 98 MKI vessels. On 6 June 2023 in Abuja, a contract signing ceremony was held between the Nigerian Navy and Turkey's Dearsan Shipyard to construct a new 57-m Tuzla class patrol ship. South Africa is building four units of the Damen-6211 type, which constitutes the Warrior class, to improve control of its maritime borders.

A Dynamic European Market

Several European countries have plans to equip or renew their patrol ships, including France, Portugal, and Denmark. The French Navy participates in two OPV programmes; these are for six Patrouilleurs Outremer (POM) of which two will be based in New Caledonia, two in French Polynesia and two in the island of Reunion. The last of these six POM ships should be delivered at the end of 2025. French company Mauric designed the ship and Socarenam ensured the construction in Saint-Malo and then in Boulogne-sur-Mer.

The vessels have a steel hull and aluminium superstructure measuring 79.9 m in length and 11.8 m wide, with a draft of 3.5 m. The new patrol vessels, which can move with a full load of 1,298 tonnes, are equipped with a passive stabilisation system comprising two water tanks on the deck, just in front of the gangway. They have a maximum speed of 24 kn and can operate without refuelling for 30 days. From 0 to 12 kn, they use only electric propulsion, after which the two main diesel engines are employed from speeds of 12 to 22 kn, with diesel and electric propulsion combined to reach 24 kn. The armament consists of a Nexter's NARWHAL and an optronic solution supplied by Exavision. The POM can operate the Navy's Mini Aerial Drone System (SMDM) to expand its surveillance and identification capabilities. The Aliaca is a light fixed-wing tactical drone developed by French company SURVEY Copter, a subsidiary of Airbus. The drone is 2.2 m long with a 3.6 m wingspan, and weighs only 16 kg. The Aliaca fields a TV/IR camera (with ×30 zoom) and an Automatic Identification System (AIS) receiver.

The 2024-2030 military programming law foresees the construction of ten patrouilleurs hauturiers (PH) to replace the D'Estienne d'Orves class (Type A69 Aviso) and three OPVs. Seven will be delivered between 2024 and 2030 and three more between 2030 and 20357. The DGA notified Naval Group in October 2021 of the contract relating to the preliminary and detailed design of the ships. Piriou, CMN and Socarenam will secure the construction together in a consortium. The main armament will consist of the RapidFire RWS, developed by Nexter and Thales, and armed with a 40 mm CTAS cannon. The vessels will be equipped with up to three RHIBs, should be able to reach 22 kn (41 km/h), with a 40-day autonomy, while being able to navigate 5,500 NM at an economical pace. An NS54 radar and a BlueWatcher hull sonar will equip the PH, and Naval Group will provide the combat system.

Portuguese shipyards are building a second series of six Viana do Castelo OPVs, while four are already in service. The new units will join the Portuguese Navy between 2026 and 2030. The ship has a 30 mm cannon, two RHIBs and can operate a Super Lynx MK95 helicopter. The ships operate unmanned systems, a single Sagem SA Vigy 10 MKIII naval surveillance and observation platform, three water cannons, and two rigid inflatable boats. The United Kingdom is also a manufacturer of military vessels including OPVs. BAE systems was involved in the River or the Khareef class for Oman. HMS Spey is the fifth in the series and entered service in June 2019. BAE Systems in Glasgow built all the vessels belonging to Batch 2 (the ships Forth, Medway, Trent, Tamar, and Spey). Babcock International has a portfolio of class-leading inshore patrol vessels (50 m long) and OPVs (90 m long). A few years ago, the company delivered four patrol vessels for the Irish

Credit: Cotecmar

Several South American countries have modern patrol boats, some of which are locally built.

Naval Service, based on a Vard Marine Inc. (formerly STX Marine) design.
Denmark has just launched a programme to acquire new patrol vessels with the configuration still needing to be finalised. Danske Patruljeskibe K/S – a consortium founded by Terma, Odense Maritime Technology and PensionDanmark – leads the project. Seven European states, along with two observers are involved in the European Patrol Corvette (EPC) programme, which aims to develop new missile corvettes and OPVs. It is possible that the change in strategic context will have an impact on the development of this programme. Turkey will soon launch the TCG Akhisar (P-1220), which is the first of ten Hisar class OPVs. These vessels are derived from the MILGEN corvette, but are streamlined to be made faster and cheaper.

Bright Prospects in Asia-Oceania
Demand is high in the Indo-Pacific region. Dutch shipyard Damen supplied the Pakistan Navy with the PNS Yarmook, built in Galati (Romania) and commissioned in February 2020. The vessel is based on the Damen OPV 1900 design and features an overall length of 91.3 m, a beam of 14.4 m, and a hull draft of 4 m. The patrol ship will be equipped with the CM-302 supersonic anti-ship cruise missile (ASCM).
The Philippine Navy (PN) is strengthening its capabilities to face China and in this regard, the Philippines Department of National Defence (DND) has signed a contract with Hyundai Heavy Industries (HHI) to construct and deliver six new OPVs. The ship has a length of 81 m, a beam of 13.1 m, a draft of 3.5 m, and a maximum speed of 21 kn. It also is armed with a 76 mm main gun, a remote-controlled weapon station carrying a 30 mm secondary gun, and two MBDA Simbad-RC launchers for the Mistral missile family.
Australia has launched an extensive procurement programme to replace existing Armidale class and Cape class patrol ships. German shipyard Lürssen's OPV 80 gained the contract after a lengthy process to form the Arafura class, which is 80 m long and has a maximum speed of 20 kn. The first two vessels are already under construction by Lürssen Australia and ASC in Adelaide. Lürssen Australia and Civmec will build the remaining ten vessels in Henderson, Western Australia. The Royal Australian Navy (RAN) is in talks to procure a containerised variant of Rafael's C-Dome to increase the firepower of its future OPV.
China produces different models of OPVs which are mainly operated by the Chinese Coast Guard. The country sold this type of patrol boat for military use in African countries – for instance Nigeria operates two P18N type OPVs.

Sustained Demand in South America
Countries in South America are also keen on patrol ships, which are often heavily armed. The Mexican Navy has many patrol vessels and in 2020, it commissioned the long-range OPV, ARM Reformador. Renamed Benito Juárez, the ship is based on the Damen shipyard's SIGMA 10514 design, displacing 2,570 tonnes, with a length of 105.1 m, a beam of 14 m, and a draft of 3.7 m. Reformador has Thales' Tacticos combat management system, SMART-S air/surface surveillance radar, and Stir EO fire-control radar. Armament includes RGM-84L Harpoon Block II surface-to-surface missile launchers, RIM-116 RAM Block II surface-to-air missiles, Raytheon MK 54 Mod 0 torpedoes, a 57 mm BAE Systems Bofors Mk 3 gun, and four mounts for 12.7 mm machine guns.
The Colombian shipyard Cotecmar has just completed the first block of the Colombian OPV 93 hull, ordered at the end of 2022. The vessel is a 100% Colombian design adapted to the Colombian Navy's operational needs and the region's navies since it should also be exportable. The vessel travels at a maximum speed of 18 kn (33 km/h) and has a range of 10,000 NM (18,520 km) at 12 kn (22 km/h). Chile was the first country to order two OPV 80 ships from Fassmer; these large OPVs have exceptional sea-keeping characteristics. Their hull design makes them fully seaworthy and suited for naval and coastguard missions with a range of over 10,000 NM.

The Middle East
The various navies of countries in the Gulf have received countless OPVs, several of which are from Italian and Spanish shipyards. On 28 December 2022, Edge Group's ADSB (Abu Dhabi Ship Building) PJSC announced the steel-cutting ceremony for the first Falaj 3 for the United Arab Emirates Navy. These vessels have a length of 60 m, move 641 tonnes at a speed of 26 kn, with a range of 2,000 NM and are based on the Italian Diciotti class. Qatar also has Italian-built ships as Fincantieri has developed the Musherib class for the Qatari Emiri Navy with a displacement of 745 tonnes, and 21 days of endurance. The armament comprises an OTO Melara 76 mm gun, eight VL-MICA surface-to-air missiles, four MM40 Block3 missiles, and two 20 mm cannons.

Wrapping Up

To conclude, OPVs perform a growing number of missions, with capabilities now including the launching of anti-ship missiles or engaging land targets. Despite the dominance of European countries in the market, new local players can build good-quality ships. While new producers have emerged in Latin America and the Middle East, Turkey could also become a dynamic player in this sector. ■

Staying Ahead of the Game: Type 26 Targets Evolving ASW Challenge

Dr Lee Willett

The UK Royal Navy's Type 26 frigate is designed specifically to address the anti-submarine warfare (ASW) threat. Given the continued increase in the ASW threat, the frigate's design has wide appeal.

For Western navies operating in the Euro-Atlantic theatre, the core tasks of traditional, high-end naval warfare hold enduring importance today. The operational presence of Russian surface action groups, featuring new frigates and the combat-proven Kalibr long-range anti-ship/land-attack sea-launched cruise missile (SLCM), underlines the need for anti-surface warfare (ASuW) capability. Kalibr and other Russian cruise and ballistic missile capabilities point to the importance of enhancing anti-air warfare (AAW) capability, plus integrated air and missile defence (IAMD) when considering the robust activities of Russian maritime aviation across the region. The Russo-Ukraine war has underscored the territorial risk in the land domain, meaning that amphibious and wider littoral capabilities must be honed to deter and defend against any threats to, for example, NATO member state territories on the alliance's northern flank.

Underpinning these threats is the underwater domain. Russian submarine Euro-Atlantic presence ranges from under-ice activity in the High North down to operations in the congested waters of the Eastern Mediterranean, and above critical seabed infrastructure and below critical sea lines of communication (SLOCs) in between. Russian submarine activity presents probably the biggest strategic, operational, and tactical challenge for NATO and partner navies. New Russian boats are increasingly quiet and increasingly capable (including carrying Kalibr): they are also being operated more effectively, regularly, and widely across the region, and in greater numbers.

Tackling the complexity of the ASW threat requires a layered approach. NATO's major submarine operators – especially the nuclear-powered submarine (SSN) navies of France, the UK, and the US but also the various high-end diesel-boat drivers – are working increasingly closely to build integrated underwater domain coverage. In the air, the US, UK, and Norway are P-8A Poseidon operators, with Germany coming next. New, emerging technological concepts such as ASW barriers built around uncrewed system capabilities like gliders, autonomous underwater vehicles (AUVs), and extra-large uncrewed underwater vehicles (XLUUVs) are designed to be integrated with crewed sub-surface, surface, and air platforms, and to implement sonar detection concepts like multistatics, to address the submarine threat (especially across key choke points like the Greenland-Iceland-UK (GIUK) or Bear Island gaps).

The last layer, but certainly not least, is the surface ship. Many NATO navies are developing new multipurpose frigates with a focus on ASW. One of the most prominent is the UK Royal Navy's (RN's) Type 23 City-class frigate.

Credit: US Navy

The increasing threat from submarines is increasing the requirement for new and improved ASW capability, including in destroyers and frigates. Pictured is a US Navy (USN) Arleigh Burke-class destroyer captured on the periscope of a USN 688/Los Angeles-class nuclear-powered attack submarine.

Ahead of its Time

In some senses, Type 26 was ahead of its time. Work on what was billed from the outset as a frigate designed from the hull up as an ASW platform began at a time when the Russian ASW threat was only just beginning to re-emerge. Today, the fact that the Type 26's broader Global Combat Ship (GCS) design concept has been downselected for the Royal Australian Navy's (RAN's) Hunter-class future frigate and the Royal Canadian Navy's (RCN's) Canadian Surface Combatant (CSC) programme is testament to what Type 26 brings as an ASW platform designed to operate in the high-end naval warfare fight. Indeed, other countries may follow suit.

Author

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In March 2010, the Type 26 programme's assessment phase got underway, with a design contract award to BAE Systems. A demonstration phase contract followed in April 2015, with a build contract for the first three ships awarded in July 2017.

From the RN's perspective, given the rapidly growing and changing nature of the Russian submarine threat, it seems prescient to be preparing to receive into service a platform that brings primary focus on ASW, while still having the multi-mission capability common in contemporary frigates and certainly required for today's complex, integrated high-end fight. For the navy right now, commencement of Type 26 deliveries probably cannot start fast enough.

Eight Type 26s are replacing the eight ASW-focused Type 23 Duke class frigates. Four Type 26s are currently in build. Lead ship Glasgow entered the water on 2 December 2022, is due for delivery to the RN in the mid-2020s, and to enter service in 2028. In oral evidence given on 31 January 2023 to the UK House of Commons Defence Committee (HCDC), Commodore Stephen Roberts – the RN's Type 26 programme senior responsible owner – said that "[the RN is] expecting the ship to sail for its first sea trials sometime in 2024," prior to continuing outfitting work.

As regards overall programme delivery dates, Cdre Roberts explained that ships will be entering service on a drumbeat of 12 to 18 months after the first ship, with the final ship arriving in 2035. Build progress with ship two, Cardiff, is continuing. On 21 June 2023, shipbuilder BAE Systems announced that the forward section had emerged from the build hall in Govan, Scotland. The company's statement added that the aft section would follow in the coming days, as the yard prepares to join the ship together outside on Govan's hardstanding. Cardiff is scheduled for floating off in 2024. Ship three, Belfast, is in build.

Credit: BAE Systems

An artist's rendering (from 2017) of the Royal Australian Navy's future Hunter class frigate. The frigate is derived from the Type 26-based Global Combat Ship design.

In November 2022, BAE Systems was awarded a contract to build the final five ships. The keel for the first ship of this second batch, Birmingham, was laid on 4 April 2023. BAE Systems said, in its statement, that Type 26 build work is expected to be completed by the mid-2030s. Going forward, construction of a new shipbuilding hall at Govan will enable ships three to eight to be assembled undercover, and thus not vulnerable to weather-driven delays, the statement added.

Credit: BAE Systems

The bow section of the second Type 26 HMS Cardiff is rolled out of the shipbuilding hall at BAE Systems' Govan shipyard, prior to being joined with the stern section on Govan's hardstanding. In future, all ships-in-class will be assembled undercover, in a new shipbuilding hall currently under construction.

The multi-mission options within the 8,000 tonne full-load displacement Type 26 are reflected in its modular design and build, with a 24-cell Lockheed Martin Mk 41 vertical launching system (VLS) installed to enable a range of missile-based capabilities to be carried. The UK's investment in the Kongsberg/Raytheon Naval Strike Missile (NSM) provides one option here. AAW capability is provided by two 24-cell VLS launchers carrying the MBDA CAMM (known as GWS 35 Sea Ceptor in RN Service) air-defence missile. The flight deck is large enough to take a Chinook helicopter. A modular payload area can accommodate a mix of up to ten 20 ft ISO shipping containers, maritime unmanned vehicles, or small boats including rigid-hull inflatable boats (RHIBs).

Of course, the ASW capability stands out. The hull, machinery, and electrics are designed for enhanced acoustic quieting. Sub-surface sensing capability is provided by the Ultra Electronics Type 2150 medium-frequency hull-mounted sonar and the Thales Sonar 2087 low-frequency active/passive towed sonar array. The two medium helicopters slated for embarkation – the AW101 Merlin HM2 or AW159 Wildcat HMA2 – provide the organic air capability, including ASW.

Making Progress

Naturally, the build progress is good news for the navy. Speaking at the RN's 'First Sea Lord's Seapower Conference 2023' – co-hosted by the RN, the Council on

The UK Royal Navy's (RN's) first-in-class Type 26 frigate HMS Glasgow hits the water for the first time. Type 26 is designed from the keel up to address the anti-submarine warfare (ASW) threat.

Geostrategy, and King's College London at Lancaster House, London in May – First Sea Lord and Chief of Naval Staff Admiral Sir Ben Key noted that the decision to award the contract for the last five Type 26s was one of several bits of procurement 'good news' for the navy over the last 12 months, with other such news including new submarines and support ships, and vessels designed to tackle hybrid risks (including threats to critical undersea infrastructure). Pointing to the platform's flexibility, Adm Key noted that its Mk 41 VLS fit "will enable potential use of a large variety of current and future anti-air, anti-surface, ballistic missile defence, and strike missiles".

The procurement activity in recent years, including of Type 26, will deliver new capability in the coming years. "The next decade is one of real change for the RN; the investment is hugely welcome across a spread of capabilities," said Adm Key.

Building a high-end specification, high-end capability platform like Type 26 does not come cheap. In modern RN terminology, high-end platforms like Type 26 are referred to as 'exquisite' systems, but the navy notes in turn that 'exquisite' systems are needed to defeat 'exquisite' threats – like that posed by Russian submarines. Here, Type 26 will deliver a core military task that is of the highest politico-strategic importance for the UK – ASW protection of the UK's two strategic deterrents, the nuclear-powered ballistic missile submarine (SSBN)-based nuclear deterrent and the aircraft carrier-based conventional deterrent. "The primary purpose of Type 26 is to protect the continuous at-sea nuclear deterrent and the carrier strike group, so [the frigate] will be optimised for the North Atlantic and for blue water operations," said Cdre Roberts. Thus, the evident nature of the ASW threat raises the question of balancing cost against value for money, including quantity versus quality in platform numbers.

In the former context, Adm Key explained, "As we watch the increasing deployment by Russia of their most modern submarines, some of the very quietest in the world, you would expect me to be investing in the cutting-edge technology anti-submarine capabilities that allow us to detect, find, and if necessary defeat them," "This is not cheap – but I don't see coming second in the theatre ASW battle as a desirable option," he added. In the latter, Adm Key continued, "Clearly, I would welcome more ships, but that cannot be at the expense of being able to undertake the most complex tasks."

The relatively limited number of RN surface ships – a number that has reduced dramatically since the end of the Cold War – down to a force level of 19 destroyers and frigates – is certainly a focus area for the RN, in terms of improving availability in general. As regards to Type 26 availability in particular, the RN is already looking to do what it can to bring forward the in-service date for first-in-class Glasgow.

Cdre Roberts told the HCDC that the RN has about a dozen personnel posted onboard Glasgow to begin understanding the ship and its systems, develop standard operating procedures for the ship class, and engage with industry with an aim to advance development and planning. Such activity enables the RN to pursue any opportunities there may be to bring the delivery date forward.

Broader Developments

The strategic, operational, and tactical importance for navies of re-building high-end ASW capability, and the relevance of Type 26 to this requirement, is demonstrated by the fact that the RAN's and RCN's future frigate programme requirements are being met by derivatives of the Type 26-based GCS design.

Given current demand for ASW capability and the fact that select navies, for example in the Euro-Atlantic theatre, are looking at frigate replacement programmes, the UK believes wider-still interest in the design may exist. Speaking at the 'First Sea Lord's Seapower Conference 2023', Minister for Defence Procurement James Cartlidge said "At an industrial level, Type 26 continues to garner interest in the export market."

For the RAN, nine Hunter-class frigates will be delivered, starting in the late 2020s. For the RCN, 15 frigates will be delivered under the CSC programme, starting in the early 2030s. Both countries will be building their ships in-country.

For the RAN, Australia's recent Defence Strategic Review (DSR) – published in April 2023 – put forward some new principles that should underpin RAN and wider Australian Defence Force future force structures. For example, to enhance maritime power projection and build layered deterrence and defence through long-range offensive capability that can strike at and from the sea, the RAN "must have enhanced lethality – including through its surface fleet", the DSR stated.

Prior to the DSR, the RAN had already moved to enhance such lethality for the Hunter-class frigates, with the acquisition of NSM and Raytheon's Tomahawk land-attack SLCM to provide land-attack and anti-ship strike capability at different ranges (both missiles provide both capabilities, but Tomahawk brings greater reach).

The DSR underscored the need to assess whether the frigate fleet's strike capability can be enhanced further still, however. Two core strands in the requirement for this assessment are to enhance capability to protect Australia's extended SLOCs, and to enhance capability and operational complementarity with the RAN's new SSN capability, to be delivered under the SSN-

AUKUS submarine programme within the trilateral Australia/UK/US AUKUS strategic partnership. Thus, the RAN will be conducting an independent assessment of the surface fleet's force structure, force mix, and overall capability, including weighing the balance between the RAN's larger and smaller surface ship numbers. Review work is already underway, and is scheduled to be completed in the third quarter of 2023.

For the RCN's CSC, media reports at Euronaval in October 2022 noted that Canada aimed to complete preliminary design review work by early 2023, with production activities set to begin in early 2024.

Future Requirements, Future Opportunities

The high-end nature of the Type 26 capability and the high-end nature of the ASW threat limits the number of navies able to acquire the capability to meet this threat. Yet increasing submarine activity in certain locations around the world means that some navies are in a geostrategic position that dictates a need for specific focus on ASW capability.

The Royal Norwegian Navy (RNoN) is one such navy. The RNoN is beginning to assess requirements to replace its four in-service Fridtjof Nansen-class ASW-focused frigates. First, intensifying submarine activity in northern Europe means that Norway may increase its frigate numbers. On 7 June 2023, Norway's Ministry of Defence published 'The Military Advice of the Chief of Defence 2023'. In the report, Chief of Defence General Eirik Kristoffersen recommended that Norway should procure up to six new frigates, buying a multipurpose platform delivering ASuW and AAW capability but prioritising ASW.

Credit: US Navy

The Royal Norwegian Navy (RNoN) is set to start looking at requirements for replacing its in-service Fridtjof Nansen-class frigates (HNoMS Thor Heyerdahl is pictured). The RNoN will be looking to collaborate with international partners on design and build for the replacement frigates.

Second, Norway will be looking to use an international design for its future frigates, as it did when teaming up with Spain's Navantia and Lockheed Martin from the US for its Spain-built, Aegis combat system-capable Fridtjof Nansen ships. Speaking at the 'First Sea Lord's Seapower Conference 2023', the RNoN's Chief of Navy Rear Admiral Rune Andersen said that cost challenges and the need to enhance innovation in future designs and capabilities for high-end platforms mean Norway must seek a design that is not unique to the RNoN, as well as seeking deeper integration with like-minded countries on platform acquisition.

While Norway is not yet at the stage where it needs to downselect a future frigate design, relevant options could include (amongst others) the Spanish Navy's F-110 and the US Navy's FFG-62, as well as Type 26 itself.

The RNoN remains convinced that the need for credible high-end ASW capability remains clear. Speaking at the Royal United Services Institute's (RUSI's) Seapower conference, held in London in April, Rear Adm Andersen said that while there have been questions over the performance of Russian ground forces in Ukraine, "we don't transfer that to some of the maritime capabilities that have been prioritised for several years, in particular the submarine fleet, which is modern and capable. We don't underestimate the quality or effectiveness, and we see that in our daily operations". ■

Type 31/Arrowhead 140 Frigate Programmes: Status Report

Conrad Waters

Four years ago, at the time of DSEI 2019, Babcock International announced that its 'Arrowhead 140' design proposal had been selected as the preferred bid for the United Kingdom's Type 31 frigate programme. Since then, production of the new class has commenced at a new building hall at Babcock's Rosyth facility, from where the first ship of the class will be launched in the months ahead. Arrowhead 140 has also achieved early export success, with both Indonesia and Poland selecting the design for indigenous frigate construction. This article provides a status report on the progress that has been achieved with both the British and export contracts.

Project Origins

Arrowhead 140 traces its origins to a requirement to replace the ageing Type 23 frigates that currently form the core of the British Royal Navy's (RN's) surface fleet. The United Kingdom's 2015 Strategic Defence & Security Review determined that previous plans to replace all 13 ships of this design that were then in RN service with a single class of Type 26 frigate, also known as the Global Combat Ship, would be revised. Eight of the highly sophisticated and costly Type 26s would still be built to meet the requirements of 'high end' anti-submarine tasking. However, a new class of five less expensive, general purpose light frigates would also be acquired to maintain fleet numbers. These new light frigates quickly received the Type 31 designation.

Credit: Babcock International

A graphic of the British Royal Navy's Type 31 frigate, which is based on the Arrowhead 140 design, showing the basic configuration as of 2021. In addition to meeting the Royal Navy's frigate requirement, Arrowhead 140 has also gained early export success.

Author

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The programme to acquire the Type 31 was formally launched on 7 September 2017. The project was heavily influenced by the conclusions of a new British National Shipbuilding Strategy (NSS), which had been published the previous day. The NSS aimed to revitalise Britain's naval sector through, amongst other measures, a more cohesive approach to warship procurement and an increased focus on exports. The Type 31 acquisition was viewed as a priority programme within the NSS and the inter-related factors of affordability and exportability were to be an emphasis of its core design. It was intended to be an adaptable, modular frigate focused on less intensive maritime security roles, thereby releasing the RN's complex warships for 'high end tasks'. The focus on affordability was reflected in an average target cost of just GBP 250 M (EUR 290M) per unit for the five frigates, which were to be delivered from 2023 onwards. Yards would also be required to agree a fixed-price contract to build the ships. Whilst both a UK-owned design and a British build strategy were mandatory features

of the programme, the involvement of international suppliers willing to meet these requirements was encouraged.

Although initial interest in the Type 31 programme was encouraging, the demanding programme requirements soon reduced the number of potential participants. It also became clear during discussions with industry that there was reluctance to accept the level of risk associated with the programme given the challenges involved. This even resulted in the temporary suspension of the programme during mid-2018 whilst the way forward was evaluated. Finally, in December 2018, three groups were each awarded GBP 5 M (EUR 6 M) contracts to refine their design proposals. One of these was the Babcock-led Team 31, which also included Thales as a principal partner. The other finalists were consortia comprising BAE Systems and Cammell Laird, as well as Atlas Elektronik UK and thyssenkrupp Marine Systems. On 12 September 2019, it was announced that Babcock Team 31's Arrowhead 140 design had been chosen as the preferred bid to meet the programme requirement.

As a brief note on nomenclature, the Type 31 programme was initially designated Type 31e; the 'e' referring to export. Subsequently, the designation Type 31 has been used for the RN variant of the Arrowhead 140 design, with the Arrowhead 140 terminology being used for export campaigns. The national Indonesian and Polish frigates both use Arrowhead 140 as their baseline.

Credit: Conrad Waters

The development of the Arrowhead 140 design traces its origins to the need to replace the Royal Navy's ageing Type 23 frigates. This photograph shows HMS Kent, which was delivered in the year 2000.

Type 31 Design Description

The Arrowhead 140 design developed by Babcock as the basis for its Type 31 bid was derived from the Danish Absalon and Iver Huitfeldt class series of frigates built for Denmark in the early 2000s. They are directly based on the latter class's hull. Odense Maritime Technology (OMT), designers of the original ships, provided important technical assistance as part of Babcock Team 31. In particular, their expertise in adopting commercial practices to warship construction provided invaluable in meeting the affordability required in the new ships. Although the ships have not adopted the well-known Danish containerised 'StanFlex' system, OMT's heritage of involvement in modular designs was also a major factor in achieving the adaptability that was aimed for in the Type 31. British maritime and defence consultancy BMT also provided significant input into the Team 31 design effort.

With a length of 138.7 m, a maximum beam of 19.8 m and a displacement of around 6,000 tonnes, Arrowhead 140 is a larger vessel than the Type 31's original 'light' frigate designation would imply. This approach helps to ease ongoing maintenance and provides greater scope for through-life upgrades. Importantly, it also provides considerable flexibility with respect to meeting the varying equipment requirements of export customers. The design is sufficiently large to be equipped with a flight deck that can support a heavy helicopter and the hangar can house a rotorcraft of Leonardo AW101 Merlin size. Another nod to affordability is the use of a cost-effective and efficient combined diesel and diesel (CODAD) propulsion arrangement using four Rolls-Royce MTU 20V 8000 M71 engines. Given that the RN ships are not primarily intended for the anti-submarine warfare role, the noise penalties associated with this arrangement can be accepted.

Credit: US Navy

The Babcock Arrowhead 140 design is based on the hull of the Royal Danish Navy's Iver Huitfeldt class air defence frigates. This photograph shows HDMS Niels Juel, the third and final member of the class.

The 'digital heart' of the Type 31 Arrowhead 140 variant is provided by Thales' well-established 'Tacticos' combat management system (CMS). Its selection represented an important break-through into the UK CMS market, which had previously been dominated by BAE Systems. Thales is also responsible for the supply of other important electronic equipment used in the Type 31. This includes the class's integrated communications system and NS110 surveillance radar. Actual weaponry is reflective of the new ships' proposed maritime security role. In addition to the MBDA Sea Ceptor surface-to-air missile system, each frigate will be equipped with one 57 mm BAE Systems/Bofors 57 Mk3 (US Navy Mk 110) and two 40 mm BAE Systems/Bofors 40 Mk 4 naval guns.

Credit: Babcock International

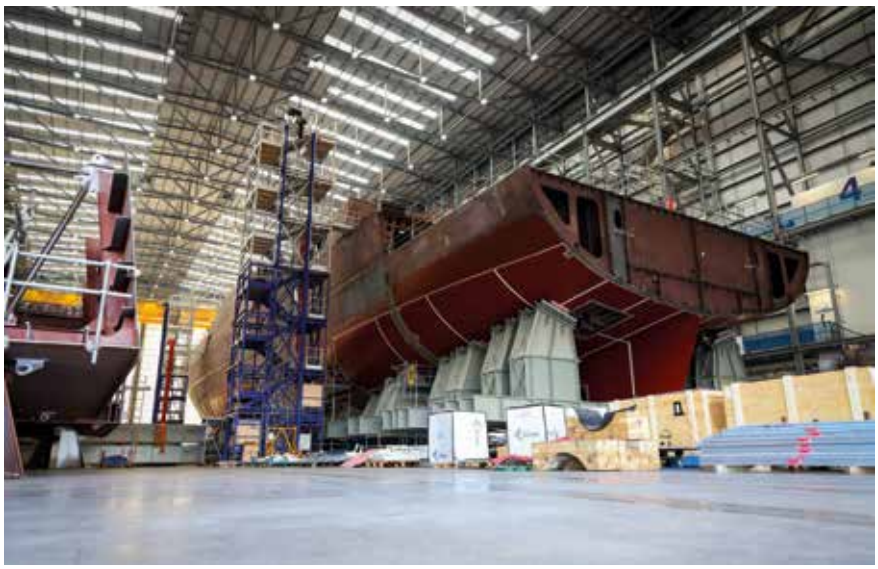
A generic graphic of the Arrowhead 140 design that was released at the time Babcock Team 31 became preferred bidder for the Type 31 contract. The family resemblance with the Iver Huitfeldt class is obvious.

UK Progress

The selection of Babcock Team 31 as preferred bidder for the Type 31 programme was followed by the award of a formal construction contract on 15 November 2019. Announcement of the agreement confirmed that the average production cost of GBP 250 M per ship targeted at the time of programme launch had been achieved. However, it seems that this ambition was only met by excluding additional expense in areas such as government furnished equipment from the headline figure. By this stage, initial hopes that the first ship in the class would be delivered by 2023 had also been adjusted. Instead, the aim was to have the lead frigate launched by 2023, with manufacturing of all five ships completed by 2027/2028. It was also intended that May 2027 would see the first Type 31 complete crew training and validation to enter full operational service.

Despite these revisions, implementation of the Type 31 programme has subsequently proceeded at pace. A key element of Babcock's plan for delivering the new frigates is their assembly in a new covered construction hall at their site in Rosyth, near Edinburgh. Named the 'Venturer Building', this assembly hall provides a state-of-the-art ship building and integration facility utilising the latest manufacturing and information management processes. Measuring 147×62×42 m, it is equipped with two, 125 tonne gantry cranes and can support the simultaneous assembly of two frigates. Babcock believes that the assembly hall will benefit not only Type 31 delivery but also participation in subsequent British and international shipbuilding projects. Ground-breaking for the facility took place in April 2020 and it was completed in November the following year. By that time, work on the lead frigate, the future HMS Venturer, was already underway following an official first steel cutting ceremony by then British Defence Secretary Ben Wallace on 23 September 2021. The five ships of the class – Venturer, Active, Bulldog, Campbeltown and Formidable – will collectively be known as the 'Inspiration' class under a decision announced in May 2021.

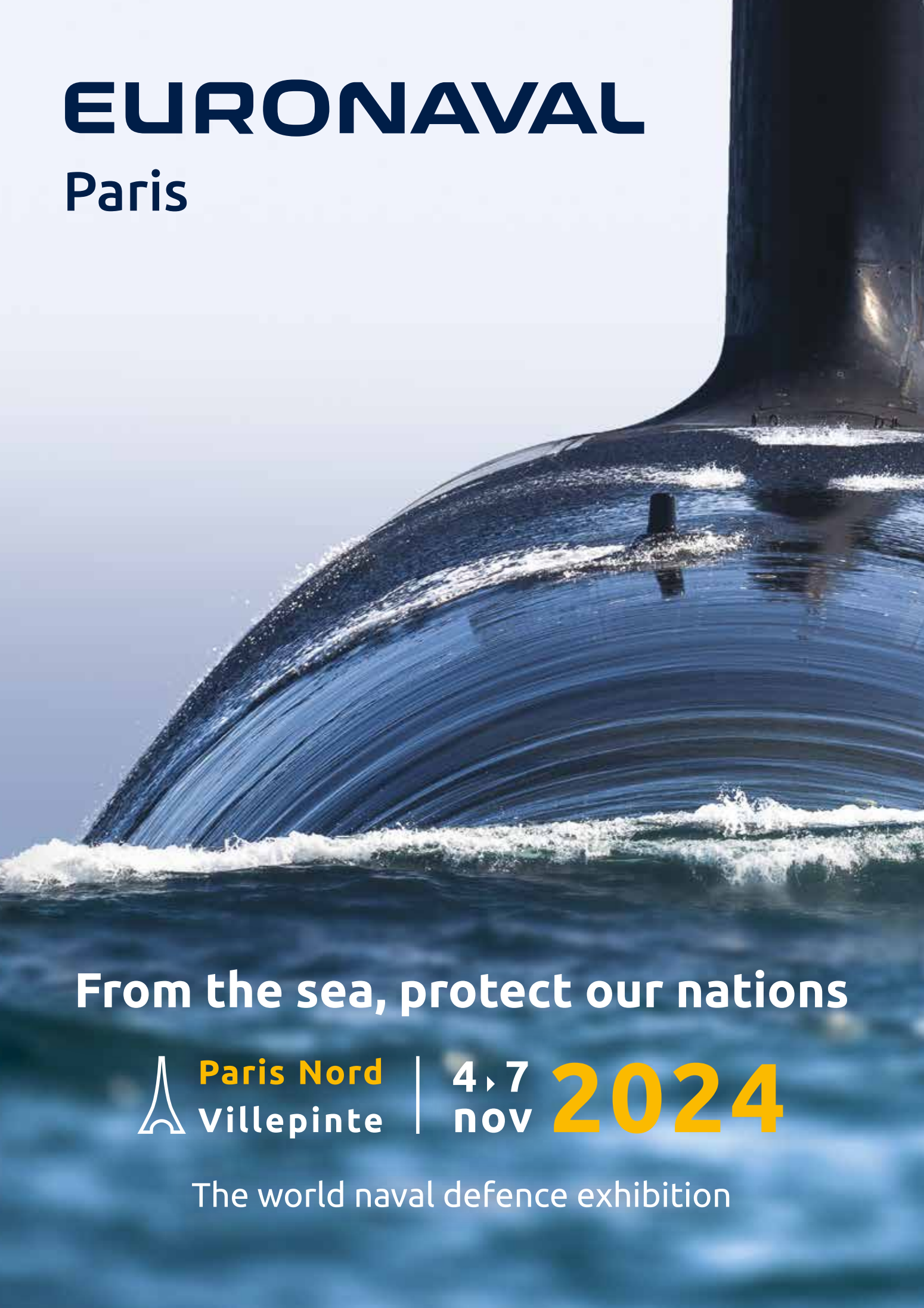
Credit: UK MoD



The lead Type 31 frigate HMS Venturer under construction in the namesake Venturer Building in July 2023. She is due to be launched by mid-2024.

The start of construction of HMS Venturer has been followed by the successful achievement of a number of other project milestones. The keel-laying ceremony for the lead frigate was held on 26 April 2022 and was followed by first steel cutting for the second Type 31, HMS Active, in January 2023. Subsequently, in July 2023, the British Ministry of Defence (MoD) reported that the initial crew members had been assigned to the first-of-class to help prepare for launch and subsequent delivery. At this stage, it was stated that, "Venturer is due to emerge from the construction hall at Babcock's Rosyth facility within a year". As of mid-2023, the official keel-laying of HMS Active was also imminent, thereby marking the start of simultaneous multi-ship assembly. All-in-all, the programme currently remains on track to meet a demanding production plan.

Despite the very real progress that has been achieved in the face of the COVID-19 pandemic, implementation of Type 31 construction has not been without its complications. In April 2023, Babcock announced that macroeconomic changes that had taken place since the contract was first agreed – likely the impact of high inflation – had resulted in an increase in actual and projected costs to deliver the programme as planned. They stated that they had entered a dispute resolution process with the MoD to establish who was responsible for this additional expense. In the event they cannot recover the costs, a loss of between GBP 60M and GBP 100M (EUR 70 M to EUR 115M) would need to be recorded. Babcock's 2022-23 accounts, released on 20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Credit: Babcock International

A computer generated graphic of the Polish Arrowhead 140-based Miecnik frigate. The design, which has evolved since this image was released in 2022, has similarities with the British Type 31 frigate but is equipped with a more comprehensive outfit of weapons and sensors in line with the Polish Navy's requirements.

July 2023, recorded a GBP 100.1 M provision against the Type 31 frigate contract. Another potential challenge relates to a decision revealed in May 2023 to increase the Type 31's warfighting potential by equipping the 'Inspiration' class with the Mk 41 vertical launch system (VLS). The basic Arrowhead 140 design is already configured to accept this weapon, but it is not yet known whether the work will be undertaken during build or at some later stage of the class's life. Answering a question asked by ESD via Babcock in June 2023, the MoD said, "Working closely with the US Department of Defence and US Navy, the UK Ministry of Defence have commenced an assessment phase to explore the options, installation opportunities, and costs associated with fitting T31 with Mk 41. At this time, it is too early to speculate on the timing of fitting this capability."

Export Success

As previously mentioned, a key driver of the initial Type 31 programme was to increase the exportability of British warship designs. Recognising the highly competitive nature of the global frigate market, Babcock sought to market Arrowhead 140 as a warship that could be readily customised to meet a wide range of national requirements whilst doing so in an affordable way. One of Babcock's leading advantages in developing this proposition was the extensive experience that it had already gained in providing maintenance and other support services throughout the world. This has enabled it to position Arrowhead 140 to deliver value for money not only in terms of initial capacity/cost considerations but also in subsequent through-life support. This can extend to the wholesale revitalisation or, even, creation of an indigenous shipbuilding sector. In September 2021, Babcock took the opportunity presented by DSEI 2021 to launch its Arrowyard product in support of this approach. Arrowyard brings together transfer of knowledge and technology options to enable the construction, final assembly and outfitting of Arrowhead 140 frigates, whilst supporting implementation of a sovereign in-service support capability.

It also seems likely that having the RN as Arrowhead 140's lead customer has proved to be another important advantage in export campaigns. This factor has been conspicuously absent from many other recent British warships that have been designed for export, robbing them of association with one of the world's most respected navies. To give just one example of the new approach, all Arrowhead 140 customers are able to join a RN-chaired Babcock AH140 user group. Here they can assimilate lessons learned during the design, build and acceptance stages, participate in concept of operations development and – eventually – share 'real world' operational experience. In any event, Arrowhead 140 looks set to be one of the most important British naval exports of recent times, already gaining two early sales successes.

Indonesia: Arrowhead 140 achieved its first export sale in September 2021 when Babcock signed a design licence contract with Indonesia's state-owned shipbuilder, PT PAL. The Indonesian Navy's requirement encompasses two frigates and is known locally as the 'Merah Putih' ('Red White') programme, after the colours of Indonesia's national flag. Babcock's responsibilities under this programme are to provide a comprehensive package of baseline Arrowhead 140 design materials, undertake technical liaison with counterparts in PT PAL during the build process, and provide whatever additional engineering support may be required. PT PAL meanwhile, as lead contractor for the programme with the Indonesian MoD, has responsibility for adapting the design to meet the Indonesian Navy's requirements, and will construct the frigates at their shipyard in Surabaya.

Physical implementation of Indonesia's Arrowhead 140-based construction began with a first steel cutting ceremony for the lead ship at Surabaya on 9 December 2022. The programme's delivery schedule has been determined between PT PAL and the Indonesian MoD. It is believed to involve delivery of this lead unit around the end of 2026. The equipment fit determined by the Indonesian Navy is reportedly optimised for the air defence role and, consequently, is different from that adopted by their RN 'half-sisters'. Another significant variation is the selection of Turkish company Havelsan's 'Advent' CMS to provide the Indonesian frigates' command and control (C2) functions.

Poland: Arrowhead 140's second export success was announced in March 2022 when Babcock was selected as the platform design provider and technology partner for Poland's 'Miecznik' ('Swordfish') frigate programme. Arrowhead 140 had previously been one of three designs initially shortlisted for the Polish require-

Credit: UK MoD

The first crew members assigned to the lead Type 31 frigate HMS Venturer line up in front of the ship's hull at Rosyth. The progress achieved with the Arrowhead 140-based Type 31 frigate and export contracts has helped to put the British naval sector back on the map.

ment alongside German tkMS MEKO A-300 and Spanish Navantia F-100 based proposals. The British and German designs had subsequently been down-selected for detailed consideration, with Babcock's offer winning out in this final phase.

Babcock has subsequently been awarded a number of contracts related to class design and transfer of technology activities pending conclusion of a design licence agreement that, as of mid-2023, was close to being finalised. This envisages the construction of three frigates based on the Arrowhead 140 design by the PGZ-MIECZNIK Consortium for delivery towards the end of the decade onwards. On 17 June 2023, an event was held at the PGZ Naval Shipyard in Gdynia to mark the start of work on construction of a ship hall and other facilities that will support the Polish ships' build. It is currently planned that a ceremony will take place at Gdynia on 16 August 2023 to mark the first steel-cutting for the lead ship.

Details that have emerged of the Miecznik frigate's configuration suggest a number of similarities with their British Type 31 counterparts. Notably, they will likely also incorporate a Thales Tacticos CMS and be equipped with the MBDA Common Anti-Air Modular Missile (CAMM) that forms the core of Sea Ceptor. However, the Polish ships will be outfitted as 'high end' general purpose frigates. Poland's specification of additional anti-surface and anti-submarine weaponry supported by suitably advanced sensors demonstrates the ease with which the baseline design can be flexed to accommodate various user requirements.

In addition to these initial contracts, Arrowhead 140 has formed the basis of a number of proposals to other countries incorporating construction options ranging from licensed build to full assembly at Rosyth. These include ultimately unsuccessful discussions to meet the Hellenic Navy's recapitalisation requirements. It has also been reported that the supply of an Arrowhead 140-based frigate to Ukraine was considered within the broad ranging Ukrainian Naval Capabilities Enhancement Programme (UNCEP) signed in June 2021, before the current war with Russia disrupted the country's naval modernisation plans.

Speaking to ESD in July 2023, Babcock stressed that the location of Arrowhead 140 construction for any future programmes would be entirely based on customer preference. They stated that, "Babcock's offer allows customers to take advantage of our Arrowyard concept and decide upon a range of services from the provision of export design licenses, through the additional provision of product design and build support services where the customer seeks to build the ships, or parts of their ships, in their own shipyards. Delivery of the entire programme of full design and build services at our Rosyth shipyard facilities in Scotland is also an option."

Current Arrowhead 140 Frigate Programmes

Programme	Country	No. of Ships	Shipyard
Type 31 Frigate	UK	5	Babcock, Rosyth, UK
Merah Putih	Indonesia	2	PT PAL, Surabaya, Indonesia
Miecznik	Poland	3	PGZ Naval Shipyard, Gdynia, Poland

The Way Ahead

The British RN's Arrowhead 140-based Type 31 frigate programme has clearly made considerable progress since Babcock Team 31 was selected as the project's preferred bidder some four years ago. Despite the significant disruption caused by the COVID-19 pandemic, construction to date has progressed largely in line with a timetable that was always considered aggressive compared with other British warship procurement. Moreover, Babcock's early achievement of overseas sales of the Arrowhead 140 design suggests that the focus on exportability engendered by the NSS has already started to achieve tangible results.

It has not all been plain sailing. The current dispute over the impact of unexpectedly high inflation on Type 31 programme costs is certainly an unwelcome distraction for a project that has otherwise served as something of a 'poster boy' for British shipbuilding's revitalisation. It should also be noted that Type 31 construction has yet to progress to the most complex, outfitting stage. This suggests that challenges to timely project delivery remain. In this regard, it is worth noting that the licensed-construction projects are at an even earlier stage in their implementation.

Nevertheless, both the RN Type 31 programme and Babcock's Arrowhead 140-based export sales are currently meeting the expectations set for them. Moreover, Babcock continues to leverage the adaptability of the Arrowhead 140 hull-form to incorporate a range of customer capability choices for ongoing export campaigns, as well as the requirements of the proposed British Type 32 frigate programme. The group's concept design team continue to develop other concepts and innovations in response to rapid technological advances and evolving customer expectations. Most importantly, Arrowhead 140 has proved the ability of its mix of capacity, flexibility and cost-effectiveness to disrupt the global shipbuilding market. In doing this, it is helping put the British naval sector back on the map.

On Patrol: Poseidon Brings Enhanced MPA Capability

Dr Lee Willett

The Boeing P-8A Poseidon maritime patrol aircraft is bringing enhanced presence and capability for NATO maritime operations, particularly in anti-submarine warfare and particularly in critical regions like the North Atlantic.

On 1 July 2023, the Norwegian Armed Forces announced on social media that the Royal Norwegian Air Force's (RNoAF's) Lockheed Martin P-3 Orion maritime patrol aircraft (MPA) fleet had conducted its last day of operations. Already waiting in the wings – and, in fact, already deploying on operations – was the RNoAF's new fixed-wing airborne anti-submarine warfare (ASW) fleet, in the form of the Boeing P-8A Poseidon MPA. "Now, our fleet of P-8 Poseidons take over the important mission of monitoring maritime areas in the High North region," the armed forces' statement added.

Norway has become the third member of the P-8A Poseidon club to be operating the aircraft in the Euro-Atlantic theatre, after the US and the UK – with Germany next up as the fourth member. Australia, India, and New Zealand are the established P-8A operators in the Indo-Pacific theatre, with South Korea and (possibly) Canada set to follow suit. Canada, with strategic interests across three oceans (the Atlantic, the Arctic, and the Pacific), would of course deploy its MPA capability across both the Indo-Pacific and Euro-Atlantic theatres.

The P-8A Poseidon has arguably now become the pre-eminent fixed-wing airborne ASW platform around the world. It has become so at precisely the time when the operational requirement for ASW capability has returned with some significance amongst Western and partner navies operating across these two theatres.

Credit: Forsvaret

A Royal Norwegian Air Force (RNoAF) P-8A Poseidon maritime patrol aircraft (MPA) is pictured operating out of the RNoAF's Evenes airbase, during the NATO 'Joint Viking' exercise in northern Norway in early 2023. Norwegian P-8A presence will add significant impact for NATO anti-submarine warfare (ASW) activities in northern waters.

In the Euro-Atlantic theatre, the RNoAF's P-8A presence at Evenes airbase, just south of Andoya, illustrates the geostrategic nature of the ASW challenge facing NATO and other navies operating in the region. MPA presence in that region traditionally has been focused on – and still needs to focus on – the Greenland-Iceland-UK (GIUK) Gap. The GIUK Gap has been a choke point that NATO forces have picketed – in the air, on the surface, and below the surface – to monitor, deter, disrupt, and defend against Soviet and then Russian submarine movements south through the Gap and into the North Atlantic. The enduring nature of the ASW challenge around the GIUK Gap has been underlined by the fact that several countries – the US, UK, and Norway, but also France and Germany – have worked together to provide MPA presence across the region, working out of RNoAF bases, but also UK Royal Air Force (RAF) bases in Scotland, and Iceland's Reykjavik airbase.

Today, the submarine threat is different. While in the Cold War days, the Soviet Union demonstrated more of a global presence, the Russo-Ukraine war (which broke out in February 2022, with Russia's invasion of Ukraine) demonstrated that Russia's geostrategic focus now falls much more on the European side of the Euro-Atlantic theatre. In this geostrategic context, Russia's development of improved submarine technology, when harnessed with key capabilities like the Novator 3M14 Kalibr long-range sea-launched cruise missile system, means that Russian nuclear-powered attack (SSNs), nuclear-powered guided-missile

Author

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Credit: Forsvaret

A USN P-8A is pictured deployed to Evenes airbase, northern Norway during 'Joint Viking' in 2023. With several NATO members now operating the P-8A, basing facilities are shared within a wider programme of collaboration on operations, logistics, and training.

(SSGNs), and diesel-electric submarines (SSKs) can all remain further North, in and immediately around Russian waters, while still being able to threaten targets ashore and at sea across Northern Europe.

Consequently, the geostrategic circumference of NATO's ASW focus has expanded, particularly to the east, to encompass what is now becoming known as the Bear Island Gap. Running south from Svalbard, past Bear Island, to northern Norway, and dividing the relatively shallow waters of the Barents Sea from the deep waters of the Norwegian Sea, the Bear Island Gap has become a new choke point for NATO forces to picket. Monitoring this new choke point and providing airborne ASW across it will be a key task for NATO MPAs.

Layered Capability

In terms of delivering ASW capability, MPAs provide just one of several layers – layers covering the air, surface, and subsurface environments – to provide capability for detecting, localising, classifying, and tracking a submarine target.

The airborne ASW layer deployed across Northern Europe includes rotary-wing aviation assets, such as the Lockheed Martin MH-60R Seahawk, Northern Helicopter Industries' NH-90, and AW101 Merlin HM2 ASW helicopters. In the ASW role, helicopters are used to deploy sonobuoys and dipping sonars. Destroyers and frigates provide the bulk of the surface coverage, not only embarking these and other ASW helicopters as their organic aviation capability but also carrying hull-mounted and towed array sonars. Below the surface, submarines and – increasingly – unmanned underwater vehicles (UUVs) including gliders and autonomous underwater vehicles (AUVs) provide sensing capability and, especially, capacity to track and target an adversary's submarine 'close in'. The sub-surface ASW layer also includes capabilities such as static seabed-based sonar networks.

Naval operators and analysts may say that the best way to hunt a submarine is with another submarine. Yet each layer contributes in different ways, hence the requirement for layered ASW. Today, such layers work in an ever-more integrated manner, for example through multi-static ASW operations, where multiple assets across the networked layers can process the acoustic 'pings' made by other assets, reducing the target submarine's ability to focus solely on the acoustic 'source' of the sonar 'ping' as the threat.

In explaining the broad role of an MPA capability in layered ASW operations, Dr Sidharth Kaushal –Research Fellow for Sea Power at the Royal United Services Institute (RUSI) think-tank in London – noted that an MPA provides, in effect, the second layer in this ASW capability. As the first layer of defence, "low-granularity sources of data such as hydrophone arrays or low-frequency active sonar can identify possible contacts," Kaushal explained. "However, to identify them as a possible target of interest requires an asset [for example, an MPA] with the speed to get to the rough location in a timely way before the contact has moved too far away."

"MPAs that combine speed, endurance, and a range of acoustic and non-acoustic sensors are useful for this," Dr Kaushal added. Discussing the role of MPA capabilities in the on-going development of ASW capability, Dr Kaushal said that multi-static sonobuoy fields will be a key part of building MPA contributions to ASW networks. Here, he pointed in particular to the Sparton/Ultra Electronics AN/SSQ-101 and AN/SSQ-125 sonobuoys that the US Navy (USN) already deploys from its P-8As. A multi-static approach, including through the use of sonobuoys, brings the benefits of mitigating the effects of

Credit: US Navy/Spc. 2nd Class Sean R. Morton

A US Navy Aviation Warfare Operator from Patrol Squadron Ten (VP-10), Red Lancers, loading sonobuoys on a P-8A Poseidon during deployment to Argentina, on 22 November 2017.

Credit: US Navy/Petty Officer 1st Class Juan Sua

US Navy Personnel from Patrol Squadron Eight (VP-8) load an AGM-84D Harpoon missile to a P-8A Poseidon aircraft during a live-load proficiency exercise on Misawa air Base, Misawa, Japan.

acoustic reverberations underwater (for example from the source of any acoustic 'ping') and extending the sensing range of the assembled assets including sonobuoys, Dr Kaushal explained.

In this operational context, an MPA's contribution can be assessed in two ways. First, broadly in terms of deployability, an MPA brings speed in reaching a target both close in and at distance: it also brings increased surveillance time-on-target, due to sustained endurance. Second, broadly in terms of ASW operations, it brings the ability to search, identify, and prosecute the submarine, both independently and as part of a joint network (including in a multi-static context). Thus, in the ASW operational context, the P-8A's contribution is clear, and is supported by core capabilities.

The P-8A is based around the commercially proven Boeing 737-800 airframe. Most of the P-8A operating club members are using a sensor and weapons fit that follows that fitted onboard USN P-8As. This includes, in sensor terms: the Raytheon AN/APY-10 multi-mode synthetic aperture radar; inverse synthetic aperture radar capability; the L-3 Communications WESCAM MX-20HD optoelectronic infra-red (IR) system; the Northrop Grumman AN/ALQ-240 electronic support measures (ESM) capability; and up to 129 sonobuoys of different types (including active, passive, and multi-static active). In weapons terms, the aircraft's fit includes: the USN/Raytheon Mk 54 lightweight torpedo; and the Boeing AGM-84D Harpoon anti-ship missile. Communications are provided through the Link 16 and the Common Data Link (CDL) tactical communications networks, which can help underpin the P-8A's input to any ASW networks as a command-and-control (C2) node.

Operational Experimentation

The contribution of airborne assets to networked ASW was tested – and demonstrated – recently during NATO Allied Maritime Command's (MARCOM's) annual, North Atlantic-based ASW exercise, 'Dynamic Mongoose'. The exercise, based around Standing NATO Maritime Group 1 (SNMG1), takes place in the deep North Atlantic waters between Norway and Iceland.

'Dynamic Mongoose' provides a 'live exercise' (LIVEX) forum to enable NATO allies to test various ASW capabilities; it also provides a forum for demonstrating – to various adversaries – such capabilities in a 'real world' operational environment and context. Certainly, the waters between Iceland and Norway will be a hive of submarine and anti-submarine activity, as NATO seeks to build maritime deterrence and defence capability of its northern flank to offset risk of the Russo-Ukraine war spilling over into the maritime domain.

The 2023 iteration of 'Dynamic Mongoose' took place in May, once more between Iceland and Norway – waters that MARCOM referred to (in a statement issued at the exercise's conclusion) as a "strategic location". MARCOM added that the exercise included "significantly higher" participation this year, along with conduct of the full spectrum of ASW procedures. Twelve NATO members took part, with 10 of these providing a combined total of 15 surface ships and seven of them providing a combined total of eight MPAs.

The MPA presence included: two Royal Canadian Air Force Lockheed Martin CP-140 Auroras; one French Air Force Dassault Aviation Atlantique Mk 2; one German Navy P-3C Orion; two UK RAF P-8As; and two USN P-8As, a MARCOM spokesperson told ESD in a statement on 7 July. During the exercise, the MPA capability was focused on ASW with search, track, and engagement of submarines using active and passive sensing capability.

"Airborne ASW assets, particularly MPAs, can contribute significantly to a networked, deep-water ASW [capability]. They can provide long-range, persistent, multi-sensor, multi-weapon, networked, all-weather capabilities that can complement and enhance other assets over the whole ASW theatre," the MARCOM spokesperson continued. "Moreover, MPAs equipped with multi-static sonobuoys can improve networked, deep-water ASW by providing longer detection ranges and lower false alarm rates than conventional mono-static sonars."

NATO operators are now building experience of putting P-8A capability into operational practice in the Euro-Atlantic theatre.

User Requirements

The RNoAF's transition from P-3C to P-8A points to the accelerating speed of P-8A capability arrival in the North Atlantic region. The first RNoAF P-8 arrived at Evenes in February 2022. All five aircraft are scheduled to be in Evenes by the end of 2023. In June 2023, the Norwegian Ministry of Defence published 'The Military Advice of the Chief of Defence 2023', drawn up by Chief of Defence General Eirik Kristoffersen following a November 2022 government request for recommendations on requirements for re-structuring the armed forces to meet the increasing and changing nature of defence and security threats to Norway's interests. Norway's last 'Military Advice' report was issued in 2019.

The latest advice noted that maritime patrol is one of "a core set of capabilities" that the Norwegian Armed Forces must retain, in order to maintain both joint operations capability and the capacity to inflict losses in all domains upon an adversary. Within the air domain, the Chief recommended that the RNoAF continues

European Security & Defence

Exhibitions & Conferences 2024

January		
22.-25.01.	**IAV (International Armoured Vehicles)**	London / UK
23.-24.01.	**DWT – Prospects for the Defence Industry 2024**	Bonn / Germany
24.-25.01.	**Mobile Deployable Comms**	London / UK
February		
04.-08.02.	**WDS**	Riyadh / Saudi Arabia
26.-29.02.	**Enforce Tac / IWA / U.T.SEC**	Nuremberg / Germany
27.-29.02.	**Int'l Mil Helicopter**	London / UK
March		
tbc	**ISDEF**	Tel Aviv / Israel
04.-05.03.	**Defence Logistics CEE**	London / UK
04.-06.03.	**DIMDEX**	Doha / Qatar
05.-06.03.	**Future Indirect Fires / JMTS**	Bristol / UK
11.-13.03.	**DGI**	London / UK
11.-13.03.	**Future Soldier**	London / UK
12.03.	**Parliamentary Evening**	Berlin / Germany
12.-14.03.	**Combat Engr/Log**	Warsaw / Poland
19.-21.03.	**DWT – Applied Research for Defence and Security in Germany**	Bonn / Germany
April		
09.-11.04.	**IT²EC / UDT / MILSIM CEE**	London / UK
May		
tbc	**IDEB**	Bratislava / Slovakia
06.-08.05.	**GPEC**	Leipzig / Germany
06.-09.05.	**DSA**	Kuala Lumpur / Malaysia
06.-09.05.	**SOF Week**	Tampa / US
07.-08.05.	**DWT – Multi-Domain Ops**	Bonn / Germany
07.-09.05.	**SEDEC**	Ankara / Turkey
13.-15.05.	**AOC Europe**	Oslo / Norway
14.-16.05.	**Aerospace Seville**	Seville / Spain
21.-23.05.	**CNE**	Farnborough / UK
22.-24.05.	**BSDA**	Bucharest / Romania
29.-30.05.	**CADSI**	Ottawa / Canada

June		
05.-08.06.	**Hemus**	Plovdiv / Bulgaria
05.-09.06.	**ILA**	Berlin / Germany
17.-21.06.	**Eurosatory**	Paris / France
26.-27.06.	**AFCEA**	Bonn / Germany
July		
02.-04.07.	**DCC Shrivenham**	Shrivenham / UK
22.-26.07.	**Farnborough**	Farnborough / UK
26.-27.07.	**Helicopter Forum**	Bückeburg / Germany
September		
02.-06.09.	**SOFEX**	Aqaba / Jordan
08.-11.09.	**MSPO**	Kielce / Poland
23.-25.09.	**DWT – MarineWorkshop**	Linstow / Germany
tbc	**SPIE**	Berlin / Germany
tbc	**DVD UK**	Millbrook / UK
October		
08.-09.10.	**DWT – Energy Transition in the Military Context**	Bonn / Germany
14.-16.10.	**AUSA**	Washington D. C. / US
16.-18.10.	**Future Forces Forum**	Prague / Czech Republic
22.-26.10.	**SAHA**	Istanbul / Turkey
November		
04.-07.11.	**Euronaval**	Paris / France
08.-11.11.	**Indodefence**	Jakarta / Indonesia
19.-22.11.	**IDEAS**	Karachi / Pakistan
26.11.	**Parliamentary Evening**	Berlin / Germany
tbc	**NIDV**	Rotterdam / Netherlands
December		
10.-11.12.	**DWT – IT Conference**	Bonn / Germany
tbc	**I/ITSEC**	Orlando / US
tbd	**International Fighter**	tbd

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Credit: US Navy

Two US Navy (USN) P-8As are pictured at Sigonella Naval Air Station, Sicily, in the shadow of Mount Etna. Operating out of the Sigonella 'hub', USN P-8As deploy widely across the Euro-Atlantic theatre.

to prioritise, alongside fighting for air supremacy, the mission of contributing to ASW in the maritime domain. Perhaps most notably, the Chief's report stated that "The capability to conduct anti-submarine operations will require further investment in complementary capabilities": here, the report noted the need for increasing investment in satellite surveillance, ground-based sensors, and MPAs. While the report did not discuss any potential increase in RNoAF P-8A platform numbers, it did state that Norway's MPA capability is one of several core air domain capabilities that "must therefore be shielded from cuts insofar as is possible."

All nine of the UK's P-8A Poseidons are in service, having arrived between February 2020 and January 2022. The aircraft are based at RAF Lossiemouth, on Scotland's northeast coast. The UK's 2021 Defence Command Paper – the UK Ministry of Defence's most recent iteration of its capability development plan – noted that the P-8A is primarily focused on ASW to secure the UK's waters. Putting this perhaps more precisely, the UK's P-8A capability plays a critical role in securing the UK's twin strategic deterrents: the nuclear deterrent, delivered by the four Vanguard-class nuclear-powered ballistic missile submarines; and the conventional deterrent, delivered by the two Queen Elizabeth-class aircraft carriers.

With USN P-8As forward-based at Sigonella Naval Air Station, Sicily and having been deploying widely across the Euro-Atlantic theatre for some time now, the trilateral US/UK/Norway partnership today now encompasses operational co-operation as well as basing, logistics, and training. Such co-operation, especially at the operational level, provides improved combined capability especially through the generation of mass. Such mass is critical when policing choke points like the Bear Island and GIUK gaps and prosecuting submarine targets trying to slip through the ASW nets NATO seeks to lay across these gaps.

In one of the most recent examples of such trilateral integration, in July 2023 the RAF deployed a P-8A to Evenes in Norway for bilateral exercising. According to an RAF news report, "The exercise was designed to strengthen bilateral working arrangements ... [and gave] the RAF crew valuable experience of operating from an unfamiliar location over mountainous terrain." Moreover, the report continued, the deployment included anti-surface warfare (ASuW) training and tested the capacity of the RAF P-8As to integrate effectively into Norwegian Air Operations Centre tasking.

"UK Poseidons operating in the High North are critical to maintaining the safety and security of the seas around our Joint Expeditionary Force [JEF] and NATO allies. In light of an aggressive and expansionist Russia operating within close proximity to our territorial waters, it is vital we continue to secure our seas," Wing Commander Ben Livesey, Commanding Officer of the RAF's 120 (CXX) P-8A Poseidon Squadron, said in the report.

Norway and the UK are two of the 10 partner members of the UK-led JEF construct, which brings particular focus on maritime matters and is designed to provide a strategic and operational bridge across the sub-conflict threshold security phase that links national defence interests and NATO requirements to conduct deterrence and defence of member state interests and territories at the higher end of the operational spectrum.

The RAF P-8A's training development across 2023 has included other tasking in addition to ASW and ASuW exercising. For example, in May an RAF P-8A participated in the annual NATO 'Formidable Shield' integrated air and missile defence exercise. The UK P-8A capability

Credit: Crown copyright/UK Ministry of Defence 2021

A UK Royal Air Force P-8A test launches a Mk 54 lightweight ASW torpedo, during trials off the Scottish coast in 2021. The various global P-8A operators usually follow the standard USN fit for Poseidon sensors and weapons.

has also been making its presence felt in real-world operations. In June, a P-8A worked with the RN Type 45 air-defence destroyer HMS Defender to monitor three Russian warships – including an Admiral Grigorovich class frigate and two Steregushchiy class corvettes – that were operating close to UK waters.

Later in June, a UK P-8A deployed to work with the USN's USS Gerald R Ford carrier strike group (CSG). The Ford CSG is the USN's newest CSG, and was back in European waters for its second deployment in quick succession – this time, for its first operational deployment (its first visit in late-2022 was for the NATO-led 'Silent Wolverine' task group integration exercise). Also part of the Ford CSG for this most recent deployment were RN and Royal Norwegian Navy (RNoN) surface ships. In a further RAF news report, the service noted that "These exercises are designed to enhance combined interoperability and develop the ability to maintain agile, capable, and expeditionary forces with the ability to flexibly operate within the High North region."

In the report, the RAF added that integrated exercises with task forces such as the Ford CSG – as well as continuing training to support MARCOM and associated units – were further steps being taken in building the UK's P-8A output towards full operational capability.

P-8A presence across the North Atlantic, but perhaps especially in critical areas such as the Baltic and North seas, will be enhanced in due course by the arrival of German Navy P-8As. In September 2021, Germany announced a deal for five aircraft, and all five are scheduled to be delivered by the end of February 2025.

Integrated NATO capability

The P-8A is fast becoming the predominant MPA across the NATO area of operations. In spreading its capability across the Euro-Atlantic theatre, the P-8A provides presence from strategic, to operational, to tactical levels.

Strategically, the P-8A is bringing together an integrated maritime network of operators deploying state-of-the-art MPA capability across the theatre, and in a manner that is becoming interchangeable in terms of basing locations and contributions to allies' and partners' task groups.

In the latter context, the P-8A is also demonstrating the significance of its operational impact, with the presence of P-8As in operational task groups underlining not only the aircraft's role in integrated task group protection, but also how the wider presence and specific prosecution of ASW targets is once more becoming a task force – in other words, joint – activity for NATO navies.

In tactical terms, the P-8A's ability to provide rapid response and a range of ASW capabilities quickly on target underlines the flexibility of its contribution to NATO's tactical ASW fight.

This combination of strategic, operational, and tactical capability and effect in one airframe could be seen as perhaps the single, stand-out answer to the question of what the P-8A Poseidon provides in terms of making a unique airborne contribution to contemporary ASW operations. ■

Mapping Activity Patterns: Using Technology and Information to Secure Seabed Infrastructure

Dr Lee Willett

To offset the emerging, but now enduring, threat to seabed critical underwater infrastructure (CUI), navies are looking to build CUI security through co-operating on information sharing and operational responses. Innovative technology and information analysis are playing a key role in enhancing such cooperation and response.

The explosions suffered by the two Nordstream gas pipelines on the Baltic seabed in September 2022 could seem on the surface to have been an isolated event. Yet a pattern of incidents relating to the security of critical underwater infrastructure (CUI) on the seabed had perhaps been developing for some time prior to the Nordstream explosions.

In November 2021, reports emerged that large sections of seabed cable had been removed from an environmental monitoring network off Lofoten, northern Norway. In January 2022, news surfaced of reported damage to seabed communications cables connecting the SvalSat satellite ground station on Norway's Svalbard Island to the Norwegian mainland. In October 2022, communications cables connecting Scotland, the Shetland Isles, and the Faroe Islands were reported to have been damaged. While the source of or explanation for each incident has not been confirmed publicly, human activity was reported to have been involved in each case.

Certainly, military leaders across several NATO countries had been warning publicly for some time of the greater risk to CUI security. For example in December 2017, in one of the first public discussions by a senior Western military official of the growing threat, the then-UK Chief of Defence Staff (CDS) Air Chief Marshal Sir Stuart Peach told the Royal United Services Institute's annual CDS lecture that Russia's growing focus on 'grey zone' warfare was creating "a new risk to our way of life", especially through the potential exploitation of "the vulnerability of the cables that criss-cross the seabed".

Credit: Norwegian Armed Forces

The Norwegian Coast Guard's Barentshav-class salvage vessel Sortland is pictured patrolling waters around offshore oil and gas installations, in late September 2022 following the Nordstream pipeline explosions.

Such mentions by senior Western officials are now routine. For example, speaking to media during a visit to Jagel airbase, Germany in June 2023, NATO Secretary General Jens Stoltenberg said "We know that CUI, such as gas pipelines, oil pipelines, [and] not least older internet cables, are critical for our modern societies and they are vulnerable .... We are stepping up what we do to protect critical infrastructure."

NATO's steps have included establishing: the Critical Undersea Infrastructure Coordination Cell at NATO headquarters in Brussels, to provide a strategic-level contact point for countries, militaries, industry, and other stakeholders to engage and co-ordinate in addressing the risk; and the NATO Maritime Centre for the Security of Critical Undersea Infrastructure at NATO Allied Maritime Command (MARCOM), Northwood, UK, to be the operational-level contact point for such stakeholders to engage, including on key tasks such as building an enhanced maritime situational awareness (MSA) picture.

The centrality of the seabed CUI risk for NATO in the context of the wider security

Author

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threats the alliance faces was reflected in the fact that the issue was addressed in the communique released following NATO's latest summit, held in July in Vilnius, Lithuania.

"The threat to CUI is real and it is developing," the communique stated. "We are committed to identifying and mitigating strategic vulnerabilities and dependencies with respect to our critical infrastructure, and to prepare for, deter, and defend against the coercive use of energy and other hybrid tactics by state and non-state actors." "The protection of CUI on allies' territory remains a national responsibility, as well as a collective commitment," the communique added.

Credit: Crown copyright/UK Ministry of Defence 2023

Russia's Project 22010 survey and research vessel Yantar is pictured in the English Channel in 2018. Yantar is equipped to conduct underwater activities, and is one of a range of Russian platforms that can be used for seabed operations.

Risk Context

Certainly, the CUI risk is regarded by Western state and multinational actors as being a clear and present danger. This is especially so given the context of Russia's invasion of Ukraine in February 2022 and the ongoing war, Russia's targeting of Ukrainian economic infrastructure ashore during the conflict, and continuing patterns of Russian naval and wider maritime activity in the vicinity of key CUI nodes at sea across the Euro-Atlantic theatre.

According to social media reports on Twitter (now 'X'), for example on The Lookout military and defence analysis page, in May 2023 a group of Russian surface ships spent several days in the North Sea and in waters off Bergen, Norway. Also in May 2023, Irish media outlets reported that Irish Naval Service and UK Royal Navy (RN) vessels were monitoring a group of Russian ships sailing off Ireland's West coast, with other Russian ships reported to be conducting unusual manoeuvres off Galway near a newly-laid seabed cable.

In April 2023, a BBC report cited a joint Danish, Finnish, Norwegian, and Swedish media investigation noting that a group of Russian ships including research vessels and fishing trawlers was conducting activities around CUI sites in the North Sea. Also in April, UK Defence Secretary Ben Wallace told a media briefing during a visit to Washington, D.C. that Russian submarines operating in the North Sea, Irish Sea, and wider North Atlantic were using "some strange routes they normally wouldn't do".

In February 2023, Reuters reported that the Netherlands' military intelligence agency (MIVD) had revealed in a media briefing that a Russian ship had been escorted away after being detected sailing close to an offshore windfarm in the North Sea.

In December 2022, a Russian naval group was shadowing a US Navy carrier strike group sailing in the Straits of Otranto, between Albania and Italy, and a tanker from the group detached to operate close to a CUI site having turned off its Automatic Identification System (AIS) signal.

As regards the September 2022 Nordstream incident, NATO and Baltic regional countries publicly attributed the explosions to an act of sabotage. Following the incident, official and media reports noted that Russian vessels including an auxiliary ship had been present in the vicinity of the site several days prior to the explosions.

Credit: Crown copyright/UK Royal Navy 2018

The UK Royal Navy Type 23 frigate HMS St Albans is pictured shadowing the Russian Federation Navy Neustrashimy-class frigate Yaroslav Mudryy off the UK coast. Monitoring Russian presence patterns is a central component of understanding CUI risk.

Range of Risk

These prominent activity patterns are clearly one component of the seabed CUI risk. Other components include the vast expanses and depths of water that must be surveilled across a range of different geographical regions, and the fact that there are many different types of CUI, such as: oil and gas rigs and pipelines; offshore windfarms; and cables carrying power, military communications or sensors, telephone communications, or internet and financial data.

Moreover, climate change may bring increased geophysical risk to CUI, such as rising sea levels threatening cable connections on land, stormier seas generating larger waves and currents that can move or damage seabed cables, and extreme weather impacting energy production sites at sea.

The challenge in monitoring and securing the array of CUI types across the depths and distances is compounded by the fact that an adversary like Russia has a range of

Credit: NATO Maritime Command

NATO ships are pictured operating in the North Atlantic in April 2023, during the alliance's 'Dynamic Mongoose' exercise. A key challenge in CUI security is building coverage at sea across large areas.

platforms that can be used to conduct seabed operations. For Russia, these platforms include: submarine types designed specifically for seabed activities; surface ships and other submarine types that can deploy uncrewed underwater vehicles (UUVs) as part of their routine naval operations; auxiliary vessels including intelligence, surveillance, and research ships; and even commercial vessels like fishing trawlers. Simply put, it is not just 'grey ships' that are involved.

Set against the geographic coverage the West must generate to secure CUI that is of significant national and international strategic value, and set too in the context of deteriorating Euro-Atlantic security as illustrated by war in Ukraine, Russia's range of capabilities affords it an opportunity to exploit Western CUI security vulnerabilities.

Experts assess there are clear implications. Speaking to ESD in a personal capacity, Dr Paolo Braca – a senior scientist, and project manager for data knowledge and operational effectiveness (DKOE), at the NATO science and technology office's (STO's) Centre for Maritime Research and Experimentation (CMRE) in La Spezia, Italy – said "This is why they are mapping now, so that they know where to go." Dr Braca was co-author, with several CMRE colleagues, of a paper titled 'Monitoring of Critical Undersea Infrastructures: the Nordstream and Other Recent Case Studies,' published in the IEEE Aerospace and Electronic Systems Magazine in June 2023. The paper discussed the use of data in CUI protection.

Military operators need to gather and process increasing amounts of data, with different military operators needing access to different data depending on their different domain requirements. This data then must be assessed, turned into information, and disseminated, both between platforms and – in the case of CUI security – between countries. Within a focus on developing capability for all-domain situational awareness, a common MSA picture for the maritime domain is essential, including for tackling the CUI threat. CMRE's DKOE programme looks broadly at the role of science and technology research in improving MSA, but particularly at how emerging technologies like artificial intelligence (AI), 'Big Data' analytics, and improved computing power, alongside emerging concepts like intelligence and information fusion (I2F), can be integrated to enhance MSA overall, in particular providing capacity to address current challenges like detecting risks to CUI, including through enhancing the process of information collation, distillation, and dissemination.

Data Analytics and Information Sharing

The extensive and varying nature of the threat underlines the need to approach the development of any solution from a co-operative, integrated, and holistic perspective, Dr Braca explained. From his personal perspective, he said, "There isn't a silver bullet for this problem. There isn't a single vessel that can do it: [we] need a range of connected assets and sensors."

Perhaps more significantly, Dr Braca underlined the importance of how data gathering and analysis can be developed to better understand movements at sea in risk areas, in order to better predict where a CUI vulnerability may emerge and where a threat to that CUI asset may come from.

Taking the Nordstream incident as an example, from the scientific perspective Dr Braca noted that the issue was not so much needing to know who was responsible, but rather what was the pattern of activity and how could any anomalies be identified to indicate that somebody was doing something unusual. Here, he explained, commercial ships for example conduct transits in a certain way, such as sailing directly from point A to point B. Even a government or commercial maritime asset conducting search-and-rescue tasking, which by definition requires repeat transits over certain areas, would use patterns that are commonplace. A vessel – or, more notably, a group of vessels – conducting suspect activity at a CUI site may spend several days there and may operate in an unusual manner.

Mapping and monitoring CUI is a complex, time-consuming task. This is the case for conducting operations from both offensive and defensive perspectives. Russian strategic focus on CUI sites is such that ships conducting these missions are often doing so in groups of vessels. However, even though extended presence of such groups could indicate an imminent risk, if such presence is not detected, then the alarm cannot be sounded.

Increasing Information

"The key point for monitoring is to increase the number of sensors that can collect information," said Dr Braca. The sensors need either to carry, or have a connection to, an on-site 'hub' that can collect, process, and assess data, and then pass on the information gleaned and/or sound the alarm.

The role of on-site 'hubs' for processing data and sharing information underlines the importance of being able to combine multiple data sets when identifying risks to CUI. Dr Braca noted that combining multiple data sets – ranging from strategic intelligence data on an adversary's activities down to geophysical data like seabed topography – is a key development that can assist with CUI risk as-

sessment, along with understanding key geographical risk points and observing locations that an adversary tends to prioritise. While an adversary may avoid an area where there is a significant presence of NATO forces, such presence can also be an indicator to an adversary that the area is of importance.

Speaking in his personal capacity, Dr Braca highlighted a key point: "The biggest problem is you do not have assets to protect the whole area. What you can do is send assets to protect critical parts," he said. This highlights the issue of limited asset numbers – certainly, at least in terms of crewed platforms – but also underlines the role of networking and information sharing in delivering expanded, integrated presence.

The development of integrated sensing and communications capability to support effective CUI security can be enhanced through using AI and data analytics. Here, Dr Braca explained, AI can be used to predict the position of a ship looking a few hours ahead into the future. "Why is this important?" he asked. "It is because we know that, if the vessel is predictable, then it is not going to do anything [it shouldn't do]." The capability already exists to use AI to predict ship positions in order to avoid collisions, Dr Braca added.

Risk Response

In sum, to enhance capacity to respond effectively to the CUI risk, there may be a need to map the CUI network and understand its vulnerabilities, to provide networked sensing capability from seabed to space to monitor suspicious movements on or below the surface, and to be able to deploy appropriate assets to the scene to deter or defend in response.

As regards the networked sensing capability itself, there is the question of whether CUI nodes, including cables, can be designed to carry sensing capability. Dr Braca noted that, given the requirement to add sensing capacity, the CUI network could be developed to carry sensors, conduct processing, integrate with other information sources, and sound the alarm if required.

The spate of recent events, including the Nordstream explosions, and the regularity of a sustained Russian vessel presence in certain regions raises the question of what further steps NATO countries could take to improve their capacity to address the CUI risk.

At the strategic level, improved information sharing – relating for example to the locations both of CUI nodes and national assets able to provide CUI protection – should be a priority. Speaking at the RN-led 'First Sea Lord's Sea Power Conference 2023', held in partnership with the Council on Geostrategy and King's College London at Lancaster House, London on 16-17 May 2023, the Royal Norwegian Navy's (RNoN's) Chief of Navy Rear Admiral Rune Andersen said that, in the wake of the Nordstream incident, the RNoN contacted the Norwegian oil and gas commercial sector and found out that the sector owned up to 600 commercial UUVs. Norway then came together with Denmark, Germany, the Netherlands, and the UK to surveil 9,000 km of cables and pipelines in the Northern European region in three months, with countries in the region recognising the strategic need to grant underwater access to their CUI sites to allow surveillance to take place.

In previous times, countries were barely prepared to publicly discuss underwater security matters, never mind allowing even their closest allies to access sensitive waters and information. In the wake of the Nordstream incident and the wider emergence of the risk to CUI, this pattern is evidently changing.

By Stealth to the Shore

Peter Felstead

With the coastal subsurface domain remaining an area that Western special forces can exploit, a number of companies are providing platforms to facilitate such operations. Peter Felstead looks at recent developments in this sphere.

While the close-in surveillance of hostile shores can increasingly be achieved by unmanned platforms, when it comes to covertly putting personnel ashore for special operations, the subsurface domain remains an area that can be exploited by novel technology. While sustaining personnel under the water's surface clearly has its challenges, the lack of any visual or noise signature being discernible from the shore – at least until special forces operators have actually landed – provides obvious advantages.
Reflecting this, a number of developments in swimmer delivery vehicles (SDVs) have breached the surface in recent years, which seek to deliver a tactical edge to Western maritime special forces.

Credit: US Navy

US naval special warfare operators conducting navigation training in a Mk 11 SEAL Delivery Vehicle out of Pearl Harbor on 13 May 2020.

New US Platforms

In the United States US Special Operations Command (USSOCOM) has introduced two new complementary SDV platforms in the form of the Shallow Water Combat Submersible (SWCS) produced by Teledyne Brown Engineering (TBE) and the Dry Combat Submersible (DCS) developed by Lockheed Martin in co-operation with Texas-based Submergence Group.
The SWCS was developed to replace USSOCOM's Mk 8 SEAL Delivery Vehicle under a July 2011 contract and is designated the Mk 11 SEAL Delivery Vehicle in US service. The first test unit was delivered in late 2014 and in October 2019 TBE was awarded a sole-source USD 178 M contract from Naval Sea Systems Command (NAVSEA) for the follow-on production of Mk 11 SWCSs, including spare parts production and the provision of engineering and technical support services through to fiscal year 2024. The SWCS entered service in 2020, with USSOCOM's Program Executive Office - Maritime (PEO-M) telling *ESD* on 16 August 2023, "A total of 10 SWCS have been funded for production. Six SWCS have been delivered and the remaining four SWCS will be delivered by FY24 [financial year 2024]".

The DCS, meanwhile, was developed as a replacement for the cancelled Advanced SEAL Delivery System, with an initial operational capability (IOC) with the system reached in June 2023, according to USSOCOM, at which point two systems had been delivered with a third undergoing finishing work. The DCS allows special forces operatives to travel for extended distances below the surface of the ocean without the need for wetsuits or exposure to the elements. The vessel features a lock in/lock out system to allow special operators to exit or enter the vessel while it is entirely submerged, thus minimising any chance of being detected.
PEO-M told ESD that the DCS can be launched from a variety of platforms and that full operational capability with the craft is anticipated in FY24. The DCS is designed to carry a crew of two plus a team of up to eight fully equipped swimmers. The vessel is 12 m long, 2.5 m high and has a beam of 2.2 m. Weighing 28 tonnes, it has an operating depth of 100 m and a range of 66 NM (122.2 km) at 5 kts (9.2 km/h), when submerged and on a standard battery.

Credit: Lockheed Martin

A Dry Combat Submersible (DCS) departs from Lockheed Martin's facility in Palm Beach, Florida, in transit to open water sea trials, which were completed in March 2023.

While the DCS is too large to be deployable from the dry deck shelters (DDS) of submarines, the SWCS will have this capability, although the US Navy's current DDSs will have to be lengthened by 1.3 and their weight capacity tripled to facilitate this. The smaller size of the SWCS – with a length of 6.8 m, beam of 1.5 m and height of 1.5 m – will mean it will be able to enter areas that the DCS cannot.
USSOCOM also developed the Mk 9 SDV. This carried two SEALs along with a pair of Mk 31 or Mk 37 torpedoes. It was designed to attack surface ships rather than deploying combat swimmers, but was retired by the mid-1990s and was never operationally deployed, given that the Mk 8 SEAL Delivery Vehicle could accomplish its mission.

Credit: JFD

The Carrier Seal TDV "is in operation", according to JFD. The first model (CS001) went into the water for the first time in 2006.

New UK Capabilities

Under a capability sourced through a US Foreign Military Sales request in 2018 the UK's Special Boat Service (SBS) is known to be operating three SWCSs, which, as with US special forces, replaced Mark 8 SEAL Delivery Vehicles in SBS service. However, UK-developed SDV capabilities are now coming to the fore.
At the DSEI 2023 defence exhibition in London in September Inchinnan-based JFD, perhaps most known for its submarine rescue capabilities, is presenting its latest Shadow Seal SDV, which the company first exhibited at the SOF Week show in Tampa, Florida, in May this year. Shadow Seal, which JDF terms a tactical diving vehicle (TDV), is a four-person vessel that entered the JFD portfolio through its acquisition of Dutch company Ortega Submersibles in August 2019. Shadow Seal has a maximum surface speed of 5.5 kts (10.2 km/h), a maximum subsurface speed of 4.5 kts (8.3 km/h), a surface range of 80 NM (148.2 km) and a subsurface range of 25 NM (46.3 km). The vessel carries up to two personnel in each of two compartments, and can be piloted from either of these stations. It can thus deliver three operators or alternatively be bottomed out and shut down in shallow water to allow four divers to be deployed.
Regarding the latest developments in relation to Shadow Seal, a JFD spokesperson told ESD on 15 August 2023, "Following the [Ortega Submersibles] acquisition, the prototype model has gone under further development and rigorous trials. We are in the process of completing the build of the first production model, which is going to our partners in the US, Blue Tide Marine, for training and demonstration purposes."
Shadow Seal complements JFD's Carrier Seal TDV, which is an eight-person SDV that is 10.45 m long with a beam of 2.21 m and a height of 1.65 m. Carrier Seal can transit on the surface at up to 30 kts (55.6 km/h), propelled by a water-cooled 257.3 kW (345 hp) diesel engine coupled with a Rolls-Royce waterjet, before transiting to a semi-submerged mode, where a sprint speed of up to 6 kts (11.1 km/h) can still be achieved. The vessel can then operate fully submerged down to a depth of up to 50 m, propelled by two 10 kW (13.4 hp) electric thrusters, at speeds up to 4 kts (7.4 km/h). An additional fuel bag can afford Carrier Seal a maximum surface range of up to 300 NM (555.6 km), while its submerged range of 30 NM (55.6 km) can be doubled with additional battery packs. JFD was understandably reticent to talk about its sales, but the company spokesperson did note that Carrier Seal "is in operation and is an established product in our portfolio".
Meanwhile, Portsmouth-based SubSea Craft unveiled its Victa-class diver delivery unit at the DSEI 2019 exhibition. The unique Victa design combines the characteristics of a high-speed, long-range insertion craft (LRIC) and an SDV, transitioning from surface to sub-surface operation to covertly deliver and recover divers.
The Victa can reach a surfaced planing speed of more than 40 kts (74.1 km/h), a cruise speed of 30 kts (55.6 km/h) and a submerged speed of 8 kts (14.8 km/h). The vessel has a surface range of 250 NM (463 km), can transition between surface and subsurface modes in two minutes, has a maximum dived depth of 30 m and is designed to deliver eight fully equipped operators to their objective. On the surface the Victa is propelled by a Seatek diesel engine delivering 540.6 kW (725 bhp), while submerged propulsion is provided by electric thrusters powered by

Credit: JFD

The Shadow Seal TDV entered the JFD portfolio when it acquired Dutch company Ortega Submersibles in August 2019.

Credit: SubSea Craft

SubSea Craft's Victa craft undertaking open-water trials off Portland, Dorset, on 27 June 2023.

Li-ion batteries that provide up to four hours of submerged operation.

SubSea Craft states that the Victa's state-of-the-art fly-by-wire control system and human-machine interface provide "surface and sub-surface navigation whilst ensuring both optimal stability under water and outstanding manoeuvrability and sea-keeping on the surface" to reduce pilot workload and accommodate autonomous options. The first Victa prototype entered the water for the first time in September 2021, with initial testing of the vessel conducted adjacent to the company's headquarters in Portsmouth before moving on to the waters around Gosport and then to SubSea Craft's Trials, Testing, and Training (T3) facility at Portland in Dorset.

Asked by ESD for an update on progress with Victa, SubSea Craft CEO Scott Verney replied on 9 August 2023, "Our technology ecosystem has allowed us to advance through the development of Victa at pace; our headquarters at The Camber in Portsmouth is a designed-for-purpose building able to facilitate the manufacture of further craft; Craft 2 is already in production. A digitalised, agile methodology underpins our processes, to enable us to focus and prioritise system development."

Verney added, "We have continued to trial the Victa-class prototype past proof of concept, initially in a controlled dock environment and latterly in Portland, where … our centre and the protected waters provide an ideal environment for our advanced testing, especially subsurface. Privately funded, we continue to evaluate and further develop the technology and capabilities in and beyond the concept of Victa."

France: Capability Regained

The French combat divers of the Commando Hubert are among the dozens of maritime special operators around the world that operate platforms made by Stidd Systems of Greenport, New York, which supplies both its Diver Propulsion Device and Multi-Role Combatant Craft: an innovative vessel that is capable of operating on the surface or either semi- or fully submerged. These assets, however, have since late 2019 been supplemented by the Special Warfare Underwater Vehicle (SWUV) made by France's ECA Group. The SWUV, which was unveiled at the Euronaval exhibition in Paris in 2014, is 8.5 m long and capable of carrying six operators, including a crew of two. The craft has a maximum speed of 10 kts (18.5 km/h) and can operate down to 100 m below the surface. It is understood that around a dozen SWUVs were ordered for use by the Commando Hubert.

The French Navy had, in fact, lost its ability to deliver SDVs from submarine-based DDSs with the retirement of its last Agosta-class submarines in 2001. However, with the advent of the SWUVs and the entry into service of Suffren (Barracuda)-class submarines, the first of which became operational in June 2022, this capability will be regained.

Undersea-warfare-focused journalist H I Sutton notes on his website (hisutton.com) that the Barracuda-class boats "are designed to carry a DDS behind the sail. This will be larger than previous French ones and incorporate direct access into the hull so that divers can access the chamber whilst it is drained, which is a massive operational advantage".

Meanwhile, French undersea technology provider Alseamar has developed two SDVs – the Coryphene and Sphyrene – in addition to its Murene diver propulsion device. The Coryphene has a length of 6 m, a beam of 1 m and accommodates three divers. It has a maximum speed of 8 kts (14.8 km/h), a range of 50 NM (92.6 km), an operating depth of 25 m, an onboard sonar with a range of 350 m and a gas capacity for six hours of submerged operations. The Coryphene can also optionally be fitted with a telescopic mast with optronics system.

The Sphyrene is 8 m long, with a height of 1.4 m and a beam of 1.45 m, and can accommodate two pilots and four additional divers. It has a maximum speed of 9 kts (16.7 km/h), a range of 70 NM (129.6 km) at 8 kts (14.8 km/h), an operating depth of 25 m, an onboard sonar with a range of 350 m, a gas capacity for 10.5 hours of submerged operations and, like the Coryphene, can be optionally fitted with a telescopic mast equipped with an optronic sighting system.

Both the Coryphene and Sphyrene are stated by Alseamar to be interoperable with both submarines and warships, and are stated to feature high-end navigating and piloting systems, user-friendly human-machine interfaces, and satellite communications.

Credit: Alseamar

The Coryphene is the smaller of Alseamar's two SDV models, with room for three crew.

Italy's CABI Cattaneo launched the Deep Shadow SDV in 2018.

A spokesman for Alseamar confirmed to ESD on 13 August 2023 that the Coryphene is in French service, stating that its size "makes it as versatile as a jeep", while the Sphyrene "is a preliminary project intended for export because the fashion at the moment is to have larger vehicles that can be compared to buses".

Italy Follows its Heritage

In Italy, which has a long heritage of underwater warfare capabilities dating back to the First World War, the Navy's Underwater and Raider Command (COMSUBIN) is understood to be operating six-person SDVs supplied by Milan-based CABI Cattaneo. From its experience in developing these, CABI Cattaneo in 2018 launched the Deep Shadow SDV, which is 9 m long, 1.8 m high and has a beam of 1.45 m. Carrying two pilots and four other operators, the Deep Shadow can be submerged down to 100 m when attached to a submarine, and has a range of 46 NM (85.2 km) 5 kts (9.3 km/h), with a maximum speed exceeding 8 kts (14.8 km/h).

In August 2023 it was announced that CABI Cattaneo had signed a memorandum of understanding with Italian shipbuilder Fincantieri regarding the integration of underwater vehicles with larger vessels designed from the outset as motherships.

A Domain for Exploitation

Such recent SDV developments attest to the companies working in this niche area seeing new opportunities to insert novel capabilities. While in some circumstances this is a case of developing capability and then seeking a market for it, rather than the more traditional procurement model of addressing stated requirements, the market is flexible in that Western special forces communities tend to be more agile in their procurement than regular forces.

"The operational wish-lists of the current era rely on new and evolving technology – networked capabilities, remote/autonomous, digitalised frameworks etc; Subsea Craft closes that gap," SubSea Craft's Verney told ESD. "From the outset our business model has been to be a solution provider: product first, flexible to changing requirements, not dependent on requirements to start a technology journey. Listening to the client but merging that with deep research, we are able to accelerate the delivery of the next-generation solutions for maritime manoeuvre. Victa sits at the centre of this model as a product and a test and evaluation platform."

Alistair Wilson, strategy and sales director for JFD, told ESD that special operations communities "have suddenly rediscovered the water" and that the subsea domain "is really the last available environment from a battlespace perspective [where special forces are] free to operate", which is allowing the SDV market to gain traction.

Rob Hales, JFD's head of defence, noted that there is extra benefit to platforms where "you're not dependant as you would have been historically on having a submarine to get you to the point where you can use a diving system or swim into the area of operation". Such 'over-the-horizon' capabilities, he said, "can do it at a far lower cost point, and actually in a more flexible and covert way in many respects, that you can from being dependent on a submarine".

Hales additionally envisaged a model where the insertion of fighting forces ashore "can go up the scale slightly from what would traditionally be special forces", putting larger forces onto the beach more covertly than what would be possible with surface craft.

Wilson also envisaged a hybrid capability that would combine manned and unmanned craft, similar to the 'loyal wingman' concept with combat air assets, and said that JFD is looking at autonomising its craft with that in mind.

Given that SDVs have not yet been used in substantial numbers, the systems that would seek to counter them, such as shore-based sonar systems and swimmer detection systems around hostile harbours and naval bases, are not yet widely deployed. For as long as that remains the case, the market for niche underwater platforms in the littoral appears likely to be a small yet increasingly dynamic one. ■

A view from inside a submerged JFD Carrier Seal TDV.

Nuclear Options

Tim Guest

This article looks briefly at some of the threats to world peace from nuclear weapons in today's geopolitically explosive world. These threats have brought us to the edge of a very dangerous abyss. It also touches upon nuclear deterrence as the option favoured by Western powers and the Alliance, bolstered by strength and nuclear options that include US strategic forces and land-based missile systems.

If an aggressor decides to use a nuclear weapon in the context of today's global geopolitical tensions, the result will not be good for any life form on this planet. There will be no winners and, undoubtedly, a nuclear response will follow, an option that did not exist before when in WW2, the world's eyes were opened to the horrors of what unleashing a nuclear 'option' on the battlefield looked like, with Hiroshima and Nagasaki suffering the effects of what, today, would be seen as tactical yields. The Japanese possessed no atomic bomb with which they could respond and so the Americans had no fear when they dropped 'Little Boy' and 'Fat Man' on their respective targets.

Since those horrors in 1945, and despite other lesser conflicts, Cold War tensions, and more – including the Cuban Missile Crisis – there has been a relative period of peace from large-scale confrontation, with a largely rules-based approach followed by all powers sharing the planet. One could almost be forgiven for thinking that two world wars had taught enough lessons to last an eternity.

Credit: USAF/Staff Sgt. Trevor McBride

A USAF weapons system officer changes radio frequencies in a B-52 Stratofortress during a mission over the Baltic Sea, October 2019.

The Nuclear Spectre over Ukraine

Yet a rules-based world no longer seems to prevail. Nuclear weapons are now being waved around in threat displays on the battlefields of Ukraine by Vladimir Putin, and in regular shows of technological capability though overt aggressiveness by North Korea. Indeed, Putin is obviously willing to flaunt international conventions as has been displayed with attacks on civilians and civil infrastructure, and his disregard for causing mass destruction wrought from the breaching of the Kakhovka Dam in southern Ukraine. This caused extensive flooding along the lower Dnipro River and suggests he may be more than willing to escalate further. At the time, Ukrainian President Zelensky called it 'an environmental bomb of mass destruction' and the country's prosecutor general's office called it a possible crime of 'ecocide'. However it is seen, Putin's nuclear sabre rattling since last February's invasion of Ukraine has been a mainstay of the Kremlin's playbook to keep Ukraine and the West afraid and guessing. By way of example, Ukrainian intelligence claimed in late June 2023, that Russian leadership may even instigate a nuclear incident around the Zaporizhzhia nuclear power plant. Were that to happen, how the West would respond is uncomfortably uncertain, for damage or destruction of the power plant could result in radiological contamination across a wide European geographical landscape. Would such an act warrant a NATO response of any kind, since Alliance nations would certainly be affected by the fallout? In 2022, the Ukrainian Hydrometeorological Institute simulated what a disaster at Zaporizhzhia might look like, with a radioactive cloud modelled to disperse over 13 countries, including the three Baltic States, Belarus, Czech Republic, Hungary, Moldova, Poland, Romania, Serbia, Slovakia, Russia and, of course, Ukraine. Considering contamination after the 1986 Chernobyl disaster was carried as far as Norway, Sweden and north Wales, this list may be conservative.

Russia's nuclear options also include tactical nuclear weapons stationed on Belarusian soil, which was begun in May 2023 and by mid-June Putin announced the first batch had been moved. President Lukashenko used language suggesting a willingness to use them, when he compared them to the weaponry supplied to Ukraine by NATO nations, stating: "they're all just weapons". While the US has been critical of the nuclear deployment, it has stated no intention of altering its own posture on strategic nuclear weapons, nor has it seen any signs that Russia might be preparing to use a nuclear weapon. That said, the

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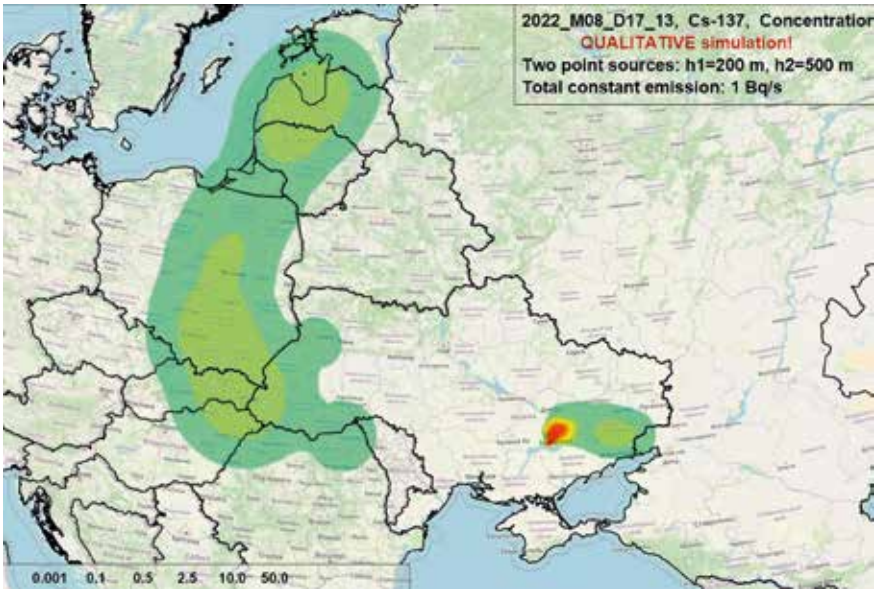
Russians have not revealed which tactical nuclear warheads have been deployed, although Lukashenko has said they are three times more powerful than the atomic bombs dropped on Japan in August 1945. Putting that in perspective, the enriched uranium-235 'Little Boy' dropped on Hiroshima was about 15 kilotons, equivalent to 13,600 tonnes (15,000 US tons) of TNT, while the plutonium-239-based 'Fat Man' bomb dropped on Nagasaki was about 21 kilotons. Sobering, considering Lukashenko cautioned in the same breath that any aggression against Belarus would result in an instant response, with targets already defined.

That the same forces who blew up the Kakhovka Dam possess tactical nuclear weapons, and are currently in a defensive posture, combined with the fact that the US has upped the weapon-supply ante with deliveries of cluster munitions to Ukraine, has caused concern that tactical nuclear weapons will be used if the counteroffensive looks like succeeding. The likelihood that they will be used is thought to be even greater should Russian forces look like they are being routed, and especially, if Crimea, including the naval base in Sevastopol, comes under serious threat. Basically, if Russia looks like losing, Putin, may simply give the order to use tactical nuclear weapons – either from Russian or Belarusian territory, to force Ukraine into submission. One last, desperate attempt to take control and save himself while possibly obliterating major cities and civil infrastructure.



Credit: Ukrainian Hydrometeorological Institute

Nuclear fallout from Zaporizhzhia; initial spread model. Later models show fallout reaching beyond the Baltics.

Threats from Elsewhere

Beyond the immediacy of the nuclear threat from Russia in Ukraine, as already mentioned, North Korea keeps nuclear tensions high on the Korean Peninsula and beyond with its repeated test launches of ballistic missiles into the East Sea, also known as the Sea of Japan, and nuclear developments showcased for all the world to see. What option does the West have in this regard? Diplomacy to try and get the regime to end its nuclear programme has failed miserably.

Indeed, in 2018, Former US Secretary of State Henry Kissinger, said that North Korea was the greatest threat to global peace at that time and that, "the essence of the matter: North Korea acquired nuclear weapons to assure its regime's survival; in its view, to give them up would be tantamount to suicide." Chillingly, around the same time, he also posited that the world was almost at the point, or may soon reach it, when taking the option of a pre-emptive strike was the only remaining way to deal with North Korea, since diplomacy, Chinese co-operation and all other means had failed – although no administration members have ever suggested anything similar. Certainly, this geopolitical cauldron cannot be ignored.

Then there's Iran, not yet a nuclear power, but allegedly heading in that direction. In early June 2023, the country's Islamic Republic News Agency reported the unveiling of a medium-range ballistic missile (MRBM) named Fattah. Interestingly, the missile appeared to use a manoeuvrable re-entry vehicle (MaRV) design, featuring a manoeuvring second stage with aerodynamic control surfaces, and appearing to be paired with a rocket motor with a thrust vector control (TVC) capability. These features would respectively allow it to manoeuvre in both endo-atmospheric and exo-atmospheric conditions, significantly complicating the task of intercepting it.

In terms of official statements regarding its capabilities, Revolutionary Guards Corps head, Amirali Hajizadeh, was quoted by Iranian state media as saying that, "The precision-guided Fattah hypersonic missile has a range of 1,400 km and it is capable of penetrating all defence shields." State television said the missile the missile's top speed could reach Mach 14 (15,000 km/h), which is not particularly surprising for a ballistic missile. While Iran has consistently denied any ambition to obtain a nuclear bomb, its resumption of nuclear-oriented activities since 2018, after the US withdrew from the 2015 nuclear deal between six leading nations has reignited fears that producing a nuclear bomb remains its ambition. Whether Israel would stand by and watch that happen is unlikely.

Credit: Tasnim News Agency/Hossein Zohrevand, via Wikimedia Commons

The Fattah MRBM shown at its unveiling ceremony on 6 June 2023.

Credit: US Navy/Navy Petty Officer 2nd Class Dominique Pineiro

Crew of a Boeing B-52H at Minot AFB, North Dakota during nuclear triad operations.

No analysis on the threat to world peace from nuclear weapons would be complete without mention of China. Its 'Belt and Road' initiative since 2013 has given Beijing a footprint, a foothold even, the world over, through a global infrastructure development strategy to invest in more than 150 countries and international organisations. Yet, its militarisation of the South China Sea and bellicose statements in the direction of Taiwan have been a cause for significant concern in the West. Kissinger said recently that he believed US-China tensions are imitating those of the Cold War era. This time, however, with the possibility for destruction having increased drastically, including the likelihood that the US and its allies will be at war with China by 2030. If that is so, the potential for nuclear exchange, both at tactical and strategic levels, is significant.

However, rather than continuing along such alarming lines the article will continue with a look at US and NATO ally fundamentals of nuclear deterrence, along with other reassuring developments.

The Option of Deterrence – a Political Choice

In its 2022 Nuclear Posture Review (NPR), the US Department of Defense (DoD) outlined the 'Declaratory Policy' of the US: 'As long as nuclear weapons exist, the fundamental role of US nuclear weapons is to deter nuclear attack on the United States, our allies, and partners. The US would only consider the use of nuclear weapons in extreme circumstances to defend the vital interests of the United States, or its allies and partners.'

That said, the US has reduced the size of its land-based nuclear weapons stockpile by over 90% since the height of the Cold War, including the number of nuclear weapons stationed in Europe, which nonetheless remain a fundamental part of NATO's nuclear calculations. Indeed, for NATO, US nuclear weapons are the mainstay of the Alliance's nuclear arsenal. They are also a core component of its overall capability for deterrence and defence, alongside conventional and missile defence forces. As long as nuclear weapons exist, NATO makes clear that it will remain a nuclear alliance with a deterrent policy and a non-offensive nuclear capability intended to preserve peace, prevent coercion, and deter aggression.

Two documents set out NATO's current nuclear policy which have been agreed by all Alliance members; one is 'The 2022 Strategic Concept', and the other 'The 2012 Deterrence and Defence Posture Review (DDPR)'. In the concept document agreed at the 2022 Madrid Summit, deterrence and defence are stipulated as core tasks and principles of the Alliance based on an appropriate mix of nuclear, conventional and missile defence capabilities, complemented by space and cyber capabilities, with Article 30 of the Strategic Concept stressing that, "NATO will take all necessary steps to ensure the credibility, effectiveness, safety and security of the nuclear deterrent mission. The Alliance is committed to ensuring greater integration and coherence of capabilities and activities across all domains and the spectrum of conflict, while reaffirming the unique and distinct role of nuclear deterrence. NATO will continue to maintain credible deterrence, strengthen its strategic communications, enhance the effectiveness of its exercises and reduce strategic risks."

That said, for such deterrence to be effective, NATO makes clear that Alliance unity and resolve in such deterrence must be underpinned through the broadest possible participation by those allies concerned with agreed, nuclear burden-sharing arrangements. To this end, it was the 2012 DDPR that, while noting the fundamental purpose of Alliance nuclear forces is that of deterrence, also impressed that any decision to take a nuclear option is, essentially and definitively, a political one. So, despite Alliance forces maintaining and being the custodians of its effective deterrence, nuclear weapons are under political control in all circumstances,

Credit: US DoD

Air Force Global Strike Command unarmed Minuteman III launch, February 2023.

with nuclear planning, consultation and actions within the Alliance conducted purely in accordance with strict political guidance.

To that end, the key principles of NATO's nuclear policy are established by all NATO heads of state and government, with the development and implementation of Alliance nuclear policy the responsibility of its Nuclear Planning Group (NPG), which provides the forum for consultation on all issues that relate to NATO's option of nuclear deterrence. With the exception of France, all members of the Alliance are in the NPG.

Credit: US DoD/Air Force Senior Airman Clayton Wear

The US and its allies rely on a strong strategic deterrence. Pictured: An unarmed Minuteman III ICBM test, February 2020.

NATO's Nuclear Options and Capabilities

While the circumstances under which NATO might have to use nuclear weapons are remote, their use by a belligerent against an Alliance member would fundamentally alter the nature of any conflict. In such a scenario, NATO states that it has the 'option, capabilities and resolve to impose costs' on an adversary that would be unacceptable and far outweigh the benefits that any such enemy force could hope to achieve by using nuclear weapons. Indeed, NATO's strategic forces, particularly those of the US, are the greatest guarantee of Alliance security, along with the independent strategic nuclear forces of the UK and France, which have deterrent roles in their own right, with separate decision-making centres. France, the UK, and the US contribute to deterrence by also complicating the defensive/offensive calculations potential adversaries must make. Not only must they contend with NATO's overall decision-making, but also the independent decision-making from political leaders in the US, the UK and France, should the adversary choose to attack an Alliance member and use nuclear weapons.

As stated above, NATO's nuclear deterrence posture relies on forward-deployed US nuclear weapons in Europe, in addition to infrastructure provided by allies concerned, together with their own nuclear-relevant capabilities. Several NATO member countries

Credit: USAF

The world faces greater peril from belligerent nuclear powers than ever, with effective deterrence remaining the West's favoured option. Pictured: CG render of an LGM-35A Sentinel, which will replace Minuteman III.

contribute a dual-capable aircraft (DCA) capability to the Alliance, which are available for nuclear roles at various levels of readiness central to NATO's nuclear-deterrence option, and for which they are equipped to carry nuclear bombs in a conflict. Such nuclear sharing plays a vital role in the cohesiveness of the Alliance and the indivisibility of security of the whole Euro-Atlantic area. That said, while the Allies provide military support for the DCA mission with conventional forces and capabilities, the US maintains absolute control and custody of its forward-deployed nuclear weapons.

America's Approach and Nuclear Triad

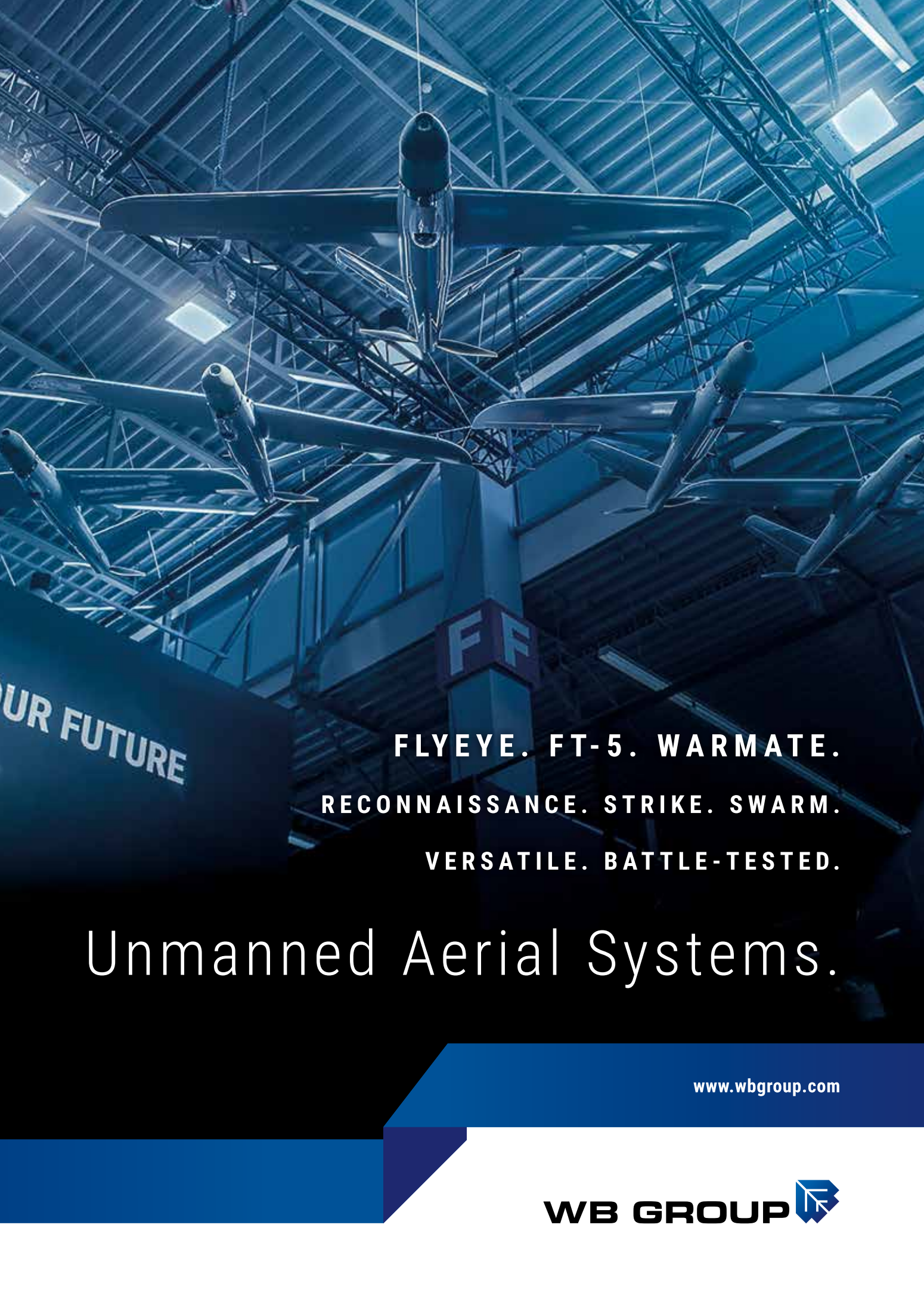
On land, at sea and in the air, a compilation of platforms and weapons, the three legs of the US nuclear triad, serve as the backbone of America's national security, as well as offering wider security to its allies and NATO member countries. This triad, along with assigned forces, provides 24/7 deterrence and stands ready to deliver a decisive response, anywhere, anytime. Indeed, the aforementioned 2022 NPR states that the US must be able to deter both large-scale and limited nuclear attacks from a range of adversaries. It also states that the capability to deter limited nuclear attacks is critical, given that some adversaries, "have developed strategies for warfare that may rely on the threat or actual employment of nuclear weapons in order to terminate a conflict on advantageous terms". The NPR adds: "given the US global alliance network is a military centre of gravity, the US will continue to field flexible nuclear capabilities and maintain country-specific approaches that reflect our best understanding of adversary decision making and perceptions".
The US' domestic nuclear forces include more than 10,000 people, who provide up to 400 on-alert, combat-ready LGM-30G Minuteman III intercontinental ballistic missiles (ICBMs), in hardened silos across five states and make up the most responsive leg of the nuclear triad. These strategic weapons are dispersed to protect against attack and connected to an underground launch control centre through a system of hardened cables. This ICBM force has remained on continuous, round-the-clock alert since 1959, though is soon to be replaced by the USAF LGM-35A Sentinel weapon system, (formerly the Ground-Based Strategic Deterrent programme), which will begin the replacement of Minuteman III and modernisation of the 450 ICBM launch facilities in 2029. The Sentinel is scheduled to attain an initial operational capability (IOC) in 2029, and full operational capability in the mid-2030s.
Following detailed environmental analysis, clearance to begin the construction phase of Sentinel was given in May 2023. The effort to modernise the land-based leg of the US nuclear triad affects multiple states, covers thousands of miles, and impacts communities in Arizona, Colorado, Montana, North Dakota, Utah and Wyoming.
While up for replacement, Minuteman III remains at total readiness. Indeed, in April 2023, a joint team of USAF Global Strike Command and USN personnel aboard the Airborne Launch Control System launched an unarmed Minuteman III ICBM equipped with one test re-entry vehicle from Vandenberg Space Force Base in California. This was part of routine, periodic activities, with such tests having occurred over 300 times before. the US emphasised at the time that this recent test was not the result of current world events. A previous test launch had taken place in February.
The ICBM test launch programme demonstrates the operational capability of Minuteman III and ensures the US ability to maintain a strong, credible nuclear deterrent. Data collected from test launches is used for continuing force development evaluation. As for USAF Global Strike Command, this is a major command with headquarters at Barksdale AFB, Louisiana, which oversees the nation's three intercontinental ballistic missile wings, the USAF's entire bomber force, including: B-52, B-1 and B-2 wings, the Long-Range Strike Bomber programme, Air Force Nuclear Command, Control and Communications systems, and operational and maintenance support to organisations within the nuclear enterprise. Approximately 33,700 personnel are assigned to two numbered air forces, with nine wings, two geographically separated squadrons, and one detachment, based in the continental US and deployed around the globe.

Credit: USAF/Senior Airman Eugene Oliver

Two USAF B-52 Stratofortresses fly over RAF Fairford, England, 22 August 2020.

Sobering Thoughts

Back to Ukraine. Certainly, NATO, and the West in general, will have their respective nuclear doctrines, plans, options set out, but if the unfolding scenario between Russia and Ukraine does not go Putin's way, this may lead us into the most dangerous period of the war so far. Having a response ready, were that to happen, is essential. We've already been tested: a critical infrastructure event causing mass destruction. A nuclear detonation could become the next big test. ■



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