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# The World on a Knife Edge

As 2023 draws to a close, the security picture appears bleaker than it did at the same time last year. The War in Ukraine continues unabated, but is now joined by the prospect of a regional war in the Middle East, with Israel and the US keen to degrade the capabilities of Iran-backed non-state armed groups following the Gaza-based Hamas terrorist organisation's brutal attacks in Israel on 7 October 2023, leading to over 1,400 Israelis killed. Elsewhere, US-China tensions in the South China Sea are growing, following a Chinese J-11 fighter coming within around 3 m of a US B-52 bomber during an intercept on 24 October 2023. Meanwhile in West Africa, following the coup against Niger's President Mohamed Bazoum on 26 July 2023, the threat of state-on-state conflict has not dissipated, and ECOWAS states continue to mull resolution of the situation by force.

To examine the situation in Ukraine in more detail, the picture looks somewhat different compared to November/December 2022, with the probability that Ukraine's forces could break through Russia's defences and defeat their opponent in the field now looking increasingly remote. In ESD 9/2023, I provided a table comparing Russia's losses in 2022 to their losses in 2023, based on figures from the Oryx Blog. At the time, the table compared a 311-day period in 2022 to a 234-day period in 2023, and I noted that due to this time discrepancy, it was not an entirely fair comparison. Now that time has passed, a closer comparison is possible, and this time the table compares a 311-day period in 2022 to a 303-day period in 2023. Based on feedback, the table was also simplified to make it easier to follow:

| Type | Losses from 24/02/2022 to 31/12/2022 | Losses from 01/01/2023 to 30/10/2023 | % Change in Losses – 2022 to 2023 |
|---|---|---|---|
| **Tanks** | 1600 | 837 | -48% |
| **Assorted AFVs** | 743 | 281 | -62% |
| **IFVs** | 1872 | 1085 | -42% |
| **APCs** | 283 | 85 | -70% |
| **MRAPs** | 43 | 6 | -86% |
| **Infantry Mobility Vehicles** | 176 | 46 | -74% |
| **Command Posts** | 217 | 37 | -83% |
| **Engineer Vehicles** | 261 | 94 | -64% |
| **SP AT Vehicles** | 32 | 10 | -69% |
| **Arty Support** | 90 | 19 | -79% |
| **Towed Arty** | 151 | 177 | +17% |
| **SP Arty** | 302 | 283 | -6% |
| **MRLs** | 166 | 133 | -20% |
| **AA Guns** | 16 | 3 | -81% |
| **SPAAGs** | 23 | 2 | -91% |
| **SAM Vehicles** | 84 | 91 | +8% |
| **Radars** | 20 | 26 | +30% |
| **Jammers** | 22 | 36 | +64% |
| **Fixed-Wing Aircraft** | 67 | 26 | -61% |
| **Helicopters** | 74 | 58 | -22% |
| **UCAVs** | 4 | 10 | +150% |
| **Recce UAVs** | 152 | 151 | -1% |
| **Ships** | 12 | 4 | -67% |
| **Trucks, Utility Vehicles** | 2156 | 794 | -63% |

Compared to the table in ESD 9/2023, there are a few minor changes, including an uptick in Russian SAM vehicles and Jamming systems lost, and a slight closing of the gap on helicopter losses, following the 'Operation Dragonfly' strikes of 16-17 October 2023 on two Russian airfields in Berdyansk and Luhansk. However, the broad trend, which showed a sharp reduction in Russian losses in nearly all materiel categories over 2023, has largely held true. While Russian losses over 2023 have by no means been minor, in some categories they have now become effectively sustainable for an armed force the size of Russia's, and backed by the country's economic and military-industrial potential.

These trends paint a fairly bleak picture for Ukraine's Armed Forces, standing in stark contrast to the relative optimism of the beginning of the year, where many outside observers had expressed hopes that major deliveries of Western military hardware could turn the tide of the war. Additionally, while Ukraine has kept a tight lid on their casualty figures, indirect indicators give some cause for concern. Case in point, on 1 October 2023, Ben Wallace, the former UK Secretary of State for Defence, writing for The Telegraph, noted that In Ukraine's Armed Forces, "The average age of the soldiers at the front is over 40." If this figure is accurate, it suggests a rather high attrition rate, which does not bode well going into 2024. All told, 2023 has been a challenging year.

**Mark Cazalet**

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# Masthead

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**Cover Photo:** A C-17 Globemaster III assigned to the 911th Airlift Wing sits on the flightline at the Pittsburgh International Airport Air Reserve Station, Pennsylvania, on 12 February 2020.Credit: USAF/Joshua J. Seybert

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## The Hamas Offensive: 'A 9/11 and a Pearl Harbor Wrapped Into One'

(pf) More than 48 hours on from the launch of an unprecedented offensive into Israel from Gaza by Palestinian Islamist militant organisation Hamas on 7 October 2023, the Israel Defense Forces (IDF) were still fighting militants on Israeli territory. The barrage of Hamas-launched rockets fired from Gaza, which for many heralded the start of the offensive, was still continuing.

While preparations for a ground assault into Gaza were also underway by that time, with 300,000 reservists called up, and a total blockade of Gaza declared, military and civilian Israelis alike were still struggling to comprehend the grave intelligence failure that allowed such a major Hamas offensive to come seemingly out of nowhere.

Credit: CBC videograb

Jonathan Conricus, a former lieutenant colonel who previously served as the IDF's international spokesperson, told the BBC of the attacks, "This could be a 9/11 and a Pearl Harbor wrapped into one." He added, "It is, by far, the worst day in Israeli history. Never before have so many Israelis been killed by one single thing, let alone enemy activity, on one day."

The current IDF spokesperson, Rear Admiral Daniel Hagari, addressed the international media on 8 October with a statement that said, "This weekend Hamas started a war against Israel with the worst massacre of innocent civilians in Israel's history," adding that Hamas "was more barbaric and more brutal than ISIS" in the perpetration of its raid.

He went on to say, "This horrific terror act demands a forceful, determined, and sustained response — which is exactly what we are doing and continue to do."

More than 1,400 people inside Israel were killed by the Hamas attack, while Gaza's Health Ministry stated on 18 October that around 3,478 Palestinians had been killed there by that date as a result of Israeli airstrikes on known Hamas and Islamic Jihad locations and rocket launch sites.

The Hamas attacks came 50 years and a day after the last time Israel suffered a comparable failure of intelligence, when a coalition of Arab states launched a surprise attack on Israel on 6 October 1973 that began what became known as the Yom Kippur War.

### A Failed Tripwire

Israel's borders are renowned for their multitude of sensors designed to detect potential hostile infiltration, but while these measures might be effective in highlighting small-scale activities, they proved to be of little use in the face of such a large-scale Hamas assault.

The Hamas planners chose the Jewish Sabbath, which was also a holy festival day, to mount their offensive and at 06.30 local time unleashed thousands of rockets directed at Israeli territory. Although the IDF's Iron Dome air-defence system is designed to only intercept rockets on trajectories that would hit designated zones, the massive Hamas barrage, which would have taken a considerable time to stockpile, was clearly intended to overwhelm the capacity of the Iron Dome launchers.

Meanwhile, just as daylight broke Hamas fighters were swarming into Israel from Gaza. While some chose to circumvent the border by paraglider or boat, most came through breaches made in the border fence, either cut through or in at least one case simply bulldozed open. According to the IDF an estimated 1,500 Hamas fighters took part in the incursion. They assaulted more than two dozen locations, apparently with instructions to shoot on sight, and reached as far as the town of Ofakim, which is 22.5 km east of the border with Gaza. A Hamas attack on a music festival near Re'im killed more than 260 people.

Knowing that an IDF land offensive into Gaza was virtually inevitable as a result of its attacks, Hamas abducted at least 199 people during the attack, according to Israeli sources, and took them back to Gaza as human shields. This will no doubt complicate IDF land operations in Gaza.

While the IDF planned their next moves in the wake of the attack, however, the overriding question on Israeli minds is how such a devastating intelligence failure could have occurred despite the reputation and resources of Israeli agencies such as Mossad, Shin Bet and Aman (the Military Intelligence Directorate).

One possible explanation is the divergent degrees to which the IDF, on the one hand, and Hamas and its allies, on the other, now rely on technology.

When the IDF withdrew from Gaza in 2005 they lost a vital aspect of human intelligence by no longer being on the ground and patrolling there. Technology, in the form of measures such as border sensors and roaming unmanned aerial vehicles, was supposed to compensate for this.

Hamas and allied Islamic militants, on the other hand, may have ultimately learnt to go the other way. Realising the use of phones and computers left them open to being surveilled by a sophisticated Israeli intelligence operation, they may have conducted their planning face to face, in environments immune to surveillance.

Other analysts have pointed to the disarray in Israeli politics and a preoccupation with unrest in the West Bank as contributing to Israeli intelligence taking its eye off Gaza.

Writing in the Israeli newspaper Haaretz on 8 October, columnist Amos Harel noted that Israeli military intelligence and the IDF General Staff "often claimed that Hamas is deterred by Israel following the results of earlier campaigns and is not looking for another war. In fact, hundreds if not thousands of Hamas fighters were preparing for a surprise attack for months, with none of this being leaked."

Beyond Hamas having apparently put Israeli military intelligence to sleep, Harel confronted another stark reality: that the Hamas attack had "completely demolished the operational defensive conception on the Gaza Strip border".

Harel noted that retired IDF colonel Yossi Langotsky, a veteran of military intelligence and an IDF paratrooper unit, warned in an article in Haaretz in 2018 that the IDF was "building a wasteful Maginot Line in the Gaza Strip, which would be breached when it came to a crunch", adding that "Yesterday, he was proven right."

## Putin Claims Russia has Tested Nuclear-Powered Cruise Missile

(pf) Russia has tested an experimental nuclear-powered cruise missile, according to a statement made by President Vladimir Putin on 5 October 2023 during a speech in the Black Sea resort of Sochi.

"We conducted the last successful test of the Burevestnik nuclear-powered global-range cruise missile," Putin told a gathering of foreign policy experts. His statement was the first announcement of a successful test of the Burevestnik, which translates as 'Storm Petrel'.

Beyond announcing that Russia has effectively completed the development of the 9M730 Burevestnik cruise missile and the Sarmat heavy intercontinental ballistic missile (ICBM), which Russia declared opera-

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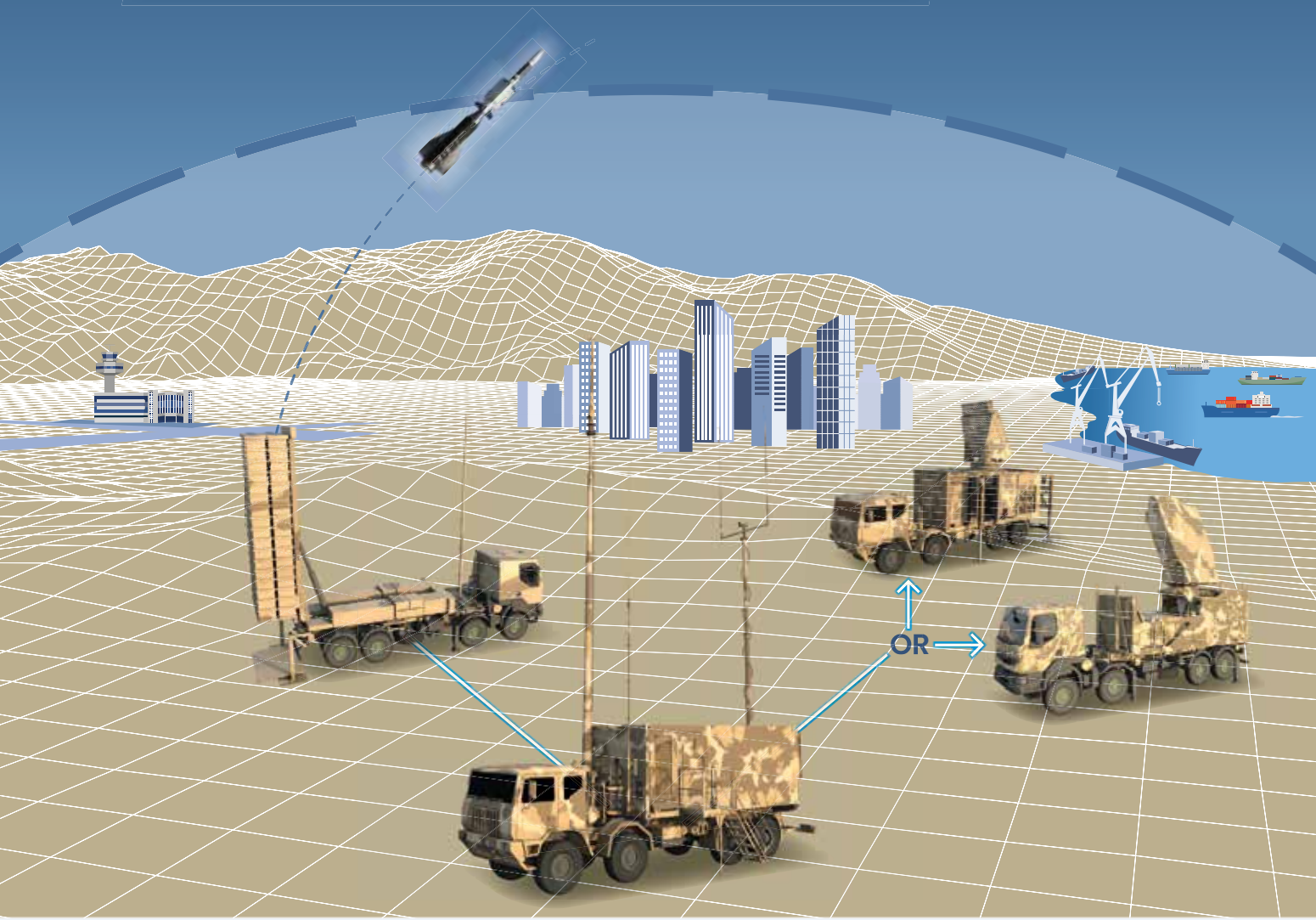


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tional at the beginning of September 2023, Putin did not elaborate.
Little is known for certain about the Burevestnik cruise missile, which NATO has codenamed the SSC-X-9 'Skyfall'. If nuclear powered, however, it would effectively have a virtually unlimited range in practical terms and could thus home onto its target from an unexpected direction. However, nuclear propulsion for air vehicles is certainly controversial from an environmental perspective.

Credit: Sky News videograb

Both the Soviet Union and the United States pursued nuclear-powered bomber programmes in the 1960s during the Cold War but ultimately gave them up. The key difference now, however, is that the march of technology has meant that a nuclear powerplant can be made small enough to fit inside a cruise missile. Western analysts have speculated that the Burevestnik cruise missile is a subsonic air vehicle powered by a nuclear-heated turbojet or turbofan.
On 8 August 2019 a radioactive explosion at Russia's State Central Navy Testing Range at Nyonoksa that killed five engineers and injured at least three more was thought by some analysts to relate to the Burevestnik programme. According to that narrative the Russians were recovering a missile from the Barents that was lost during a test flight when it exploded.
The Burevestnik system was first mentioned by Putin in March 2018 when, as part of his presidential address to the Russian Federal Assembly, he announced five new 'superoruzhie' ('super weapons'). As well as the Burevestnik, these were the Kinzhal air-launched ballistic missile, the Avangard nuclear-armed hypersonic glide vehicle, the Poseidon nuclear-powered, long-range unmanned underwater vehicle and the Sarmat heavy ICBM. Around the same time details emerged of a sixth Russian 'super weapon': the Tsirkon hypersonic anti-ship cruise missile.

## Belgium Steps Up to Provide Ukraine with F-16s from 2025

(pf) Belgium has said it will provide Ukraine with Lockheed Martin F-16 fighters from 2025. The future transfer was announced by Belgian Defence Minister Ludivine Dedonder during an interview with the Belgian Bel RTL radio station on 11 October 2023.
Dedonder did not specify the number of F-16s to be transferred to Ukraine, indicating that this would depend on the ramp-up of the Belgian Air Component's fleet of Lockheed Martin F-35 Joint Strike Fighters.
The Belgian Air Component currently operates a fleet of more than 50 F-16A/B fighters, but these will be replaced by 34 F-35As. The first four of these were due to be delivered in 2023, but Belgium opted to decline accepting the delivery of F-35s in their new Technology Refresh 3 configuration, the certification and qualification of which has been delayed.
The first F-35s are expected to enter Belgian Air Component service in 2025, marking the date from which retiring Belgian F-16s could be transferred to Ukraine.


Credit: Belgian MoD

Belgium's offer of F-16s to Ukraine has come at an opportune time. Although Denmark and the Netherlands have previously announced plans to supply Ukraine with F-16s this situation was somewhat complicated on 11 October when the US State Department gave Denmark approval to sell 24 F-16s to Argentina.
Meanwhile, US Defense Secretary Lloyd J Austin III announced, also on 11 October, that the United States is to lead a newly formed coalition focused on developing Ukraine's air force in a bid to bolster the country's long-term capability to defend itself against Russian attack.

## Czech MoD Announces Intention to Acquire Two Embraer C-390s

(pf) The Czech Ministry of Defence (MoD) announced on 17 October 2023 that it has initiated discussions with Brazil's Embraer regarding the potential acquisition of two C-390 Millennium airlifters.
The Czech decision to start negotiating a C-390 purchase, according to an Embraer 17 October press release, was based on a market assessment and analysis prepared by Czech MoD that identified the C-390 as the most suitable solution for meeting the requirements of the Czech armed forces.
Such an acquisition would significantly augment the Czech Air Force's airlift capabilities, which currently comprise only twin-turboprob types in the form of six Airbus C295s and four Let L-410s.
The two C-390s would be used for a range of missions, including air transport, air assault operations, aerial resupply, medical evacuation, humanitarian aid flights, air-to-air refuelling and firefighting.
The Millennium, which has a wingspan of 35.05 m, has a maximum payload of 26 tonnes, a maximum cruise speed of 470 KTAS (870 km/h), a ceiling of 36,000 ft and a range with its maximum payload of 2,000 km. When configured with an air-to-air refuelling capability, with the designation KC-390, the Millennium can refuel another KC-390 as well as other aircraft types. Embraer claims the C-390 requires significantly less maintenance than its competitors, which translates into higher availability rates and lower life-cycle costs.
"We are honoured to be selected by the Ministry of Defence and Armed Forces to start negotiating on this significant acquisition and we are ready to provide the most advanced medium transport aircraft available in the market to the Czech Republic," Bosco da Costa Junior, president and CEO of Embraer Defense & Security, was quoted as saying. "The C-390 Millennium is drawing the attention of several nations around the world due to its unbeatable combination of high productivity and operating flexibility with low operating costs."
The negotiations cover the acquisition of two aircraft and associated support – including a complete training solution for pilots, loadmasters, and technicians – as well as spare parts and a robust entry-into-operation plan with a local presence of Embraer personnel in country for an initial period.


Credit: Embraer

With the announcement from Prague the Czech Republic becomes the sixth nation and fourth NATO country in Europe to select the C-390. Brazil has ordered 19 C-390s, Portugal five, Hungary two, the Netherlands five, and Austria four.
The type first entered service with the Brazilian Air Force in 2019, with the current fleet of six aircraft demonstrating an operational availability of around 80% with a mission completion rate above 99%, according to Embraer.

Czech company Aero Vodochody is already a strategic partner and supplier for the C-390 programme, producing parts for the rear fuselage, the doors for paratroopers and crew, the emergency door and hatches, the cargo ramp, and the fixed leading edge.

## UK Sends 200 Troops to Kosovo at Request of SACEUR

(pf) UK forces have deployed to NATO's peacekeeping mission in Kosovo following a request from NATO amid increasing tensions in the region, in particular following a violent attack on Kosovo police personnel in northern Kosovo on 24 September 2023.

Following a request from Supreme Allied Commander Europe (SACEUR) and approval by the North Atlantic Council, the UK Ministry of Defence announced on 1 October 2023 that it is deploying around 200 soldiers from 1st Battalion of the Princess of Wales's Royal Regiment to join the 400-strong British contingent already in country as part of an annual exercise. The British Army unit has been assigned to the NATO commander of the Kosovo Force

Credit: Crown Copyright

(KFOR) following a specific request from SACEUR, US General Chris Cavoli.

KFOR troops are provided by 28 countries, with the UK currently contributing two intelligence, surveillance and reconnaissance (ISR) units and staff officers to the mission headquarters, while a battalion-sized Strategic Reserve Force (SRF) has been held at 14 days' notice to move in the UK.

The UK commitment to KFOR was extended in May 2023 when Minister for Armed Forces James Heappey announced the UK would continue to contribute to the NATO mission until at least 2026.

NATO's peace-support operation in Kosovo has been running since June 1999, when KFOR was established following NATO's 78-day air campaign against the regime of Serbian leader Slobodan Milošević, who ultimately became the first sitting head of state to be charged with war crimes.

The latest tensions in Kosovo, which declared independence from Serbia in February 2008 but is not recognised by Belgrade, came to a head with a gun battle at a monastery on 24 September between Kosovo police and at least 30 heavily armed Kosovo Serbs. A police officer and three of the gunmen were killed during the fighting.

Tensions between Kosovo Serbs and the country's ethnic Albanian majority had been running especially high since local elections in April 2023 that were boycotted by most Serbs. Clashes in the aftermath of the election forced NATO to send an extra 700 troops to Kosovo at the end of May.

## Turkish Government Announces Major Defence Spending Boost

(pf) The Turkish government has indicated that its defence budget for 2024 will be two-and-a-half times the amount allocated for 2023.

In a presentation at the Presidential Complex in Ankara on 17 October 2023 Turkish

Credit: Turkish Aerospace

Vice President Cevdet Yilmaz noted that Turkey will allocate more than USD 40 Bn (EUR 37.9 Bn) to its defence budget for 2024 compared with around USD 16 Bn for 2023.

Yilmaz also noted that the government aimed to almost double the value of Turkey's defence exports – to USD 11 Bn in 2024 from the current USD 6 Bn – and to increase Turkish self-sufficiency in defence equipment to 85% from 2023's 80%.

Turkey has been striving hard in recent years to become self-sufficient in increasingly complex defence platforms. The most notable of these is the Turkish Aerospace Kaan fifth-generation fighter, previously known as the TF-X, or Milli Muharip Uçak (National Combat Aircraft), which was rolled out on 17 March 2023 and, at least before Turkey suffered a significant earthquake on 6 February 2023, was due to make its maiden flight this year.

Turkish Aerospace's Hürjet advanced jet trainer made its maiden flight on 25 April 2023.

Meanwhile, Turkish company Baykar has had considerable success in both developing and exporting unmanned aerial vehicles (UAV).

The Turkish push for greater self-sufficiency in defence was given significant impetus in 2019 when Turkey was ejected from the F-35 Jint Strike Fighter programme for refusing to abandon acquisition of the Russian S-400 air defence system.

Also on 17 October the Turkish parliament voted to extend the mandate that allows its armed forces to conduct cross-border operations into Syria and Iraq for another two years.

## USMC Completes First Flight of XQ-58A Valkyrie Autonomous, Low-Cost Tactical UAV

(pf) The US Marine Corps (USMC) has completed the first test flight of the XQ-58A Valkyrie autonomous, low-cost tactical unmanned aerial vehicle (UAV) out of Eglin Air Force Base, Florida, with the aircraft performing as expected, the USMC announced on 5 October 2023.

The flight, which took place on 3 October, was conducted in collaboration with the Office of the Undersecretary of Defense for Research and Engineering (OUSD(R&E)), the Naval Air Systems Command and Naval Air Warfare Center Aircraft Division (NAWCAD) and was supported by the US Air Force's 40th Flight Test Squadron, 96th Test Wing. The flight marks a key milestone in the USMC's Penetrating Affordable Autonomous Collaborative Killer – Portfolio (PAACK-P) programme. Future test flights will inform USMC XQ-58A Valkyrie requirements for the Marine Air-Ground Task Force Unmanned Aerial System Expeditionary (MUX) Tactical Aircraft (TACAIR).

"This XQ-58A test flight and the data collected today not only help to inform future requirements for the Marine Corps," said Scott Bey, a prototyping and experimentation portfolio manager at OUSD(R&E). "It fuels continued joint innovation and experimentation opportunities and demonstrates the agility that can be achieved through partnership."

Credit: USAF

The XQ-58A has a total of six planned test flights with objectives that include evaluating the platform's ability to support a variety of intelligence, surveillance, and reconnaissance (ISR) missions; the effectiveness of autonomous electronic support to crewed platforms; the potential for artificial intelligence (AI)-enabled platforms to augment combat air patrols; and continued maturation of other manned-unmanned teaming (MUM-T) capability objectives.

The USMC received the first of two XQ-58A UAVs on 14 March 2023 to support platform prototyping and integration efforts for the PAACK-P programme.

"The Marine Corps constantly seeks to modernise and enhance its capabilities in a rapidly evolving security environment," Lieutenant Colonel Donald Kelly, from the Headquarters Marine Corps Aviation Cunningham Group and Advanced Development Team, was quoted as saying. "Testing the XQ-58 Valkyrie determines requirements for a highly autonomous, low-cost tactical [unmanned aerial systems] that complement the need for agile, expeditionary and lethal capabilities in support of both the Marine Corps' stand-in force operations in austere environments and the Joint Force."

## British Army Receives its First Interim Archer SPH

(pf) The first BAE Systems Bofors 155 mm Archer 6×6 wheeled self-propelled howitzer (SPH) has been delivered to the British Army, the UK Ministry of Defence's (MoD's) Defence Equipment & Support (DE&S) organisation announced on 6 October 2023. It is the first of 14 Archer systems that the UK MoD agreed to buy from Sweden in March 2023 as an interim capability in advance of fulfilment of the British Army's longer-term Mobile Fires Platform (MFP) programme, which is designed to replace its fleet of tracked AS90 155 mm SPHs. The Archers are replacing 32 AS90s that the United Kingdom has donated to Ukraine.

Credit: BAE Systems Bofors

The 14 ex-Swedish Archers, which use a Volvo 6×6 all-terrain chassis, were bought under a government-to-government agreement with the Swedish Defence Materiel Administration (FMV) and have been upgraded to a UK specification by BAE Systems Bofors.

The first Archer system will be fielded by 1 Deep Recce Strike Brigade and initially held by 19 Regiment Royal Artillery (The Scottish Gunners), based at Larkhill, Wiltshire, where capability integration activity and safety trials will be carried out in order to meet an initial operating capability with the Archer system in 2024.

Colonel Rob Hollinrake, DE&S team leader responsible for the Interim 155 mm project, was quoted as saying in a DE&S press release, "The delivery of the first Archer gun system to the British Army so quickly after the initial contract agreement is testament to the hard work and diligence of all those involved in the project. We are totally committed to equipping the UK armed forces and soon as possible and supporting them whilst meeting our obligations to operational commitments."

## French Navy Conducts Successful Firing of New-Generation Exocet Missile

(pf) A successful firing by the French Navy of the latest-generation Mer-Mer 40 Block 3c (MM40 B3c) Exocet anti-ship missile took place on 20 September

Credit: MBDA

2023, manufacturer MBDA announced on 28 September.

The firing was conducted by the FREMM frigate Alsace off the coast of the Direction générale de l'armement (DGA) missile test centre, located on the French Mediterranean island of Ile du Levant.

The MM40 B3c is the latest generation of MBDA's Exocet family of anti-ship missiles, which can be integrated onto a wide variety of platforms, including surface ships, submarines, fast jets, helicopters and coastal batteries. Previous versions of the Exocet are in service with several navies around the world.

The B3c generation builds on the successive improvements made to the Exocet throughout its service. The MM40 B3c includes all the characteristics for which Exocet is renowned, in particular its all-weather capability and high flexibility of use. In addition, this latest missile benefits from new seeker technology and the development of new algorithms designed to meet the latest operational requirements of anti-ship warfare.

"I am extremely proud of the success of this operational evaluation firing of the Exocet MM40 B3c, performed from the multi-mission Alsace frigate," MBDA CEO Eric Béranger was quoted as saying in a company press release. "It proves the new capabilities of the missile's latest generation, whose major developments keep it at the forefront in a high-intensity context. Exocet is a real symbol for MBDA, and this success is further proof of the skill and technical excellence of MBDA's people. I would also like to thank the DGA and French Navy for this firing."

MBDA has continued to develop the Exocet since it first entered service in 1975. The Exocet MM40 B3c is MBDA's response to new conflicts with an evolving threat spectrum, in particular high-intensity combat in complex electronic warfare environments.

## ■ Sikorsky Receives Contract to Produce Eight MH-60R Seahawks for Spain

(pf) Lockheed Martin's Sikorsky business has received a contract via the US Navy to produce eight MH-60R Seahawk helicopters for the Spanish Navy (Armada), Lockheed Martin announced on 12 October 2023.

The US Department of Defense's contracts website noted that this Foreign Military Sale is valued at USD 379.58 M (EUR 361.46 M) and that work under the contract is expected to be completed in March 2027.

Designed, built and integrated with advanced mission systems and sensors for anti-submarine and anti-surface warfare, the future Spanish MH-60Rs will significantly upgrade and broaden the range of maritime capabilities performed by its current Seahawk fleet; the Armada operates 12 SH-60Bs acquired from 1988 to 2001 and six ex-US Navy SH-60Fs received from 2017. In 2022, meanwhile, the Armada retired the last of 18 Sikorsky SH-3 Sea King helicopters that were delivered from 1966.

Credit: Sikorsky

"The new MH-60R will upgrade mission systems and sensors of the SH-60B fleet, elevating the Armada to the highest level of anti-submarine and anti-surface warfare capability," an Armada spokesperson was quoted as saying in a Lockheed Martin press release. "We expect a smooth transition from the SH-60B to the MH-60R."

Spain's eight new MH-60Rs will join 330 of the type operational worldwide; they are currently serving with the US Navy, Australia, Denmark, Saudi Arabia and India, while aircraft deliveries to Greece and South Korea are set to begin in 2024.

In May the US Navy announced the global MH-60R fleet had surpassed a million flight hours.

"Spain's confidence in the MH-60R is an attestation to our shared commitment to national security and the security of our allied nations," Captain William Hargreaves, US Navy H-60 Multi-mission Helicopters programme manager, was quoted as saying by Lockheed Martin. "We are committed to supporting Spain throughout this process from contract award through delivery while further solidifying our global partnership. The increased capabilities and new technologies of the MH-60R Seahawk will allow the Spanish Navy to remain a ready, capable and equipped fleet."

## UK MoD Signs Contracts for Next Stage of SSN-AUKUS Submarine Programme

(pf) The UK Ministry of Defence (MoD) signed contracts with BAE Systems, Rolls-Royce and Babcock worth GBP 4 Bn (EUR 4.62 Bn) on 1 October 2023 for the next phase of the UK's next-generation nuclear-powered attack submarine (SSN) programme.

The contracts for the Detailed Design and Long Leads (D2L2) Phase of the programme represent a significant milestone for both the UK and the trilateral AUKUS programme as a whole in the lead-up to the building of the future class of SSNs known as the SSN-AUKUS class.

The contracts will progress the programme through the design, prototyping and purchase of main long-lead components for the first UK submarines, allowing construction to commence in the coming years and ensure the stability and resilience of the UK's domestic supply chain, the UK MoD noted in a 1 October press release.

Credit is: BAE Systems

"Building on more than 60 years of British expertise in designing, building and operating nuclear-powered submarines, the D2L2 contracts will support thousands of highly skilled jobs in the UK – a clear demonstration of how the AUKUS programme supports the prime minister's priority to grow the economy," the UK MoD stated.

"Alongside the design development and long-lead procurement, infrastructure at the submarine shipyard in Barrow-in-Furness and the nuclear reactor manufacturing site in Raynesway, Derby, will be developed and expanded where needed to meet the requirement of the future submarine build programme," the MoD added.

The aim of the SSN-AUKUS programme is to deliver the first UK submarines into service in the late 2030s to replace the current Astute-class SSNs, with the first submarines for Australia following in the early 2040s.

"These will be the largest, most advanced and most powerful attack submarines ever operated by the Royal Navy, combining world-leading sensors, design and weaponry in one vessel," the MoD stated.

Construction of the UK's submarines will take place principally in Barrow-in-Furness, while Australia will work over the next decade to build up its submarine industrial base in order to build its submarines in Australia, with Rolls-Royce supplying the nuclear reactors for all UK and Australian submarines.

The 1 October D2L2 contract announcement follows the AUKUS announcement in March by the leaders of Australia, the UK and the United States that outlined the next-generation submarine-building programme.

BAE Systems announced on 1 October that the funding will cover development work to 2028, enabling the company to move into the detailed design phase of the programme and begin to procure long-lead items. Manufacture of the SSNs will start towards the end of the decade.

"This multi-billion-pound investment in the AUKUS submarine programme will help deliver the long-term hunter-killer submarine capabilities the UK needs to maintain our strategic advantage and secure our leading place in a contested global order," UK Defence Secretary Grant Shapps was quoted as saying in a BAE Systems press release. "I'm committed to backing our defence industry, because it's only with the mission-critical support of businesses like BAE Systems that the UK can develop the advanced equipment our armed forces need to defend the British people in a more dangerous world."

Regarding the current Royal Navy fleet, BAE Systems has already delivered five of seven Astute-class SSNs to the navy, with the remaining two boats at advanced stages of construction. The company is also designing and building the UK's next-generation nuclear-powered ballistic missile submarines (SSBNs), the Dreadnought class, with work underway on three of the four new boats.

## MBDA to Integrate Mistral ATAM Anti-Air Missile Onto Korean Marine Attack Helicopter

(pf) European missile house MBDA announced at the ADEX 2023 defence exhibition in Seoul on 16 October 2023 that it has received a contract from Korea Aerospace Industries (KAI) to integrate the Mistral ATAM anti-air missile system onto the Korean Marine Attack Helicopter (KMAH).

Credit: KAI

The Mistral ATAM is based on the Mistral short-range anti-air missile, which MBDA says is "known for its fire-and-forget engagement mode, ease of operation and unrivalled kill probability".

The ATAM integration on the KMAH will include two launchers per helicopter, each carrying two missiles. Manportable Mistral air defence systems are also in service with the South Korean armed forces.

The Mistral ATAM can be launched at altitudes up to 15,000 ft while the launch platform is travelling at speeds of up to 200 kts (370.4 km/h). It travels at high supersonic speed and can engage targets at ranges of up to 8 km and at altitudes of up to 6,000 m. The missile, which weighs less than 20 kg, has a 3 kg warhead coupled with a laser proximity and impact fuze.

Unveiled by KAI at the ADEX show in 2021, the KMAH is the armed variant of the Marineon helicopter, which is a variant of KAI's KUH-1 Surion.

KAI received a contract from South Korea's Defense Acquisition Program Administration (DAPA) to develop the KMAH for the Republic of Korea Marine Corps in October 2022.

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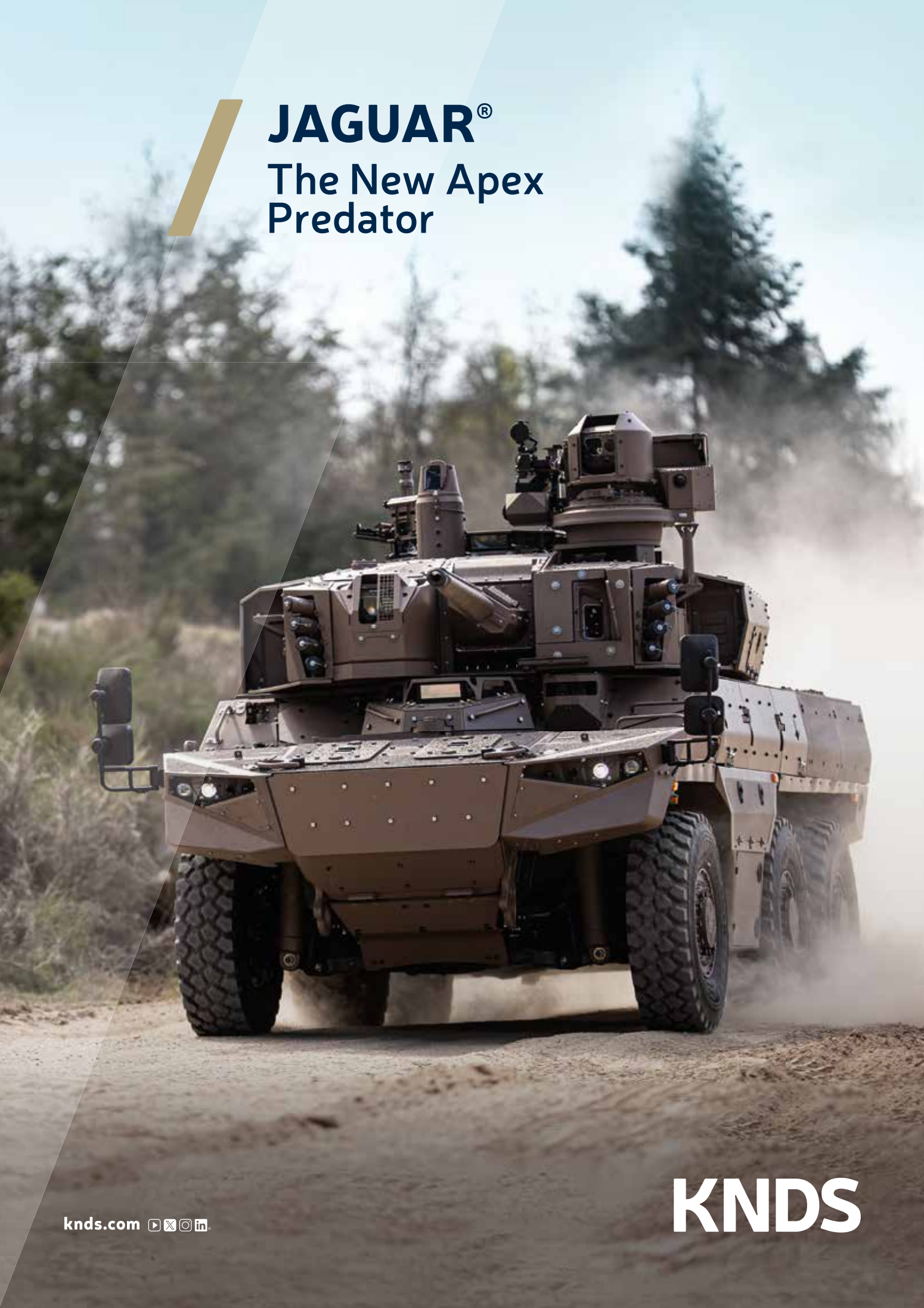

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## US Air Force General Charles Q Brown Jr is New JCS Chairman


Credit: Office of the JCS Chairman

(pf) US Air Force (USAF) Charles Q Brown Jr became the 21st Chairman of the Joint Chiefs of Staff (JCS) on 1 October 2023, succeeding US Army General Mark Milley.

As JCS Chairman Gen Brown thus becomes the country's highest-ranking military officer, whose duty it is to be the principal military advisor to the US president, secretary of defence and National Security Council. Gen Brown previously served as the 22nd Chief of Staff of the USAF.

After earning his commission in 1984, Gen Brown has served in a variety of positions at the squadron and wing levels, including an assignment to the US Air Force Weapons School as an F-16 Fighting Falcon instructor. His notable staff tours include serving as Aide-de-Camp to the Chief of Staff of the Air Force and Director of the Secretary of the Air Force and Chief of Staff Executive Action Group. His joint assignments include three assignments to US Central Command: as Air Operations Officer, Current Operations Division; Deputy Director, Operations Directorate; and Deputy Commander.

Gen Brown has commanded a fighter squadron, the US Air Force Weapons School, two fighter wings, and twice served as a Combined/Joint Air Component Commander with command tours at US Air Forces Central Command and Pacific Air Forces.

As a command pilot with more than 3,000 flight hours (including 130 combat hours), primarily in the F-16, Gen Brown has flown 20 additional fixed- and rotary-wing aircraft types.

Throughout his career, he deployed or directly supported Operations 'Southern Watch', 'Northern Watch', 'Enduring Freedom', 'Odyssey Dawn', 'Unified Protector' and 'Inherent Resolve'.

In his retirement speech on 29 September Gen Milley did not hide his disdain for former president Donald Trump, under whom he served as JCS Chairman from October 2019 until January 2021 and who ridiculously accused Gen Milley of "treason" for not supporting the illegal efforts to overturn his loss in the 2021 presidential election.

In his last speech as the president's top military adviser and the nation's top general, Gen Milley stated, "We are unique among the world's militaries. We don't take an oath to a country, we don't take an oath to a tribe, we don't take an oath to a religion. We don't take an oath to a king, or a queen, or a tyrant or a dictator. "And we don't take an oath to a wannabe dictator," he pointedly added. "We take an oath to the Constitution and we take an oath to the idea that is America – and we're willing to die to protect it."

## ARTEC Shareholders Agree to Set Up UK Subsidiary

(pf) The shareholders of ARTEC GmbH – Krauss-Maffei Wegmann, Rheinmetall Landsysteme and Rheinmetall Defence Nederland – have elected to set up a new subsidiary in the United Kingdom known as ARTEC Boxer UK Ltd, Rheinmetall announced on 4 October 2023.


Credit: ARTEC

The company will be a wholly owned subsidiary of ARTEC GmbH and assume responsibility for its operational activities in the UK. These primarily involve providing the British Army with service and maintenance support for the Boxer 8×8 multi-role armoured vehicle (MRAV), but the company will pursue export orders for the vehicle. Its operational goals include growing its market share in the UK service sector as well as gaining ground in the global market for highly protected 8×8 vehicles.

The agreement to create ARTEC Boxer UK Ltd was signed during the DSEI 2023 defence show in London in September.

After initially withdrawing from the Boxer programme in July 2003, the UK announced in April 2018 that it would rejoin to deliver the British Army's Mechanised Infantry Vehicle (MIV) programme. An initial 523 Boxers were ordered by the UK in November 2019, with an additional 100 ordered in April 2022.

The first Boxers for the British Army were delivered for trials in July this year.

## Dan Sallet Named as BAE Systems Inc's Senior VP for Finance

(pf) BAE Systems Inc has named Dan Sallet as its senior vice president for finance, the company announced on 11 October 2023.

Sallet will be responsible for the financial operations of the company's US-based businesses, which have more than 35,000 employees in the United States, United Kingdom, and Sweden, and generated 2022 sales of nearly USD 12.6 Bn (EUR 12 Bn).

Sallet will report to BAE Systems Inc President and CEO Tom Arseneault and serve as a member of the company's senior leadership team.

"Dan's exceptional financial acumen and leadership, and his dedication to our mission, will be instrumental as he continues to drive our financial success," Arseneault was quoted as saying in a company press release.

During his 35-year career with the company, Sallet has held a number of leadership positions within the finance organisation. Most recently he served as the vice president of finance for the Electronic Systems sector.

Sallet succeeds Guy Montminy, who will be retiring next year.

"I want to thank Guy for nearly four decades of service to our company," said Arseneault. "His leadership and unwavering commitment to excellence has helped us to deliver for our employees, customers, and shareholders."

Sallet holds a master's degree in business administration from Bentley University and a bachelor's degree in business administration from the University of Massachusetts (Lowell). He is also a graduate of the BAE Systems' Financial Leadership Development Program.

## Loïc Rocard Appointed as External Director of the Thales Board of Directors

(pf) Thales announced on 28 September 2023 that it has appointed Loïc Rocard, chairman and CEO of TechnicAtome, as an 'External Director' of the Thales Board of Directors, succeeding to Philippe Knoche.

Rocard has also been appointed chairman of the company's Governance and Compensation Committee. His term of office runs until the close of the Annual General Meeting called to approve the financial statements for fiscal year 2023.

A former student at the Polytechnique engineering school, Rocard is also a graduate of the ENAC engineering school and holds a degree in History from Paris IV Sorbonne and a Master of Science from the University of California at Berkeley. He began his career in 1997 at Aéroports de Paris, where he worked for 10 years. He was first an advisor to the Director of Flight Operations, then Operations Director for the Roissy Charles de Gaulle 2 terminals, before heading up the airport's two automatic metro projects.

Rocard subsequently joined Vinci Group to manage rail concession projects, in particular the tender for Sud Europe Atlantique (the Tours-Bordeaux high-speed line). In 2010 he became operations director of Cofiroute before being appointed CEO there in 2012.

From May 2014 to May 2017 Rocard was an advisor to the Head of the Transport, Environment, Energy, Housing and Urban Planning Department in the French Prime Minister's Office.


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# Tactical Air-to-Ground Weapons

**Sidney E. Dean**

**Numerous classes of conventionally-armed air-to-ground munitions (AGMs) are in service. Many are currently being upgraded. New, even higher-performance tactical AGMs are being developed.**

## Bomb Guidance Kits

Despite the plethora of missiles in modern inventories, aerial bombs remain a major tool of warfare. Unguided gravity bombs have largely been replaced by precision bombs, whereby legacy gravity ordnance is frequently endowed with precision attributes through add-on kits. These kits consist of a sensor and guidance system affixed to the head of the so-called 'dumb bomb', and a set of aerodynamic control surfaces attached to the rear.

The Armement Air-Sol Modulaire (AASM; ENG: Modular Air-to-Ground Ordnance) produced by Safran Electronics and Defense is one of the newest bomb guidance kits available. Internationally it is also known as the Highly Agile Modular Munition Extended Range or HAMMER. Introduced in 2007, the all-weather capable AASM is available in various bomb-weight classes (125 kg to 1,000 kg). The modular system can be fitted with a choice of guidance suites including Inertial Navigation System (INS)/ Global Positioning System (GPS), INS/GPS/Infra-Red (IR), or INS/GPS/Semi-Active Laser (SAL). These varied guidance system options make the HAMMER resistant to electronic jamming and Global Navigation Satellite System (GNSS) denial, and (with SAL targeting) permit destruction of moving targets. According to Safran, ongoing technology upgrades continue to enhance performance, versatility and reliability for collaborative and high-intensity operations. The kit's integrated propulsion system enables a stand-off range in excess of 70 km. This can be achieved from any deployment altitude, from high to very low. The system's fire-and-forget capability enables the pilot to program and release up to six bombs simultaneously. Each bomb can be set for either airburst, impact or penetration (impact delay) detonation. Tactical capabilities cover the complete AGM-mission spectrum, including suppression or destruction of enemy air defences (SEAD/DEAD), close-air support (CAS), and engagement of stationary and moving targets. AASM is fully integrated with the Dassault Rafale fighter aircraft, but Safran has developed the Hammer Stand Alone System (HASAS) to permit integration on other aircraft models. The firm also offers integration on light attack fighters as well as transport aircraft. According to Safran, the HAMMER has achieved a 99% success rate in combat.

Credit: Safran

*AASM or HAMMER guided bombs on a French Air Force Rafale fighter.*

## Ultra-High-Yield Bombs

Very large 'bunker buster' and area-effects bombs constitute a small portion of bomb inventories, but stand out due to their size and their dramatic results. The two best known are the GBU-43B Massive Ordnance Air Blast (MOAB) and the GBU-57A/B Massive Ordnance Penetrator (MOP). Operated exclusively by the US Air Force (USAF), they are considered the world's strongest non-nuclear weapons, and are reserved for exceptional targets.

The GPS-guided MOAB, manufactured by Dynetics, entered service in 2003. A total of 15 were procured. Only one has been used, targeting a tunnel complex in Afghanistan in 2017. The 9 m long weapon weighs 9,800 kg and must be deployed via the cargo ramp of an MC-130 aircraft. It is designed to detonate immediately before impact in order to destroy soft-to-medium surface or near-surface targets. While the blast effect extends some 1,600 m from the point of impact, the weapon's power also unfolds well in contained environments where the blast energy is channelled, such as a cave or tunnel complex.

In contrast to MOAB, the Boeing-built MOP is configured as a deep-penetration weapon to destroy hardened targets such as underground command and control centres or weapons of mass destruction facilities. The 14,000 kg weapon was declared operational in 2011 and is currently the world's largest bomb; it is currently only deployable on the B-2 bomber. The warhead weighs 2,500 kg. The AFX-757 plastic-bonded explosive used in the warhead was developed by the Air Force Research Laboratory and offers both higher blast characteristics and greater stability than other military grade high explosives. The major penetration effect is achieved through the kinetic impact of the very dense and hardened structure of the bomb casing. USAF acquired 20 units, none of which has yet been deployed in combat. Since 2010 the Air Force has been pursuing development of the Next Generation Penetrator (NPG). The service hopes to acquire a weapon with comparable performance but circa one-third the weight of the MOP.

## Guided Glide Bombs

**SDB**

At the opposite end of the size spectrum lies the GBU-39B Small Diameter Bomb (SDB). The Boeing-produced munition entered service in 2006, with 24,000 units now in the USAF inventory. At only 114 kg weight and 1.8 m length, SDB permits fighter aircraft and bombers to carry significantly more ordnance per sortie (up to 28 bombs on an F-15E), speeding suppression of enemy forces while reducing exposure of the aircraft and crew. The upgraded GBU-53B SDB II Stormbreaker is produced by Raytheon. The 93 kg Stormbreaker incorporates a multi-mode target seeker that utilises an IR channel, millimetre wave (MMW) radar and SAL seeker in addition to the original GPS/INS guidance system; this permits precise engagement of moving targets even under severely degraded visibility. The bomb has a standoff range of circa 110 km against stationary targets and 72 km against moving targets, with a circular error probable (CEP) of 1 m. The 48 kg warhead is lethal against armoured and soft targets.

**SmartGlider**

Reflecting the need for ever-greater standoff-range capability, MBDA is developing

Credit: MBDA

*A Dassault Rafale deploys a SmartGlider swarm (MBDA concept image).*

Credit: USAF

***The BRU-61 bomb rack fits four Small Diameter Bombs in a 2x2 configuration, allowing four bombs to be carried on a single underwing hardpoint.***

the SmartGlider family of PGMs, described by the firm as "a new generation of air-to-ground tactical strike weapons for the decades to come." SmartGlider comes in a light and a heavy variant in order to maximise the operational profile which includes air interdiction, offensive counter air (destruction of enemy air assets on the ground), CAS and SEAD/DEAD. Fixed and stationary targets including networked short and medium-range surface-to-air systems can be engaged. The light variant is nearly 2 m long and weighs 120 kg. It is armed with an 80 kg multi-effect unitary charge warhead. MBDA's Hexabomb Smart Launcher (HSL) permits fighter aircraft to carry 12-18 small SmartGliders per mission in support of stand-off saturation attacks against enemy air defences, convoys or force concentrations. The heavy variant is 4 m long and weighs 1,300 kg. This includes a 1,000 kg warhead capable of delivering combined high penetration and blast effects against large and hardened targets.

The 'fire and forget' SmartGlider family combines INS/GNSS navigation with a multi-mode terminal guidance suite which includes low-light television (TV), IR, and a SAL seeker. Radiofrequency sensors, particularly useful against air defence networks, are optional. The aircrew can implement in-flight targeting updates via data link. Available payload effects include airburst, impact and delayed detonation.

According to MBDA, both versions achieve a range "much greater than" than 100 km when launched from circa 12 km altitude. As a glide bomb, SmartGlider does not utilise a propulsion motor. Once launched, the weapon unfolds two glide wings which offer a high lift-to-drag ratio. Pitch and flight control are regulated by the triform tail. The manoeuvrable glider can evade obstacles and threats and assume variable angles of attack to facilitate precision strike. MBDA unveiled the SmartGlider concept at the 2017 Paris Air Show. The light version is expected to be available by 2025, followed by the heavy variant.

## Air Launched Cruise Missiles

Conventional air launched cruise missiles (ALCM) combine the high payload potential of aerial bombs with much greater range as well as the ability to change course and altitude throughout their flight. Their very high standoff range permits bomber and fighter aircraft to stay well beyond enemy air defence zones while delivering precision strikes on high value targets.

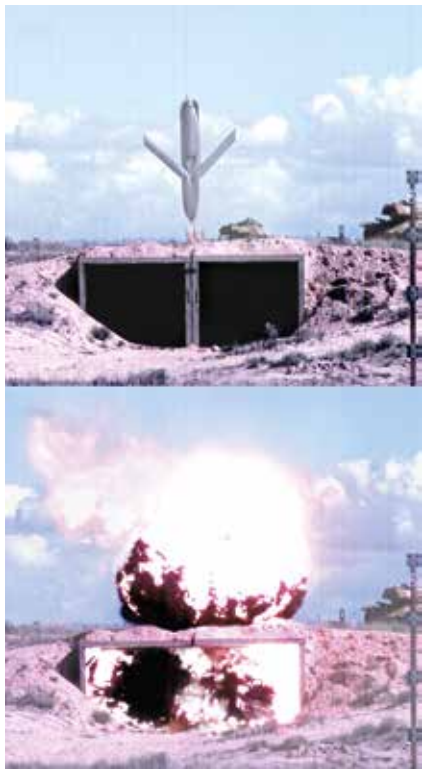
### JASSM

The AGM-158 Joint Air-to-Surface Standoff Missile (JASSM) was originally developed by Lockheed Martin for USAF and the US Navy, with initial production beginning in 2001. Armed with a 450 kg penetrator warhead, the air force variant cruise missile is designed to attack fixed and relocatable targets including moderately hardened or buried targets. Low-observability technology is applied in order to reduce the detection range by air-defence systems, permitting JASSM to fly at higher altitudes than many cruise missiles.

JASSM continues to be upgraded and enhanced. The subsonic cruise missile uses GPS/INS navigation and an Imaging Infrared (IIR) terminal seeker. An anti-jam GPS receiver is currently being pursued. The AGM-158A baseline version has a range of circa 370 km. The AGM-158B JASSM-ER was introduced in 2014, utilising a more efficient engine and extending range to over 900 km. Production of the AGM-158A ceased in 2016 in favour of the JASSM-ER variant. Development of the 'extreme range' AGM-158B-2 or JASSM-XR began in 2018, with low-rate initial production (LRIP) beginning in 2021; deliveries are to commence in early 2024. The XR variant more than doubles the effective range to circa 1,900 km.

The next iteration is the proposed JASSM New Variant (JASSM-NV) which is intended to improve survivability and lethality when operating in contested environments against sophisticated defences. USAF awarded Lockheed Martin a non-competitive development contract in October 2022. The NV variant will have "added capabilities" over the current ER, but most details remain classified.

Credit: USAF



***Testing JASSM against a hardened target, shown here prior to impact and in the very early phase of warhead detonation.***

### TAURUS KEPD 350

The Target Adaptive Unitary & Dispenser Robotic Ubiquity System / Kinetic Energy Penetration Destroyer (TAURUS KEPD 350) is produced by Taurus Systems GmbH, a joint venture of MBDA Deutschland GmbH and SAAB Dynamics. The KEPD 350 flies at high-subsonic speeds (Mach 0.6-0.95) and achieves a 500 km range. The ALCM features stealth attributes including a radar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Credit: TAURUS

*The TAURUS KEPD 350 on a German Air Force Eurofighter. The ALCM is certified for the Eurofighter Typhoon, Gripen, Tornado, F-15 and F/A-18.*

absorbent coating and curved air intakes which, together with terrain-hugging flight tactics and electronic countermeasures, enabling high penetration potential against dense air defence networks. The Tri-Tec multi-mode navigation system utilises INS supported by GPS, image-based navigation (IBN) and terrain-reference navigation (TRN) to achieve high strike accuracy. The on-board sensors are integrated with and reference databases to constantly monitor the missile's location and trajectory as it approaches pre-programmed waypoints en route to target, making it independent of GPS access.

The terminal attack phase is guided by image recognition of the target, referencing an on-board visual database. The 1,400 kg missile carries the 480 kg MEPHISTO tandem warhead equipped with an initial precursor shaped charge warhead (understood to be a High Explosive Anti-Tank (HEAT) type) capable of breaching hard and deeply buried targets, and secondary warhead consisting of a delayed-fuze penetrating main charge packaged inside a kinetic penetrator casing. According to SAAB, the KEPD 350 is the only AGM which can be programmed to detonate the main charge on a pre-selected floor of the target; this is achieved through layer counting and void sensing technology. Alternately the KEPD 350 can be set to detonate in air-burst mode to destroy high value surface and area targets including major radar installations, bridges, and runways. The ALCM entered service with the German Air Force in 2005, followed by Spain and South Korea. The modular architecture of the KEPD 350 enables regular upgrading of key components.

Credit: RAF

*An RAF Tornado GR4 mounting two Storm Shadow ALCMs beneath the fuselage.*

**Storm Shadow/SCALP**

The British-French Storm Shadow ALCM (designated the 'Système de Croisière Autonome à Longue Portée – Emploi Général or SCALP-EG in Frech service) entered service in 2003, and has been deployed in nine different conflicts, including the ongoing war in Ukraine. It has demonstrated a high success rate against various targets including airfields, bridges, bunkers and moored naval vessels. The combination of stealthy design and terrain-hugging flight reduces the risk of intercept. According to manufacturer MBDA, Storm Shadow flies at Mach 0.8 and has a range exceeding 250 km. The navigation system utilises INS, GPS and TRN. Near the pre-programmed coordinates the missile pops up to acquire the target utilising an IR sensor in conjunction with an onboard image database. A final steep dive achieves precision strike with minimised collateral damage. Detonation options for the circa 450 kg tandem warhead include air-burst, impact, or penetration (delayed) modes.

In 2017 the UK and France contracted with MBDA for mid-life refurbishment of the Storm Shadow, adapting the system to counter evolving threats and extending the missile's service life to 2032. In addition to this refit, the missile also received a software upgrade which permits attacking targets located up to 4,000 m above sea level. In 2017, France and the UK jointly launched the Future Cruise/Anti-Ship Weapon (FC/ASW) program aimed at replacing the Storm Shadow/SCALP ALCM as well as the Harpoon and Exocet anti-ship missiles; and in June 2023 Italy joined the project. Following conclusion of the concept phase, preparatory works were initiated in February 2022. According to MBDA, two complementary missile concepts are being assessed, namely "a subsonic low observable concept and a supersonic, highly manoeuvrable concept." It is currently unclear whether MBDA will ultimately present a single, dual-role weapon or two specialised missiles. FC/ASW is expected to be operational in the early 2030s.

## Precision-Guided Missiles

Conventionally propelled precision guided missiles (PGMs) mostly rely on solid-fuel motors, as opposed to the air-breathing engines of ALCMs. They are smaller and cheaper than ALCMs, and are produced in considerably greater numbers. Most have a short to medium operating range, although longer range configurations are being introduced. Unlike ALCMs, they can be deployed by helicopters and UAVs as well as by fixed-wing manned aircraft.

**AGM-114 Hellfire/JAGM**

One of the most ubiquitous PGMs is the AGM-114 Hellfire, which has been acquired by some 30 countries. Produced by Lockheed Martin, the subsonic Hellfire missile has undergone several enhancements since initial introduction in 1982. Depending on variant, the 1.6 metre long weapon weighs 45-49 kg and achieves a maximum range of 8 km. The two most important variants in the current arsenal are the AGM-114L Longbow (produced 1995-2005) and the AGM-114R Romeo (in production since 2012). The Longbow is a beyond-line-of-sight (BLOS) 'fire and forget' weapon which utilises a MMW radar seeker to acquire its target, preserving operational proficiency in the face of adverse weather and battlefield obscurants; the tandem-HEAT warhead can engage heavy tanks. The Romeo uses a Semi-Active Laser (SAL) targeting system which requires the target to be illuminated by the host aircraft or a third party; the AGM-114R replaced several previous variants and carries a multipurpose tandem-HEAT warhead with a fragmentation sleeve, capable of defeating different target classes – including hard, soft and enclosed objectives – with the same warhead. A major enhancement found on the AGM-114R is the three–axis inertial measurement unit (IMU) which enables the missile to manoeuvre and attack the side or rear of targets without requiring the firing aircraft to position itself behind the target.

Credit: US Army

*The AH-64D/E Apache attack helicopter can carry 16 AGM-114 Hellfire missiles.*

A special variant designated the AGM-114R9X was developed for targeted anti-terrorist strikes. To significantly minimise the risk of collateral casualties, the 'R9X' does not carry an explosive warhead. On impact, it deploys six long blades which dismember any targets who survive the ki-

netic energy of the missile's impact; these blades have given rise to the unofficial nickname 'Ninja missile'. The weapon's existence was first reported by the Wall Street Journal which described initial deployment against targets in Syria in 2017.

The planned successor to the Hellfire family is the AGM-179 Joint Air-to-Ground Missile or JAGM. Based on the AGM-114R missile body, it features a new seeker head with a multi-mode guidance system which combines MMW and SAL capabilities, and retains the Romeo's warhead. The enhanced all-weather, fire-and-forget guidance capabilities promise greater versatility and combat effectiveness against stationary or moving targets in all operational environments, as well as enhancing the missile's ability to overcome countermeasures. LRIP began in 2018, advancing to full-rate production in 2022. The new weapon is being fielded incrementally, with the US Marine Corps'AH-1Z and the Army's AH-64E Apache to be equipped first. In November 2022 Lockheed Martin tested the advanced JAGM-MR (Medium Range) variant. It would double the JAGM's effective range from 8 km to 16 km, and expands the guidance system through addition of an IIR sensor.

**Brimstone**

The Brimstone AGM family developed by MDBA UK entered service with the RAF in 2005. The Brimstone 2 entered service in 2016, although it is not clear if this version remains in production given that the follow-on Brimstone 3A (previously known as Brimstone 2 Capability Sustainment Programme (CSP), to extend the service life beyond 2030) was contracted in March 2018 and was reported to be in the "Manufacture/Migration" phase in a UK MoD report titled 'Setting the context: current capability plans to enable Integrated Force 30' from July 2022. According to the MoD's 'The Defence Equipment Plan 2021 – 2031' report published in February 2022, Brimstone 3A is due to enter service in Spring 2024, following manufacturer delays.

The Brimstone 2 is a 1.8 metre long, 50 kg missile equipped with a solid fuel engine; it flies at Mach 1.3 and has an operating range of 60 km when launched from a fixed-wing aircraft (triple the range of the original Brimstone launched from a fixed-wing platform). The weapon is optimised for armoured and hardened objectives; the target profile includes fast and manoeuvring tanks and armoured vehicles as well as bunkers. Up to three missiles can be carried per underwing or winglet weapons mount; depending on aircraft type, this permits deployment of up to 18 units during one mission. The Brimstone 2 can operate in three guidance modes: SAL only (against static targets with limited radar cross section), SAL plus MMW (for fast-moving targets and to distinguish targets in cluttered environments), and fully autonomous MMW (for simultaneous engagement of multiple targets in fire-and-forget mode). The Brimstone 2 features a 'man-in-the-loop' option, enabling last-minute mission abort or redirection, and has an insensitive munition (IM) compliant rocket motor and warhead. The 6.3 kg tandem-HEAT warhead can be initiated using a choice of impact, delayed, air-burst, or proximity fuzing modes. According to the UK MoD, the Brimstone has demonstrated "well over 90 percent" accuracy and reliability during combat operations, including over 98% during the 2011 intervention in Libya.

Credit: Crown Copyright 2018

***Brimstone 2 precision guided missiles on the RAF Protector RG Mk1 UAV.***

The upgraded Brimstone 3A, which successfully conducted a first test launch in March 2019. It incorporates the latest dual-mode SAL/MMW seeker, micro-electromechanical system (MEMS) based IMU, an enhanced autopilot, improved battery. According to MBDA, the Brimstone 3 also includes a significant memory and processing update to "future-proof the missile." The cockpit crew will be able to pre-determine flight trajectory, angle of attack and impact angle to guarantee precision engagement of targets moving at up to 110 km/h.

Going beyond the Brimstone 3A, in 2021 MBDA announced the integration of a major software upgrade for the 3A variant, to result in the Brimstone 3B variant. The 3B variant was listed as being in the "Assessment & Demonstration" phase in the July 2022 MoD report, and according to the February 2022 report, integration of this variant with the UK's Apache helicopters has been cancelled, but it will be integrated on the Typhoon FGR4 fighter aircraft and Protector RG Mk 1 Unmanned Aerial Vehicle (UAV), with the former selected as the lead platform to host Brimstone 3B. This missile variant has also been offered to the MoD under the UK's Battle Group Organic Anti-Armour (BGOAA) programme which aims to replace some of the UK's legacy ground-based anti-armour guided weapons.

## Air Launched Effects

Air Launched Effects (ALE) are a new concept intended to outfit manned helicopters and unmanned aircraft with flexible air-to-ground weapons. ALEs are being primarily pursued by the US armed forces, especially the Army. They will ultimately be fielded in various sizes and models, with larger types having greater payload and performance profiles including an operational range of several hundred kilometres. These multi-mission effectors can deploy as reconnaissance assets (including beyond-line-of-sight targeting aids for long-range artillery), loitering attack munitions, communications nodes, or as signals intelligence or electronic warfare (EW) assets. ALEs can be deployed singly or in swarms, permitting coordinated saturation of airspace sectors. Tactical benefits include extending the aircraft's sensor range and engaging targets while the aircraft remains beyond detection or engagement range of enemy anti-aircraft systems. They are conceived as comparably low cost, making them procurable in large numbers, and expendable. While of interest for use on current operational aircraft, the US Army is particularly focussed on ALE as a force multiplier element of the Future Vertical Lift 'ecosystem' which will consist of the Future Long Range Assault Aircraft (FLRAA), Future Attack Reconnaissance Aircraft (FARA), and the Future Tactical Unmanned Aerial System (FTUAS) programme.

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***The first flight of the General Atomics Eaglet ALE took place on 8 December 2022, launching from a US Army MQ-1C Gray Eagle UAV.***

**US Army ALTIUS**

The US Army is currently experimenting with the first air-launched prototype of the Agile-Launched, Tactically-Integrated, Unmanned System (ALTIUS). ALTIUS' production team is led by Anduril's subsidiary AREA-I, which also provides the air vehicle. Testing of the tube-launched ALE is being conducted from UH-60/ MH-60M helicopters and Gray Eagle UAS, although it can also be deployed from the AC-130J and the unmanned Valkyrie XQ-58. ALTIUS offers greater endurance and a larger payload capacity than most comparably-sized UAVs.

The original ALTIUS is derived from AREA-I's Altius 600 UAV. The tube-launched drone's wings unfold after launch, extending to a span of three metres. The body is 15.3 cm in diameter, while the precise length remains classified. Payload capacity is 3.2 kg, with up to four hours endurance and circa 450 km range.

A larger ALE variant designated as the ALTIUS-700M was flown by Anduril in 2021. With a 500 km range and a 15.9 kg warhead, this model would expand the target set to include heavily armoured vehicles and artillery systems.

A single operator can control multiple drones, whereby a high level of autonomy reduces operator workload by facilitating ALE collaborative teaming and coordinated strikes. Major General Wally Rugen, head of the Army's Aviation Cross Functional Team, stated in May 2023 that the service was favouring a networked "wolf pack" approach with one drone acting as leader and others performing specific tasks to contribute to the swarm's overarching objective. In April 2022, the Army demonstrated this capacity by launching four sequential swarms of seven ALTIUS-600 drones each to form a networked swarm of 28 units which proceeded to hunt and destroy simulated ground targets. Additionally the drones – which were controlled by a single operator – passed reconnaissance data back to an incoming air assault force, providing updated tactical intelligence before reaching the landing zone.

According to Army budget documents, the service is pursuing an incremental approach that allows rapid prototyping and operational fielding of technology as it becomes viable, while continuing engineering efforts to mature and implement additional capabilities. This is accomplished through parallel and/or sequential development, simulation and physical prototyping activities for the air vehicle, payloads, and mission system architecture. Prototype evaluation is slated to continue through Fiscal Year 2024, while the Army refines its requirements and an initial concept of operations. Budgeting documents show plans to publish a request for proposals in late FY24, with the engineering and manufacturing development contract to be awarded in the third quarter of FY25.

Credit: US Army

***Test launch of the ALTIUS 600 ALE from a UH-60 helicopter.***

**General Atomics Eaglet**

Meanwhile, General Atomics Aerial Systems is developing its own ALE, designated Eaglet. It is primarily designed to be launched from larger UAV, a helicopter or a ground vehicle. The Eaglet prototype achieved first launch from an Army-owned General Atomics Gray Eagle UAV in January 2023. Aircraft such as the Gray Eagle could transport the ALE over thousands of kilometres before deploying it, enabling deep penetration missions over hostile territory. Eaglet is being considered primarily as a reconnaissance and EW asset, with additional utility as a deep-penetration command and control node.

**USMC Developments**

The US Marine Corps (USMC) is also experimenting with ALEs. As part of the service's Force 2030 modernisation program, the Corps plans to exchange a portion of its Hellfire arsenal for "a low-cost, air launched family of loitering, swarming munitions." The main impetus is the significant range advantage offered by some loitering munitions. "That is a capability that brings hundreds of kilometres, and that allows us to be able to use a current platform to be able to do things that we never thought we'd be able to do," said Brig. Gen. Stephen Lightfoot, director of the USMC's Capabilities Development Directorate. Lightfoot predicted that ALEs would be operationally fielded "within the next few years." ■

# Viewpoint from Kyiv

Credit: Author

# Taking Stock of Ukraine's Counteroffensive

**Alex Horobets**

This spring, Ukraine launched a counteroffensive in the country's South with the objective to advance to the coast of the Sea of Azov and sever a land corridor along the south-east of Ukraine connecting mainland Russia with occupied Crimea. Ahead of the operation's start, various speculations had appeared in the media as to the possible date for the effort being launched, along with wide expectations of a rapid advance, recalling the example of 2022's liberation of vast areas in Kharkiv Oblast and the right bank of the Dnipro in Ukraine's South. Such expectations could be due to the lengthy training of Ukrainian assault brigades and supplies of Western-made armoured vehicles. In June 2023, reports started to emerge of intensified combat engagements on the southern front, which many took to mean that the counteroffensive had indeed been launched.

However, there was no blitz breakthrough of the Russian defence lines as Ukraine's offensive effort dragged on. This led to broad criticism of the slower-than-expected advance. Naturally, Russian propaganda could not miss such an opportunity, immediately picking up on the wave and spinning unverified allegations of Ukraine's losses in terms of armoured hardware and manpower.

At the same time, many in expert and military circles had not shared overly-optimistic expectations of the counteroffensive, realising the complexity of the situation. After all, in the southern part of Ukraine, where the main blow was expected, the Russian military had enough time to dig in as Ukraine was waiting for the required weapons to arrive and troops to be trained.

In turn, hopes for a quick counteroffensive were fed by the fact that Western partners were providing training and donating military equipment to the Ukrainian Armed Forces, including heavy armoured vehicles. It must be noted that the armour supplied by partners truly turned out to outperform Soviet models in many ways, including maintainability, ease of use, and crew survivability. This was evident from the first weeks of offensive operations. However, the dense minefields, as well as the sophisticated network of trenches and other obstacles, prevented Ukraine from making full use of the advantages offered by Western technology. Moreover, Ukrainian commanders ordered attacks on Russia's defensive lines while doing their utmost to preserve soldiers' lives, given Russia's objective advantage in terms of manpower.

Another reason for the sluggish advance is the lack of air superiority. Since the start of the offensive, Russian forces have deployed guided bombs, loitering munitions, and attack helicopters, especially in the South. Ukraine was forced to preserve its fleet of aircraft, not allowing them to get too close to the front lines, given the limited capabilities of Soviet-era warplanes. In turn, Western doctrine initially assumes the regular use of aviation to support ground forces, as was in the case in Iraq.

Considering that the quantity of heavy armour received from Western partners was also rather limited, Ukrainian commanders decided that deploying these assets directly to the front lines would be risky. In this context, just weeks into the launch of assault operations, the Ukrainian military adjusted its strategy, with the aim of minimising its own losses while continuing to degrade Russian troops through artillery and long-range missile strikes.

Once these considerations are laid down, the latest offensive trends along the Zaporizhzhia front gives grounds for some cautious optimism. At the same time, it is clear that the Russians will do their best to hold their ground. The success of Ukraine's Armed Forces in these areas will further call into question the implementation of the initially stated objectives of Russia's so-called 'Special Military Operation' in Ukraine.

Meanwhile, the Kremlin is working to legitimise the occupation regime in the occupied territories, where it held sham elections. Should towns such as Tokmak be regained or even besieged by Ukraine, this would deal a major reputational blow to Moscow, since the only city that the Russian Federation managed to capture during the Winter 2022 – Spring 2023 offensive was Bakhmut in Donetsk region.

It must also be noted that Russia's reserves in the southern operational zone are rather ambiguous. The main defending forces have been amassed in the areas of the Ukrainian offensive. This raises the question of whether Russian forces will be able to keep defending if the Ukrainians penetrate the main line of defence. Moreover, following Ukraine's receipt of Storm Shadow/SCALP cruise missiles, Russian high-value targets have been struck fairly frequently.

Although optimism for Ukraine's counteroffensive has diminished for the moment, its success should not be regarded as equivalent to an ultimate victory. First, the outcome of the effort remains unclear. Secondly, statements voiced by Russian officials suggest Moscow is nowhere near suspending their military campaign, at least not going into the winter and spring. However, this position may change if Russian forces find themselves unable to defend and retreat from territory they presently occupy. This scenario could be accelerated if Ukraine's Western partners deliver ATACMS tactical ballistic missiles, and F-16 fighter aircraft as they have signalled. Fortunately, Ukraine's allies have broadly indicated that they understand the importance of these deliveries for Ukraine's war effort.

# Diversity in Airlift

**Georg Mader**

**Air mobility and airlift capabilities represent critical assets, as they guarantee deployment and sustainability of forces, both globally as well as within the European theatre.**

Both assets cover a wide range of tasks, such as strategic long-range outsized cargo transport, intra-theatre logistics, special operations or medical evacuation and provide access to theatres across the globe. Whether these tasks are foreseen for military or humanitarian purposes, for critical crisis response, or long-term peace stabilisation roles, they can easily 'eat up' a fair portion of the lifespans of whole fleets or individual aircraft types, which are often already decades old in some cases.

Russia's invasion of Ukraine has further exacerbated the problem, creating a sense of urgency within Allied military headquarters. In addition to probably ending the use of the iconic Antonov-124 by European nations, this war has also reminded Western nations of some critical needs, not least of which is the ability to transport and deploy – either for their own militaries or as with Ukraine, to support a third party in dire need – quantities of large air platforms at short notice. With this particular domain however, organisation(s) and individual nations, are quite widely stretched. This article attempts to provide a short overview of military airlift developments and the various platforms, both currently operational and planned.

Credit: Georg Mader


***Since in service with Germany (53), France (50), Spain (27), UK (22), Turkey (10), Belgium (7), Luxembourg (1), Malaysia (4), the European heavyweight Airbus A400M 'Atlas' has also been selected by Kazakhstan and Indonesia, with two each.***

## Organisationally Oriented via a Multitude of Acronyms

The wide range of acronyms related to the heavy lift domain (ETAC, MCCE, ETAP, FMTC and SATOC) can initially look quite confusing. We begin with the multinational European Air Transport Command (EATC), headquartered at Eindhoven in the Netherlands. Since the first Franco-German idea in 1999 of identifying NATO- and EU-shortfalls in the domain of strategic transportation (some of which are still present) and its inauguration by four founding members, the Netherlands, Belgium, France and Germany, EATC has demonstrated its objective of improving the effectiveness and efficiency of its member nations' military air transport efforts. Today, the fleet comprises over 150 assets, located at national air bases of the founding four nations, in addition to Luxembourg (2012) Spain and Italy (2014). All EATC nations are also members of MCCE, the Movement Coordination Centre Europe.

Then there is the European Tactical Airlift Programme (ETAP), developed with a view to improving the operational airlift capability of European countries, coupled with the aim of achieving greater interoperability between participating nations. The programme also aims to improve and develop common tactics, techniques and procedures in order to overcome the challenges of flying transport aircraft in a modern joint and joint operating environment. ETAP is divided into three distinct programmes: European Tactical Airlift Programme – Course (ETAP-C); European Tactical Air Transport Programme – Instructor Course (ETAP-I) and European Tactical Air Transport Training Program (ETAP-T). ETAP-C provides aircrews with a comprehensive course in airlift tactics, in order to enhance the tactical knowledge of the forces involved and expand the area of expertise, also in hostile scenarios. The latter also seeks to expose trainees to SAM- and fighter-threats.

From 5–16 June 2023, this year's edition of ETAP-C's Element Lead exercise was held in Orléans. Six transport crews from France, Belgium, Spain and Germany took part for the precious Element Leader qualification, which documents the ability to prepare, lead and debrief a mission involving two or three aircraft. In order to achieve the qualification, each aircraft flew eight missions in two- or three-plane formations, sometimes as leader, sometimes as wingman.

Currently taking place in Beja, Portugal, ETAP-T is a periodic two-week training exercise, where each type of mission is experienced. According to the characteristics and requirements of each participant, the aim is to generate greater interoperability between the various participating countries, thereby creating a foundation for successful joint and combined operations.

ETAP-I is for European airlift instructor pilots with greater experience and knowledge of

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the different types of existing transport aircraft, and is designed to train and assist crews during flight preparation and support them during mission execution.

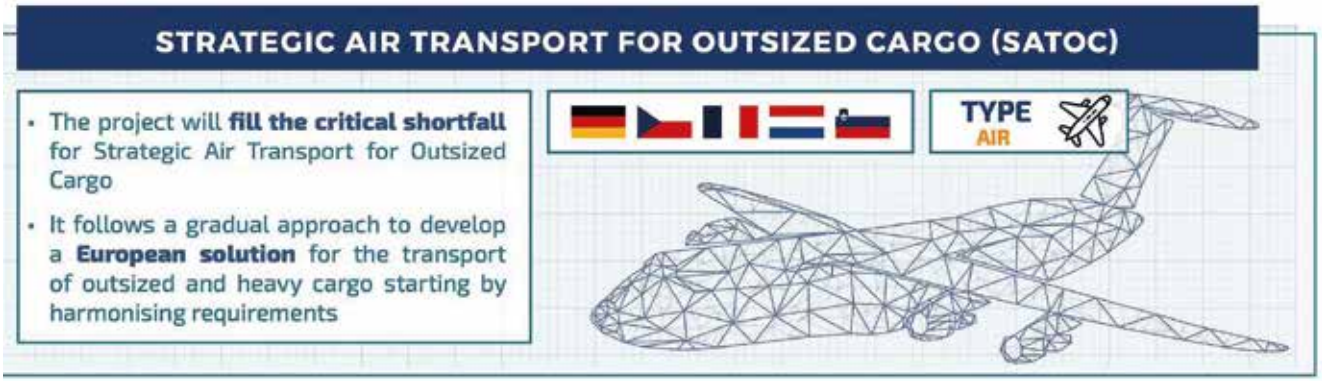
## The Role of the EDA

The European Defence Agency (EDA) has a role to play in this field. Following a request from their project coordinators, since January 2023 the EDA has supported three Permanent Structured Cooperation (PESCO) projects focused on the harmonisation of the requirements of two totally new platforms designed to shape future European airlift capabilities in the realm of mid-sized and out-sized cargo. While the current conditions for European nations to commit to a new unified effort may be positive, key considerations to be taken into account relate to development funds versus potential sales figures.

When it comes to the supported projects, European countries are looking at the Future Medium-Size Tactical Cargo (FMTC) and the Strategic Air Transport for Outsized Cargo (SATOC). Both projects were launched in the fourth cycle of PESCO projects and are coordinated by France and Germany respectively. FMTC gathers France, together with Germany, Spain and Sweden as project members while SATOC gathers Germany, together with the Czech Republic, France and the Netherlands in this four-nation SATOC project. FMTC seeks to enhance air mobility capabilities with a new mid-size tactical cargo aircraft that aims to complement the missions of the A400M, including on shorter, unprepared landing strips. The study plan for a draft joint document proposes an analysis of the operational needs for EU tactical transport in the period 2030–2050, with the identification of opportunities for the development of FMTC in Europe. The tender, which asks for an evaluation of one or two aircraft, was signed in June 2022 and remained open until 24 November 2022. The chosen platform might well be a European derivative of Embraer's C-390M, which is an almost perfect fit and partly consists of key sub-assemblies already produced in Portugal and the Czech Republic.

SATOC on the other hand aims to fill the critical shortfall for the crucial larger, strategic transport of outsized and heavy cargo. The programme involves a 3-step approach, firstly identifying a sufficient number of project members, secondly harmonising requirements, and finally identifying and agreeing on a common European solution for the transport of outsized cargo.

Moscow's assault on Ukraine has also underscored the importance of outsized and heavy cargo transport, coupled with the fact that the destruction of several Antonov aircraft - including to the world's largest cargo aircraft, the An-225 Mriya - has further reduced access by armed forces in Europe to strategic airlift possibilities. That leaves the three C-17A aircraft of the Strategic Airlift Capability (SAC) based at Pápa Airbase in




Credit: EDA

***An early proposal for the European C-5 'Galaxy'-like SATOC heavy lifter, realisation will depend on development funds versus potential sales figures.***

Credit: USAF

***According to the USAF, this revolutionary and highly-efficient blended wing body demonstrator by JetZero should fly in 2027.***

Hungary as the segment's only alternative. In 2016, SAC, with its 12 participants (11 NATO, plus Sweden) moved to new facilities there, including the largest purpose-built C-17 hangar on the European continent, while a new C-17 simulator building is scheduled for construction in 2025.

This current two-fold harmonisation phase carried out by EDA is a positive development. However, as ever when it comes to European 'jointness', it has to be supported by a clear expression of interest for a fixed number of aircraft, so as to provide manufacturers (such as Airbus) some degree of visibility regarding the project's viability.

## Ageing Fleets

Currently, EU Member States, the US Armed Forces, and also larger operators such as India, operate a wide range of tactical cargo aircraft, including the C-130H/J, C-390, C-295 and C-27J. Apart from the 180 units of the A400M, a modern strategic-tactical cross-over platform, and Embraer's C-390, a portion of these platforms will be approaching the end of their life cycle in the coming decade. This also is the case for rest-of-the-world fleets of Russian (or indeed Soviet-era) Il-76s, with the notable exception of a huge build-up to 100+ Chinese C-17 'sibling' Soloviev aircraft, powered by Xi'an Y-20A Kunpeng and Y-20B with domestic WS-20 engines. On 9 April 2022, six Y-20 aircraft landed at Belgrade's Nikola Tesla International Airport, delivering a shipment of FK-3 SAM-systems and on 28 June 2022, six Y-20 aircraft arrived in Afghanistan to deliver 105 tonnes of humanitarian aid in response to the June 2022 earthquake. In early 2023, one Y-20A was visiting as far away as Innsbruck in Austria's Alps, to support a Chinese mountain troop unit participating in a mountaineering challenge.

Coming from US manufacturers, there are three mainstays in operation, of which the strategic C-17 has been out of production for eight years now, and which continues to serve the armed forces of the UK, India, Australia, UAE and Qatar. A total of 52 C-5M life-extended Super-Galaxy aircraft have been re-delivered since 2018 and are set to transport the heaviest and largest US assets until 2040. A genuine replacement is not in sight, apart from the recent USD 235 M contract awarded in August 2023 to JetZero to produce a flyable full-size demonstrator of the radical tailless flying-wing blended-wing body (BWB) XBW-1 by the first quarter of 2027. However, the goal – so far at least – is to only demonstrate the capabilities of BWB technology, giving the DoD and commercial industry partners more options for their future air platforms. According to Air Force Secretary Frank Kendall, the USAF and NASA would also contribute to producing the test aircraft, as would JetZero's partner Scaled Composites, owned by Northrop Grumman.

## India's Byzantine Projects

New Delhi is known to many aviation observers for its often large-scale and ambitious projects, which have been known to take a considerable amount of time to materialise. This is certainly the case regarding India's airlift capability, where the 2020 border stand-off with China has obviously changed the nature of airlift and support for the Indian Army in high-altitude areas.

New Delhi is looking to procure a light tank weighing up to 25 tonnes for de-

Credit: Georg Mader


***Boeing's last C-17A was made in 2015 and this has become the Indian Air Force's 11th airframe.***

C-390 MILLENNIUM

# UNBEATABLE COMBINATION

## MISSION-READY WITH THE PORTUGUESE AIR FORCE

We're delighted to announce the Portuguese Air Force now joins the Brazilian Air Force as a C-390 Millennium operator. The first Portuguese aircraft of the newly formed 506 Squadron is now in service at Beja Air Base, with four more aircraft to be added in the near future. A growing number of countries are choosing the C-390 Millennium (including Hungary, Netherlands, Austria and Czech Republic) attracted by its unbeatable combination of technology, speed, performance and multi-mission capabilities. Hungary will take delivery of their first C-390 Millennium in 2024 – another milestone for an incredible aircraft that has already achieved 10,000 flight hours with the Brazilian Air Force.

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***There is already a market for used C-130Js, such as this former RAF-example in Bahrain.***

ployment in the mountains, especially in Eastern Ladakh. This has resulted in a fresh look at procuring a medium transport aircraft (MTA) and resulted in a comprehensive study to identify the current and future payload-carrying requirements. A Request for Information (RFI) was issued to global manufacturers for aircraft in December 2022, with an unusually broad load-carrying capacity between 18 to 30 tonnes. Three companies responded with a 'Rough Order of Magnitude [ROM] cost of aircraft and associated equipment' for a batch of 40, 60, or even 80 aircraft until an extended deadline of 31 March 2023. The three included Airbus, with the A-400M with a maximum carrying capacity of 37 tonnes and with user Malaysia already in the region; Lockheed Martin with its C-130J (20 tonnes); and Embraer with the C-390 (26 tonnes). So far, and unsurprisingly, at present nothing has been decided with the MTA programme.

On the other hand, in September 2021, the Indian Defence Ministry signed a contract with Airbus and Space S.A., Spain, for the procurement of 56 smaller C-295MW transport aircraft to replace the decades-old Avro 748 and part of the An-32 aircraft fleet, executed in partnership with Tata Advanced Systems Limited (TASL), and with a final assembly line to be set up in Vadodara, Gujarat. The first C-295 aircraft was inducted into the Indian Air Force (IAF) on 25 September 2023. The IAF's hodgepodge transport fleet currently consists of over 100 An-32s, Avro 748s, IL-76 heavy transports (45–50 tonnes of payload) and IL-78 tankers, as well as 12 C-130J Super Hercules and 11 C-17 Globemaster strategic airlifters (70 tonnes).

## The Indefatigable Hercules

The most numerous airframe type – and not only in the US inventory – remains Lockheed Martin's evergreen C-130 series; with the C-130J and stretched 30-model still in production at Marietta – not only for US forces – but currently also for a new customer, Germany. As the world's most widely operated tactical-transport aircraft, the 525 Super-Hercules delivered thus far (in 18 versions) have accumulated more than 2.5 million flight hours by 25 different operators in 21 countries. Lockheed Martin's Director of Air Mobility and Maritime Missions, Richard Johnston spoke to the author and emphasised that "the best replacement of the venerable Hercules is another, new built one".

Credit: Georg Mader

***On 20 September 2023, Austrian Minister of Defence Klaudia Tanner announced the selection of Embraer's C-390 as the future Austrian airlifter***

For some users, including Australia and Indonesia, this seems straightforward and logical. However, in the case of Austria and its (ex-RAF) C-130K replacement for example, on 20 September, it was decided to procure four jet-powered Embraer C-390s instead. In this particular case, the requirements demanded the capability to transport the locally produced Pandur EVO IFV with mounted remote controlled weapon station (RCWS) or to airlift an S-70 Black Hawk helicopter. Vienna has decided to operate a 'supply and humanitarian military cargo airline.' Interestingly, the Austrian plan is to attempt to jump on a currently negotiated form of G2G agreement with the Netherlands, where five of the Brazilian 'new kids on the block' have already been selected. In addition to Portugal (with five ordered, one delivered) and Hungary (two in production), the Czech Republic and Sweden are expected to follow.

Embraer claims that its C-390 Millennium was developed together with the Brazilian Air Force to explicitly address the shortcomings of the C-130; however the Força Aérea Brasileira (FAB) will now receive 19 instead of the originally planned 28. Subsequently, there are enough slots for new customers who are 'in a hurry', including the Austrians who are against spending another EUR 30+ M on heavy maintenance, repair and overhaul costs. One of the three 1967 airframes was overhauled at OGMA in Alverca, Portugal last year, but on the other two – though satisfied with the quality – Vienna wanted to avoid this scenario, in light of the swift arrival of the C-390s.

Regarding Austria and Sweden, both countries were briefly looking for replacements of their decades-old C-130s on the used aircraft market, when they were examining Italian C-130Js from the early 2000s temporarily stored at Pisa. However, upon learning that their avionics-standard was 6.1 (new builds are 8.1 standard) both countries stepped back. Bahrain, however, received the first batch of ex-RAF C-130Js, which were retired early in 2023 since they are 20+ years old. Even older airframes have entered service elsewhere, with the Polish Air Force in 2021 taking on five C-130Hs built in 1985 and stored in the Arizona desert since 2017, via a grant from the Pentagon's Excess Defense Articles programme for USD 14.3 M. This covers the cost of aircraft regeneration and retrofits, which includes a replacement of the centre wingbox. The five aircraft should all enter operational service at the 33rd Transport Air Base at Powidz by 2024, and still be 15 years younger than the previously operated 'stone-age' E-model Hercules acquired in 2012. ■

# Gambit – DARPA's Rotating Detonation Engine Programme

**John Antal and Mark Cazalet**

**International competition for hypersonic weaponry is growing more intense every day, and the US and its allies have a bit of catching up to do with the Russians and Chinese.**

An article recently published in the *Wall Street Journal* on 16 September by Sharon Weinberger clearly stated the situation: "Hypersonic Missiles Are Game-Changers, and the US Doesn't Have Them." As far back as 1 March 2018, during his presidential address to the Russian Federal Assembly, President Vladimir Putin announced the deployment and serial production of a new hypersonic missile. He claimed that Russia's hypersonic missiles were the best in the world. Russia has been actively working on and testing different hypersonic missile systems since 2015.

The Avangard hypersonic glide vehicle (HGV) is a widely recognised example as it was reported to have a maximum speed in the region of Mach 20 to 27. The Russian military formed its first missile regiment equipped with Avangard HGVs in December 2019. Another Russian hypersonic weapon development is the scramjet-propelled Zircon hypersonic cruise missile, which can be launched from ships or submarines and is estimated to reach speeds of around Mach 9. It is understood to use a solid rocket booster to propel itself to the required speed for scramjet functionality. Zircon was understood to have entered operational duty with Russia in January 2023, loaded onto the frigate *Admiral Gorshkov*, for its voyage across the Atlantic and Indian Oceans, as well as the Mediterranean Sea. Both Avangard and Zircon are assessed as being capable of carrying nuclear warheads.

Elsewhere, China has been working on fielding hypersonic missiles for many years, and deployed a new hypersonic missile, the DF-17, in 2020. The DF-17 is a medium-range hypersonic missile which mounts the DF-ZF HGV, and is also assessed to be capable of carrying a nuclear warhead. In 2021, the Chinese Rocket Forces also surprised observers when they conducted a test of an HGV-equipped missile, which reportedly flew around the world in 2021, but "missed its target by about two-dozen miles [38.6 km]" according to a report by the *Financial Times*. US intelligence agencies are rushing to find out how much further Russia and China are in their hypersonic missile programmes.

Credit: PLA


***Image show's China DF-17, mounting the DF-ZF HGV, during a Parade in Beijing on 1 October 2019. Developments such as Avangard and DF-17 have caused a measure of concern by US and European leadership, that the West currently finds itself lagging in the Hypersonic arms race.***

Hypersonic speeds are defined as in excess of Mach 5 (about 6,174 km/h or 3,836 mph). However, there are large number of weapons which fit into this category, even the German WWII-era V-2 rocket came close to hypersonic, reaching a top speed of around Mach 4.3, and the subsequent US-made test missile based on the V-2, known as V-2/WAC Corporal, reached a top speed of Mach 6.7 in 1949. As such, the 'hypersonic weapon' label is typically applied to endo-atmospheric weapons which are capable of manoeuvring at hypersonic speeds. This ability to manoeuvre makes hypersonic weapons more difficult to intercept by most currently deployed anti-ballistic missile systems, since they can change course to avoid interception or known defended areas. These qualities of high-speed and manoeuvrability also make hypersonic missiles a good first-strike weapon.

## Design Challenges

Building new propulsion technologies can be a dangerous process. Conventional rockets require large quantities of highly explosive fuel to operate in the Earth's atmosphere or launch payloads into space. The Saturn V rocket, used to launch the Apollo moon missions, exemplifies this. It was a super-heavy lifter that consumed approximately 20 tonnes of volatile fuel each second of burn. The first stage fuel tanks held 768,438 litres of highly-refined kero-

**Author**

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

sene (RP-1), along with 1,252,971 litres of liquid oxygen as the oxidiser. The second and third stages used liquid hydrogen and LOX. The Saturn V weighed an astonishing 2,800 tonnes when fully fuelled. While the first Saturn V was launched 56 years ago, the rocket is still a marvel of engineering. During the development process, rocket engineers experienced significant problems with the Saturn V's rocket engines caused by combustion instability – in which rapid pressure changes in the burning propellants created hot spots and vibrations strong enough to damage or destroy the engine.

Due to the high volatility and difficulty storing liquid rocket propellants, most military rockets and missiles use solid fuel. Rockets rely on deflagrative combustion for propulsion. A deflagrative combustion rocket engine produces thrust when the fuel and oxidiser mixture burns, releasing energy relatively slowly over a longer period. Heated gases are directed through a nozzle at high speeds to produce thrust in the combustion process. An opposing force is created as a result, propelling the rocket forward. Rockets are an effective solution for reaching space, but they burn through propellant very quickly, making them somewhat impractical to use for sustained hypersonic speed and manoeuvre inside the Earth's atmosphere. As such, air-breathing engines are preferable. The main type of air-breathing engine used in hypersonic flight is the scramjet.

Credit: USAF/Joshua Armstrong

***Air Force Cadet 2nd Class Eric Hembling uses a Ludwieg tube to measure the pressures, temperatures, and flow fields of basic geometric and hypersonic research vehicles at the United States Air Force Academy's Department of Aeronautics, on 31 January 2019.***

The term 'scramjet' stands for 'supersonic combustion ramjet'. Scramjets are more complex than ramjets but can achieve higher speeds because of their efficient combustion process. Using supersonic combustion, a scramjet allows for sustained flight at hypersonic speeds and is a type of air-breathing jet engine. Scramjets work by using the forward speed of their host platform to compress incoming air to supersonic speeds, following which fuel is mixed with compressed air, which is then ignited to produce

## Marketing Report: EVPÚ

# Enhancing the Defensive Capabilities of AFVs through Electro-Optics

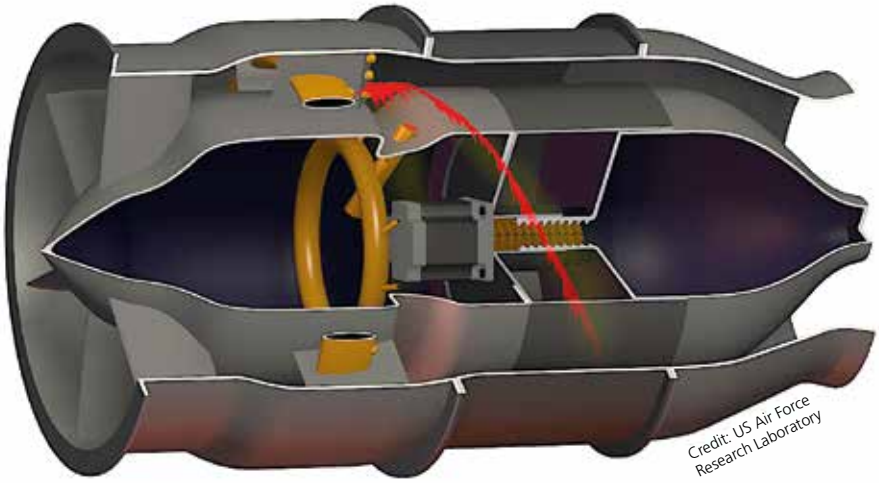
Armoured vehicles are the backbone of modern ground military operations, and their effectiveness is paramount to mission success. The latest remote-controlled electro-optical technologies such as weapon stations and commander and gunner sights provide not only enhanced vision in adverse conditions such as low light, smoke or dust, but also the capability to detect and track enemy targets from extended distances, thereby significantly increasing crew safety and the vehicle's defensive capabilities.

"EVPÚ Defence's weapon stations are sophisticated gyrostabilised systems that can be remotely operated from a secure location within a military vehicle," says Martin Vala, the company's optical specialist. "Various available solutions are designed to mount a range of weaponry such as machine guns, anti-tank missiles or even non-lethal weapons like smoke grenades. Our remote-controlled weapon stations have a wide scope of application which includes, for example, helping to monitor and respond to potential threats along national borders, engaging hostile targets with minimal risk to special forces operators in counterterrorism operations, and protecting vehicles against low-flying air threats."

EVPÚ Defence's weapon stations are equipped with multi-sensor electro-optical sights. As a minimum, these containers offer a combination of a Full HD day camera, a high-resolution thermal imaging camera and a laser rangefinder. The stations' modular concept allows the Czech producer to meet the customer's needs in terms of both sensor and weapon requirements as well as modify the easy-to-use operator software which is developed in-house.

What are the key advantages that EVPÚ Defence's systems can ultimately bring to the operators? First and foremost, they improve overall safety and decrease casualties. Moreover, they provide the necessary situational awareness and surveillance capabilities to reduce the element of surprise during combat and act as force multipliers, enabling smaller units to hold their ground against larger adversaries.

Credit: EVPÚ Defence

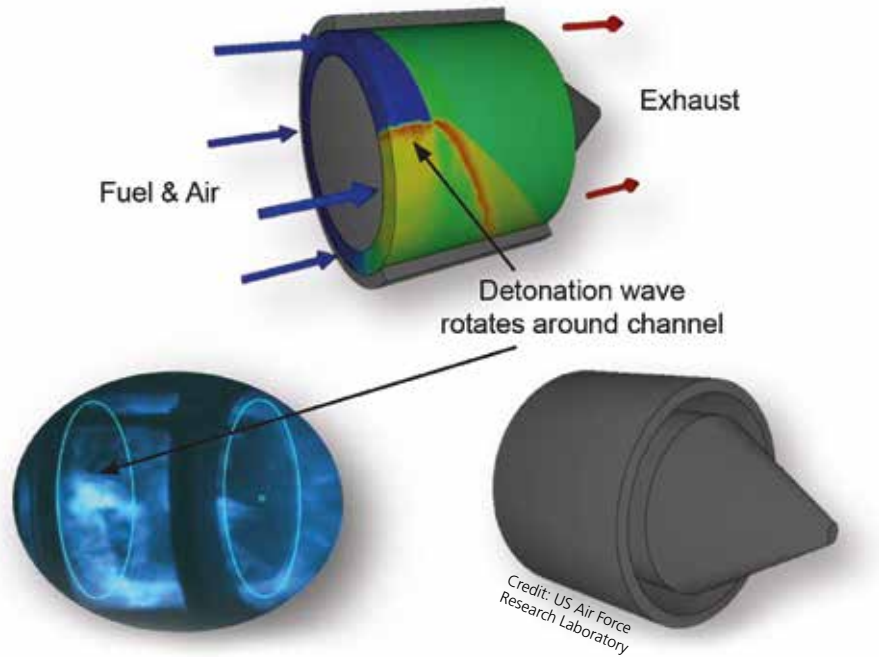



***CG render of an RDE engine, showing the path taken by the rotating detonation wave in red.***

thrust. This reliance on using the platform's speed to compress air to supersonic speeds means that scramjets are only usable once the platform has already reached high supersonic speeds. For this reason, platforms using scramjets have often been paired with rocket boosters to get the platform up to the required speeds for the scramjet to work. One proposed solution to this problem is the dual-mode ramjet (DMR), which functions as a ramjet up to supersonic speeds, and then once the requisite Mach number is reached, begins to operate as a scramjet, to reach hypersonic speeds.

An alternative proposal to the scramjet design is the Rotating Detonation Engine (RDE). This type of engine promises to develop more power while using less fuel than traditional engine designs and could be usable at a wider range of speeds than Scramjets. There are two primary types of RDE – the air-breathing variant, commonly referred to as an RDE, and the rocket engine variant, which uses liquid oxygen as the oxidiser, commonly referred to as a Rotating Detonation Rocket Engine (RDRE). The RDE operates by using detonative combustion (as opposed to deflagration, as with traditional jet and rocket engines) to produce a continuous pressure wave that rotates around an annular combustion chamber before being expelled as hot gas. The supersonic waves produced by fast explosions in detonative combustion has been reported to potentially be as much as 25% more efficient than traditional deflagrative combustion. On the whole, RDEs could be smaller, more efficient, and cheaper to run, than traditional gas turbine (jet) engines. On the other hand, they create more noise, and maintaining a stable detonation wave poses a serious engineering challenge. From the US military's point of view, the perfection of an RDE could lead to a step change in in rocket, tactical missile, aircraft, and even marine vessel propulsion design.

The RDE is not in of itself a new idea, it was first proposed by Soviet Physicist Bogdan Vyacheslavovich Voitsekhovskii in a 1960 paper published in the *Soviet Journal of Applied Mechanics and Technical Physics*. However, as with many designs conceived during the Cold War, there were barriers to its successful implementation. Now, with the benefit of modern technologies and materials science as well as clear use cases, the idea is once again receiving serious attention.




***CG render showing the key operating principles of an RDE engine.***

## RDE Working Principles

While the specifics of how DARPA's RDE will work are classified, RDE engines generally use these steps to create hypersonic flight: The first step involves providing the required propellant to the RDE. It usually involves a fuel and an oxydiser – these would typically be a hydrocarbon-based fuel and atmospheric oxygen respectively for RDEs, or in the case of RDREs, liquid hydrogen and liquid oxygen. After the propellants are supplied, an initial ignition source is necessary to start the detonation process. A spark or another ignition mechanism can achieve this. After the initial ignition, the detonation wave spreads through the combustion chamber. To maintain steady engine performance, it is crucial to maintain a stable and continuous detonation wave – something that is very difficult to do. Shock waves from the detonation wave compress and mix the fuel and oxidiser. The mixture's temperature and pressure rise quickly due to this compression, resulting in rapid combustion. As such, the engine must be engineered to withstand the stress of detonations, heat and pressure. When the combustion products expand and are expelled through a nozzle, thrust is generated. The nozzle is shaped to efficiently convert high-pressure, high-temperature gases into directed thrust.

For the entire flight duration, the detonation process must continue. Regulating the flow rates of fuel and oxidiser, as well as the temperature and pressure, allows for a sustainable stable detonation within the RDE. Various sensors, monitoring systems, and control mechanisms are employed

# Czech Manufacturer PBS Velká Bíteš Doubling Turbojet Engine Production

The evolving global security landscape, spurred by conflicts in Ukraine and Israel, has thrust PBS Velká Bíteš into the spotlight. This Czech defence powerhouse is seeing surging demand for propulsion units, particularly for cruise missiles and Unmanned Aerial Vehicles (UAVs). PBS Velká Bíteš plans to address the current increasing demand by doubling it production in upcoming year or two.

"Indeed, we understand the current strong demand of the independent democratic world for security and defence solutions. That is why we are reacting and planning to double our production in the very near future. Our presence in the market of engines used in defence systems will get significantly stronger, particularly in our key markets. such as the United States and Europe. Engines of our production are also used in deliveries to Ukraine," says Milan Macholán, CEO of PBS Velká Bíteš.

In 2023, we witness PBS Velká Bíteš, a respected Czech company with expertise in turbine engines, auxiliary power units, and environmental control systems, poised on the brink of a transformative year that will chart its future expansion. This transformation results not only from a changing industry landscape in general but also from the substantial partnerships it has established with key players in the aerospace sector, including some of the biggest US companies.

Such partnership is represented, for example, by the recently signed MoUs with two leading American aerospace companies, Lockheed Martin and Pratt & Whitney.

Cooperation with Lockheed Martin is designed to create a collaborative relationship in research, development, and co-production projects, utilizing PBS Velká Bíteš' production capabilities. As part of delivering these aircraft to the Czech military, PBS Velká Bíteš will be one of the few Czech companies involved in producing F-35 aircraft components.

The partnership with Pratt & Whitney aims to leverage both companies' expertise to identify and capitalize on emerging trends in APU development. They are looking to redefine next-generation APU concepts, targeting the evolving needs of fixed-wing and rotary-wing aircraft, including hybrid electric propulsion systems.

Another significant milestone for PBS is represented by a Memorandum of Understanding (MoU) with Ivchenko Progress SE, a prominent Ukrainian aircraft engine manufacturer. This MoU focused on the production and advancement of the AI-PBS-350 engine, which provides 3,400 N of thrust and is also designed for missile propulsion. This compact engine features a four-stage axial compressor and a single-stage axial turbine.

The company also plans to complete with the development of the latest jet engine in the 2,300 N thrust category as soon as possible. The new engine will be officially launched at the Farnborough Airshow in July 2024. The main advantage of the engine will be its exceptional thrust-to-weight ratio and very compact frontal diameter. The engine will primarily be designed for missiles and other high-speed UAVs.

In the Auxiliary Power Units (APUs) category, PBS Velká Bíteš unveiled the PBS APU SPARK40 during the Paris Air Show 2023. This APU delivers twice the AC power to onboard systems in comparison to earlier models. Notable enhancements have been implemented in various subsystems and components to enhance overall reliability and operational capabilities. The choice of the PBS APU SPARK40 for a new medium helicopter project by a NATO member nation highlights its exceptional quality and performance.

In conclusion, 2023 marks a significant year for PBS Velká Bíteš, setting the stage for the company to strengthen its position in the worldwide aerospace and defence industries. Through key partnerships, advancements in engine technology, and a dedication to emerging innovations, PBS Velká Bíteš is fully ready to address the changing demands of a dynamic and demanding world.

Credit: PBS Velká Bíteš

to ensure the RDE operates within safe and optimal performance parameters. By continuously monitoring factors such as temperature, pressure, fuel flow rate, and thrust, these systems are capable of making any necessary adjustments.

## Recent RDE Advances

In 2020, a team from the University of Central Florida (UCF), working with the US Air Force Research Laboratory, tested the world's first working RDE. In a *New Atlas* article published on 4 May 2020, Loz Blain quoted Kareem Ahmed, an assistant professor in UCF's Department of Mechanical and Aerospace Engineering and the leader of the research, who said: *"The study presents, for the first time, experimental evidence of a safe and functioning hydrogen and oxygen propellant detonation in a rotating detonation rocket engine" adding, "Just a few months prior, a number of US rocket engine experts had publicly declared that hydrogen-oxygen detonation engines were not possible" before stating, "The US Air Force is targeting a rocket launch flight test by 2025, and we are contributing to achieving that goal."*

In March 2022, Pratt & Whitney, a subsidiary of RTX (formerly Raytheon Technologies Corporation), received a contract from the Air Force Research Laboratory (AFRL) for an RDE ground test demonstration programme. The programme will feature the novel RDE architecture. Pratt & Whitney, Raytheon Missiles & Defense, and Raytheon Technologies Research Center will jointly execute the programme.

RDEs are also of interest to the US Navy. Gas-turbine engines are used for propulsion aboard the majority of the Navy's warships. When RDEs are created for ships, according to the US Naval Research Laboratory (NRL), they will produce 10% more power and be 25% more fuel efficient than traditional engines. On both an operational and strategic level, RDE fuel efficiency could benefit US naval operations in the Pacific.

## Gambit's Design Phases

In the US, the development of a ground-launched, intermediate-range missile using RDE propulsion is being spearheaded by the Defense Advanced Research Projects Agency (DARPA), under the Gambit programme, which "develop and demonstrate a novel Rotating Detonation Engine propulsion system that enables a mass-producible, low-cost, high-supersonic, long-range weapon for air-to-ground strike in an anti-access/area denial (A2AD) environment." Overall, the programme is split into two phases.

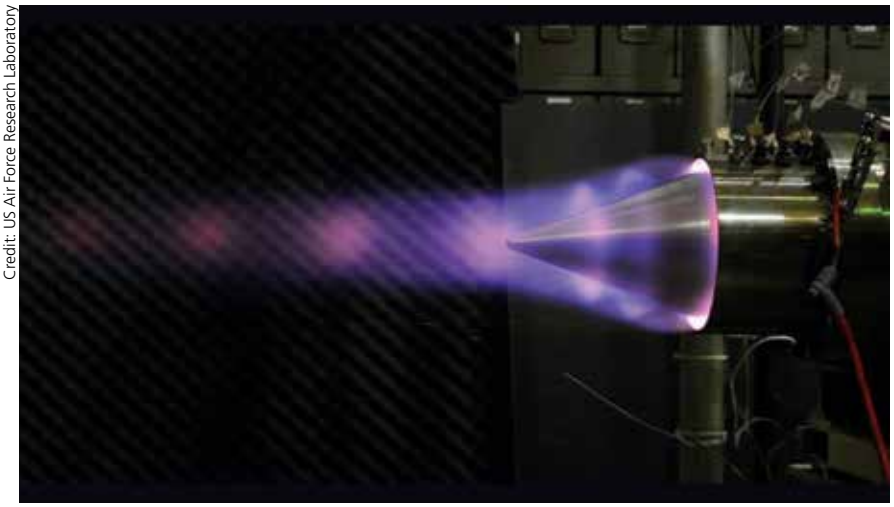
Phase 1 of the programme is expected to span 18 months, and is focused on the preliminary design of the RDE propulsion system and execution of direct connect combustor testing as well as free jet inlet testing. Direct connect combustor testing demonstrates the ability of the RDE to achieve sustained detonation combustion. The free jet inlet testing demonstrates the ability of the RDE to ingest and accelerate air. DARPA developed a preliminary design for the full-scale RDE test article and initiated fabrication of key components for the full-scale RDE test article. In August 2022, DARPA held a proposers day to provide information for potential proposers to develop an RDE. Following this, a development contract for the Gambit programme RDE was awarded to RTX on 4 October 2023. This award was understood to be concerned primarily with the first phase of the programme, with RTX stating: *"Under the contract, RTX will rely heavily on iterative development of performance models which will be anchored by real-world data from incremental system tests…Future optional phases of the Gambit program will shift to building hardware to conduct a flight weight free-jet test."*

Phase 2 of the Gambit programme will focus on detailed design, fabrication, and testing of the full-scale RDE. This test engine will be designed to demonstrate the performance of the RDE in a simulated air-to-ground strike environment. Phase 2 is also anticipated to last 18 months and involves full-scale testing of an RDE in a free jet test facility under flight conditions, as well as comprehensive design of the propulsion system. The results of the Phase 2 free jet testing will serve as the basis for a later programme to test a weapon prototype in flight using the RDE. The programme is also planning to begin fabrication of a full-scale RDE in preparation for Phase 2 testing. If successful, Phase 2 will lead to the development of a new class of propulsion systems that enables mass-production of low-cost, high-supersonic, long-range weapons for air-to-ground strike.

## Rushing Forward

Using detonation rather than deflagration to power an engine promises to be a serious leap forward. The RDE has a straightforward mechanical design but is dynamically quite complex and demands exact timing and fuel delivery rates. The development and potential applications of RDE by DARPA represent a paradigm shift in propulsion technologies. From enhanced fuel efficiency, increased power-to-weight ratios, to adaptability and scalability, RDE engines have the potential to revolutionise aviation and even space exploration – albeit in the latter case using a liquid oxygen fed variant rather than air-breathing design.

Despite the challenges faced in ensuring combustion stability, optimising engine controls, and addressing material constraints, ongoing research and development projects promise a bright future for RDEs. As technology advances and research progresses, RDEs have the potential to transform our understanding of propulsion systems and open new frontiers in aerospace capabilities. The Gambit programme is a critical step towards developing a new generation of high-speed weapons that are more affordable, reliable, and capable than current systems. Until recently, RDEs have been theoretical. DARPA's Gambit programme hopes to turn the theoretical into the practical. ■



Credit: US Air Force Research Laboratory

***RDE Engine static rig test.***

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# The Expanding Market for AEW&C Solutions

**Luca Peruzzi**

**Russia's invasion of Ukraine and heightened tensions along NATO's eastern flank, coupled with multi-domain operations in the Indo-Pacific Region, have placed considerable pressure on NATO members' ageing fleets of manned Airborne Early Warning & Control (AEW&C) aircraft. This has triggered an accelerated procurement drive not only by NATO members, but also from different customers with national programmes.**

Aside from commercial aircraft, for the last two decades, the trend in the AEW&C domain has been towards utilising business aircraft platforms which can fly higher, faster, longer, and able to operate from shorter runways with a reduced logistical footprint, while costing less to sustain, operate and maintain.

Credit: USAF


*The USAF is procuring a fleet of up to 26 E-7As to be delivered by 2032 with the first of two rapid prototypes planned to be fielded in 2027.*

## Boeing E-7

In February 2023, the US Air Force awarded Boeing a USD 1.2 Bn contract to develop two US variant rapid prototype platforms of the E-7 AEW&C aircraft. The E-7A is intended to replace the ageing Boeing E-3G Sentry, which for nearly 50 years served as the backbone of the US Air Force AWACS fleet, and is currently being retired since it has become increasingly hard to maintain. The USAF decided to buy a fleet of up to 26 E-7s – to be delivered by 2032 – with the first of two rapid prototype E-7 aircraft planned to be fielded in 2027, and a production decision on the remainder of the fleet due in 2025.

The USAF is the latest customer for the E-7 AEW&C aircraft, which is already in service with the Royal Australian (RAAF), South Korean and Turkish Air Forces and is also under production for the UK's Royal Air Force (RAF). The USAF E-7 is a highly modified airborne battle management and command and control (BMC2) aircraft integrating a Boeing 737-700 Next Generation, with increased gross weight, reinforced undercarriage, wings and central fuselage. The central fuselage has been designed to accommodate the Northrop Grumman multi-role electronically scanned array (MESA) radar mounted on top of this section, alongside two 180 kVA generators to meet power generation needs alongside the power provided by the commercial CFM-56 engines. The US version shares the technologies and systems already installed on the still in-production version for the UK's RAF, including the two-screen configuration for the 10 multifunction operator mission consoles (MFCs), as well as the specific systems requested by the US customer including the incorporation of M-code GPS, mobile user objective system (MUOS) satellite communication, open mission system software and mission system updates for cyber security and programme protection. The US E-7 will also have an open mission system (OMS) architecture to simplify future upgrades, with the technology to be tested by the USAF in 2025. Although not specified, a customised electronic warfare self-protection suite (EWSPS) is expected to be incorporated.

In terms of defensive features, the E-7A Wedgetail for the RAAF has been equipped with Northrop Grumman's missile warning system (MWS) and directional infrared countermeasures (DIRCM), countermeasures dispensing system (CMDS), as well as electronic support measures (ESM) and radar warning receivers (RWRs).

The E-7's MESA's radar design provides coverage through 360°, with an integrated identification friend or foe (IFF) system. The antenna is an active electronically scanned array (AESA) design, employing transmitter/receiver modules (TRMs) with gallium nitride (GaN) technology, and operating in the L-band to provide long-range search and tracking capabilities. The antenna is packaged in an aerodynamic dorsal mount to dimmish drag compared to legacy designs such as

on the E-3A. In contrast to legacy AEW radar systems limited by mechanical scan rates of 10–12 seconds, the MESA radar has variable scan rates and instantaneous target revisit rates to satisfy diverse mission priorities.

In March 2019, the UK MOD signed a USD 2.1 Bn contract with Boeing for five E-7A Wedgetail AEW1 platforms, later reduced to three, but this decision could be revisited based on a recent programme assessment. These are based on second-hand civilian platforms which are modified and equipped with the mission suite by UK STS Aviation; the first platform is expected to be handed over in late 2024. The UK baseline mission suite is similar to the US but with self-protection systems (SPS) by Leonardo including MAPPS (modular advanced platform protection system) and Thales Elix-IR threat warning system and Vicon-XF CMDS. In July 2023, the US, UK and Australian Air Chiefs signed a 'joint vision statement' with the intended declaration to co-develop the E-7 Wedgetail and maintain interoperability.

## IAI Elta CAEW, and Joint Solutions with L3Harris and Embraer

In July 2022, Israel Aerospace Industries (IAI) announced the signing of a contract valued at over USD 200 M to provide special mission aircraft to a European NATO member. No further details were provided but evidence later emerged from Italian MOD documentation that the contract was signed in March 2022 with an Elta Systems subsidiary and was related to two conformal airborne early warning & control (CAEW) ELW-2085 aircraft mission suites for procurement and installation on two Gulfstream Aerospace G-550 platforms already acquired separately by the Italian MOD, together with associated in-service support. The new CAEWs will increase the Italian Air Force's fleet of two platforms to ensure a continuous air surveillance of national airspace and support the Alliance in overseas operations, as demonstrated by their contribution to NATO's eastern flank surveillance operations triggered by the Russian–Ukrainian conflict and their recent deployment in the Far East with F-35A fighters.

Delivered initially to the Israeli and then Republic of Singapore air forces, the IAI/Elta CAEW ELW-2085 aircraft distinguishes itself by having pioneered the current trend of using high performance fuel-efficient business jets for AEW&C solutions and its unique low drag conformal installation of the main mission sensor. The multi-mode, dual band (L- and S-bands) AESA radar developed by Elta Systems features two lateral conformal L-band and front/back S-band antennas using GaN technology, with dynamic resource allocation, ECCM and low false alarm rate in addition to an IFF system, to provide long-range continuous 360° surveillance against airborne and maritime threats. Managed by a NATO compatible BMC2, with six MFC operator stations and two pilots. The platform is fitted with multi-band radios, data links and SATCOM suite to act as a full network centric operation (NCO) communication node, and the CAEW mission package also includes an ESM/ELINT suite and an EWSPS including MWS, RWR and CMDS. With an endurance of 9+ hours, the CAEW systems can reach a flight altitude of 13,530 m within 20 minutes, with the radar ready shortly after take-off.

IAI/Elta and L3Harris Technologies have recently expanded their teaming agreement to provide US and NATO interoperable AEW&C solutions. The two companies are offering a modified Bombardier Global 6500 AEW&C solution for NATO's interim Allied Future Surveillance and Control (AFSC) programme, and for the Republic of Korea Air Force's AEW&C programme in cooperation with Korean Air Lines, in addition to several other NATO partners. Under the proposal, the L3Harris would function as the system integrator, outfitting the platform with Elta's conformal AEW systems and BMC2 suite, as well as L3Harris' communications suite.

Credit: Singapore MINDEF

***The IAI/Elta CAEW suite, here depicted on a Republic of Singapore's G-550, is also being proposed on a Bombardier Global 6500 platform, in partnership with L3Harris.***

Credit: Saab

***Based on the Bombardier Global 6000, the GlobalEye is equipped with a multi-domain radar sensor suite.***

The same family of S-band radar as that on the CAEW ELW-2085 aircraft was used on the P600 AEW aircraft developed in partnership by Embraer and IAI/Elta. Based on the Embraer Praetor 600 business jet, the AEW version is centred on the Arkhe mission management system from Embraer's Atech with three operator consoles. The latter manages the radar in a dorsal radar antenna with 240° coverage (120° on each side of the aircraft), communications, IFF, ESM/ELINT and self-protection suite. With a service ceiling of up to 13,200 m, the Praetor 600 has a top speed of Mach 0.8 and flight endurance of 7.5 hours.

## Saab GlobalEye

In June 2022, Saab received an order from Swedish Defence Materiel Administration for two GlobalEye AEW&C aircraft, with deliveries planned during 2027. The contract, worth SEK 7.3 Bn, includes options for two additional platforms. Sweden is the second GlobalEye customer, the latest iteration of the Saab AEW/AEW&C system suite installed on board the Bombardier Global 6000/6500 business jet. The launch customer was the United Arab Emirates (UAE), which signed a USD 1.27 Bn contract in November 2015 for two platforms, followed by an order for three additional aircraft. So far, three aircraft have already been delivered, while the fourth conducted its first flight on 3 April 2023. The fourth UAE aircraft features new radomes to protect unspecified sensor antennas.

Based on the Bombardier Global 6000, and providing over 11 hours of operational endurance, the GlobalEye AEW&C is equipped with a multi-domain sensor suite capable of long-range detection and identification. The playform's mission systems include the Saab Erieye ER air surveillance AESA radar, Leonardo Seaspray 7500E family multi-role radar, Teledyne Flir Star Safire 380HD optronic sight, Saab ESM/ELINT suite, automatic identification system (AIS), and IFF/ADS-B. The gathered information is fused and managed by a human-centric C2 system. Contained in the distinctive 'ski-box' mounted on top of the fuselage, the new S-band Erieye ER incorporates GaN TRMs, and has an instrumented range of over 650 km – which is a 70% increase compared to the Erieye's predecessor – as well as resistance to jamming and clutter rejection. For maritime surveillance, the Erieye ER works in combination with the optronic sight and the Leonardo Seaspray 7500E radar, which provides a long-range wide area, ground-moving target indicator (GMTI). In addition to the HES-21 RWR function, the EWSPS includes MWS, LWS and CMDS. The C2 system consists of a number of 30-inch display-equipped MFCs defined by system configuration, and a comprehensive communications suite. On-board artificial intelligence allows for improved real-time data analysis.

The Saab AEW/AEW&C system was sold in different configurations and platforms to Brazil, Greece, Mexico, Pakistan, Poland, Saudi Arabia (even if not officially stated), Sweden, Thailand and UAE, all with the baseline Erieye radar. Poland, as the most recent customer, has contracted Saab on July 2023 for the delivery of two Saab 340 AEW aircraft. ESD understands that the two AEW aircraft are second-hand (ex-UAE) platforms returned to Saab, as the first refurbished

Credit: US Navy

***The E-2D AHE suite is centred on the AN/APY-9 UHF-band radar, multi-sensor integration, theatre missile defence, glass cockpit, cooperative engagement capability, alongside in-flight refuelling capability.***

aircraft was handed to the customer in September 2023, only two months after the contract was signed.

## Northrop Grumman E-2D Advanced Hawkeye

In mid-September 2023, the US Naval Air Systems Command (NAVAIR) awarded a USD 845.5 M contract to Northrop Grumman for the E-2D Delta System Software Configuration 6 (DSSC 6), scheduled to enter service from 2028. Intended to provide the most significant change to the E-2D Advanced Hawkeye (AHE) AEW&C suite, the DSSC 6 replaces the current integrated navigation, controls and display systems and tactical mission computer on the aircraft with a modern Hawkeye cockpit technical refresh (HECTR) and the theatre combat identification (TCID). The latter includes the upgrades of the 25-year-old computing infrastructure, alongside rapid integration of new capabilities.

Northrop Grumman's E-2D AHE introduced new technology and capabilities, centred on the AN/APY-9, a mechanically and electronically scanned phased array radar operating in the UHF-band radar, with multi-sensor integration, and theatre missile defence capabilities. The platform features a glass cockpit and the cooperative engagement capability (CEC) as part of the naval integrated fire control (NIFC), alongside the in-flight refuelling capability. Conceived as a carrier-based airborne C2 platform, in addition to the French Navy's E-2Cs operated from the *Charles de Gaulle* aircraft carrier, the E-2 versions found success with land-based operations, having been acquired by six customers and is presently in service with Egypt and Mexico (E-2C), Taiwan (E-2T) and Japan. The latter has a fleet of 13 E-2C aircraft and since mid-2000s has put five E-2Ds into service out of the planned fleet of 13. In March 2023, the US Congress was notified by US DOD/DSCA of the approval for the possible sale of up to five additional E-2D platforms, spares, support and training for an estimated USD 1.38 Bn. In January 2021, the French MOD signed a Letter of Offer and Acceptance to procure three E-2Ds from the US Navy through Foreign Military Sales (FMS) for a maximum value of USD 2 Bn, scheduled to be delivered by 2028. NAVAIR is currently working on operational testing and release of the DSSC-4, focused on enhancements to provide GPS access in an electronic attack (EA) environment, the replacement of the multifunction information distribution system low volume terminal (MIDS-LVT) with the MIDS-Joint Tactical Radio System (MIDS-JTRS) with incorporated Link 16 concurrent multi-netting and tactical targeting networking technology (TTNT), in support of NATO Intelligence Fusion Centre (NIFC) missions. Alongside this, the E-2D secret internet protocol router (SIPR) chat capability will support integration of various tools including tactical text communications, real-time tasking, and air tasking order (ATO) distribution. The DDSC-4 radar counter electronic attack (CEA) capability will be further expanded with the DSSC-5, alongside data fusion and CEC enhancements.


Credit: USAF

***Boeing is conducting upgrades on Japan's E-767s.***

## Boeing E-767

The E-767 AWACS combines the 767-200ER airframe with the S-band APY-2 radar, ESM and equipment suite similar to USAF E-3 AWACS. In February 2018, Boeing was contracted by AFLCM for installation and checkout of enhanced mission computing capability, ESM, traffic alert and collision avoidance system, next-generation IFF interrogator and datalink upgrades on the Japanese E-767 fleet.

In June 2023, the US Air Force Life Cycle Management Center (AFLCM) returned the first Boeing E-767 AWACS platform to the Japanese Air Self-Defense Force (JASDF) following the completion of a major upgrade. The first of the four E-767 aircraft was redelivered after completing a mission computing upgrade (MCU), providing them with improved battlespace command and control, real-time information sharing among

Credit: Indian Air Force

***In October 2023, Indian Air Force Chief of Staff announced procurement plans for more AEW&C Netra Mk I platforms in addition to six larger and more capable Mk II aircraft.***

the service, decreased target identification time and increased lethality, alongside better interoperability with US systems. According to the programme content and Japan's Acquisition Technology and Logistics Agency (ATLA), the upgrade also includes new electronic warfare support measures equipment to better detect and identify between various threats, but no details were provided on the equipment installation.

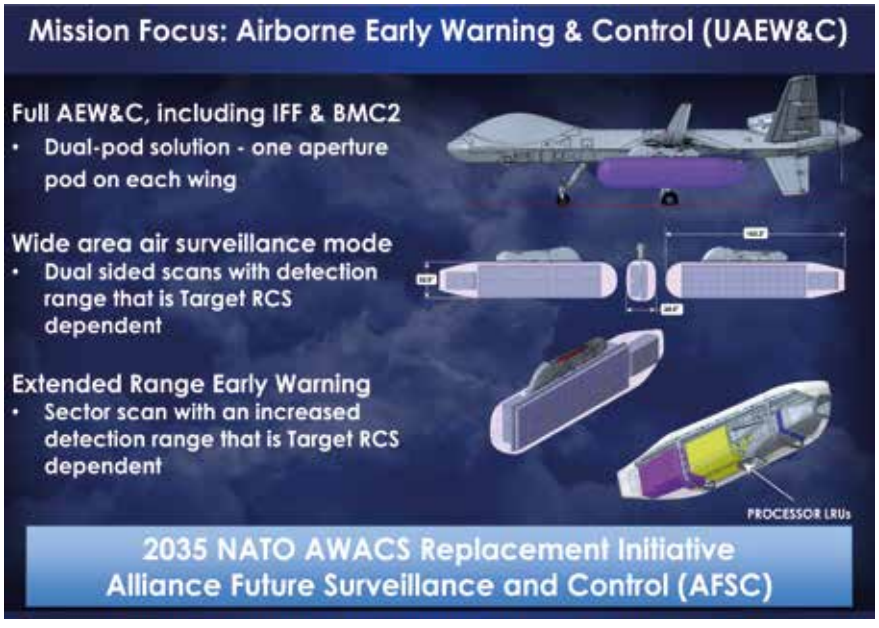
## India's DRDO solutions

In 2017, India declared their EMB 145 Netra Mk 1 AEW&C aircraft operational, and currently has two platforms in service. In early October 2023, the Chief of Staff of the Indian Air Force (IAF) announced plans for the procurement of an additional six platforms. These are due to be equipped with the same radar but will employ the latest-generation TRMs.

The Netra Mk 1 is based on the Embraer ERJ 145SM platform, modified to install the AEW&C mission suite developed by the Indian MOD's Defence Research & Development Organisation (DRDO) and IAF alongside an inflight refuelling capability, new electrical generation and cooling systems. Developed by the DRDO's Centre for Airborne Systems (CABS), the Netra Mk 1 mission suite is centred on a dorsal early warning multi-mode S-band radar featuring back-to-back AESA solid-state antennas and integrated IFF providing a 240° coverage (120° on each aircraft side) out to 250 km. The radar data, together with other sensor information, are fused by the multi sensor data fusion tactical software which interacts with the intercept control battle management, acting as a decision-making aid to attain air superiority over contested airspace. The platform combines radar electronic support measurement (RESM) and communication electronic support measures (CESM) systems, and self-protection systems (MWS, RWR and CMDS). The communications suite, including data links and SATCOM, are managed by five MFCs.

In September 2021, the Indian MOD gave the green light to procure and develop the more capable Netra Mk II variant. The IAF is collaborating with DRDO and Airbus Defence to modify six former Air India A321 aircraft, and plans to install the radar and mission suite in India. With an endurance of over seven hours and operating altitude of over 11,880 m, the platform will come with 12 MFCs, a larger and more powerful main radar in the same dorsal installation and nose, with GaN TRM modules to provide extended coverage compared to Netra Mk I, as well as IFF, ELINT/COMINT capabilities and improved communications and an EWSPS.

Credit: GA-ASI




***The GA-ASI MQ-9B UAV is a potential candidate to conduct persistent wide-area surveillance/AEW missions from land and aircraft carrier platforms.***

## General Atomics Aeronautical Systems Unmanned AEW&C Concept

The MQ-9B SkyGuardian/SeaGuardian unmanned aerial vehicle (UAV) is a potential candidate to conduct persistent wide-area surveillance/airborne early warning (AEW) from land and aircraft carriers, in the latter thanks to proof-of-concept demonstrations to be conducted starting from this autumn in the US. General Atomics has conducted concept development and engineering studies to see if the MQ-9B could conduct different demanding operations including AEW missions supported by a radar manufacturer. During the Combined Naval Event 2023 conference at Farnborough in the UK, General Atomics showed an MQ-9B-based AEW&C solution with IFF and BMC2 capabilities. This configuration of the MQ-9B platform was equipped with a dual-pod radar solution, with each underwing pod accommodating a radar antenna. The platform also featured a central conformal pod hosting the processing and cooling capabilities. ■

# World Defense Show – Preview

**What will be the highlights of the 2024 edition of WDS?**

As well as seeing the return of such successful show features as the International Women in Defence Forum, Future Talent Form and the content theatres, there are a new show features for the 2024 edition.

Front and centre is the dedicated Space Arena, reflecting the enormous importance and constantly evolving nature of this domain. Leading space companies from all over the world will come together to show their latest technologies and international projects, giving visitors an informed insight into the future of space defence. Through discussion and presentations, it will showcase capabilities, encourage innovation and inspire future leaders in this fast-changing field.

Returning to WDS, and one of the networking and connection programs that are central to the show's value proposition, is the Meet the KSA Government program. This program provides the global defence industry with a platform for understanding Saudi Arabia's defence sector. Acting as a roadmap for the nation's long-term strategic goals, the program enables investors to interact with key defence stakeholders in Saudi Arabia, to learn about the country's defence strategy and objectives and gain insights into the Kingdom's tendering and procurement guidelines and partnership requirements.

A further industry connection highlight is the Delegations Program, an exclusive platform facilitating engagement between exhibitors and top-level international dignitaries and military representatives, that paves the way for establishing vital business-to-business and business-to-government connections. In 2022, the program hosted over 100 delegations from 42 countries and facilitated over 1,000 meetings. Expect WDS 2024 to be bigger.

Also a key part of the event is B2B Connect, a networking program built on the foundations of the highly successful Meet the Buyer program. Through one-on-one meetings, participants have the opportunity to cultivate relationships and establish business leads with prime, startups, government entities and industry movers across the supply chain. These meetings serve as a foundation for enduring partnerships and have the potential to spark new ventures and extended cooperation within the defence and security industry.

**Is there a specific key theme which is being particularly explored in depth at this edition of WDS?**

World Defense Show 2024 is themed Equipped for Tomorrow and emphasises the importance of innovation and technology in the global defence industry. The event will showcase the latest developments across the domains of land, sea, air, space and cybersecurity.

The show features dedicated hubs, new technology launches and conferences that highlight the most advanced and promising developments in the industry, bringing together inventors, investors, academia and government entities with players across the supply chain, from primes to start-ups.

Central to this theme is the Journey to the Future, an integral part of World Defense Show 2024, offering an immersive experience that guides VIPs, delegations and visitors through the event's most forward-thinking features, exhibits and debuts. This interactive experience will engage and inform attendees about the latest trends and technologies shaping the defence landscape.

Credit: WDS

**How many countries and exhibitors will be newcomers to WDS in 2024?**

While the final figures are not complete, the show is expecting approximately 750 exhibitors, which equates to an increase of 25% of overall exhibition space from that of 2022.

The number of participating countries represented currently totals more than 60, again an increase from the 42 countries who took part last year. Visitor numbers last year registered 65,000 visits from attendees from 85 countries over the four days. For 2024 the show has been extended to five days, to include an exclusive preview day on 2 February, open only to VIPs, delegations, KSA government entities, exhibitors and the press and expects to see 100,000 visits.

**Compared to the show's previous edition, can we expect to see a greater range of domestically-developed equipment from Saudi Arabia and its Gulf neighbours?**

Saudi companies are well represented, with more than 100 taking part, and the KSA is the biggest single county pavilion. Countries across the Gulf have taken great strides in developing domestic production through joint ventures and investment and WDS expects to see the results on display from the many regional exhibitors.

Saudi Arabia continues to seek out partners and investors to work with the domestic defence industry, aiming to fulfil the national strategic goals of localisation of 50 percent of domestic defence equipment and services expenditure by 2030.

**Which sectors of the defence equipment market are currently seeing particularly high demand in the Gulf region right now?**

World Defense Show does not have definitive figures or forecasts for demand within the regional defence industry, but it is certainly an area of growth. WDS was founded in part to support with the Kingdom's vision to localise 50% of defence expenditure across the supply chain. The show covers the five key domains of defence and the wide international interest shown and support for an expanded and extended event, highlights the global industry's interest in supporting that vision.

# Combat Search and Rescue: Sustainment and Modernisation Efforts

**Sidney E. Dean**

**Armed forces must reexamine their combat search and rescue (CSAR) capabilities in light of operational realities associated with the return to great power competition and peer-warfare.**

The acronym CSAR can stand for Combat Search and Rescue or Combat Search and Recovery. While CSAR is dedicated to finding and retrieving any military personnel who are cut off or in danger in a conflict zone (including at sea), these missions most frequently seek to recover downed aircrews, usually in hostile or conflicted territory. Personnel recovery missions often go far beyond deployment of a single CSAR helicopter. Depending on the operational environment – and especially the threat level – they can be highly complex and involve dozens of aircraft and potentially ground units. One of the largest CSAR missions of the Vietnam War, the rescue of the Callsign Boxer 22 aircrew, occurred in December 1969 and lasted three days. It involved 336 sorties, mostly by combat aircraft suppressing enemy air defence positions and North Vietnamese Army (NVA) ground forces who were hunting the American pilots. More than 1,400 bombs and rocket pods were expended. Five of ten CSAR helicopters involved in the mission incurred so much damage that they had to be retired.

During the half century following that mission, highly sophisticated air defence systems have been developed, which can hold CSAR aircraft at risk potentially even hundreds of kilometres ahead of their destination. The special aspects of CSAR lead to specific attributes required of CSAR platforms. These include: long range and endurance; preferably aerial refuelling capability; sufficient size to accommodate a ground-search party and/or to recover several servicemembers in one mission; robust and redundant navigation systems; multiple sensors including radar and optoelectronic sights to detect and identify both hostile and friendly forces; passive and active self-defence capabilities including electronic countermeasures and jamming, chaff and flares, as well as armaments for self-defence; broad spectrum communications systems capable of receiving situational awareness updates in real-time, while also interfacing with survival radios carried by the downed pilots. Speed and manoeuvrability are paramount, especially during the actual personnel retrieval phase of the mission.

Credit: USAF/Staff Sgt. Aaron Irvin

*US Air Force Pararescue Jumpers exit an HC-130J Combat King II over Djibouti, on 9 May 2023.*

## CSAR Helicopters

Since the Korean War, helicopters have been the primary CSAR platform. Very few armed forces can afford to operate aircraft dedicated solely to personnel recovery. The majority conduct CSAR with aircraft which are optimised for a limited number of additional complex missions such as special operations forces (SOF) support and transportation, and casualty/medical evacuation (CASEVAC/MEDEVAC).

### HH-60W Jolly Green II

The United States is a notable exception here. While the other US service branches deploy multi-mission helicopters for combat and non-combat personnel recovery, the US Air Force (USAF) operates dedicated CSAR helicopters; personnel recovery is officially one of the twelve core functions of the USAF. The HH-60G Pave Hawk entered service with USAF in 1982. It is now being replaced by the HH-60W Jolly Green II under a 2014 contract award to Sikorsky, with the HH-60W having achieved Initial Operating Capability (IOC) in 2022. USAF originally planned to acquire 113 of the new helicopters, but this was cut to only 75 in the Fiscal Year 2023 defence budget; Congress added back an additional 10 aircraft into the 2023 budget, for a total procurement of 85 units. They are due to be permanently based in Italy, Japan, and various domestic locations.

The HH-60W is based on the UM-60M Black Hawk variant, which introduced the digital or 'glass' cockpit which integrates all tactically relevant information, from aircraft diagnostics to moving maps, on one set of displays. Communications systems include wideband-UHF and narrow-band satellite communications (SATCOM), Link 16, Video Data Link (VDL), Situational Awareness Data Link (SADL) and Automatic Dependent Surveillance - Broadcast (ADS-B). The

Flight Director navigation tool includes an improved autopilot which allows the crew to automate certain flight manoeuvres such as hovering, move in a specific direction, or initiating a go-around, freeing the pilots to deal with other high-priority tasks during critical phases of the mission. Other enhancements over the HH-60G include improved hot weather/high altitude performance, an enlarged cabin capable of accommodating more personnel, and double the internal fuel capacity.

The new helicopter achieves a top speed of 280 km/h (151 kn) and a range of 1,100 km, which can be extended through aerial refuelling. Armament options consist of either two 7.62 mm gatling guns or two 12.7 mm (.50 cal) machine guns, with either option mounted externally. Force protection attributes are geared to defeating sophisticated threats and include: a digital radar warning receiver (RWR); the Distributed Aperture Infrared Countermeasure System (DAIRCM) which provides missile-, laser-, and hostile fire alerts and automatically triggers countermeasures; the Degraded Visual Environment Pilotage System (DVEPS) which helps pilots fly through dense dust, sand, snow and fog; as well as cockpit and cabin armouring to provide a degree of protection from small arms fire.

The HH-60W performed its first real-world recovery mission in January 2023, rescuing two wounded soldiers from a battlefield in the Horn of Africa. The recovered personnel were medically stabilised in flight by pararescue specialists. Neither the nationality of the wounded nor the precise location of the operation was released. The helicopter was on rotational assignment to the Combined Joint Task Force – Horn of Africa (CJTF – HOA), headquartered in Djibouti.

Credit: USAF/Staff Sgt. Enrique Barcelo

***The HH-60W arrives at the 58th Special Operations Wing at Kirtland Air Force Base, New Mexico, on 17 December 2020. The 'Jolly Green II' designation honours the 'Jolly Green Giant' CSAR helicopters of the Vietnam War.***

**H225M Caracal**

While the HH-60W is a specialised CSAR helicopter which can be used for additional high-end missions as needed, the H225M Caracal is a multi-mission aircraft optimised for SOF support and related missions including CSAR. The Caracal is the newest member of the Airbus Super Puma/Cougar family. It entered service with the French Air Force in 2005 as a CSAR system, and is currently operated by nine countries for various missions, and in June 2023 the Royal Netherlands Air Force announced that it would also acquire 14 units.

The all-weather, all-climate-capable aircraft has been deployed in Afghanistan, Lebanon, and various African theatres. It can operate from land or from ships. For CSAR missions the unrefuelled tactical radius of action is 370.4 km (200 NM), which can be extended through aerial refuelling. According to Airbus, the aircraft has a 95% readiness rate and can deploy within five minutes of an alert. The airframe is optimised for survivability, enhancing the odds of reaching and extracting the endangered personnel. Survivability aspects include: a reinforced structural frame; energy-absorbing landing gear; self-sealing crashworthy fuel tanks; armoured and energy-absorbing crew seats; armour plated fuselage sides and flooring; infrared shielding of the exhaust system; and a small arms fire resistant rotor system.

Improvements over the previous Super Puma/Cougar aircraft include a low-vibration five-blade main rotor system and a reinforced gearbox. The glass cockpit features four 25×20 cm displays with full navigational and flight control data as well as collision and targeting alerts. The four-axis dual-duplex autopilot ensures flight stability and automatically adjusts performance when one of the two engines is inoperable. Additionally, it manages flight patterns and can automatically transition the helicopter to a hover when the target is acquired, ensuring the fastest possible transition to extraction mode. Fast rope beams and a double hoist with a sling capacity of 4.75 tonnes facilitate swift egress of rescue specialists and extraction of injured or ambulatory personnel. The cabin can accommodate up to 28 passengers, enabling recovery of platoon-

Credit: USAF/Master Sgt. Tristan McIntire

***A US Air Force HH-60W Jolly Green II refuels from an HC-130J Combat King II.***

Credit: Airbus

*A French Air Force H225M Caracal on a special operations mission.*

sized groups, naval crews, or responding to downed aircraft carrying a larger crew or paratroopers. Alternately the cabin can fit 11 litters plus four pararescue specialists. The helicopter evacuates the pickup zone with a 3.6m/s climb rate and a maximum airspeed of 315.8 km/h (170 kn), or at a fast cruising speed of 227.8 km/h (150 kn).

## Fixed Wing Aircraft

Fixed-wing aircraft can also be deployed for CSAR missions, often augmenting and supporting helicopters. Advantages of fixed-wing aircraft include greater airspeed, a higher potential service ceiling which permits surveillance of larger swathes of territory, a larger airframe capable of mounting additional sensors and weapons for suppressing ground fire, and the ability to take a larger number of people and more equipment on board. The latter includes pararescue specialists as well as all-terrain vehicles. Tactical aircraft can land in clearings or roads to deploy search personnel who can proceed on foot or by vehicle into difficult or defended terrain to locate and extract their targets. Alternately, search and rescue personnel and vehicles can be airdropped.

**HC-130J Combat King II**

The USAF's dedicated fixed-wing CSAR aircraft are designated the HC-130J Combat King II. Introduced in 2013, the 39-unit HC-130J fleet replaced the Vietnam-era HC-130N/P Combat King. A standard crew consists of two pilots, a combat systems officer (CSO), two loadmasters, and a three- or four-person rescue team. Performance parameters include an 8,334 km (4,500 NM) range, which is extendable via refuelling, a 10,000 m (32,808 ft) service ceiling, and a 583.4 km/h (315 kn) airspeed at sea level. In practice, the aircraft fly at medium to low altitudes over land and water to minimise risk of detection. When possible, flight operations are conducted at night under blackout conditions and communications silence. In addition to inserting pararescue teams and airdropping survival kits to cut-off personnel, the HC-130J refuels American and allied/partner CSAR helicopters in flight via underwing pods, or lands to establish a forward area refuelling point.

The new aircraft features numerous technology upgrades including an improved refuelling receptacle, optoelectronic day/IR cameras, dual SATCOM, integrated inertial navigation system (INS) and GPS navigation, as well as night vision goggle (NVG) compatible lighting. The integrated situational awareness and force protection suite is configured to provide the aircraft with a modern self-defence capability. Key elements include the Block 8.1 avionics suite; the Lightweight Airborne Radio System (LARS) which incorporates the new 406 MHz distress frequency, and promises to facilitate location of missing aircraft, vessels, and personnel; the Situational Awareness Capabilities Upgrade (SACU), which includes a Link 16 datalink, blue force tracking, advanced mission planning, and enhanced displays; as well as the Northrop Grumman Advanced Threat Warning (ATW) system which includes missile warning capability, hostile fire indication, laser warning, and situational awareness; radio frequency countermeasures (RFCM); and integrated flare and chaff launchers.

Credit: USAF/Senior Master Sgt Ralph Branson

*Airmen of the 1st Expeditionary Rescue Group prepare to launch their HC-130J Combat King II on 24 February 2020, at an undisclosed location in Southwest Asia.*

## Changing Operational Environment

Despite the advances in operational systems and force protection technology, even the latest CSAR platforms may prove inadequate in future war scenarios. Advanced air defence radars, long range missiles, and sophisticated manned and unmanned aircraft threaten to down rescue helicopters well before they reach the pickup zone. Another perceived challenge is the fact that great power conflicts are expected to involve offensive operations at much greater distances than recent conflicts in the greater Middle East and Afghanistan. Retrieving aircrews lost on such deep penetration missions could strain or exceed the operational range of current helicopters. In the Indo-Pacific theatre, the odds of aircraft being shot down over the sea increase significantly, which brings additional challenges – including a shorter window of opportunity – to the CSAR mission.

The Pentagon, in particular, is currently re-evaluating its CSAR force structure in light of the evolving threat picture and operational environment. This reassessment is behind the USAF's decision to truncate HH-60W procurement, said US Air Force Secretary Frank Kendall. "When we were doing counterinsurgencies, and we were losing pilots in those kinds of situations, the needs were different. The acts of aggression like we're seeing in Europe, or we might see in the Pacific [...] put us in a very different scenario," Kendall told reporters in March 2023. Liuetenant General Jim Slife, Air Force deputy chief of staff for operations, echoed this sentiment during an April 2023 Senate testimony. *"The challenge we are facing is really how to address the question of how will we do personnel recovery in a contested environment. We are actively looking at nontraditional ways in order to fulfil that moral imperative of leaving nobody behind. But until we can come to a definitive answer on that, I think the one thing we can say is that helicopters [...] that fly 115 knots refuelled by C-130s with pararescuemen that ride a hoist up and down is probably not the answer in our most stressing scenarios."*

Credit: USAF/Staff Sgt. Devin Boyer

***CSAR retrieves personnel from all environments including the sea.***

Credit: Joby Aviation

***The Joby eVTOL being tested by USAF air taxi can seat five people and fly autonomously, but currently has only a 185.2 km (100 NM) range.***

## Looking to Unmanned Systems

One proposed solution to overcoming hostile defences is to employ swarms of unmanned CSAR aircraft. Electric Vertical Take-Off and Landing (eVTOL) aircraft based on modern air taxi concepts could land, pick up several servicemembers, and return to safety, while manned or unmanned combat aircraft provide cover. The UAVs could be simultaneously deployed from numerous angles and cover a broad search area or simply provide redundancy, ensuring sufficient aircraft are able to reach the pickup zone. One major challenge will be extending the operational range, battery endurance and airspeed of eVTOL aircraft to enable deep penetration of the conflict zone. An alternate proposal would be deploying unmanned variants of high-performance helicopters such as those competing for the US Army's Future Vertical Lift (FVL) programme.

Over time, technology is likely to mitigate issues such as range, speed and mission autonomy limitations, thereby improving unmanned VTOL systems' ability to penetrate contested airspace. However, there remains the fact that wounded personnel may be unable to enter a UAV and secure themselves without human assistance. This would imply that unmanned aircraft would best serve as reconnaissance assets and as decoys to assist a single manned aircraft – either an advanced helicopter or tiltrotor outfitted with high-performance sensors, electronic countermeasures and survival suites – in performing the actual recovery. In practical terms, such solutions are probably still a decade away. ■

# Reassessment of Soviet-era Weapons in the Ukraine War

**Alex Horobets**

**The Russian invasion of Ukraine is already leading to changes in NATO's defence concept and a reassessment of the principles of modern warfare. Ukraine's unique experience of confronting a much larger enemy force in terms of manpower and hardware is being taken into account in this reassessment.**

NATO's military strategy is changing and moving towards the principle of defending every square inch of Allied territory from Day 1 of a potential conflict, instead of the previous strategy of retaliation. The latter strategy assumed that in the event of an attack on any NATO member country, other Allies would take time to consult to draw up a response. It was also assumed that at the initial stage of aggression, the concerned NATO member could be partially or completely occupied until the main Allied forces arrived to engage the adversary. However, following the atrocities committed by Russian troops in Ukraine, such an approach would be unacceptable. Implementing the new approach requires strengthening defences in case of potential aggression, which in turn requires clearly understanding the threat. During its invasion of Ukraine, Russia has deployed huge military formations, with large numbers of armoured vehicles and artillery, many of them dating back to the Soviet era. The question for NATO is how effective this approach could be under modern conditions.

Having launched a full-scale war against Ukraine, Russia has been unable to abandon the use of Soviet-era military equipment, despite boasting in previous years about the production and supply of modern equipment to their troops. This new equipment includes the T-72B3M, T-80BVM, and T-90M main battle tanks (MBTs), BTR-82A armoured personnel carriers (APCs), BMP-2M infantry fighting vehicles (IFVs), BMPT 'Terminator' fire support vehicles, along with various others. The massive losses of Russia's newest military equipment in the first months of the invasion has led to Russia being forced to reactivate and refurbish older models for deployment in order to plug capability gaps incurred through losses.

Credit: General Staff of the Armed Forces of Ukraine

***M142 HIMARS in service with the Armed Forces of Ukraine. The MRL system has proved a valuable asset against Russian high-value targets.***

## Old Equipment from Russian Stocks

Since the start of the war, Russia has removed approximately over 40% of its Soviet-era tanks and APCs from the largest mothballed equipment base in Buryatia. This certainly represents a significant figure, but Russia has another 20 smaller, similar storage bases, which can also be used to reconstitute units destroyed in combat. Before the start of Ukraine's summer offensive, the Oryx blog estimated that Russia had lost over 10,000 units of heavy armoured equipment, including 7,000 irretrievably destroyed, and more than 2,800 captured by the Ukrainian Armed Forces. The Oryx blog's tally only includes confirmed losses, verified by photos or video evidence. However, despite giving a good approximation of Russia's losses, these figures do not tell the whole story. On the one hand, the amount of equipment Russia has lost is likely greater, since not everything is recorded on camera. However, on the other hand, many of the losses tallied by the Oryx blog include damaged, abandoned, and captured equipment, which may potentially be repaired, recovered, or recaptured and returned to service, thereby lowering 'real' losses. Furthermore, these same vehicles may subsequently end up being documented as losses after having been returned to service, raising the risk of counting the same equipment multiple times. Despite these problems, there are few good open-source alternatives to the Oryx blog's visually-documented loss tally.

As of mid-October 2023, the Oryx blog's tally of Russian armoured vehicles lost on Ukrainian battlefields exceeded 12,500, of which more than 8,680 units were destroyed, in excess of 2,890 captured, more than 470 abandoned, and over 520 damaged. By contrast, the Oryx blog's tally of Ukraine's losses stood at over 4,580 units, of which 960 were captured. However, there is likely to be some degree of under-counting occurring, since Ukraine has generally been very careful not to share its casualty figures, with many confirmed losses coming through Russian social media. Despite this, the perceived disparity in losses has cast doubt on Russia's actual military capabilities.

Throughout the years prior to the full-scale invasion of Ukraine, Russia has presented its new arms projects as globally unique. This presentation of modern arms was in part designed to attract export customers. Yet

despite this supposed advantage in modern equipment, Russian units are broadly assessed as having under-performed on the battlefield fairly often. The initial Russian offensive of 24 February 2022 involved their best-trained troops operating with the most modern equipment. By contrast, in these early stages, the Ukrainians were often equipped with outdated or modernised Soviet-era military equipment. However, this is not necessarily down to the equipment in use – the initial operation has been near-universally assessed by military analysts as being very poorly-planned and implemented.

As high-intensity military operations continued, the share of modern military equipment in Russian Russian stocks has fallen, leading on greater reliance on older Soviet-era equipment in many units. The Armed Forces of Ukraine, were similarly not able to completely abandon their own use of Soviet-era equipment. Gradually however, at least for certain types of equipment, Ukraine's share of Western hardware began to increase, thanks to military assistance from its allies and partners. Therefore, for various reasons, both warring parties continued to use equipment of different ages and degrees of modernisation, which has forced them to look at Soviet-era military equipment from a different perspective. Its role in modern military operations has been revised accordingly by both the Ukrainian and Russian sides.

## Plugging Gaps with Equipment from Storage

The Russian Armed Forces' need to use outdated military equipment became evident by the summer of 2022. At that time, the first losses of de-mothballed tanks were recorded. The number of destroyed T-62s increased by the autumn of 2022 and since spring 2023, T-54/55 tanks, produced sometime between 1946¬–1979, have been taken out of storage. The Russians themselves admitted that these tanks were deployed in the occupied areas of the Zaporizhzhia region, but their role on the battlefield was unclear. Later it turned out that there were several options for their use. In particular, they could be deployed as artillery systems for non-precision fires, due to the loss of a large amount of tube artillery. This was necessary to strengthen the defensive line in the occupied territories and provide fire support for units anticipating the Ukrainian counteroffensive.

Also in August 2023, a photo appeared of a damaged Russian T-55 tank equipped with a grille welded to the turret (nicknamed the "barbecue"), intended for protection against kamikaze drones. Such grilles were also used on other tanks and armoured vehicles. Cases where Russia deployed T-54/55 tanks laden with explosives to act as kamikaze vehicles to attack Ukrainian positions were also recorded. However, all these tanks had a common feature – improvised modifications with no factory-level modernisation, often lacking even explosive reactive armour (ERA). This indicates that such tanks were not intended for serious frontline fighting.

Credit: The Republic of Buryatia official portal

***Refurbished T-62 being transported by rail.***

Russia's use of outdated armoured vehicles has confirmed that its combat capabilities have been degraded. The toll was such that the Russian defence industry was unable to keep up with manufacturing competitive models on the required scale. Therefore, while production and/or refurbishment or modernisation of T-72, T-80, and T-90 variants has continued, these have had to be supplemented by refurbished or modernised T-54/55 and T-62 variants. Due to a shortage of components, Sosna-U thermal imagers are spotted less and less often on captured Russian T-72 tanks as they were replaced with older and/or cheaper or domestic alternative models. The same applies also to other types of high-tech equipment.

A similar situation is observed among other types of armoured vehicles in the Russian Army – APCs, IFVs, and howitzers dating from the 1940s, and naval guns from the 1950s, mounted on IFVs. Replenishments are required both because of the need to replace losses and to arm new units amid the ongoing mobilisation campaign. In a situation where the Russian defence industry was capable of producing no more than 20 new tanks per month of various modifications, according to a February 2023 estimate by The Economist, older equipment had

Credit: Uralvagonzavod

***T-90M tanks being produced at Uralvagonzavod's Nizhny Tagil Plant in May 2022. Production of these modernised variants has continued through the war.***

Credit: Lockheed Martin

*M270 Multiple Launch Rocket System (MLRS) conducting a launch.*

to be taken from stocks to make up the shortfall in demand, and eventually, it was turn of those tanks produced more than 60 years ago. Consequently, Russia's (and indeed Ukraine's) the front lines are filled with various types of weapons, ranging from obsolete to more or less modern equipment.

The Russian Federation is now considering the possibility of resuming production of T-80 family MBTs with new-build hulls, alongside continuing its production of T-90M MBTs (both new-build and upgraded from older T-90/T-90A models), and continuing to upgrade T-72s to the T-72B3M (2022/2023) standards. Apparently, production capacity and specialists can quickly be mobilised for the production of the T-80, though the precise variant(s) of the T-80 family to be produced are as yet unspecified.

## Ukraine's Transition to Western Hardware

In Ukraine, the situation is radically different. The Ukrainian Army entered into this full-scale war with a bulk of Soviet-era weapons and a certain share of Soviet hardware modernised by the Ukrainian defence industry since independence. Had the Russian Federation not invaded Ukraine in 2022, sooner or later the question of the need to purchase Western hardware or cooperate with foreign defence companies to produce it would have arisen regardless, since it would have been impossible to simply continue with modernising Soviet equipment for much longer. The war greatly accelerated this process, and thanks to the help of the Allies, the Ukrainian Armed Forces now operate Western armoured vehicles alongside their remaining Soviet-era weaponry and vehicles captured from the Russians.

With captured hardware, the Ukrainian Army has had to address several problems simultaneously. Seized Russian armoured vehicles need to be repaired and prepared for combat, but some models, such as the BMP-3 IFV, had not previously seen service with the Ukrainian Army. A similar problem arose when it came to the repair of completely different types of equipment donated by Ukraine's allies. Ukraine is so far dealing with this quite successfully. However, it should be understood that in the long term, Ukraine will have to abandon its Soviet-era hardware, at least due to the fact that there is a limited amount of ammunition and spare parts available. Meanwhile, the number of military personnel trained to operate Western equipment is constantly increasing.

Credit: General Staff of the Armed Forces of Ukraine

***Budget UAVs are redefining warfare in Ukraine, having proven incredibly cost-effective.***

## Soviet and Modern Technology Colliding

Beyond the relative merits of Western or Soviet equipment, the realities of combat operations on Ukrainian battlefields have forced a reassessment of more than just the role of armoured vehicles in this war. Since neither side has achieved air superiority, the main striking force is artillery. The daily number of artillery rounds fired by Russia and the intensity of shelling has broken records. Russia still boasts a large number of various artillery systems in its stocks, including MRLs, and it is somewhat difficult to estimate their actual numbers. It is also hard to assess Russia's actual ammunition stocks for these systems. Ukraine has received both tube artillery and MRLs from its allies, which deliver precise strikes well beyond the front line, however the quantities of modern artillery received so far are relatively modest.

Aside from artillery, the use of various types of unmanned aerial vehicles (UAVs) and loitering munitions by both Russia and Ukraine has reached record levels, which makes it even more difficult for the warring parties to keep their hardware and personnel safe from airborne threats. Here the question arises of how to better exploit the advantages of modern weaponry in conditions of trench warfare and how to counter an enemy capable of waging a war of attrition. This is a field where seemingly obsolete and hi-end technology collide.

Accordingly, previous concepts of the use of armoured formations developed must be revised. On the one hand, large-scale tank battles are largely off the table (although tank battles have occurred in certain sectors of the front). On the other hand, the use of precision-guided munitions is not a panacea against them. Additionally, large numbers of not-too-modern armoured vehicles still need to be treated as a serious threat, since they can still allow one side to seriously attrit the other or deplete their resources in dealing with them. The fruits of modern technology, including high-precision weapons, satellite imagery, and network-centric combat operations are extremely useful, but are by no means guarantee that their user will instantly prevail over an enemy with enormous manpower capacity and huge stocks of Soviet-era hardware. If there is one thing this war has shown, it is that mass still matters. ■

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# The Winding Path to Military Autonomous Vehicles

**Gordon Feller**

**As militaries around the world test and deploy new autonomous vehicles, commercial enterprises are developing innovative solutions which could change the battlefield in both big and small ways.**

In late 2022, BAE Systems Australia supplied two fully autonomous vehicles (AVs) for a 'battlefield simulation' demonstration for the Australian Army. This is just one more milestone in a long stretch of such announcements, including one in late 2021 that the Australian Department of Defence had completed overseeing the Army's autonomous truck technology a series of road trials. This project aims to develop a fleet of AVs using 'leader-follower vehicle' technology.

In parallel, the Australian Road Research Board is partnering with the Institute for Intelligent Systems Research and Innovation (IISRI) of Deakin University in a related project. The aim is to design and build what the military calls "an autonomous leader-follower convoy", with advanced obstacle avoidance. A multi-vehicle convoy is now being developed and tested at multiple locations. One important place where testing occurs is at the RAAF Point Cook base in Melbourne's west.

Deploying AVs has been a major goal of both the civil and military sectors for many years. One US-based specialist, Bryan Clark, a Senior Fellow at the Hudson Institute, has stated that despite this demand, AVs "have failed to reach maturity due to the inherent complexity of passenger driving conditions, which span everything from well-defined highways to chaotic urban streets and unmarked country roads". However, as Clark points out, "driver assist technologies have made dramatic improvements in vehicle safety, essentially breaking down the automated driving mission into a set of discrete tasks that are assigned to the vehicle or the driver depending on who is best suited".


## Author

**Gordon Feller** has spent the past 40 years examining how and where government and military organisations respond to emerging technologies. He serves as Global Fellow at The Smithsonian Institution in Washington DC.


Credit: Rheinmetall

*In 2022, Rheinmetall-MAN demonstrated leader-follower capabilities using two Rheinmetall-MAN HX2 military trucks fitted with an automation kit, at the US Army's Grafenwöhr Training Area in Bavaria.*

Clark's argument is that "managing speed, direction, and lane alignment are tasks automation does well. Making decisions on whether to leave a standing stop or turn are often best left to the driver, as some well-publicised accidents showed over the last several years."

US-based Robotic Research Corp. (RRAI) provides proprietary 'leader-follower' systems to defence sector customers. A growing number of commercial programs in which they are involved include 'leader follower' technologies and 'automated convoy' technologies. Their customers are doing truck convoying for logging and resource roads, for express bus/shuttle platooning, and for various other controlled environment use cases.

Credit: Kratos Defense

*Leader-Follower Platoon deployment of biodiesel tanker trucks, representing the first self-driving tanker truck deployment in the US.*

Senior DoD officials, and others, are focused on procuring 'human-in-the-loop' and leader-follower type automation systems. Presently, development and evolution of commercial truck automation is proceeding rapidly, due in part to the infusion of massive venture-capital financing over the past six years. This work in the private sector has focused on advancing the technologies which enable what these companies call 'automated following solutions', 'leader-follower solutions' and 'connected vehicles'.

DoD and allied governments, both inside and outside NATO, are ramping up support for human-in-the-loop automation systems. They recognise the ongoing importance of human-led systems, even as individual automated vehicles are developed for some specific use-cases.

ndustry publications and other media reports (see articles below) indicate that top brass see key importance of moving forward with deployment of human-in-the-loop, leader-follower automation in order to bring automation more rapidly to key parts of military operations – including military supply convoys as well as various types of combat convoy applications. Expanded deployment of automated convoy/leader-follower capable vehicles can also be complementary to the longer process of developing automated individual vehicles/trucks that can operate on their own in various types of environments.

Trucking is an AV use case that allows more of the tasks involved with driving to be shifted to the vehicle. Shipping depots and distribution centres generally have well-defined traffic patterns and are close to major highways with minimal complex city traffic in between. As a result, human operators can offload nearly all the tasks involved in driving to the vehicle's control system and focus on supervising.

Credit: Kratos Defense

***HMMWVs in a convoy to support US Army training and weapons evaluation missions. The regular automation of convoying would provide major benefits to militaries worldwide.***

## Grappling with Transition Problems

The US Army has been aggressively studying military vehicle convoys. Clark notes that, unlike their civilian counterparts, such convoys *"may have to go anywhere, preventing automation from relying on known routes, road markings, and traffic rules. They also often must travel through areas lacking a formal road network. The US military has been addressing this using automation technology that allows a lead vehicle operated by drivers to guide automated vehicles along the route".*

This reduces the number of human drivers needed and reduces the risk to soldiers. To allow communications between vehicles that may be separated by obstructions like buildings or terrain, Clark points out that *"the Army is using drones as communication relays. In many of these experiments, automation in the lead vehicle allows the human driver to focus mostly on decisions regarding where to go, while the truck manages the tasks of avoiding obstacles and proposing routes using Google Maps-like decision aids."*

According to Sagie Evbenata, Senior Research Analyst at Guidehouse Corp., "the ongoing mobility transition toward auto-

mated, autonomous, and zero-emission vehicles is transforming how the global commercial and defence communities move people and goods—the traditional boundaries of how vehicles are fuelled, stored, and utilised are being redefined". Furthermore, a changing climate and an increase in extreme weather conditions are creating an urgent need for companies and militaries to adapt mission capabilities to incorporate resilient equipment and installations.

On the defence side, local commanders will need to assess the impact of incorporating these new vehicle capabilities and needs into their daily operations. Evbenata noted that "these vehicles will require updates to existing infrastructure and operating procedures, specifically in the areas of fleets (types of vehicles), fuels (including electricity), and facilities (such as alternative fuelling infrastructure). These updates will also be critical to enabling new vehicles to achieve their mission while creating a more resilient infrastructure network."

To maintain a leading and modern army composed of human-machine teams, the British Army adopted their 'Robotics and Autonomous Systems' approach to adopting emerging military technologies. Evbenata state that "a key objective is the minimisation of risk to human life by the increased deployment of automated air and ground systems. As a result, the Army is involved in a number of research projects to assess and develop automated technologies with military potential".

Evbenata cites one example of this: Project Theseus, which "looks to identify self-driving ground and air technologies to provide last-mile deliveries of military supplies such as ammunition, food, and other critical items to the battlefield". As part of this, the British Army has been developing and evaluating Uncrewed Ground Vehicles capable of transporting cargo over off-road terrain in high-risk environments. He points out that "the Army has partnered with Rheinmetall to retrofit AI-powered automation systems to some of its fleet of Polaris MRZR-D4 light strike and reconnaissance all-terrain vehicles".

Furthermore, the British Army has been testing Multi-Utility Tactical Transport (MUTT) Robotic Platoon Vehicles that, in addition to transporting infantry equipment, provide intelligence, surveillance, target acquisition, and reconnaissance. MUTTs can be configured to travel semi-autonomously or by remote operation.

Credit: Kratos Defense


***Biodiesel tanker trucks in a Leader-Follower Platoon.***

Evbenata concludes that, "with the growth of automated military vehicles, the need for secure communications infrastructure becomes increasingly important". At the centre of the action are communications technologies – such as mobile ad-hoc networked datalinks and the 'Internet of Battlefield Things' – "to connect army personnel and smart equipment with a reliable network", which is vital in combat zones.

## Commercial Support for Military Operations

Automated commercial vehicles also have the potential to support military operations. Civilian truck operators can benefit from operational cost savings, and the ability to economically continue

Credit: Kratos Defense


***Automated Highway Maintenance vehicles deployed in a Leader Follower Platoon increasing work zone safety removing the driver from a high-risk maintenance operation.***

operations as labour shortages become more pronounced. Presently, automated trucks are being deployed in several pilot projects in Europe, North America, and Asia. Guidehouse Insights anticipates that 1.2 million automated trucks will be in commercial deployments worldwide by 2032.

To get the military's perspective, we consulted with Maj Gen S Hutchings OBE, Master General of Logistics with The UK's Royal Logistic Corps. He stated that *"the British Army is committed to enhancing its operational logistic capability through the use of Robotic Autonomous Systems (RAS)"*. In this he includes optionally crewed leader-follower capable large goods vehicles to enable logistics personnel to increase delivery throughput. Hutchings argues for *"operational advantage in enabling greater endurance at increasingly longer distances with greater volumes of materiel, enhancing operational effectiveness. The RAS ambition also includes smaller autonomous systems, such as drones, which can be optimised to undertake the last-mile logistic tasks, for example distributing blood product and critical spares"*.

Hutchings concluded that "all of these require integration of sensors to enable data capture and usage at a standard and volume that has yet to occur on the battlefield". However, Hutchings is aware that the logistics liability for operating these systems must be understood: *"Maintaining a resilient supply chain for autonomous systems will be essential as will the ever-closer integration of our industry partners. It is also clear that a conversation about how skills may be transferred into the military workforce if needed in a crisis must be had, else we will fail to ensure that autonomous systems can be sustained and repaired in a conflict zone."*

A veteran of Operation Iraqi Freedom with insights here is Michael P. Noonan, PhD, Senior Fellow at the US-based Foreign Policy Research Institute (FPRI). He argues that, *"as technologies mature, the automation of trucks is of importance to both civilian industry and the military. While some of the uses of this technology would overlap—increasing the safe delivery of supplies and materiel over extended distances—there would also be large differences in their uses. Neither civilians nor the military would completely drive the innovation and diffusion of technological advances in this space."*

Noonan wants us to not think about any automation of supply trucks as simply replacing humans with unmanned systems: *"This process, particularly in military settings, would almost certainly be the pairing of man and machine to swiftly, accurately, and safely deliver supplies across territory where movement might be impeded or harassed by enemy forces, criminal elements, or displaced persons. The ability of crew to operate the vehicles as necessary, defend and protect the vehicle convoys, and perform necessary maintenance will be essential. One could also think about scenarios where a human-operated system could control other vehicles remotely."*

## Going Beyond R&D

Automating military trucks has been a is not simply a matter of pure research and development or science fiction conjecture. In 2011, for instance, the Army deployed the Squad Mission Support System vehicle, also known as the Ox, to Afghanistan battlefields. Noonan saw that *"these remote-operated vehicles were able to carry out missions such as delivering ammunition to special operations forces in harm's*

## Commercial Enterprises Embrace AVs and 'Leader-Follower' Solutions

Many companies have announced plans to include automated convoying/leader-follower capability for their class 8 truck systems, including the following firms:

- Farizon Auto (an arm of the China-based Geely Automotive) has released their Class 8 EV / Fuel cell truck platform. It is being rolled out in late 2023/early 2024.
- RRAI has been developing and deploying resource road/logging road 'automated truck convoy' systems, under a project funded by FT Innovations and Canadian logging industry.
- Several automated truck system developers have indicated "automated convoying capability" as one application of their systems including Rheinmetall MAN, TuSimple Crop, Pronto.ai Corp, and others.
- Several major global truck OEMs and their suppliers have, in recent years, continued to develop 'automated following' capability in parallel with individual truck automation development. Some of this work has been assisted by government funding particularly in Europe and Japan. This includes activity by: Volvo Trucks, Paccar/DAF, Scania, MAN, Daimler/Freightliner, Iveco, Ford-Otosan, Hyundai, Toyota, UD Trucks, Hino, and Isuzu.

*way or construction materials to units in rough terrain."*

Those who speculate about pure automation can readily imagine certain scenarios where that might be beneficial. Noonan's view on this is straightforward: *"One would be delivering supplies across particularly hostile territories where losses to artillery barrages or precision strike systems could reduce risks. Another would be delivering supplies across an area that was contaminated by nuclear, chemical, biological, or radiological hazards—although decontamination of the systems would still be necessary."*

As regards the path ahead for AVs, Boyd says that *"there remains a long road to commercially profitable and scalable solo driverless automated vehicles. In the meantime, new generation Advanced Driver-Assistance Systems, leader-follower systems and other connected vehicle solutions can be commercially deployed more widely. And this process is well underway, despite overall macroeconomic headwinds. This type of human-in-the-loop solutions also is complementary to the longer process of developing commercially-viable individual driverless vehicles."*

Although some AV companies continue touting near-term commercial deployment plans, Boyd's expectation is that it may take tens of billions of dollars in further investment for each major driverless AV company seeking to deploy complete systems. Furthermore, it will require a decade or more to see fully-driverless individual vehicles become commercially profitable and scalable on open roadways and in non-controlled environments.

There may be a reckoning underway in the market, one which could be especially harsh for AV companies that fail to develop significant interim revenue products or alternative long-term sources of capital. An extensive shakeout and consolidation of companies is now picking up steam, with several major companies faring badly. For those AV companies which are able to survive and adapt, partial automation products or related solutions can also be important stepping stones on the much longer road to profitable fully driverless systems.

Boyd argues that, *"over recent years, many companies have begun to develop and deploy interim products that can be deployed nearer term – such as Advanced Driver-Assistance Systems (ADAS), safety systems and automation systems that enhance the safety of human drivers, systems that require extensive direct supervision by remote human operators, and automation systems only for use in highly controlled environments - such as truck/trailer yards, private mining/logging roads, controlled routes between warehouses, mining sites, construction sites and farm fields".*

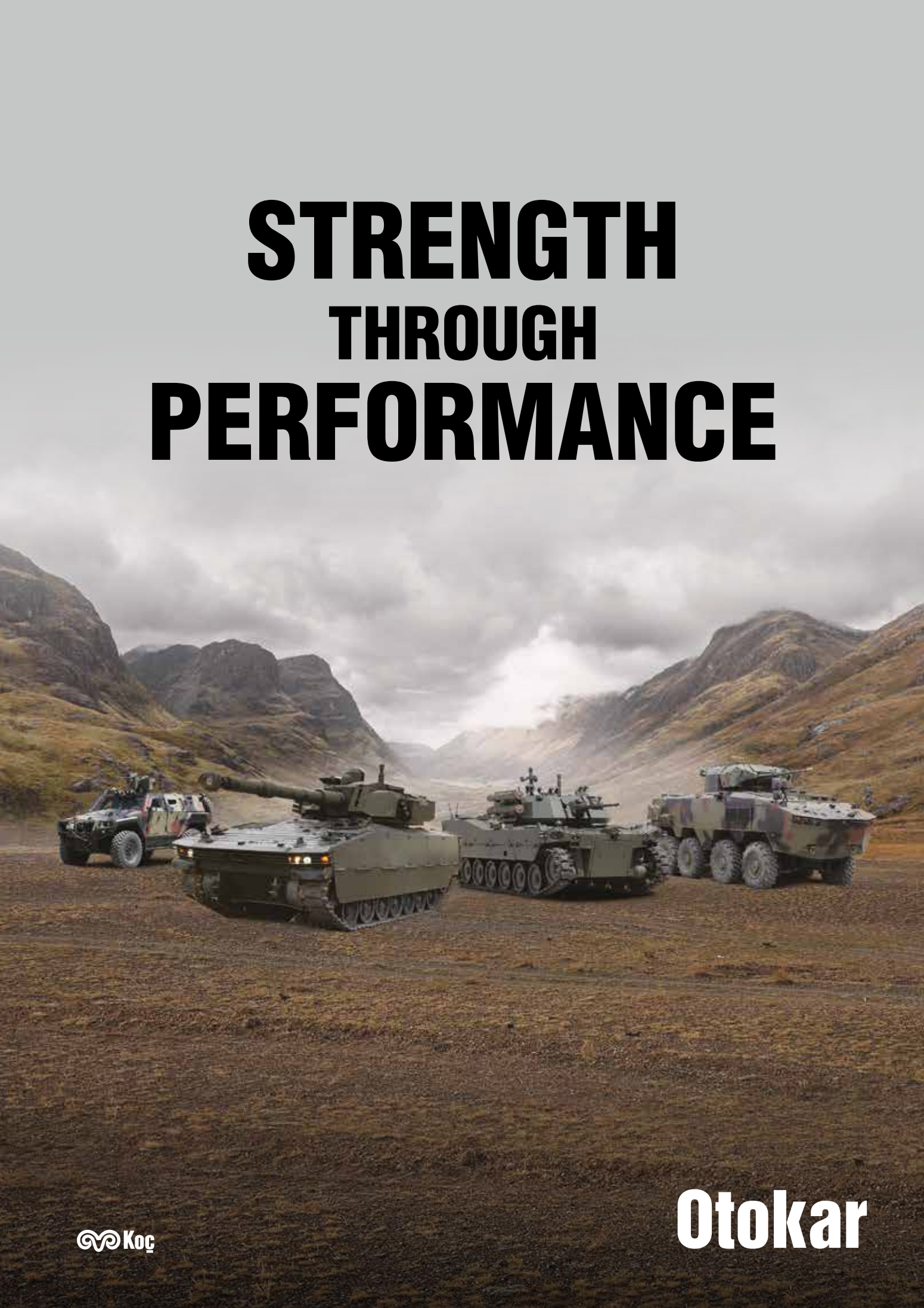
Leaders at the US DoD and other military agencies see a long timeline to the full deployment of fully driverless vehicles. As Boyd notes, *"they are focused on the practicality and safety of human-in-the-loop automation systems like vehicles with a mixture of Leader-Follower, ADAS and individual automated vehicle capabilities".* Boyd thinks that further deployments of these types of military systems, largely supported by OEMs and suppliers with affiliated commercial businesses, will complement the commercial development and deployment of similar solutions.

What lies ahead for defence organisations is a long and winding road leading to scalable solo driverless AVs. In the meantime, new-generation ADAS, leader-follower systems and other connected vehicle solutions can be deployed more widely, and this process is well underway. ■

Credit: Oshkosh Defense

***The autonomous Oshkosh Palletized Load System developed for the US Army's Expedient Leader-Follower programme, to carry ammunition and other critical supplies.***

# STRENGTH
# THROUGH
# PERFORMANCE



Koç

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# Displays: Digital Visualisation of the Battlefield

**Tamir Eshel**

**Displays are critical to modern military electronic systems, visualising sensor data, communications, and system status. As the most critical link between the human and machine, displays must be carefully integrated into the overall system architecture to enable reliable and effective presentation of information to operators.**

A key consideration is the need to balance the interface between the electronic systems providing the information, the human-machine interfaces, and the physical, electromagnetic, and prevailing environmental conditions. This integration is critical for the efficient use of the system and mission success.

## Built for the Military Environment

Unlike commercial electronics, military displays often operate in groups, tapping multiple video and data sources, fed to several operators on board and remotely from the operating platform. Modern open system frameworks such as the US Air Forces' Future Airborne Capability Environment (FACE) and Sensor Open Systems Architecture (SOSA), the US Army's Vehicle Integration for C4ISR/EW Interoperability (VICTORY) initiative, and the United Kingdom's Ministry of Defence (MOD) Generic Vehicle Architecture (GVA) are paving the way for the standardisation of vehicle electronic architectures, based on common sets of physical specifications, and electronic data bus, network adaptors, connectors, and protocols.

For the application of video distribution from multiple sensors to many displays, these architectures require video distribution units, and switches, supporting digital and analogue data, enabling operators to view multiple video sources simultaneously with minimal latency to make the most efficient use of the information gathered by the system. Many applications also require all information to be recorded or transmitted to other users. Simple display output typically mirrors the images shown on the operator's screen, thereby limiting the recorded and downlinked imagery to only the operator's view.

Credit: Tamir Eshel


***The control system of Saab's RBS-70 mobile firing unit (MFU) integrates Saab's tactical electronics and low-latency video distribution system to increase situational awareness of the battlespace.***

For these purposes, displays are optimised for the task at hand. Some are designed for minimal space weight and power (SWaP), to serve as an endpoint for an integrated system. Unlike many of today's short-lived commercial electronics, such systems must remain operational for 10–20 years. Other, more sophisticated 'smart displays' represent more expensive and capable systems, integrating an advanced computer, graphics processor, and communications protocols, enabling the display to assume the capabilities of an entire system. Such an architecture is especially useful in the upgrading of legacy platforms, where the installation of an integrated system of systems would be too costly. However, the useful lifespan of such systems is limited as they require frequent upgrades to remain up to date with the rapid advance of electronic systems.

Military devices differ from commercial equipment as they are designed to withstand the high loads encountered in an aerospace environment or built as rugged systems that withstand shock, vibration, and temperature extremes of field use in combat vehicles. These standards also specify how they are sealed and protected against damage from sand, water, and salt. Displays are also designed to be visible even in bright sunlight and avoid interference to users operating night vision imaging systems (NVIS). It should also prevent electromagnetic interference (EMI) and information leakage to nearby equipment.

## Virtual and Mixed Reality

Military displays come in all different sizes, form factors, and resolutions. From large-area displays (LAD) with touchscreen and dozens of pushbuttons integrated into the bezel, to micro-displays embedded in helmets, sights, optical devices, and wearable systems.

Other devices project images on opaque or transparent visors embedded in binoculars, weapon sights, and head-mounted systems to provide immersive sensing to pilots and warfighters. The latest trend in this field is the mixed reality display, enabling unmanned aerial vehicle (UAV) operators to fly their drones in FPV as if seated inside them, operated through virtual reality (VR) goggles, and controlled by joysticks or hand controllers. Over the past year, this concept has proliferated a new category of loitering munitions known as 'FPV drones', widely used by both sides in Ukraine. These low-cost loitering munitions are often built in informal production workshops by volunteers, and typically used to engage land platforms from a safe distance. In combat vehicles, electronic displays provide the situational awareness critical for the crew to assess and react to external factors. Emerging applications for armoured vehicles include 'see-through armour', which utilises either wearable goggle-type displays, or flat displays embedded in windows, doors, and walls, providing the crew with 'smart windows' to the outside world.

For mission planning and rehearsal, VR headsets immerse users in synthetic environments, facilitating familiarisation with operational areas and scenarios in 3D. Advanced VR simulations integrate directional audio, touch feedback, and motion platforms to heighten realism. Integrated AR/VR training shortens learning curves and improves mission readiness. Ongoing optronics research is maturing additional display technologies for military adoption.

ntelligence analysts and system operators use workstations comprised of multiple displays, some geared to provide three-dimensional imaging, to monitor many data sources simultaneously, and with the aid of artificial intelligence (AI), can tap into data obtained by high-resolution cameras to display the most operationally-useful information in a given scenario.

## Optimising Usability with Human-Machine Interfaces

The human-machine interface (HMI) connecting the operator to a display system is as important as the underlying display technology itself. The HMI encompasses both how information is visually presented and how the user physically interacts with this information. Intuitive HMIs tailored for specific platforms and mission roles are crucial for enabling full display utility.

Modern aircraft leverage glass cockpit HMIs fusing flight instrumentation including altitude, airspeed, engine status, situational awareness, and systems statuses into reconfigurable multi-purpose flat panel displays via layered synthetic graphics generation. In these cases, digital screens are fitted with a touch control, and push buttons on the bezel to enable effective operation with gloves. Another method of interaction is gaze-tracking which enables intuitive cueing of systems activated by user eye movements to dynamically overlay data or target designations based on viewing direction.

To further expand display interfaces, gesture inputs allow intuitive commands such as swiping to pan/zoom high-resolution camera feeds. Voice recognition enables the hands-free activation of display modes and menus. Motion inputs from helmet trackers dynamically orient visualisation perspectives based on operator head positioning. Haptics and force feedback further heighten user engagement.

By combining interactive multi-layered graphics and three-dimensional presentation, diverse sensor modes, and adaptive interfaces, advanced display HMI enables a more immersive and intuitive experience for operators. This allows for optimising cognitive focus and interaction efficiencies across diverse mission sets ranging including drone control, intelligence gathering, and precision targeting.

Newer systems such as the F-35 helmet incorporate spherical visor projections for full immersion in a synthetic visual environment, including visuals below and around the aircraft. Crew members of combat vehicles can also use augmented reality systems to view the outside world when protected inside armoured vehicles. Their helmet visor taps peripheral cameras to create a panoramic view, overlaying threats, navigation references, and mission updates. Such displays are also used to improve driver orientation and situational awareness.

Lightweight head-worn displays resembling eyeglasses are being widely adopted for hands-free data visualisation in the field. Remote mentorship systems use headsets to share leader viewpoints, annotations, and guidance with distributed teams, enable commanders to share a situational view from different locations, as well as allow medics utilising wearables to access self-guided remote treatment resources while keeping their hands free for patient care.

Credit: Tamir Eshel


***The unified control station (UCS) developed by Israel Aerospace Industries (IAI) integrates flat panel displays, tablets with touch screens, and ergonomic controls to provide drone operators with an ergonomic mission-optimised environment.***

## Specialised Displays Interpret Advanced Sensor Feeds

Cutting-edge sensors enable battlefield observation across the electromagnetic spectrum far beyond natural human vision. However, interpreting non-visual spectral sensor feeds requires specialised display processing and symbology. With adequate training in the underlying physics and proper interpretation of display symbology, operators can learn to 'see' through such sensors' eyes, gaining a critical battlefield advantage.

For example, sonar systems transduce underwater acoustic reflections onto visible hydrographic mapping displays. However, effective interpretation relies on understanding the fundamentals of active versus passive sonar, and sound wave propagation. Similarly, radar fuses radio or microwave frequency reflections into an aerial picture, the processing of Doppler effects, moving target indication, and synthetic aperture radar all add layers of information that require specific presentation to the user. Thermal sensors that register heat differentials present an image-like view by using false-colour or more commonly grayscale gradients to reveal the thermal signatures of objects and targets. Digital imaging and displays enable combatants to leverage many of these sensors without the technical skills and extensive training required to operate legacy analogue systems.

## Powerful Processing for Advanced Displays

The digital revolution has exponentially multiplied the sensor data available for aggregation and display. However, the human mental bandwidth remains constrained in how much information can consciously be evaluated simultaneously before reaching cognitive overload.


Credit: Tamir Eshel

***This compact integrated screen displays Axon Vision's Edge360 AI-enhanced situational picture composed of six peripheral camera feeds, processed with AI to alert the crew to enemy forces, indicating positions, directions, and range of the most critical threats.***

Therefore, advanced processing is essential to synthesise only operationally-relevant information from endless sensor data flows. For this purpose, virtual 3D displays become essential viewing tools to present multi-layered information in augmented or mixed-reality.

Enhanced by AI-enabled analytics, modern systems are designed to focus on highlights, fuse complementary feeds, and extract tactical meaning from various signals. Machine learning algorithms can be trained to emulate human-like pattern recognition capabilities tailored for battlefield contexts. By undertaking the tedious processing and analysis of sensor outputs, AI can relieve the cognitive burden on operators, allowing them to focus human efforts on higher-level insight and decision-making. Processing capability has become equally important as display technology for converting sensor inflows into timely and actionable battlefield awareness.

## The Big Picture

Digital displays are fundamentally transforming military command and control and situational awareness capabilities. Integrating high-performance visualisation into diverse manned and unmanned systems and platforms requires holistic optimisation of system interfaces, ergonomics, HMIs, and processing support. Wearable displays bring mission-critical data to operators across air, ground, and naval roles. As advanced multi-spectral sensors synergistically expand the observable spectrum, leveraging AI to distil operational knowledge from endless sensor feeds, display technologies provide the ultimate conduit for human battlefield awareness. ■

# Today's Combat Shotgun Market

**David Saw**

**The shotgun might not have the 'glamour' of some other small arms, for instance it cannot successfully engage a target at 600 m. However in urban combat scenarios, the weapon truly comes into its own.**

At present many militaries are working towards the development and fielding of new generations of small arms that combine high capability, high technology and, inevitably, high cost. This is unsurprising when you consider that next-generation assault/battle rifles are to be equipped with digital fire control systems, designed to allow the shooter to successfully engage a target and neutralise it with minimal expenditure of rounds. Yet for all its capability, the service rifle is not a universal panacea. There are other operational and specific mission requirements where something different is the correct tool for the job. This sums up the role of the shotgun.

The shotgun has often suffered from the fact that it really does not have a martial image. It is not an elegant weapon, nor is it particularly accurate weapon when used outside of its parameters. However, to the surprise of many, the shotgun is actually a uniquely flexible weapon system. In recent years shotgun capabilities have been significantly increased, further enhancing its utility for military users, as well as paramilitary and law enforcement (LE) agencies.

Credit: USMC

***Aboard the USS Iwo Jima (LHD-7), an embarked US Marine Corps unit trains with a pump action shotgun. The US military first started using pump action shotguns in the First World War, Mossberg Model 500 and Model 590A1shotguns were acquired in large numbers by the US military from the late 1970s onwards.***

## Manufacturer Diversity

If you are in the market to acquire a shotgun-type capability it is quite likely to be a considerable surprise when you suddenly discover how many shotgun manufacturers there actually are. Even more surprising will be the price points that the various manufacturers operate at.

Beretta is a diverse group capable of meeting most small arms needs, but their capabilities have also expanded into ammunition and optics amongst other areas. In terms of shotguns, Beretta are more than capable of producing weapons that could compare with the high-end providers such as Purdey and Holland & Holland, the latter of which was acquired by Beretta in 2021. However, Beretta is also a major producer of shotguns for military applications. Alongside its own range, Benelli and Franchi, two major names in the military, paramilitary and LE shotgun market are also Beretta Group companies.

In 2022, Australia's LAND 159 Lethality System Project Tranche 1 included the Australian Defence Force (ADF) Close Combat System, part of which is the acquisition of a new Combat Shotgun System. In September 2022, it was announced that the Benelli M3A1 had been selected to meet the Combat Shotgun System requirement and would replace the Remington 870 in ADF service. The Benelli M3A1 offers a selective action – it can be used in a semi-automatic recoil inertia operated mode, or the user can switch to a manually-operated pump action mode. This is a 12 gauge weapon with an eight round magazine. For the ADF application it will also be fitted with a red dot sight and white light illuminator.

There used to be substantially more shotgun manufacturers in Europe than there are today, even so apart from Italy and the UK, there are shotgun solutions on offer from Belgium, France, Germany, Israel, Russia and Ukraine. Expand your search and shotgun possibilities emerge from Brazil, China, the Republic of Korea, the Philippines, South Africa, Turkey and, of course, the US. To be fair, there are still a substantial number of manufacturers globally, but the number who could supply weapons for military and other demanding applications are inevitably far fewer in number.

## Market Options

While European manufacturers can justly claim to have the historical background in shotgun design and manufacture, US manufacturers can point to the fact that the US military has, in many ways, led the practical application of shotgun usage in the military sphere. Back in 1893, John Moses Browning, one of the truly great firearms designers, and his brother Matthew S. Browning developed a new shotgun design for the Winchester Repeating Arms Company, the definitive version being the Model 1897. Thereafter referred to as the Model 97, this was one of the first successful pump action shotguns. It was 12 gauge with a five-round magazine. Initially developed for LE and prison guards, it was described as a 'riot gun.' When the US

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Army joined World War 1 in 1917, the Model 97 was re-purposed as 'trench gun' and was found to be an ideal weapon for close combat trench clearance. Another Winchester shotgun was the Model 12, this was developed by a company engineer in 1912, and later was given the M12 designation by the US military. Both of these weapons would remain in service until the early 1960s.

The next generation of military shotguns were developed as a replacement for the Model 97 and the M12. Winchester developed the Model 1200 in the early 1960s for LE use, although the US military purchased a few. The Winchester Model 1200 was superseded by the Model 1300 in the 1980s, but by that point others were meeting LE and military needs. The Remington 870 arrived in the early 1950s, but it took until 1966 and an order from the US Marine Corps for it to see military service. Then in the 1970s, the US Army would acquire the weapon.

Mossberg is one of the major shotgun manufacturers in the US and was first established in 1919. Its product range covers pistols and rifles as well as shotguns, with the company getting involved in military production in 1940. At that point it was manufacturing weapon parts and tooling gauges, it even manufactured Lee Enfield rifle parts for supply to Britain. At the start of the 1960s Mossberg introduced their Model 500 shotgun, which was highly successful in commercial and LE markets. In terms of military applications, 1979 was the key year when the US military adopted the Model 500 as its standard shotgun. In the late 1980s, the Model 590A1 shotgun would be purchased by the US military. The weapon was widely sold internationally, and Mossberg went on to develop the 590M variant, which is fed from a detachable box magazine available in 5, 10, 15 or 20 round formats. Mossberg shotguns are still in US military service.

Credit: Australian DoD

***As a part of the LAND 159 Lethality System Project, Tranche 1, the Australian Defence Force (ADF) generated a requirement for a new Combat Shotgun system and in September 2022 announced that the Benelli M3A1 had been selected.***

In May 1998, the US Army issued an invitation to tender for a new semi-automatic 12-bore combat shotgun, contender evaluations took place in August of that year, and in early 1999 the Benelli M4 Super 90 was selected as the competition winner and type classified as the M1014 for the US military. The British Army also uses the M4, designated as the L128A1, as its combat shotgun, with Special Forces also using the Remington 870 as the L74A1/A2. The French Army has chosen a different path for its combat shotgun requirement, it has a limited number of Benelli M4, Mossberg Model 500 and a few Remington 870s. In May 2022 it was revealed that the new standard French military combat shotgun would be the Benelli Supernova Tactical.

Something a bit different in terms of combat shotguns comes from Israel Weapon Industries (IWI) and is based on their Tavor TAR-21 bullpup assault rifle design. Originally the Tavor was designed in 5.56 × 45 mm to allow the Israel Defence Forces (IDF) to replace older weapons such as the M16 in first-line service, the weapon also proved attractive to export customers. For combat shotgun requirements IWI developed the Tavor TS12, it followed a lot of the standard Tavor styling cues and has a bullpup configuration. The TS12 has three separate magazine tubes, giving a capacity of 15 rounds or 16 with one in the chamber. The weapon has a Picatinny rail on top as well as M-LOK compatible rails, allowing a wide selection of sights and other accessories to be fitted to the weapon.

Back in October 2021, French manufacturer Verney-Carron, which had been established in Saint-Etienne in 1820, decided to re-organise and separate its commercial and sport shooting activities from its defence and security activities. These were combined under a new name as the Lebel company, a name drawn from that of the famous French weapon designer Colonel

Credit: UK MoD

***The British Army acquired the Benelli M4 to meet its Combat Shotgun requirement, giving it the L128A1 designation. The weapon was acquired to improve capability in close-quarter battle environments that were being experienced in Afghanistan.***

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Credit: US Army

***US Military Police fire a Mossberg 500 shotgun during a crowd control exercise. The shotgun with less-than-lethal munitions provides the military with a critical capability when dealing with crowd/riot control in urban operations or in support of civil authorities.***

Nicolas Lebel, whose 1886 rifle along with its smokeless rounds was a revolution in small arms design.
Lebel has a complete range of less-than-lethal systems utilising Flash-Ball grenades, rubber bullets and CS gas rounds. Alongside rifles and submachine guns, the company also has a complete shotgun range, comprising the VERTAC A2, D2, and P2 models. The VERTAC A2 is a semi-automatic shotgun, the VERTAC P2 is a pump action shotgun, while the VERTAC D2 is a dual action semi-automatic or pump action system. All of these systems are used by French LE particularly in terms of riot control and by rapid intervention units.

## The Right Tool for Urban Combat

As a system the shotgun has been around for hundreds of years, its debut as a significant modern military system came in World War 1 when the US Army started using the pump action shotgun for trench clearance. Since then the shotgun has retained its military relevance and remains an ideal tool for close-quarter battle environments. As a door-breeching system, shotguns provide capability for both military and LE operators. Initially LE was the primary user of shotguns for crowd/riot control, at the start buckshot rounds were used, but over time a range of less-than-lethal rounds have emerged for this purpose. Crowd/riot control is increasingly also a military mission, hence they also require less-than-lethal rounds for their combat shotguns.
Continuing urbanisation around the world means that combat operations in urban environments will increasingly become the norm. The combat shotgun remains an essential capability for operations in these environments, be they close-quarter work or breaching operations. Operating in these urban environments, especially amongst potentially or truly hostile civilian populations, will require that the military has crowd/riot control means with less-than-lethal munitions, yet another mission for the shotgun. ■




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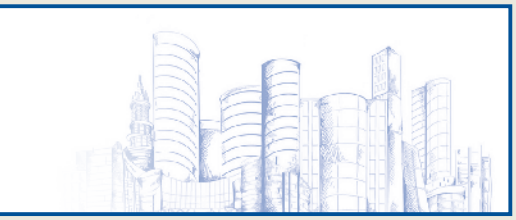


# Viewpoint from Tel Aviv

Photo: via author

# Will Israel's Seventh War Explode into a US-Iran Conflict?

**Tamir Eshel**

The attack by Gaza-based Palestinian terrorist organisation Hamas against the Israeli Defense Forces (IDF) guarding the border with Gaza and the ruthless massacre of civilian villagers and town residents in the southwestern Negev shocked the Israelis, who were caught off guard by the onslaught. After years of internal friction and nine months of civil unrest dividing progressive Israelis and conservatives, religious orthodox and nonreligious, the gay community, military veterans, and orthodox students exempt from service, the horrific attack shocked every Israeli, bringing the nation back together. With losses mounting to over 220 hostages, primarily civilians, beyond 1,500 dead and 4,000 wounded, most Israelis are raging and committed to removing the 'Palestinian Threat' across their borders once and for all, with or without international support.

The immediate response was airstrikes against Hamas infrastructure in Gaza. Still, the IDF called over 330,000 reserves, the largest recruitment since the 1973 Yom Kippur War, to enable the IDF to plan, prepare, and execute a full-scale simultaneous campaign against Hamas in Gaza, Hezbollah in Lebanon, and the Palestinian terrorist groups in the West Bank – an attack intended overwhelm the non-state armed groups and establish new conditions for security in the region.

The goal set by the Israeli government was clear: to defeat Hamas, destroy its military infrastructure, and rout the organization from the Gaza Strip. How to do so is not clear. Unlike past conflicts, Washington quickly responded and embraced Israel with unwavering moral and material support, even before the Jewish state asked for it. US President Joe Biden demanded that Israel limit its responses to actions abiding by the international law of war. However, there are more reasons behind the US generosity. Washington is concerned about 'uncontrolled' Israeli actions that may damage its position in the region.

The US quickly responded by deploying naval forces to the Eastern Mediterranean, deploying two carrier strike groups and a marine expeditionary unit (MEU), strengthening combat air squadrons in Turkey and Greece, and sending air and missile defence systems in the form of a THAAD battery and several PATRIOT batteries to the region.

At the initial phase of the war, Tel Aviv indicated its intention to seize the entire Gaza Strip and push the Gazan Palestinians to Sinai. Egypt vocally objected and said this would be an act of war. Meanwhile, possibly under US pressure, Israel has announced it would abstain from attacks in an area reserved as a sanctuary for refugees from Gaza City, where most Hamas and Palestinian Jihad terrorists are reportedly hiding in underground tunnels built under the city.

The defensive array is also fully deployed. The US and Israeli air defence systems are geared to work together and provide effective defence for Israeli and US interests in the region and neighboring countries. Such capabilities have been proven in the past by intercepting two drones in the Arabian Peninsula along with the recent intercept of four cruise missiles and eight drones over the Red Sea that Iran-backed Houthi rebels launched from Yemen against Israel. The Aegis-equipped Arleigh Burke Class Destroyer *USS Carney* and at least one Saudi air defence system were credited with carrying out these interceptions.

While Israel was caught off guard in the opening phase of the war, Tel Aviv and Washington clearly understood the gravity of the situation and acted quickly to reform their defences and establish credible deterrence against Iran. They are currently building an offensive force which will be capable of striking back when the time is right. Israel still handles the situation by employing massive air power and artillery while developing other measures to strike their enemy at the optimal time and place. Lacking the element of surprise in this case, the IDF needs time to plan, prepare, soften the battlefield, wear down their enemy, and thus reduce personnel and materiel costs.

However, Tel Aviv or Washington cannot endlessly prolong this situation, as economic realities come into play. The horrific pictures of the Hamas attacks on Israeli civilians would fade away, replaced by images of the humanitarian crisis in Gaza. Israel would also experience an economic slowdown under prolonged emergency conditions. The clock is ticking, and depending on the course chosen, the outcome may be detrimental to all sides. Unless action is taken by Israel and an international or regional coalition, the primary beneficiary is likely to be Iran. The coming weeks and months will reveal whether the Seventh Israeli War in the Middle East remains a regional conflict between Israel and non-state armed groups, or evolves into a broader regional war with US involvement.

# Future Vertical Lift (Maritime Strike): Status Report

**Sidney E. Dean**

**The US Navy has begun the search for replacements for its shipboard manned and unmanned vertical lift aircraft.**

The Future Vertical Lift (Maritime Strike) or FVL (MS) program seeks to develop and acquire a 'family of systems' (FoS) including both manned and unmanned aircraft to replace rotary lift aircraft currently deployed aboard US Navy (USN) combat ships. The 'Maritime Strike' designation references the combat and combat support role played by these aircraft.

The current vertical lift maritime strike assets of the USN consist of manned MH-60R 'Romeo' and MH-60S 'Sierra' Sea Hawk helicopters and the MQ-8B/MQ-8C Fire Scout rotary-wing UAVs. Both Sea Hawk variants are multi-mission aircraft. The Romeo is primarily optimised for combat roles and is considered the cornerstone of the Navy's helicopter concept of operations. The Sierra performs a wide range of missions including Mine Countermeasures (MCM), special operations forces (SOF) support, maritime interdiction and surface warfare, search and rescue, and general support. The Fire Scout is employed for Intelligence, Surveillance, Reconnaissance and Targeting (ISR&T), communications relay, and supply missions. The smaller MQ-8B Fire Scout is currently being phased out. The larger MQ-8C variant was introduced in 2019 and is expected to reach the end of its service life in the 2030s. The Navy also expects to begin retiring both Sea Hawk variants during the 2030s.

## FVL (MS) Requirements

The FVL (MS) program was formally initiated on 8 November 2019, when the Pentagon's Joint Requirement Oversight Council validated the Initial Capability Document (ICD), which established the requirement for a cost effective vertical lift capability to ultimately replace the MH-60R/S and MQ-8C fleet.

The Naval Air Systems Command (NAVAIR) published a Request for Information or RFI on 28 January 2021 (updated on 9 March 2021) with a response date of 4 May 2021. The Navy emphasised that this was not a Request for Proposals (RfP), and that no solicitation documents existed at that time. Rather, the RFI was

Credit: USN

*The USN needs to replace the MH-60 Sea Hawk and the MQ-8C by the mid-2030s.*

intended to inform the Navy's planning process and support the assessment of potential solutions.
The FVL (MS) FoS will be required to have the same portfolio of mission capabilities as the current aircraft, but will be required to go above and beyond the capabilities of the Sea Hawk and the Fire Scout. New assets will be required to fill capability gaps which are insufficiently addressed by current systems. This is especially critical in regard to gaps which will ensue as adversaries develop more sophisticated naval, aerial and electronic warfare systems in the coming years. FVL (MS) will also be attuned to changing US concepts of operation. The Naval Aviation Vision 2030-2035 or NAV 2030-2035 (released by the USN in September 2021) states that the new family of systems will be designed and built specifically to support Distributed Maritime Operations (DMO).
As defined in NAV 2030-2035, "the capabilities envisioned include increased survivability, long [operating] range, persistent ISR&T, integrated air and missiles defense, long-range offensive anti-surface and anti-submarine warfare (ASW), communications and data relay, fleet logistics, and personnel recovery."
The threat paradigm in the 2030-2035 timeframe – as well as the principles of DMO – dictate that FVL (MS) be able to conduct these tasks in a highly contested environment, at greater ranges, and with greater speed, endurance, and precision. "FVL (MS) will leverage advances in AI [Artificial Intelligence] and ML [Machine Learning] sensor technology, AI and ML to fully integrate the manned and unmanned platforms to form highly effective teams, thereby reducing operator workload and increasing the speed and quality of aircrew decision-making." The new aircraft will also require enhanced signature control to defeat opponents' improved sensors and evade detection.

## Challenges and Emerging Options

The requirement for the new aircraft to operate from destroyers and frigates will place restrictions on size and weight. This could make it challenging to incorporate the full capabilities profile that the Navy wants for the FVL (MS) FoS. The USN also hopes to collaborate to the greatest extent possible with the US Marine Corps (USMC), which is seeking to acquire its own new FoS of unmanned shipborne combat support aircraft. Here the services must decide how much space for compromise exists with regard to capabilities profiles, payload capacity and aircraft size. Whether joint procurement of a portion of the FVL (MS) fleet will actually be viable remains to be seen. The Navy also intends to leverage the synergies and innovative technology solutions from the US Army's FVL initiatives; again the question remains as to what extent land-optimised solutions will be applicable to maritime operations. Rear Admiral Andrew J. Loiselle, director, Air Warfare Division (N98) of the Navy Staff, expects the sea service to learn from the Army's ongoing FVL experience, especially with regard to mission systems. However, the Admiral has clearly stated that he sees no direct correlation between the Navy's requirements and the Army's envisaged airframes, which would be too large or too small for the maritime mission.
On the other hand, it ap-

Credit: Bell

***Missions for a maritime variant of the Bell V-280 could include SOF and boarding team transport, medevac and surface warfare strike.***

Credit: Bell


***The maritime-optimised Bell V-247 can carry sonobuoys, torpedoes, and air-to-ground missiles including the Naval Strike Missile depicted here.***

pears as if the USN will have no dearth of industry proposals. More than 30 aircraft manufacturers and sub-system suppliers replied to the 2021 RFI. "The information provided [...] included survivability as a key aspect to combating future threats, in addition to all mission capabilities to support the projected needs," stated Navy spokesperson Megan Wasel. While the Pentagon has not revealed the names of the responding firms or details of their responses, several manufacturers have announced interest in competing for a future FVL (MS) contract.

These include Bell Textron, which cites "synergies" between their V-280 Valor manned Tiltrotor aircraft (which was selected for the US Army's Future Long-Range Assault Aircraft or FLRAA program, but is too large to operate from destroyers) and the Valor's unmanned sister, the V-247 Vigilant. As early as 2018 Bell presented a model of a folding-wing variant of the V-280 which could ostensibly fit into the hangar of an Arleigh Burke Class destroyer. In 2022 the firm presented a downscaled version of the Vigilant which would have the same shipboard footprint as the MH-60R, and would reportedly be capable of performing every combat mission now accomplished by that manned aircraft. Depending on payload, the maritime V-247 could have an unrefuelled combat radius of up to 700 nm (1,296.4 km), extendable through in-flight refuelling.

Sikorsky, manufacturer of the Seahawk family, has neither confirmed nor ruled out offering a derivative of the manned SB>1 Defiant coaxial helicopter which lost the FLRAA competition. Northrop Grumman, maker of the MQ-8C, has announced plans to compete for the unmanned portion of the FVL (MS) program, either alone or in partnership with Leonardo Helicopters. Megan Wasel cited additional extensive coordination with other agencies, including the Office of Naval Research (ONR) and the Navy Research Lab (NRL), on a number of technology, platform and payload projects which aim to demonstrate operational capability relevant to the FVL MS mission.

## Moving Forward

The replies from industry provided feedback regarding the capacity to meet the needs identified in the ICD. This information in turn flowed into the Analysis of Alternatives (AOA) drafted by NAVAIR. The analysis portion of the AOA took nine months and was completed in late 2022. The AOA team subsequently wrote a classified final report including detailed analyses of potential materiel and non-materiel solutions, their perceived effectiveness, and expected costs. In April 2023 Admiral Loiselle informed Congress that the report had been submitted to the Pentagon's Office of Cost Assessment and Program Evaluation (CAPE). "Once [CAPE] is done with that sufficiency assessment, then we will absolutely move on to selecting a preferred alternative for the Navy, and all the costing and acquisition documentation necessary to reach a Milestone A, likely in about the [fiscal year] 2025 time frame," Loiselle said in testimony before the House Armed Services Committee. Since then neither CAPE nor Navy leadership have announced a conclusion of the internal review process, nor any decisions on how to proceed with the FVL (MS) program.

The timeframe described by Admiral Loiselle is compatible with the original aspiration defined in the 2021 RFI, which stated that "the new capability is expected to have an IOC in the mid-2030s timeframe to support all described Navy missions." To date, the Navy has not publicly adjusted that timeframe. To maintain the viability of the current maritime strike assets, NAVAIR plans to award Lockheed Martin a Service Life Extension Program (SLEP) contract for the MH-60S fleet. According to the May 2023 announcement, the anticipated work will be conducted from May 2024 through April 2026. It is expected to add approximately seven years of service to each airframe, which would keep the Sierra operational into the early 2040s. During his April testimony Admiral Loiselle stated that a SLEP for Romeo variant was not planned until the 2030s, and then only if needed. The fact that the Navy retains an inventory of surplus MH-60R helicopters in storage will serve as a hedge against any delays in developing and fielding the next generation FVL Maritime Strike capability. ■

Photo: via author

# New Slovak Acquisitions

**Martin Smisek**

At its meeting on 4 October 2023, the Government of the Slovak Republic took another step forward in the modernisation of the Armed Forces of the Slovak Republic (Ozbrojené sily Slovenskej republiky; OS SR). The Government approved negotiations for the delivery of new air defence missile systems as part of the first stage of modernising Slovakia's ground-based air defence (see ESD 6/2023 for further details). Moreover, at the same meeting, the Ministry of Defence of the Slovak Republic (Ministerstvo obrany Slovenskej republiky; MO SR) informed the Government regarding the procurement of assault rifles under the Foreign Military Financing (FMF) programme.

On 31 May 2023, the MO SR sent out requests for government proposal to ambassadors of 11 selected countries with relevant production potential for their man-portable air defence systems (MANPADS) and medium range surface-to-air missile system – mobile (MRSAM-M) requirements. The deadline for receipt of tenders was 31 July 2023.

A total of four proposals were received from four countries for MANPADS and four bids were obtained from three countries for MRSAM-M. In August 2023, a project team of approximately 60 experts of the MO SR evaluated the bids on the basis of predeclared evaluation criteria in the areas of technical capability (criterion weighting: 35%), procurement price (15%), life cycle costs (25%), delivery dates (15%), crew training (5%), and involvement of domestic industry (5%). The tables below give a breakdown of the offers evaluated by the MO SR:

**Evaluation results of submitted offers for MANPADS**

| Country (supplier) | System | Number of launchers | Overall assessment | Total price including VAT (EUR) |
|---|---|---|---|---|
| Sweden (Saab Dynamics) | RBS-70 NG | 12 | 86% | 39,514,694 |
| Poland (MESKO) | Piorun | 36 | 76% | 65,883,000 |
| France (MBDA) | Mistral 3 | 12 | 75% | 35,000,400 |
| South Korea (LIG Nex1) | Chiron | 12 | 72% | 30,952,280 |

**Evaluation results of submitted offers for MRSAM-M**

| Country (supplier) | System | Number of launchers | Overall assessment | Total price including VAT (EUR) |
|---|---|---|---|---|
| Israel (IAI) | BARAK MX | 3 (with 8 missiles each) | 95% | 128,102,880 |
| Israel (Rafael) | SPYDER | 3 (with 8 missiles each) | 84% | 149,534,880 |
| Germany (Diehl Defence) | IRIS-T SLM | 4 (with 8 missiles each) | 72% | 200,339,155 |
| France (MBDA) | VL MICA | 3 (with 4 missiles each) | 65% | 169,226,880 |

Poland's offer ranked second in the MO SR evaluation, however, it also provides a significant operational advantage with three times the number of launchers as other offers, as well as ammunition. Moreover, this was the only offer for a MANPADS conceptually similar to the current 9K38 Igla used in the OS SR. Therefore, the MO SR is due to start negotiations with the Polish government to prepare the necessary contractual documents for the acquisition of 36 Piorun systems.

IAI's Barak MX ranked highest in the MRSAM-M category, and consequently, the Slovak government has given the MO SR a mandate to negotiate with Israel for the supply of one BARAK MX system. In the case of both MANPADS and MRSAM-M, the draft contractual documents will need to be submitted to the Government of the Slovak Republic for approval before signing.

# Covert Demonstration: USVs Change the Stealth Game at Sea

**Dr Lee Willett**

**Ukraine's USV campaign in the Black Sea has demonstrated how uncrewed systems can have critical impact on naval warfare. Western navies and industry alike are taking this lesson onboard in uncrewed system operation and design.**

The use of stealth at sea by Ukraine, a country with lesser absolute and relative naval capability has enabled that country to exercise effective sea denial against Russia, a larger naval adversary, in the Black Sea, a region of vital strategic importance to both. The effective development of sea denial capability is what the Ukrainian Navy has achieved in the Black Sea in the Russo-Ukraine war through its use of uncrewed vehicles, especially uncrewed surface vessels (USVs).

The Black Sea is of significant importance to both countries. In a largely land-centric war, it is a maritime region through which Russia, for example, can attempt to flex its muscles to deter other actors from trying to shape the conflict. Operating from key bases at Sevastopol in Crimea and Novorossiysk in Russia, the Russian Navy can use the Black Sea to hem Ukraine in, to conduct land-attack strikes using long-range sea-launched cruise missiles from surface ships and submarines, or to consider amphibious actions along Ukraine's southwestern coast. Moreover, Russian naval forces roaming across the Black Sea implementing a naval blockade and conducting extensive mining can make it very difficult for commercial ships to operate there. For example, ships exporting Ukrainian grain under the Black Sea Grain Initiative have – when permitted to sail – been operating at significant risk. With Western naval powers denied entry into the Black Sea by Turkey's closure (under the 1936 Montreux Convention) of the Bosporus/Dardanelles straits to any warship or submarine not homeported in the Black Sea, in naval terms the opportunity was there for the Black Sea to become a Russian-dominated body of water.

On his open-source intelligence defence analysis website *Covert Shores*, H I Sutton provides a detailed timeline of events in the Black Sea during the war (with the piece last updated on 14 October 2023). War broke out in February 2022. Sutton noted that, by 3 March 2022, most of the Ukrainian Navy's warships had been captured, sunk, or scuttled. "Ukraine, whose fleet was massively out-gunned, is left with only a few smaller vessels," Sutton wrote. Yet, as the saying goes, no plan survives first contact with the enemy.

For Ukraine, the Black Sea also is strategically critical. It has acknowledged laying


## Author

**Dr Lee Willett** is an independent writer and analyst on naval, maritime, and wider defence and security matters. Previously, he was Editor of Janes Navy International, senior research fellow in maritime studies at the Royal United Services Institute, London, and Leverhulme research fellow at the Centre for Security Studies, University of Hull.


Credit: NATO Maritime Command

***In 2018 in the Black Sea, NATO and Ukrainian naval forces conducted a PASSEX. Here, the Ukrainian frigate Hetman Sagaidachny (centre) worked with NATO's SNMG2 in a drill countering fast attack craft. Today, NATO is learning from Ukraine's use of small, fast, uncrewed craft to deter the Russian Navy and offset the combat loss of its larger fleet assets (including Hetman Sagaidachny).***

minefields to keep Russian naval forces out of reach of its southwestern shores. It needs to shape events in the Black Sea to isolate Crimea, for example by targeting the Kerch Strait Bridge with long-range strikes and conducting amphibious raids on Crimea to target Russian surveillance capabilities. Perhaps most important for Ukraine was to stop Russian naval forces from operating in the Black Sea. Certainly, it has succeeded in severely restricting the activities of major Russian Black Sea Fleet assets. It has done so in large part by using uncrewed systems, enabled by stealth technology and tactics, to attack Russian ships and submarines at sea and in port.

The first signs of what would become a significant Ukrainian capability for conducting effective sea denial operations using stealthy, uncrewed systems emerged in late March 2022, when various Russian navy ships were hit at sea and in port. Sutton noted that Russia stopped using the port of Berdyansk, the target of one attack, for resupply. On 13 April 2022, the Russian Navy Slava-class cruiser Moskva – Black Sea Fleet flagship and a central presence of Russian naval operations in the Black Sea, Mediterranean Sea, and Indian Ocean for many years, was hit by two Ukrainian Neptune anti-ship cruise missiles (ASCMs), and sank the next day. It could be argued that the sinking of the Moskva was due to a lack of air-defence capability – as well as a ship technology, readiness, and operational – issue, and not a stealth capability issue.

However, subsequent developments demonstrated that a primary route Ukraine would use to offset its absolute and relative lack of naval numbers and capability was an asymmetric one – deploying stealth capability through the covert use of uncrewed vehicles.

## USV Operations

In the maritime domain, Ukraine has mastered the use of uncrewed vehicles in the air, surface, and sub-surface domains – including uncrewed aerial vehicles (UAVs), uncrewed surface vessels (USVs), and uncrewed underwater vessels (UUVs) – and in a way that has demonstrated to even major Western navies just how much value such capabilities can add, at the tactical, operational, and strategic levels, when used in the right way. This has been particularly true with Ukraine's USV use.

On 21 September 2022, a Ukrainian USV washed up outside Sevastopol. "Russian forces destroy it but otherwise do not appear to react to the new threat," Sutton noted. On 29 October 2022, Ukrainian USVs and UAVs struck Sevastopol, with the

Credit: NATO


***The Russian Federation Navy Krivak-class frigate Pytlivy is pictured in the Black Sea in 2018, operating close to NATO SNMG2 ships. In the Russo-Ukraine war, Ukraine's use of USVs across the Black Sea has driven Russia's major fleet assets back to port.***

USVs penetrating the harbour, and with the Admiral Gorshkov-class frigate *Admiral Makarov* (one of Russia's newest ships, commissioned in 2017) being hit. While no ships were sunk, Sutton said "Russia [withdrew] its fleet into bases and [started] initiating increased defences."

A month later, a USV attack on Novorossiysk demonstrated that Ukraine could reach right across the Black Sea with its stealthy, uncrewed capability. Novorossiysk is some distance from Ukrainian waters, and Ukraine's ability to deploy a USV from one side of the Black Sea to the other testified to the evident stealth capability it was developing with uncrewed systems.

Indeed, Sutton noted, while Ukraine has continued with its USV operations, it has continued in parallel with their technological development. Moreover, Russia has successfully defended against some Ukrainian USV attacks – but the fact that the attacks have continued, and in different Black Sea waters, suggests Ukraine also has mastered the mass issue when it comes to USV development.

In July 2023, Ukraine used its USVs to strike the Kerch Bridge: such an attack sent out quite a symbolic message. In early August 2023, the impact of Ukraine's USV attacks stepped up once more, with successful strikes on the Ropucha-class landing ship *Olenegorsky Gornyak* outside Novorossiysk (significantly damaging the ship, according to Sutton) and on a Russian oil tanker travelling south of the Kerch Bridge.

A mid-September 2023 attack highlighted another element of Ukraine's evolving USV capability, with an operation involving 10 or more USVs reported to have targeted a Russian tanker and a logistics vessel. This indicated Ukraine's capacity to launch USV attacks in numbers, offering the potential to generate swarming capability. A day or so later, a further attack followed – this time, Sutton noted, possibly involving two experimental semi-submersible USVs. Ukrainian USV attacks have continued, with Sevastopol targeted again on 13 October 2023.

## Operational Impact

Naval platform design – whether of ships and submarines, or of uncrewed vessels – has shifted increasingly over the last two decades towards the use of stealth.

Currently, the development of USVs in this stealth context is seeing them generally designed to support what are known as the '6-D' – 'dull, dirty, dangerous, dear, deep, and [long] duration' – tasks, replacing crewed platforms in conducting these tasks to enable those crewed platforms to focus on higher-end missions to which their capabilities are best suited.

The '6-D' tasks focus, for example, on intelligence, surveillance, and reconnaissance (ISR) to support missions like anti-submarine warfare (ASW) or mine counter-measures (MCM). In the former instance, USVs and other uncrewed platforms can provide sustained presence to provide the required monitoring; in the latter, they negate the need to put crewed platforms in harm's way. In both contexts, stealth is crucial to ensuring operational effectiveness.

At the recent, combined 'REPMUS'/'Dynamic Messenger' maritime uncrewed systems (MUS) exercises, which took place in southern Portugal in September and which are co-hosted by the Portuguese Navy and NATO Allied Maritime Command (MARCOM), uncrewed systems including over a dozen USVs were tested in different operational scenarios, namely ASW, ISR, MCM, and critical undersea infrastructure warfare (CUIW). Detection of uncrewed systems – UAVs, USVs, and UUVs alike – was a priority in several exercise serials. This included setting up a Thales Squire prototype phased-array radar at the exercise hub at Troia to

Credit: NATO Maritime Command

***The Turkish Naval Forces Command Aydin-class mine warfare vessel TCG Anamur, deployed with Standing NATO Mine Counter Measures Group Two (SNMCMG2), is pictured off Bulgaria in the Black Sea in 2018. Ukraine and Russia have both conducted extensive mining of Black Sea waters since war broke out in February 2022.***

conduct counter-UAV/-USV surveillance. In a separate serial, different MUS types were deployed covertly to provide ISR support for an amphibious landing.

For the assembled senior naval and NATO leaders and staff officer-level subject matter experts (SMEs), lessons learned from the use of uncrewed systems in the Russo-Ukraine war – and especially their asymmetric impact, due to their stealth technology – were right at the forefront of both the strategic-level thinking shaping NATO's approach to operations and capability development, and the technological and tactical thinking shaping the exercise serials. In sum, such systems are having significant impact on the current evolution of naval warfare thinking and capability development.

"Autonomous systems are changing naval operations. A small of cell of Ukrainian drones is successfully conducting a sea denial campaign in the Black Sea against a much stronger Russian Navy," Admiral Henrique Gouveia e Melo, the Portuguese Navy's Chief of Staff, said in his keynote speech opening the exercise's Distinguished Visitors' (DV) Day.

Ukraine's effective use of uncrewed systems, particularly USVs, is prompting NATO to consider the asymmetric impact of such capabilities in offensive terms, but also how to defend against such capabilities. As regards offensive operations, Ukraine's campaign has demonstrated how the stealthy use of uncrewed vehicles can provide NATO with another option for achieving disproportionate military effect, alongside simply deploying a large NATO task group. As regards defensive operations, and noting Sutton's point that Russia too has conducted successful Black Sea USV operations, NATO navies are now having to think about force protection and wider defence against uncrewed systems.

At the exercise, NATO leaders discussed the strategic-, operational-, and tactical-level impacts of Ukraine's uncrewed systems campaign on Russian Black Sea operations.

"If you look at the Black Sea Fleet and its operations, from the outset – before the Ukraine war – you would see that as a potent, expensive capability," a senior NATO official told a media briefing at the DV Day. "Through the use of capabilities like armed USVs – low profile, difficult to detect – and a good use of UAVs as well, Ukraine has rendered the Russian Black Sea Fleet almost ineffective, in terms of what it was going to do."

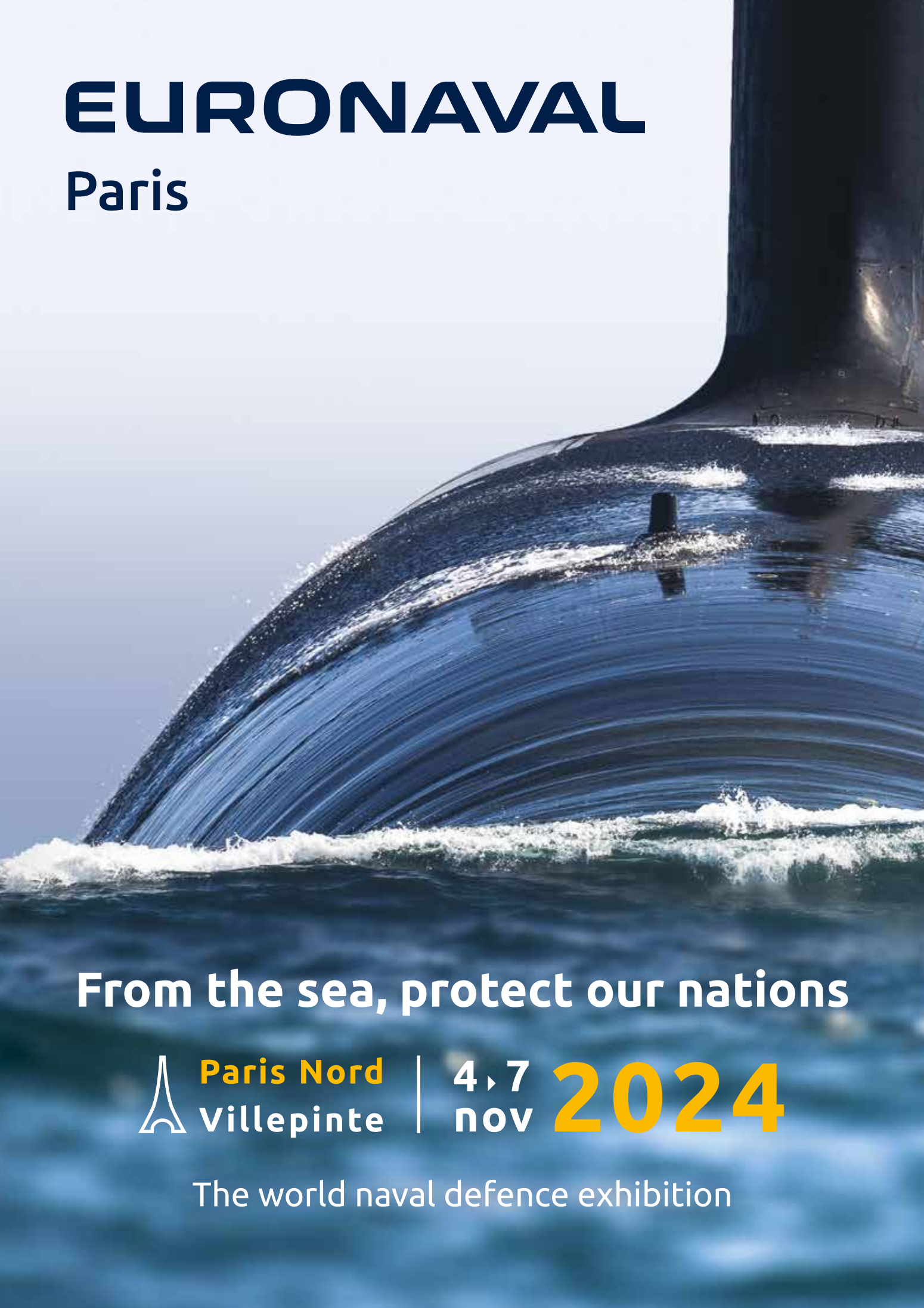
*"If you looked at the plans right at the start of the war, you were looking at bombardment in gearing up for amphibious assault from the south etcetera, but now the Black Sea Fleet assets are the other side of the Crimean peninsula, and they don't come out that often because of the threat,"* the official said.

This impact was also achieved using a threat that is "very much asymmetric", the official added, estimating that Ukraine's capability investment in uncrewed systems may have been in the order of EUR 30 M.

As regards lessons learned from NATO's perspective, the official detailed lessons at both the tactical/operational and strategic levels. As regards tactical/operational lessons, the kind of questions NATO must start asking include how to use similar types of tactics, what other tactics, techniques, and procedures (TTPs) might need

Credit: US Navy

***Ukraine's Black Sea USV campaign has demonstrated to NATO how stealthy employment of uncrewed vehicles can provide another option for achieving disproportionate military effect, alongside deploying a task group. Pictured is the US Navy (USN) Nimitz-class aircraft carrier USS George H W Bush (centre) leading a multinational carrier strike group in the Adriatic Sea in February 2023.***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The world naval defence exhibition

Credit: NATO Maritime Command

***Two USVs are pictured alongside at Troia, during Portugal's 'REPMUS' exercise in 2022. NATO navies use 'REPMUS' to test and exploit USV stealth capabilities.***

to be developed to employ such systems, what uncrewed system capabilities might allied countries need to develop, and how might existing and emerging national capabilities be integrated across the alliance.

At the strategic level, the official continued, "The other question we must ask ourselves is how do we defend against that threat? There's always a need for [Western navies to develop] exquisite capabilities, but how do you protect them against something that's very difficult to detect?"

"The war in Ukraine has showed us that we need to counter uncrewed systems in all domains. We need to think about how we protect our forces in that sense," he added. "The type of [USVs] Ukraine is using are very low profile, which makes them difficult to detect at night," the official continued.

NATO and its member state navies have previously used 'REPMUS' to test and evaluate what can be achieved with stealthy USVs. In 'REPMUS 2021', for example, the Maritime Tactical Systems' (MARTAC) Mantas T12 USV was deployed. "We used [it] to go into an area covertly with a disruptive payload that would disrupt adversary communications," the official said.

## Designed for Stealth

An overlaying principle for the design of Western naval platforms – crewed or uncrewed – is to implement a stealth design for core elements of the vessel's architecture, including for example: superstructure design, to reduce radar reflection; communications emissions, to reduce the electromagnetic signature; and heat emissions, to reduce the optical signature.

Much of the focus on increasing stealth in crewed platforms is to reduce their defensive susceptibility to incoming attacks. This focus has been sharpened by the changing nature of, for example, the missile threat in naval operations, which is now bringing increased anti-ship missile (ASM) capability through range and speed improvements – the latter including the advent of hypersonics.

One difference in naval architectural design considerations between crewed and uncrewed platforms – as demonstrated by Ukraine's USV use in the Black Sea – may be that the operational concept for using uncrewed systems is based largely on designing in stealth capability to enhance their offensive operational impact.

As noted in Sutton's analysis, an element of Ukraine's technology development with its USV capability is to build systems that are stealthy largely because they have a low-observable design with very little superstructure standing out above the surface. This design focus is continuing to the point where Ukraine is now experimenting with semi-submersible USVs.

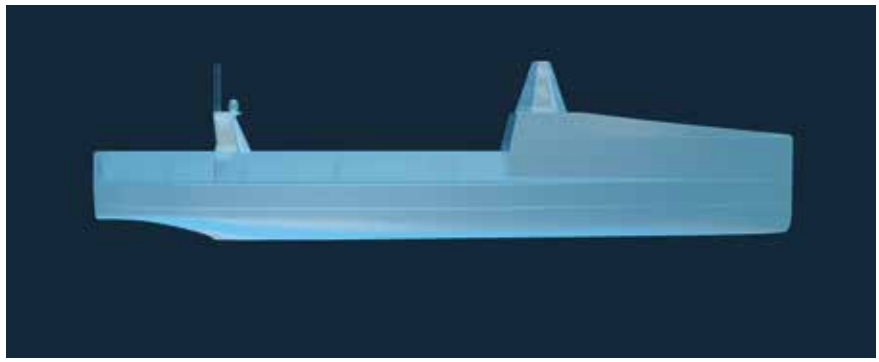
Semi-submersibles are not a new maritime concept. Industry companies have developed low-observable surface vessels that can transition to submerged operations, meeting special forces insertion requirements. Narcotics cartels have developed low-observable and semi-submersible vessels, as well as 'mini submarines'. However, these have all been crewed platforms.

Developing and operating low-observable and semi-submersible uncrewed vessels is not something that has been tried much in operational terms until Ukraine's Black Sea USV campaign. Yet stealth requirements now appear to be an integral design element for USV technology and capability development going forward.

Beyond stealth, mass is also a key consideration. For example, at the Defence and Security Equipment International (DSEI) exhibition in London during September 2023, BMT – a UK-based engineering design house and consultancy that provides naval architecture capability – launched its Large Uncrewed Surface Vessel (LUSV) concept. As set out in a White Paper the company published at DSEI as part of the LUSV launch, central to BMT's LUSV concept of operations is that such systems can be procured in numbers to generate mass, and can provide significant capability through increased use of autonomy. The White Paper also pointed to an anticipated future operating environment that will include periods of intense operations.

One lesson emerging from the Russo-Ukraine war – and as demonstrated in Sutton's analysis of Ukraine's Black Sea USV operations – is that uncrewed systems are being procured, used, but also lost (in combat) in large numbers. The fact that USV attrition rates will be high, as with any asset type in large-scale conventional conflict, makes stealth design increasingly important in reducing risk of detection and loss. Indeed, BMT's White Paper underlined the

Credit: BMT



***USVs are increasingly being designed with a low-profile, stealthy hull to reduce susceptibility to attack. Pictured is an artist's rendering of BMT's Large Uncrewed Surface Vessel (LUSV) concept.***

Credit: US Marine Corps

***A MARTAC Mantas T12 USV was deployed on 'REPMUS' in 2021 to demonstrate covert operations. Here, a T12 is pictured during testing in the Gulf with the USN's Task Force 59 in 2021.***

role of uncrewed systems in adding mass in hull numbers to offset attrition rates that can be exacerbated through using uncrewed systems, as has been demonstrated in Ukraine. "A great example of such a rapidly evolving threat environment is seen in Ukraine's effective use of small maritime surface drones to challenge Russian naval superiority in the Black Sea, conducting damaging strikes on capital ships and military tankers," the paper stated. "It is threats like this that will need greater numbers of flexible protean assets to counter."

LUSV concepts may also offer the space, with no human operators onboard, to embark larger weapons payloads, thus bringing mass in firepower too. In discussing how LUSV concepts can contribute to contemporary naval operations, the White Paper highlighted the importance of stealth in LUSV design and capability. This discussion also underlined how the absence of crew can fundamentally change platform design, offering opportunities to develop stealth capability in new ways.

The White Paper pointed out that while modularity in design for LUSVs would enable them to meet a broad range of mission requirements, a core role would be to provide sensor packages to deliver sustained ISR in support of the '6-D' tasks, enabling missions such as protecting critical undersea infrastructure nodes, establishing ASW barriers, or providing an ASW or air-defence picket capability at the outer range of a task group. LUSVs could also be deployed into contested littoral waters, where crewed ships may be considered too valuable and too at risk given the layered defences present. "The LUSV role is still an area to be fully explored, but the starting point is roles that fit the '6-Ds'," Andy Kimber, Chief Naval Architect at BMT, told ESD in a written interview on 23 October.

Nonetheless, the operational-level importance of these role underlines the need for stealth in USV design and technology, to reduce detection and attrition risk. *"As USVs will have to rely less on recoverability (as this normally requires some kind of human intervention) and potentially may be limited in their (hard-kill) self-defence capabilities, stealth is likely to be a key feature to minimise detection (or at least suggest minimal value in attacking) and enhance the potential of decoy systems as a form of self defence,"* Jake Rigby, BMT's Head of Innovation and Research, said in the written responses.

To provide such stealth, the White Paper underlined the LUSV design need for a "stealth radar profile (radar cross-section minimised from reduced superstructure – no bridge or accommodation)". Specifically, it defined the above-water signature for an LUSV as being low-observable in terms of infrared (IR) signature and radar cross section (RCS), and the LUSV's below-water signature as needing low in-water acoustic noise and low magnetic signature. Alongside the reduced 'topside' profile, with no need for a bridge onboard to provide space for human operators to conduct watch of ship operations, the absence of personnel onboard can also reduce requirements for auxiliary safety machinery, thus reducing below-water radiated noise. Overall, the White Paper assessed, an LUSV's low signature should be generated by "Focusing on underwater radiated noise and radar cross section".

As regards the overall concept for enhancing stealth capabilities in an uncrewed platform, "Making the vessel uncrewed has its challenges, but allows you to re-think the whole design layout by removing the normal constraints and limitations," Rigby added.

Yet, as with any military platform design, a balance must be struck between requirements, outputs, and costs when introducing stealth concepts and technologies. "A key aspiration for uncrewed vessels will be to reduce detectability, to allow their sensors to collect data and reduce the risk of being targeted," Kimber explained. "However, the degree of stealth that may be applied will have to be judged against ultimate effectiveness and the goal to make such larger USVs affordable enough to achieve the promise of mass."

"Stealth features will not only reduce a USV's susceptibility to attack, but will help ensure its sensors and countermeasures can operate effectively," Rigby continued, adding "but in these cost-sensitive vessels, the features must be carefully considered to ensure benefits are proportional to cost."

However, when weighing up the impact of stealth upon the cost equation for such cost-sensitive vessels, there is another factor to consider. "Recent conflicts have stressed the importance of cost-effective capability provision," said Rigby. "Stealth features do not always have to be expensive, as is often assumed. Significant benefits can be achieved through careful design and incorporation of best practice." ■

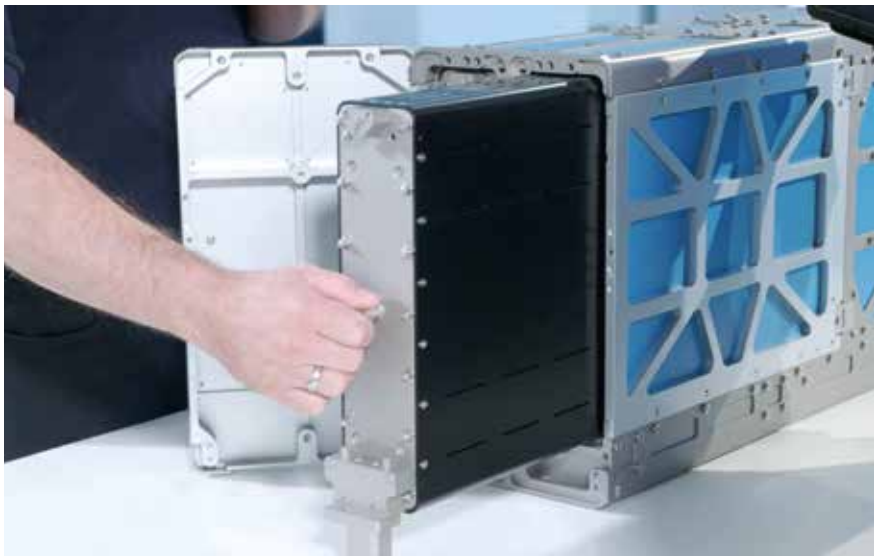
# Developments in Lithium-ion Batteries and AIP Systems for Submarines

**Luca Peruzzi**

**The latest developments in Lithium-ion battery (LIB) systems in the underwater domain have resulted in significant advantages for submarine operations compared to standard lead-acid batteries and have increased the number of new submarine procurement programmes. The aim is to provide modern submarines with maximum tactical mobility, while at the same time reducing the indiscretion rate and increasing the submerged autonomy to deal with multi-domain anti-submarine warfare (ASW) threats. This article also looks at the latest achievements in the air-independent propulsion (AIP) systems, which contribute to extending underwater range and endurance at low speeds.**

Higher volumetric and gravimetric energy density are advantages Lithium-ion technology provides compared to lead-acid batteries with the same volume. Another important benefit of LIBs is that they allow for greater utilisation of a vessel's onboard capacity, which already generates greater submerged autonomy. Moreover, they charge more quickly, which means a reduction in the time the submarine is required to use its primary power source. They also have the ability to reach maximum speed no matter the state of battery charge. Finally, they can continue to be developed over time and gain performance increases, just as we see today in the world of e-mobility. However, these benefits come together with safety issues affecting the technology, requiring extensive safeguarding solutions for the overall submarine environment.

Credit: tkMS



*In 2024, tkMS will launch serial production of its Fourth Generation Fuel Cell (FC4G), also known as Advanced Submarine Fuel Cell (ASFC).*

## Germany

The thyssenkrupp Marine Systems (tkMS) company has reached the serial production phase milestone – to be launched in 2024 – of its 4th Generation Fuel Cell (FC4G), also known as the Advanced Submarine Fuel Cell (ASFC). The latter exploits the know-how accumulated in over 30 years of fuel cell (FC) technology development, with systems either contracted or in use with nine customers, totalling approximately 50 submarines worldwide. ESD understands that this figure of nine users refers to the eight users of tkMS' current generation of FC AIP, including Germany, Italy, Portugal, Greece, Republic of Korea, Turkey, Singapore and Israel, while the ninth is expected to be Norway, which together with Germany, has awarded tkMS the joint contract for the supply of the new U212CD boats.

The ASFC is a new generation high-performance 320 kW (as baseline) AIP system characterised by high efficiency and reliability thanks to advanced Polymer Electrolyte Membrane (PEM) fuel cell technology, and a fault tolerant design. These characteristics, in addition to higher maintainability through modular build-up, easy accessibility and 'hot-swap'-replacement of defective FC modules by means of onboard spares during a mission, noticeably increases operational availability, as the submarines do not need to return to homeport, tkMS explained. The ASFC also requires only moderate integration efforts due to re-using many existing components, the German company added.

The ASFC is the result of an internally funded development programme that started in 2014, with the aim of registering the manufacturing of a functional demonstrator in 2016 at its test lab at Kiel shipyard, in addition to the testing of the first FC line system prototype in 2019 and the availability of the first serial production module in 2022. In order to qualify the system for submarine integration and operations, the international classification society DNV has monitored the design process and certified the system's safety while operating as an independent third party. The company is continuing to run stress tests to ensure the ASFC's availability. In parallel, tkMS has invested heavily in its own specialised fuel cell production site, also at Kiel shipyard, with a new and expanded production line to be completed later in 2023.

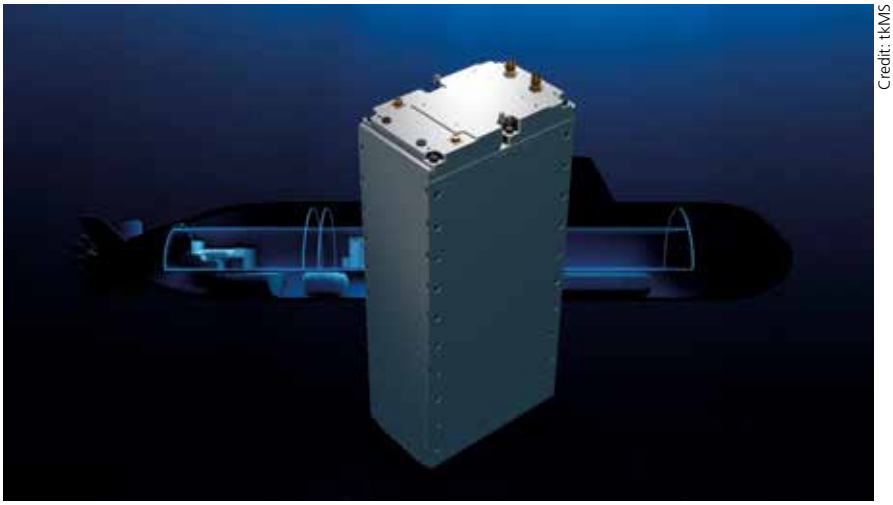
Based on the latest PEM technology and fuel cell stacks developed and produced by tkMS with membrane electrode as-

sembly supplied from different component vendors, the new generation ASFC works by feeding liquid oxygen (LOX) and high purity hydrogen into the cell, generating electricity. The oxygen is stored on board in liquid form, while the hydrogen is stored within metal-hydride cylinders. Aside from electricity, the only by-product of the reaction is pure water, which can be stored on board as ballast and subsequently pumped overboard as needed.

The new ASFC is based on a baseline 40 kW FC Stack of simple, cost-effective design with a long service life, two of which are integrated together into a so-called 'line system'. This includes the gas humidification and recirculation equipment, while the ASFC suite is composed of up to four FC line systems for a total of 320 kW, providing a quiet, safe, reliable, and compact system, independent of diving depth, and with very low oxygen consumption, according to tkMS.

The ASFC system is integrated with a reliable high-energy Lithium-ion-battery package offered by the same company, that leads to a substantial increase in submerged range and speed. The German company along with French company Saft has finalised the joint development of a LIB system for the U212A class of submarines. This is based on an R&D contract signed with German procurement agency BAAINBw in 2017, which saw prototypes being readied for testing in November 2021, followed by project completion in 2022, with the first installation planned for 2023.

Type approval has been successfully conducted in cooperation with BAAINBw. Apart from the usual tests that include shock, EMC, magnetic, environmental tests and similar, the system has undergone extensive testing, accumulating more than 30,000 hours of operation. The safety standards have been officially certified by TÜV Rheinland, an international testing and qualification institution. In addition, the batteries have undergone various tests to prove they pass all necessary safety regulations.



Credit: tkMS

***tkMS and Saft jointly developed a LIB for the U212A class submarines, based on an R&D contract signed with BAAINBw in 2017, with first installation planned for 2023.***

## France

French Naval Group offers a full LIB system for conventional submarines, responding to the latest operational needs. According to Naval Group, the aim is to provide modern submarines with maximum tactical mobility, while at the same time reducing the indiscretion rate and increasing the submerged autonomy to deal with both airborne and surface ASW threats. The battery remains the main power source of conventional submarines; the operational advantages of the LIB already exceed those of the lead-acid batteries, and are projected to evolve further over time. The shipbuilder has been studying the integration of this technology on board submarines, in particular the Scorpène class and later on the conventionally powered version of the Suffren class nuclear attack submarine, while ensuring safety and meeting operational requirements since 2006.

After a technical feasibility study completed in 2013, Naval Group was selected and partnered for the development of the LIB system with French company Saft in 2016, with the premise of safety, associated in this case with maturity and industrialisation, in addition to a track record and experience in battery systems. Related to this selection, electronic, mechanical, and thermal qualification had to be carried out to ensure its successful integration on board a submarine. In 2019, a first version of the system was qualified, and in 2020, a LIB system was integrated in an environment representative of a submarine with the appropriate level of preparation.

The LIB complies with Naval Group's technical standards for submarine design and shipbuilding, including the high demands of nuclear safety and diving safety rules. The system also complies with all international standards associated with electrical systems such as IEC among others, Naval Group claims. The latter is today ready to integrate this technology on board a submarine, focusing on continuous improvement to take advantage of all the benefits this technology can offer.

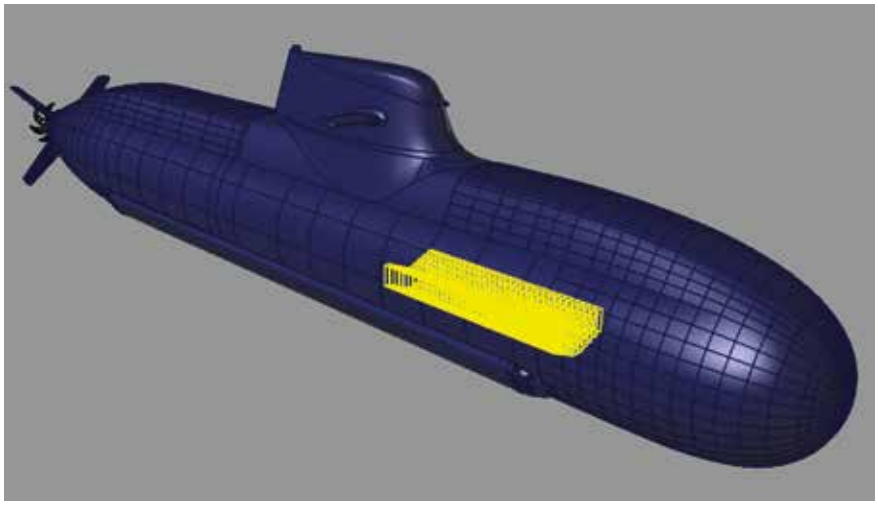
Credit: Naval Group

***Naval Group partnered with Saft to develop a new LIB which complies with Naval Group's technical standards for submarine design and shipbuilding, alongside all international standards associated with electrical systems, including IEC among others.***

## Italy

Under the U212 NFS (Near Future Submarine) AIP submarine programme, in February 2021, the Organisation Conjointe de Coopération en matière d'ARmement

Credit: OCCAR



***OCCAR, Italian MOD and Navy are planning to greenlight phase 2 of the LIB programme by the beginning of 2024.***

(OCCAR) awarded Fincantieri a contract for the development, construction, initial support for the first five years, and integrated logistics support for the first two boats to delivery, respectively in December 2027 and January 2029. The same contract also includes the development and production of a new training centre and the development of a new LIB by national industry. Construction of the first boat was launched in January 2022 while the second followed in June 2023. In the same month, the Italian Parliament also approved the procurement plans for the third and fourth boats. The contract option for the third submarine acquisition was exercised in July 2023.

Based on the successful operational and industrial experience developed under the joint U212A programme with Germany and the stringent timeline to replace the first batch of two Sauro class boats, the Italian Navy and MoD decided to develop and put into service an evolved U212A design boat. This will be characterised by a high degree of national contribution, including the integrated platform control system (IPCS), combat management suite, weapons package, and the new generation LIB.

The latter development officially started in 2015 through different subsequent national research programmes, aimed to define the most suitable technology, choosing lithium iron phosphate (LiFePO4) as the most suitable chemical compound to ensure safety. The results of the research programmes have been integrated in the LIB development programme, as part of the U212 NFS programme contract signed in 2021. Under the control and support of OCCAR and Italian Navy experts, the national industrial team, including the FIB-FAAM company (Seri Industrial group), the Power4Future joint-venture between Fincantieri SI and Faist Electronics and the Fincantieri's Cetena company finalised the design of the whole battery system, under the supervision of TÜV Rheinland. The latter is responsible for control and validation of the whole development and qualification process.

In summer 2023, hardware and software prototypes and functional mock-up were due to become available for production, testing and certification activities, with the aim of completing the development phase by the end of 2023. OCCAR, the Italian MOD and Navy plan to positively review and greenlight the follow-on phase 2 by the beginning of 2024, during which the complete LIB system will pass the land-based battery test laboratory qualification before installation on board the first-of-class boat for harbour and at-sea trials.

The new energy storage and management system has been developed to use the same dedicated compartment and interfaces used on the in-service U212A boats, allowing the system to be installed on board the latter submarines during the mid-life updates, extending their life cycle and providing operational benefits. While the contracted U212 NFS boats maintain the same tkMS/Siemens FC AIP used on the U212A class submarines, Fincantieri is working on a new-generation FC AIP, based on national technologies and industry developments. As the prime contractor, whole platform integrator and shipbuilder of the new U212 NFS, Fincantieri continues to develop new technologies and equipment for submarine and underwater applications. Among these, the propulsion and energy storage R&D activities to be launched include nanomaterials for hydrogen generation and a new electrical distribution system, in addition to the LIBs and the new-generation FC AIP as implemented on board the Zeus naval platform for zero emission propulsion testing.

## Spain

At the end of March 2023, the first-of-class Issac-Peral AIP submarine, developed and built by Navantia under the S-80 Plus class shipbuilding programme, successfully carried out its first static dive as part of the test schedule which will continue until its delivery to the Spanish Navy, planned for November 2023. The S-80 Plus class platform has been designed with a propulsion plant including a 300 kW FC AIP system and the Bio-Ethanol Stealth Technology (BEST) suite.

Developed by Navantia in collaboration with the Spanish Navy, Spanish

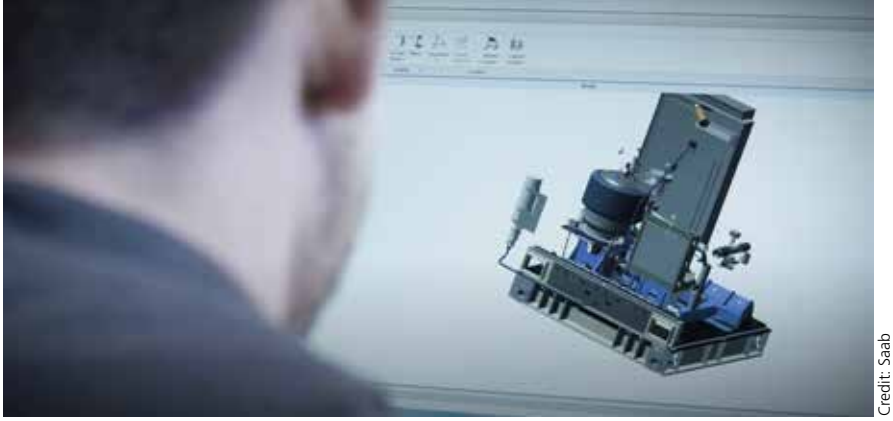
Credit: Navantia


***The S-80 Plus class platform have been designed with a propulsion plant including a 300 kW FC AIP system and the Bio-Ethanol Stealth Technology (BEST) suite. The latter consists of a miniaturised bioethanol reformer to produce hydrogen on board from agricultural bio-ethanol.***

companies Abengoa and Bionet, as well as the US-based Collins Aerospace, the new FC AIP is supplied with hydrogen produced on-board through a bioethanol reformer from agricultural bioethanol, readily available worldwide. The highly thermal efficient miniaturised bioethanol processor developed by Abengoa is fed with bioethanol fuel and oxygen, both of which are stored on board in liquid form, generating hydrogen and carbon dioxide as byproducts. The resulting hydrogen, along with oxygen are fed into the PEM FC provided by Collins Aerospace. The latter cell stacks are made of porous bipolar plates for passive water management and continuous membrane humidification. According to Navantia, this means there is no need for a humidification or liquid water removal system. This makes the fuel cell design simpler and provides double the service life compared to the market standard operating on reformate gasoline and pure oxygen, said the company. However, the bioethanol reformer process produces a stream of highly concentrated carbon dioxide and other gases, which are managed by the Carbon Dioxide Disposal System developed by Bionet, in collaboration with Navantia. This system dissolves the gaseous byproducts in seawater, which can then be pumped overboard in liquid form rather than being vented directly in gaseous form, thereby not giving away the submarine's position.

The 'BEST' AIP's capabilities have been demonstrated with long-term tests and operational mission profiles at a dedicated land-based facility at Cartagena shipyard. The suite is housed in the hull section of the S-80 Plus class boats, and includes the fully automated AIP power plant and auxiliaries on the upper deck and the structural tanks for the bioethanol and the single LOX tank – which can be refuelled through a logistics hatch in the lower compartment. These activities have confirmed a submerged endurance of up to three weeks, being fully operational through the full platform depth range, from tropical to sub-arctic environments. The new AIP has been designed for no major component substitution between overhauls (six years and over 5,000 hours), while components can be loaded or replaced through the logistics hatch, according to the Navantia.

The first platform of this class to be equipped with the 'BEST' AIP will be the third boat, which is planned to be delivered in early 2026. The first and second platforms were completed with the AIP section equipped with the lower tanks and other systems, but not the AIP suite, whose components will be loaded and assembled through the logistics hatch during the boats' first major overhaul.



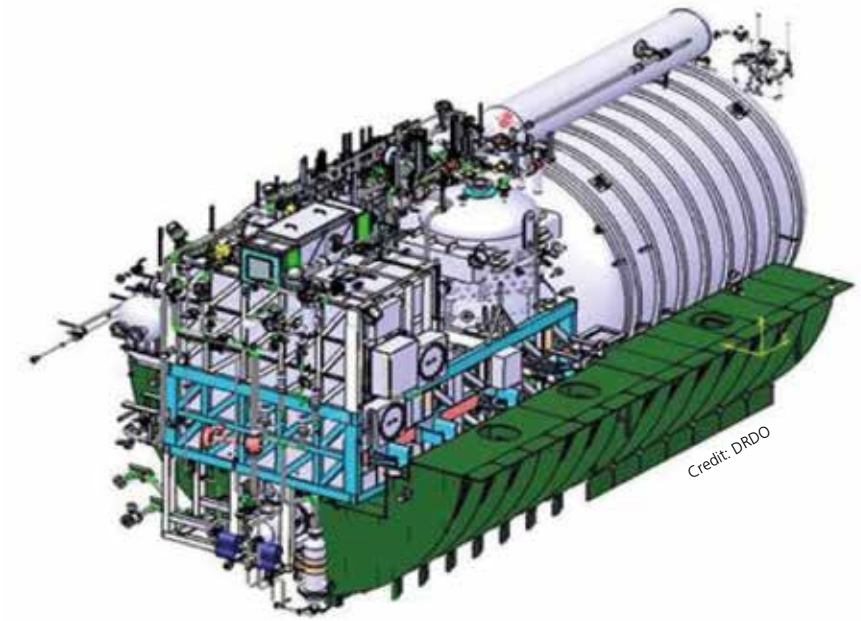
Credit: Saab

***The Stirling engine is a proven AIP system, suitable for maintenance at sea. Its supplies of fuel and LOX can be replenished in just a few hours.***

## Sweden

Saab Kockums' Stirling engine is one of the most proven AIP systems, having been developed and tested since the 1970s, and operational on submarines since 1989. The Stirling is a self-contained external combustion engine operating on a closed regenerative thermodynamic cycle. Low-sulphur standard diesel fuel from onboard tanks and LOX also stored in tanks, are mixed in a high temperature burner to generate temperatures of around 750 °C. This acts as the heat source for the engine, causing expansion of helium stored in a sealed chamber, with the gas being driven through a repeating sequence of thermodynamic changes. By expanding the helium to push against a piston and then drawing the gas into a separate cooling chamber for subsequent compression, the heat from the external combustion of diesel and oxygen can be converted into work. This in turn can then be turned into electrical energy by a DC generator, which charges the battery. As the Stirling engine is known to operate at a pressure of 20 bar, this limits the submarine's maximum depth to 200 m, unless an exhaust gas intensifier system is used for deeper operations.

Each Stirling engine can produce 75 kW of energy, with two or more installed on each submarine in sound-insulated and rubber-suspended complete AIP modules, including the oxygen tank and auxiliaries. This offers redundancy and can be maintained at sea. The submarine's operational readiness can be restored in just a few hours, by replenishing the fuel and LOX (including at sea), which reportedly gives the submarine platform the capacity for over two weeks of AIP operation at a speed of 5 kn without requiring snorting (also known as snorkelling). This has contributed to the Stirling AIP finding international success, equipping not only vessels of the Swedish Navy, but



Credit: DRDO

***In June 2023, the Indian DRDO and Larsen & Toubro group formed a partnership to develop and produce the Phosphoric Acid Fuel Cell (PAFC) AIP system developed by DRDO's Naval Materials Research Laboratory to equip Indian Navy submarines.***

Credit: GYT

***Both the last two boats of the Soryu class and the new generation Taigei class platform are equipped with LIBs developed by MHI and GYT, the latter providing the batteries.***

the upgraded Archer class submarines delivered to the Republic of Singapore Navy. It was also selected by the Japanese MoD and is locally licence-built by Kawasaki Heavy Industries to equip the Japan Maritime Self-Defense Force's (JMSDF) Soryu class submarines, operational since 2009.

Starting from the Gotland class boats' post mid-life upgrade programme, the Swedish submarines are equipped with the latest generation of Saab Kockums' Stirling AIP modules. The latter equips the newest Blekinge class A26 AIP submarines for the Swedish Navy, where the complete propulsion and energy system is optimised for covert operations. The latest Stirling iteration is also being promoted as baseline equipment for the A26 Pelagic/Oceanic family platforms being proposed on the export market. The latest-generation Stirling AIP modules bring a number of enhancements including a reduction in overall volume and more energy per unit of volume, due to improved packing and shared components. This comes in addition to greater operating efficiency thanks to an enhanced heat recovery system, an improved exhaust system which enables deeper diving, and a new control system, which altogether translate into longer underwater operational endurance.

Alongside these developments, Saab Kockums, together with the Australian PMB Defence and Dutch EST-Floattech companies, has completed a project to develop a LIB suitable for installation on conventional submarines. The project was funded by Sweden's FMV procurement agency,

## India

In June 2023, the Indian Defence Research and Development Organisation (DRDO) and the Larsen & Toubro (L&T) group formed a partnership to develop and produce an indigenous AIP System for Indian Navy submarines. The L&T company is the recipient of the Transfer of Technology (ToT) of the Phosphoric Acid Fuel Cell (PAFC) AIP system developed by the Naval Materials Research Laboratory (NMRL) of India's DRDO. This technology has been successfully developed with the support of industry partners L&T and Thermax, and according to the DRDO, it has reached the stage of maturity for mounting on-board select platforms.

According to the joint press statement, under this collaboration, two AIP system modules are being developed for the Kalvari class submarines. The latter have been built locally by Mazagon Dock Limited (MDL) shipyard together with the French Naval Group, which provided the technology transfer and support for local construction of the Scorpène submarine design. In January 2023, an agreement was signed between senior officials of NMRL and Naval Group France to extend the cooperation, entering into the detailed design phase for the integration of the PAFC AIP system developed by NMRL for the Kalvari class submarines. As part of the agreement, Naval Group France will certify the AIP design for integration in the submarines. In July 2023, the Indian MoD announced approval for the procurement of another three Scorpène submarines in addition to six contracted – five of which are already in service and the sixth is due to be in service in 2024.

## Japan

Japan's MOD and the JMSDF have been global frontrunners in the development of a LIB solution and its first operational application. For years, the JMSDF has also evaluated Saab Kockums' Stirling engine on board its training boat as an AIP system for its latest underwater platforms, before equipping its Soryu class with the new system. The Japanese MoD introduced LIBs on board its submarines after a lengthy development and testing period, which began in 2002.

The GS Yuasa Technology Corporation (GYT) and Mitsubishi Heavy Industries (MHI) signed a contract with Japan's MoD Acquisition, Technology and Logistics Agency (ATLA) in 2015 for the delivery of a whole LIB system, including the main storage battery management and safety control device for submarines. GYT started mass production of LIB batteries in March 2017 and delivered them to MHI in August 2018. The first Soryu class submarine to be equipped with the LIBs was the Oryu (11th boat of the class), with the main battery storage and battery management system integrated on the submarine from summer 2019. With its baseline Stirling engine-based AIP system, the boat was commissioned in March 2020, with the JMSDF becoming the first Navy in the world to use a submarine equipped with LIBs.

The last (and second) boat belonging to the Soryu class similarly equipped was commissioned in March 2021. In the meantime, starting from the mid-2000s, the Japanese MOD and JMSDF have been studying a next-generation submarine class exclusively equipped with LIBs. This paved the way for the Taigei class platforms, whose first-of-class vessel was commissioned in March 2022, and is now used as a test platform.

With the same dimensions, but with a slightly higher displacement compared to the Soryu class, the new and stealthier Taigei class are equipped with a more capable combat system and sonar suite, alongside a propulsion plant with a new snorkel-equipped power generation system and a more powerful energy storage and management system. Reportedly based on the same design as the Soryu class, and featuring an undisclosed higher number of batteries compared to the previous class according to local news sources, the new energy storage and management system provides longer endurance at higher speeds, which allows the vessels to patrol the vast waters around Japan more quickly than their predecessors. According to a 2017 UDT presentation provided by a former JMSDF Fleet Submarine Force commander, the JMSDF has been receiving lithium nickel cobalt aluminium oxide (Li-NCA) type batteries already provided by GYT for the Soryu class submarines, although no official statement has been released.

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A document dated December 2020 and jointly elaborated by GYT and MHI, provides a LIB development overview, referring to them as the lithium cobalt oxide type of LIB. Results published in GYT's 2022 report presentation noted the "supply (of) trials products of Lithium-ion batteries for next-generation submarines", which is understood to refer to new or more capable batteries providing extra energy and endurance.

## South Korea

On 30 March 2023, South Korea's DAPA (Defense Acquisition Program Administration) held the keel laying ceremony for the first KSS-III Batch II submarine at the Hanwha Ocean's (previously Daewoo shipbuilding & Marine Engineering, DSME) Okpo shipyard. The KSS-III Batch II boats are the second generation of the 3,000 tonne class of locally designed and built AIP submarines, and which differ from Batch I (first generation). Batch II boats have a longer hull (5.8 m) and heavier displacement (3,600 tonnes) with reduced acoustic signature, together with a more capable propulsion plant with extended endurance, alongside longer detection range underwater sensors and expanded precision strike capability, with 10 vertical launch cells compared to the six on the first generation.

The KSS-III Batch II submarines are equipped with an AIP propulsion plant based on MTU12V4000U83 diesel engines, a PEM FC AIP (already installed on Batch I boats), and for the first time a LIB system. No information has been released on the FC AIP, but according to local media reports, the KSS-III programme boats are equipped with a locally-developed AIP based on four PEM fuel cells provided by Bumhan Industries. These each generate 150 kW, fed with oxygen (stored as LOX) and pure hydrogen (stored in metal-hydride cylinders). In 2019, South Korea's DAPA chose Hanwha Defense as the supplier of LIBs for the KSS-III Batch II submarine programme. The latter passed rigorous tests under extreme conditions of fire exposure and suppression, saltwater immersion, short circuit, shock, electromagnetic compatibility (EMC), electromagnetic interference (EMI), and heat, while full scale (battery group) demonstrations were conducted at a dedicated land-based test site. Cells come from Samsung SDI and are based on commercial off-the-shelf (COTS) technology, similar to cell phone batteries.

The new battery technology will improve energy efficiency, offering better energy density, battery life and underwater endurance compared to the preceding lead-acid battery technology. Hanwha Defense Li-ion batteries reportedly provide 160% more endurance (longer output) at economic speed and 300% more endurance at maximum speed. Lithium-ion batteries also provide double the amount of charge cycles (up to 4,000 cycles – or approximately 10 years of operational life) compared to lead-acid batteries. The first KSS-III Batch II boat will be launched in 2025.

After a couple years of trials, its delivery to the ROK Navy is currently planned for 2027. In February 2022, the South Korean Agency for Defense Development (ADD) announced the development of a methanol reforming plant for submarine fuel cells, which can improve submerged performance through hydrogen production on board the submarine, showing a system developed by DSME, today Hanwha Ocean. This technology, according to the ADD, is expected to greatly contribute to improving the performance of domestic submarines in the future.

Credit: Hanwha Defense


***The KSS-III Batch II submarines are equipped with an AIP propulsion plant based on new MTU12V4000U83 diesel engines, a PEM FC AIP from Bumhan Industries and LIBs provided by Hanwha Defense.***

## Running Silent

As improvements in battery technology and AIP continue, conventional submarine performance remains on a consistent upward trajectory, with modern variants offering improved endurance, quieter running, and better safety compared to previous models. The market has grown to include a large number of contenders, offering a plethora of sophisticated and capable battery technology and AIP system options. As such, the market now offers perhaps more options than ever before for Navies to procure highly-capable conventional submarines. ■

# Detecting Missile Threats from Space

**Tim Guest**

**As the threat from manoeuvrable hypersonic missiles adds to the already vast array of ballistic and other missile threats, increasingly extensive and sophisticated space-based satellite constellations providing missile warning and tracking functionality are being deployed to bolster US missile defences for the protection of the US and its Allies.**

This article examines the threats demanding effective missile defence by the West, and at some of the latest US space-based programme developments offering missile warning and tracking (MW/MT) intended to protect against such threats. The article also reviews the DOD's recently-released strategy on the protection of current and future space-based MW/MT and related satellite assets.

## Missile Threats

Threats posed by strategic and tactical ballistic, as well as hypersonic missiles, to the US and Allied nations constitute a real and present danger, as so acutely illustrated by recent geopolitical realities. The use of ballistic and hypersonic missiles at the tactical level in Ukraine – including the first combat use of Russia's Kinzhal missile – together with Putin's continued nuclear threat rhetoric, reminds us all of the dangers posed by such weapons. Added to this are the apparent nuclear test site expansion activities at Russia's former nuclear test site on the Novaya Zemlya archipelago in the Arctic Ocean. This activity was detected by satellite in September 2023, suggesting possible preparations for future nuclear testing – a move which would throw the comprehensive nuclear-test-ban treaty into disarray. Taken together with Putin's recent statement that the RS-28 Sarmat intercontinental ballistic missile (ICBM) is now operational, the missile threat from Russia appears significant.

North Korea's nuclear arsenal and extensive ballistic missile inventory are also part of this global threat, as highlighted on 13 July 2023, with the country's latest ballistic missile test of a Hwasong-18 ICBM. Iran, too, cannot be ignored, with its nuclear aspirations. According to the Center for Strategic and International Studies (CSIS), Iran is already in possession of the 'most diverse missile arsenal in the Middle East, with thousands of ballistic and cruise missiles, some capable of striking as far as Israel and southeast Europe'. In early June 2023, Iran also unveiled a new medium-range ballistic missile dubbed 'Fattah', which is reported to have a range of 1,400 km and a maximum velocity of up to Mach 14. Added to these, China's nuclear potential is growing, and its delivery systems are increasing in sophistication.


## Author

**Tim Guest** is a freelance journalist, UK Correspondent for ESD and a former officer in the British Forces.


Credit: Northrop Grumman

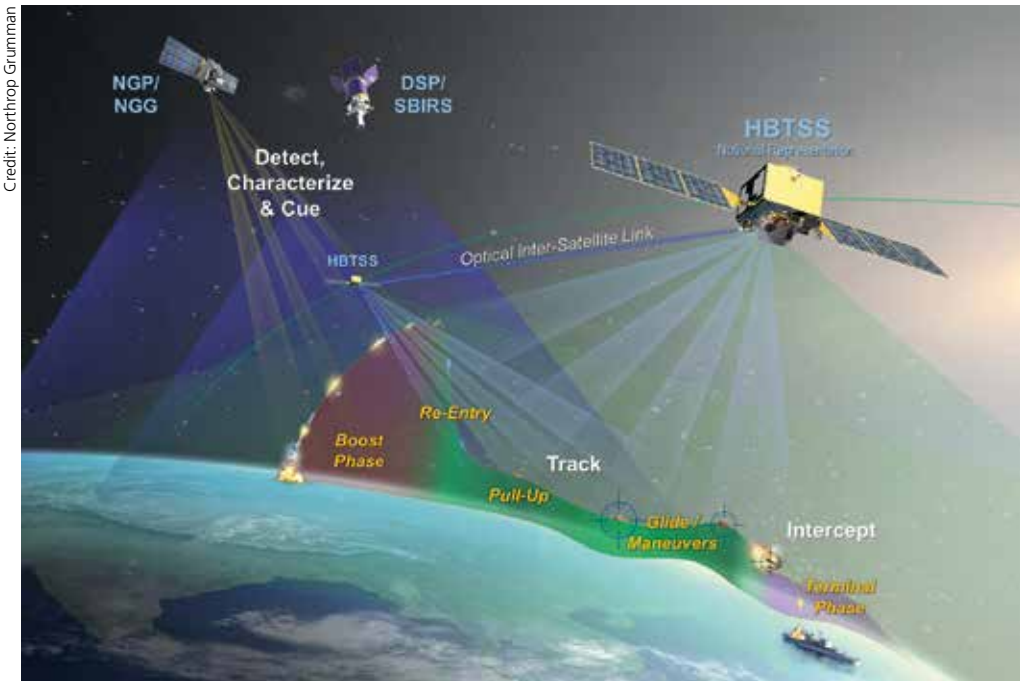



***Image shows HBTS, DSP/SBIRS, and NGP/NGG space architecture. Space is a highly contested environment and evolving missile threats will be difficult to detect and destroy.***

## Space-Based Protection

To protect against such threats, complex space-based satellites and sensors have complemented the ground-based strategic defensive early-warning capabilities of the North American Aerospace Defence Command (NORAD) for years. This includes the Defence Support Programme (DSP) satellites from Northrop Grumman, which provide missile-launch detection, tracking and targeting information to command and control elements of the land-based system. Seeking the latest information on DSP satellites, a spokesperson for Northrop Grumman told ESD that, *"Due to the critical nature of the technology, certain information regarding DSP will continue to be protected by enhanced security measures. We are unable to speak to specifics at this time beyond what we have previously released."*

However, as missile technology has advanced and arsenals grown, the need for ever more complex, interconnected, resilient and overlapping space-based MW/MT assets, sensors and constellations has increased. One unfolding programme addressing these complex needs is the US Space Force Next-Generation Overhead Persistent Infra-Red (Next-Gen OPIR) con-

Credit: Lockheed Martin

***Lockheed Martin Space's sixth and final SBIRS satellite, SBIRS GEO-6, was launched into GEO in August 2022, and joined the Space Force SBIRS constellation.***

stellation, which will eventually replace the current Space-Based Infra-Red System, SBIRS. Incidentally, SBIRS itself originally entered service to replace some DSP assets. Lockheed Martin and Northrop Grumman are working on the delivery of five Next-Gen OPIR space vehicles for the new programme; three from Lockheed Martin will be placed in a Geostationary Orbit (GEO) and are referred to as NGGs (Next Generation Geosynchronous), while two from Northrop Grumman, which will be placed in highly elliptical polar (HEP) orbits, are referred to as NGPs (NextGenPolar).

Staying with the earlier, SBIRS programme for a moment, Lockheed Martin Space's sixth and final SBIRS satellite, SBIRS GEO-6, was actually launched into GEO only in August 2022 and joined the Space Force SBIRS constellation to provide and maintain staring IR surveillance and missile warning capabilities. The company is SBIRS's prime contractor and Northrop Grumman is payload supplier. In a press release, Lockheed Martin Space said the sixth satellite was "a stepping stone toward the resilient missile warning to be provided by SBIRS's successor, the NGG system", which it said, "like SBIRS GEO-5 and GEO-6, is based on the company's modernised LM 2100 Combat Bus". This delivers additional cyber hardening, resiliency, and enhanced spacecraft power, as well as improved propulsion and electronics. The company's Vice President OPIR Mission Area, Michael Corriea, said at the time that the need for OPIR had 'never been more critical', with the statement emphasising this claim by stating ballistic missile technology had 'proliferated around the world with over 1,000 missile launches tracked annually'. So, not only would SBIRS GEO-6 bolster current missile warning architecture, but its successor, NGG, would deliver even greater capacity and expanded coverage in its role.

As for Northrop Grumman's NGP OPIR satellites, these will provide coverage over the Northern Hemisphere's polar region from HEP orbits. According to company media sources, the two satellites will include IR sensors to "detect and track ballistic and hypersonic missiles", together with an "enhanced communication system to transmit mission data to the ground, allowing decision-makers to identify IR heat signatures of incoming threats". Resiliency features to "reduce vulnerabilities to counter-space and cyberattacks", as well as having "protected, assured, survivable communications capabilities", will also be aspects of each NGP's make-up.

The HEP orbits of the two NGP space vehicles are crucial, because of the trans-polar routes being the flightpaths of choice for adversarial missiles attacking North America due to the shorter distances to reach their targets. And as satellites in GEO orbits have no direct line-of-sight over the poles due to the curvature of the Earth, coverage can only be achieved with satellites in HEP orbits.

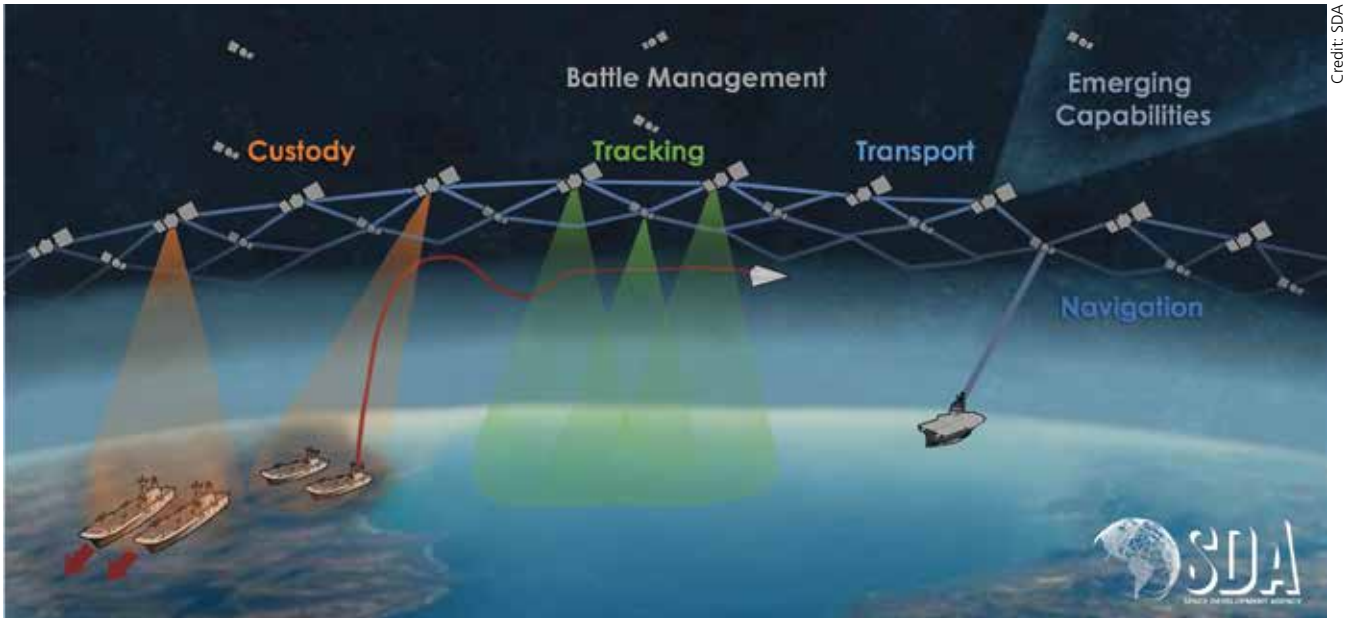
In a Northrop Grumman simulation of an NGP missile-warning event over the polar regions, NGP assets will now become the first sensors to detect the launch and flight of an enemy missile, benefiting from improved OPIR performance over earlier systems. Once detected, real-time, on-board processing will immediately kick in to characterise the event, transmitting this along with missile warning, tracking and other information using its real-time downlink to the continental US. The two-satellite NGP constellation will, according to Northrop Grumman, ensure 24/7 direct LOS communications to ground-based command and control, and will help to prevent a Northern Hemisphere surprise polar missile attack on North America.

## Participants and Programmes

Beyond the aforementioned programmes and industrial participants, the DOD has placed its other space-based missile warning and tracking manufacturing vested interests in the hands of other players, such as Boeing's Millennium Space Systems, L3Harris, and Raytheon Intelligence & Space. Each are currently delivering space vehicles (and have done so in recent years), to other DOD missile warning and tracking programmes requiring sensors on orbit in different planes, from low Earth orbit (LEO) to medium Earth orbit (MEO) and beyond to geostationary GEO orbital positions, as well as high Earth orbit (HEO) positions.

Credit: Lockheed Martin

***Lockheed Martin's Next Generation Overhead Persistent Infrared (OPIR) GEO (NGG) Block 0 early missile warning satellite.***




Credit: SDA

***PWSA will track advanced threats both now and in the future. The Tracking Layer will integrate with the Transport Layer's low-latency meshed communication network.***

Programmes such as the hypersonic and ballistic tracking space sensor (HBTSS) work for the Missile Defence Agency (MDA), the Space Development Agency's (SDA) Proliferated Warfighter Space Architecture (PWSA) Programme, or the Wide Field of View (WFOV) Missile Warning Sensor for the US Space Force; these are just some of the ongoing activities involving these industry players.

L3Harris, for example, is involved in a number of these programmes, including the MDA's HBTSS Programme, for one, as is Northrop Grumman. L3Harris was awarded a contract in June 2023 to develop an IR sensor payload digital model for the MEO – Missile Track Custody (MTC) Epoch 1 programme – to support detection and tracking of hypersonic missiles for the Space Force's future resilient MW/MT constellation. Millennium and Raytheon are also moving ahead with prototype space vehicle development for the programme, with a delivery date slated for 2026.

From the above, it is not hard to see how space has become an increasingly contested environment for both offensive and defensive actions. However, the mix of complex high-tech programmes mentioned, with their multi-layered, multi-orbit, optically-meshed-satellite approaches, advanced IR sensors and MW/MT capabilities, offer resilient design architectures that stand every chance of meeting and defeating the increasingly sophisticated, evasive and dangerous emerging missile threats.

While space precludes detailing all programmes and projects, *ESD* was able to catch up with the MDA and SDA to learn more about the latest developments regarding HTBSS and PWSA.

## HBTSS Update

According to the MDA, the HBTSS programme is intended to deliver a global constellation of HBTSS tracking satellites that will provide continuous access to missile threats, whether ballistic or hypersonic, from launch to re-entry and/or flight termination, with the provision of fire control tracking data to the overall missile defence system's command and control. According to the agency, the two satellites of the HTBSS constellation will work together with land and sea-based radar, as well as "recently-deployed Space Force tracking satellites, to demonstrate how they can track hypersonic threats and provide targeting data for intercept", adding that, "this demonstration will inform the future PWSA for the missile warning tracking defence mission".

The MDA is said to be planning to launch its two prototype HBTSS satellites by the end of 2023 to demonstrate those aforementioned on-orbit capabilities of the system, and once that takes place successfully, HTBSS will, the agency says, become "part of a critical constellation of space sensors proliferated and operated by the Space Force, which will provide increased capability to track targets and intercept hypersonic threats as missile threats evolve". At that time, the programme is expected to be handed over to the SDA.

*ESD* magazine was able to catch up with the MDA for a brief update on HBTSS's current status and whether the programme is on target to begin on-orbit sensor testing by the end of the year. MDA spokesperson, Heather Cavaliere, told *ESD* that, "For the current phase of the HBTSS programme, (On-Orbit Prototype Demonstration), MDA awarded agreements to both L3Harris Technologies, (L3H) and Northrop Grumman Corporation (NGC) in January 2021. Each performer is developing on-orbit prototype demonstration satellites that will be launched no earlier than mid-December 2023. Launch will be followed by on-orbit testing to test, characterise, and validate the HBTSS performance." Cavaliere added that, "HBTSS is responsible for detecting and tracking the threat and transmitting its data to the command and control element of the Missile Defence System."

As to how the MDA's collaborative efforts with the SDA are progressing to ensure US Forces – USAF/US Space Force, etc – have the optimum space-based missile warning capabilities in place as soon as possible, particularly in view of what has been seen in Ukraine and the missile developments being made by various US adversaries, Cavaliere responded, saying that, *"The MDA is collaborating with the US Space Force's SDA and Space Systems Command (SSC) to develop HBTSS as a prototype Overhead Persistent Infrared (OPIR) sensor, uniquely providing fire-control-quality data. Operationally, the HBTSS fire-control capability will be part of SDA's PWSA and will detect hypersonic, ballistic, and other advanced threats much sooner than terrestrial radars, providing hypersonic threat-tracking data for hand-off through linked missile defence weapons."*

## PWSA Update

Which brings us to Proliferated Warfighter Space Architecture (PWSA) developments. This is an SDA programme about which the company announced in April 2023 the successful initial launch of the 10 satellites comprising the programme's Tranche 0 (T0), the Transport and Tracking Layer satellites, which will demonstrate the low-latency communication links to support the warfighter with a resilient network of integrated capabilities, including tracking of advanced missile threats from LEO.

For the latest update on the programme, *ESD* caught up with the SDA's Deputy Chief, Strategic Engagement, Jonathan Withington, who said, *"The PWSA will track the most advanced threats both now and in the future. The Tracking Layer will integrate with the Transport Layer's low-latency meshed communication network, enabling conventional and advanced missile tracking from proliferated LEO, adding capabilities through spiral development to future generations as the threat evolves."*

Credit: SDA

***The first 10 Transport and Tracking Layer Tranche 0 (T0) satellites of the SDA's PWSA were launched in April 2023 using a SpaceX Falcon 9 reusable, two-stage rocket from Vandenberg Space Force Base.***

Withington added, *"The development and fielding of the PWSA is well underway with Tranche 0's first two launches delivering 23 of the planned 27 satellites on orbit, with a third launch planned for later this year. The first two Tranche 0 Tracking satellites achieved 'first light' just over 60 days after launch. The SDA is also on track to field the first operational generation of the PWSA, Tranche 1, beginning in late 2024."*

Another SDA official added some background for ESD, saying, *"Tranche 0 (T0), the Warfighter Immersion Tranche, demonstrates the feasibility of a proliferated architecture in cost, schedule, and scalability toward necessary performance of beyond-line-of-sight targeting and advanced missile detection and tracking. Once completed, T0 will consist of 28 satellites – 20 Transport Layer satellites and eight Tracking Layer satellites."*

The official continued, *"The agency is pleased with the initial operation of the first two groups of satellites launched in April 2023 and September 2023,"* adding, *"as they continue to go through test and checkout. SDA launched four Tracking satellites over the first two launches. Later this year, SDA will launch the final four T0 Tracking satellites with the MDA's HBTSS satellites. This launch collaboration allows for greater synergy between the PWSA's MW/MT sensors and MDA's HBTSS missile defence sensor as they conduct demonstrations for the future MW/MT/missile defence hybrid architecture."*

The SDA has begun the build phase of Tranche 1 satellites and still plans to field the first operational generation of the PWSA beginning in late 2024. "The T1 Tracking Layer," the official said, "will provide near global mono coverage for MW/MT with launches starting in 2025. The T2 Tracking Layer is in source selection and will provide near global stereo coverage for MW/MT and preliminary missile defence capability based on lessons learned from T0, HBTSS, and T1. T1 Tracking will be able to sense and enable operational responsiveness to the newest ballistic and hypersonic missile threats. T2 Tracking will continue to improve sensitivity and stay ahead of future threats." The SDA official concluded by confirming that Tranche 1 will include approximately 150 Transport and Tracking satellites.

In the SDA press statement at the time of the April launch, SDA's director, Derek Tournear, said, "Through this launch, we've demonstrated that SDA can keep a schedule to deliver enhanced capabilities every two years. This revolutionary approach is enabled by growth in the commercial marketplace, allowing the PWSA to move forward to deliver warfighting capabilities in each future tranche." The agency itself has stated that its *"programmes provide an integral part of the national security hybrid space architecture in the areas of communications, data transport, and missile warning', and that its 'unique acquisition strategy… enables faster and cheaper capability delivery by designing and rapidly deploying a threat-driven, resilient constellation of small satellites in LEO".*

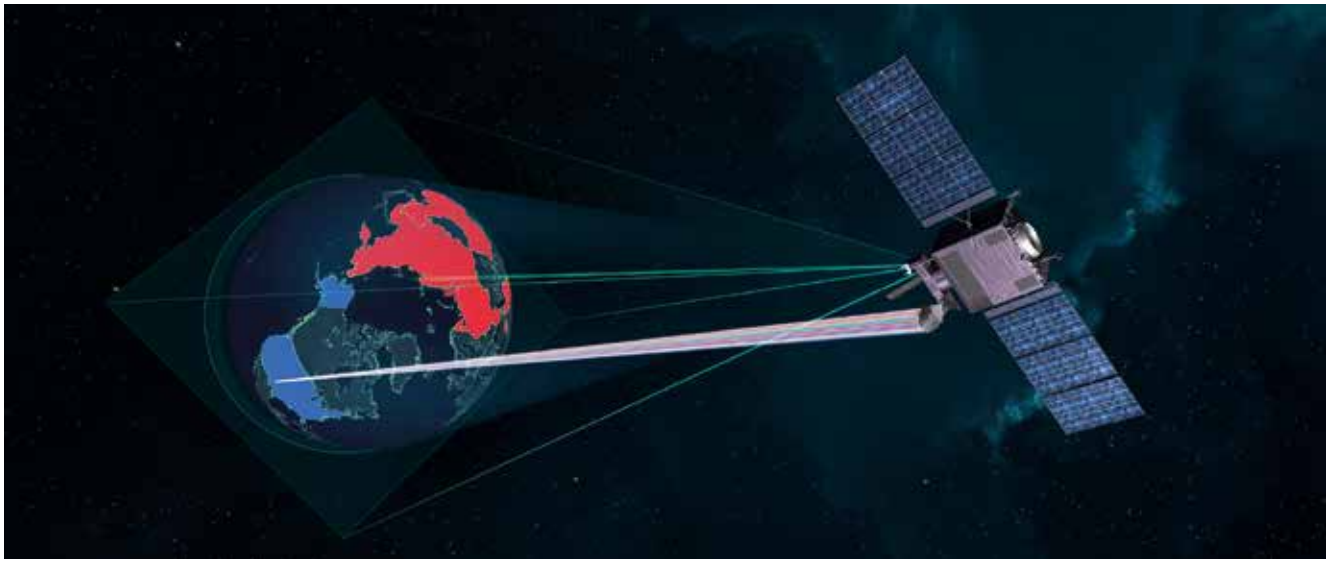
## Protecting MW/MT Space Assets - Policy Review

Placing a lot of expensive satellites in space is one thing, but when it comes to threats to, and protection of, those MW/MT and other space-based assets, the DOD's mid-September-released 'Space Policy Review and Strategy on the Protection of Satellites', addresses such issues.

Credit: Lockheed Martin

***SBIRS GEO-6 February 2021, the last SBIRS space vehicle, prior to launch. The constellation will eventually be replaced by Next-Gen OPIR system satellites.***

The document begins by highlighting Chinese and Russian threats in the space security environment over the next five years. In the first instance, it underscores China's efforts to expand its own comprehensive space-based architecture, which, it says, already comprises "roughly half of the world's space-based intelligence, surveillance, and reconnaissance (ISR) satellites". Of threats to US and Allied satellites, it adds that the People's Liberation Army (PLA) can



Credit: Northrop Grumman

***NGP will cover the northern polar region and will also provide round-the-clock coverage of the Northern Hemisphere.***

be expected to use counterspace systems to destroy, deceive or suppress friendly satellites and sensors, and these will be used along with cyberwarfare and direct-ascent anti-satellite (DA-ASAT) missiles; according to the review, the US expects the PLA will eventually develop the latter beyond just current capabilities of targeting LEO assets, and be able to hit GEO assets, also.

As for Russia, whose extensive use, as mentioned earlier, of ballistic missiles and introduction of hypersonic systems in its war on Ukraine, have reminded today's world of the terrible nature of missile warfare, the country does have "a smaller fleet of satellites than China", according to the policy document, though does, it adds, operate "some of the world's most capable individual ISR satellites for optical imagery, radar imagery, signals intelligence, and missile warning".

However, where the Russian threat to US and Allied MW/MT and other space-based assets comes from, according to the policy document, is the development, testing and fielding "of reversible and irreversible counterspace systems to degrade or deny US space-based services", including "jamming and cyberspace capabilities, directed energy weapons, on-orbit capabilities, and ground-based DA-ASAT missile capabilities". In fact, Russia's DA-ASAT competencies were demonstrated on 15 November 2021, when Russia destroyed one of its own obsolete satellites, reportedly using an A-235 PL-19 anti-ballistic/anti-satellite missile. In a press statement at the time, US Secretary of State, Anthony Blinken, said, *"This test has so far generated over 1,500 pieces of trackable orbital debris and will likely generate hundreds of thousands of pieces of smaller orbital debris. The long-lived debris created by this dangerous and irresponsible test will now threaten satellites and other space objects that are vital to all nations' security, economic, and scientific interests, for decades to come."* However, it is worth noting that the US, China, and India have all also previously developed, and tested, DA-ASAT capabilities.

In order to protect MW/MT satellite systems and sensors, the DOD's policy review and strategy states that "resilience" would be prioritised as the key method of "denying adversaries the benefits of attack in space", and that this would be achieved through "a DOD space architecture shift", moving away, where possible, "from dependence on high-value, specialised satellites to resilient-by-design architectures", a transition, it added, that was "already underway". Indeed, according to the document, the first area the DOD wants redeveloped under this approach is MW/MT. It said that an assessment had been made of "…architectures designed to meet future warfighting performance needs, establish resilience against modern military threats, and ensure cost parameters…resulting in recommendations on numbers of satellites and diversifying capabilities across orbital regimes." It adds, *"Ongoing force design studies include: fire control to address long-range threats; tactical ISR to enable forward operations; a space data network to ensure data throughout for decision-making and battle management; and protect and defend operations to protect vital infrastructure and space-based capabilities".*

The review also addresses threats to space-based assets from enemy systems designed to manipulate them physically from their orbits, or deny their operational effectiveness in other ways, such as jamming, with such mitigating actions as movement and manoeuvre options for their protection. Non-adversarial space and terrestrial natural weather events must also be considered in protecting space-based MW/MT and other systems.

The review does not forget threats from cyberspace, noting that, "cybersecurity also plays a key role in improving the resilience of US space architectures" with the hardening of networks against cyber-attacks cited as "a priority effort".

Underpinning the review's sentiments on MW/MT asset protection are budgetary commitments that support the resilient-by-design approach, with the FY 2024 budget set to devote USD 5 Bn for the development of "new proliferated resilient MW/MT architectures, including next-generation OPIR space capabilities", with accompanying ground systems that together will "track an increased range of threats, including hypersonic and manoeuvrable weapons".

In addition, the FY2024 budget also requests that USD 481 M be allocated to "ground and space-based sensors, deep space radar, and ground-based optical system projects" that can alert and warn of threats to space systems, and in so doing "improve the capability and resilience of DOD SDA".

The review concludes by citing five capabilities, seen as priorities by Commander, USSPACECOM, if the recommendations in the review document are to be achieved. These comprise: resilient command and control, integrated space fires and protection, an agile EW architecture, enhanced battlefield awareness in space, and robust cyber defence capabilities. ■

# The Battle for Low Earth Orbit and the Stratosphere

**John Antal**

**Amid an uncertain security environment, competition in Low Earth Orbit and the stratosphere is heating up.**

Credit: SpaceX

***A Falcon 9 rocket launches another batch of SpaceX satellites for the Starlink Low Earth Orbit (LEO) constellation on 25 September 2023.***


## Author

**John Antal** is a thought-leader in military affairs and best-selling author. His latest book is: 'Next War: Reimagining How We Fight'. Antal writes and speaks extensively about the art of war and the changing methods of warfare.


SpaceX launched their 42nd Starlink delivery mission of the year on 25 September 2023, at 4:48 a.m. EDT, when a Falcon 9 rocket successfully launched from Vandenberg Space Force Base in California. The rocket placed 21 V2 Mini Starlink satellites into LEO as part of SpaceX's Starlink communications constellation. The V2 is a second-generation Starlink mini-satellite that according to SpaceX offers four times more capacity per satellite than earlier Starlink models. This is thanks to the V2's improved phased array antennas, E-band backhaul and a laser communications system. LEO satellite networks are a key infrastructure requirement for the next wave of global high-speed internet coverage. This next generation technology, 6G, will better connect units in the battlespace. Along with 5G internet, 6G is the lifeblood of Joint All-Domain Command and Control and will enable virtual and augmented reality, high-definition video surveillance, and artificial intelligence (AI).

On the other side of the globe, the Chinese People's Liberation Army (PLA) view the launch of the newest SpaceX satellites as a threat. A PLA assessment from April 2022 called for the creation of strategies to monitor, disable, and destroy the Starlink satellite constellation in the event of war with the US. This 2022 PLA report, listed on China Military Online, 12 May 2022, reads: *"Orbital position and frequency are rare strategic resources in space. At present, the geosynchronous orbit has almost been fully occupied and the scramble for Low Earth Orbit and Medium Earth Orbit positions has become more intense. The LEO [layer] is able to accommodate about 50,000 satellites, over 80% of which would be taken by Starlink if the program were to launch 42,000 satellites as it has planned. SpaceX is undertaking an enclosure movement in space to take a vantage position and monopolize strategic resources."*

China is examining how Starlink is used in the war in Ukraine. When Russian forces invaded Ukraine on 24 February 2022, one of their goals was to disrupt and dominate Ukraine's digital infrastructure. Russian leadership views control of information as a key component in establishing control over a country or population. However, today's media includes the Internet, social media services such as Telegram, Reddit, X (formerly Twitter), Instagram, and Tik-Tok, as well as instant messaging. As a precursor to their ground invasion of Ukraine, on 15 February 2022, the Russians executed extensive cyberattacks on Ukraine's internet and ViaSat's satellite network. These included continual Distributed Denial of Service (DDoS) attacks culminating on the day of the invasion, when Ukraine's primary internet service provider, Triolan, was taken down by Russian DDoS offensive actions. These DDoS attacks caused internet outages across large swathes of the country and left thousands of Ukrainians without communications. This also left Ukrainian citizens in the dark about the Russian invasion, creating fear and uncertainty.

Russia has also carried out kinetic, electronic warfare (EW), and cyber-attacks on Ukraine's internet infrastructure. This denial of communications not only denigrated the ability of the Ukrainians to mount an organised resistance, it also fanned the flames of panic. Despite their initial success, the Russians did not achieve their strategic goal of eliminating Ukraine's internet. A key contributing factor for this resilience was the rapid deployment of Starlink to Ukraine.

## What is Starlink?

Several countries and private companies are currently involved in deploying LEO broadband super-constellations, such as SpaceX's Starlink, OneWeb, Amazon's Project Kuiper, and Telesat's Lightspeed. These constellations aim to provide global internet coverage by deploying hundreds (as in the case of OneWeb) to thousands (as with Starlink) of satellites in LEO. Of all these

companies, SpaceX has deployed the largest satellite constellation in orbit today. It provides broadband internet access to enable voice and data communications anywhere in the world. A constellation of thousands of satellites in LEO, circling the earth at a distance of about 550 km (342 miles), beams the signal from space to terrestrial Starlink receivers. Most single geostationary satellites orbit Earth at about 35,000 km (21,750 miles). Since Starlink satellites are much closer to ground-based stations, the data transmission time is faster, and this generates high-speed data transmission for earthbound devices. All that is needed to access Starlink is a receiver and a subscription. It also works while on the move, an important consideration for military use.

SpaceX launched the first micro-satellites in February 2018. These satellites are small compared to the size of most telecommunication satellites—3.2 m × 1.6 m × 0.2 m in size and weigh about 227 kg. Each satellite has a solar-panel array to generate power for the on-board computer and electronics. Four phased-array antennas and two parabolic antennas transmit and receive data. A unique ion-propulsion system fuelled by Krypton, the first ion–krypton drive to enter service on spacecraft, provides propulsion for manoeuvre and deorbit. Starlink satellites have a built-in, autonomous collision-avoidance system that automatically manoeuvres the satellite to avoid hitting other objects in space. The on-board navigation system scans the stars to ensure orientation, altitude, and location to provide the optimum signal to ground receivers. To improve communications security and speed up data transmission, a laser-based optical intersatellite link system was added to every Starlink satellite launched after 24 January 2021, allowing the satellites to relay data to one another without local ground stations. Starlink provides broadband internet service to over 32 countries and has over 1.5 million subscribers worldwide. In short, Starlink is a successful LEO satellite communications network that enables reliable, high-speed and secure communications around the world.

## Lessons from Ukraine

The military applications of Starlink are tremendous. In the ongoing Russia–Ukraine War, SpaceX donated 3,667 Starlink terminals to Ukraine, and the US Agency for International Development (USAID) purchased a further 1,333 terminals. The Ukrainians reformed their communications networks and learned they could use the Starlink for more than just voice and data transmissions, but also to communicate with some types of drones. In the early days of the war, the Ukrainians employed many types of drones, including small unmanned aerial vehicles (UAVs), medium altitude long endurance (MALE) armed UAVs, and loitering munitions (LMs), to find and strike Russian command posts, artillery, and other high-value targets. As the fighting has worn on, the Russians adapted, using their EW systems to jam Ukrainian drone signals. To disrupt drone operations, especially those involving small UAVs, many counter-unmanned aerial vehicle (C-UAV) weapons focus on jamming line-of-sight signals from terrestrial controllers, thereby causing the drone to either land or return to its point of origin.

Ukrainian operators adapted to Russian jamming by improvising. The Aerorozvidka NGO, functioning as the Ukrainian Army's drone specialist unit founded by volunteer internet and drone specialists, adapted Starlink to control their drones. "We use Starlink equipment and connect the drone team with our artillery team," said Yaroslav Honchar, an Aerorozvidka commander in an interview in the 18 March 2022, edition of The Times. "If we use a drone with thermal vision at night, the drone must connect through Starlink to the artillery guy and create target acquisition." As unmanned warfare increases in scale, tactical employment, and capabilities, satellite communications systems such as Starlink will be an indispensable element in modern warfare. Brandon Wall and Nicholas Ayrton, in an article in the US *Centre for International Maritime Security* (CIMSEC) published in September 2021, hypothesised, "A small fleet of semi-autonomous drones could also act as a screening force for operations, acting to provide an extended sensor net and provide greater tactical awareness, be they for combat operations or as an early warning system."

Starlink is not a 'silver-bullet' battle communications solution, but has proven to be extremely resilient in combat despite Russia's best efforts to use their cyber and EW capabilities to defeat it. As the fighting continues in Ukraine, other nations are taking notice of Starlink's effectiveness as a wartime means of communication. According to *Business Insider*, in an article by Ren Yuanzhen in *Modern Defence Technology* magazine, published in China, the PLA is studying ways to counter Starlink. The PLA understands Starlink's potential and considers it a major threat. "It is recommended to apply a combination of soft and hard killing methods to disable some Starlink satellites and destroy their operating systems." The Russians concur with the PLA's assessment. Dmitry Litovkin, editor-in-chief of the *Independent Military*


Credit: SpaceX

***Starlink service map as depicted on the SpaceX webpage.***

*Review*, as quoted on *Radio Sputnik* on 9 May 2022, stated, *"The Starlink constellation of 2,000 satellites has performed well in Ukraine. China sees it as a threat to its security. It is capable of transmitting data from aircraft and drones a hundred times faster. Therefore, in Beijing, they want to create a system that would be able to track and destroy satellites."*

Li Xiaoli, a Chinese military analyst, made the following argument in a May 2022 essay that appeared in China Military Online: *"When completed, Starlink satellites can be mounted with reconnaissance, navigation and meteorological devices to further enhance the US military's combat capability in such areas as reconnaissance, remote sensing, communications relay, navigation and positioning, attack and collision, and space sheltering. Clearly, the military applications of the Starlink programme will give the US military a head-start on the future battlefield and become an 'accomplice' for the US to continue to dominate the space."*

While China is working to put satellites in orbit, neither they, nor the Russians, have their own Starlink-like constellations. As of late-October 2023, SpaceX has 4,938 Starlink satellites in orbit, with more to be launched in the coming months.

Going beyond Starlink, in December 2022 SpaceX presented Starshield, a version of Starlink for the US military, intended to provide a secure satellite network for the US government and the military with high-assurance cryptographic capability. The Starshield programme will prioritise three key areas: earth observation, communications, and hosted payloads. The programme aims to launch satellites equipped with sensors to gather data and deliver it directly to users. It also aims to offer secure global communications and laser communications links to connect non-Starlink satellites into the Starlink network.

## Guowang – China's Own Starlink

In terms of numbers of satellite launches, China is second only in the world to the US. According to Statista, a German online platform that focuses on data collection, China has 562 navigation and observation satellites operating in space. However, China has few communication satellites in LEO. In order to compete with Starlink and other Western efforts, China revealed in early 2023 that it planned to launch a 12,992-satellite LEO broadband constellation known as 'Guowang.' These satellites will serve as the foundation for China's own national satellite internet network, similar to the Starlink and OneWeb constellations, according to a professor at the People's Liberation Army Space Engineering University quoted by the South China Morning Press. The report also suggested that "anti-Starlink" payloads could be installed on GW constellation satellites. China also considers the Guowang network as an enabler for the PLA and China's Belt and Road initiative.

On 9 July 2023, China launched its first prototype of the GW network. The project is now a major effort of China's State-Owned Assets Supervision and Administration Commission (SASAC), which oversees China's largest state-owned enterprises and is led by Chinese company SatNet. According to filings issued to the International Telecommunication Union (ITU), the company intends to create two constellations (GW-A59 and GW-2) with a coverage of 37.5 to 42.5 GHz (space-to-Earth communications) and 47.2 to 51.4 GHz (Earth-to-space communications). On 9 July 2023, a Long March 2C rocket carried a prototype satellite into LEO to conduct testing of its broadband capabilities. More launches are planned to follow once this testing is completed.

## The Stratosphere – An Alternative to LEO

Another means to provide surveillance, navigation, observation, and telecommunications short of launching satellites into LEO or farther into space is to create a network of high altitude platforms in the stratosphere. The stratosphere is that area of the Earth's atmosphere, which starts at roughly 14.5 km to about 50 km above the Earth's surface. The stratosphere is relatively stable and free from clouds as it lies above the Earth's weather systems. Only very specialised military aircraft, such as the US U-2, can operate in the stratosphere. This also means that either long-range ground-based air defence systems or relatively high-altitude-capable aircraft are needed to shoot down balloons operating at this altitude. Due to these unique operating conditions, the military applications of platforms in the stratosphere are of particular interest.

Balloons are the most mature platform for carrying heavy payloads to high altitudes for persistent communications and intelligence, surveillance, and reconnaissance (ISR) missions, even though some special aircraft and UAVs can operate in the stratosphere. Balloons manoeuvre by changing altitudes to various wind layers to stay in an operating area. Solar-powered UAVs are optimised for electric powered propeller propulsion in the thin atmosphere of the stratosphere. They are more manoeuvrable than balloons, however, they typically have a significantly lower payload capacity. By contrast, even though balloons are slow to manoeuvre, are the best way to carry heavy sensors to high altitudes for long periods of time. As such, combining balloon and UAV operations may be the best way to optimise persistent ISR at high altitudes.

The latest lighter-than-air (LTA) systems can carry large and sophisticated ISR and communications packages to provide persistent surveillance, network connectivity, and EW support over terrain obstructions. Military LTA craft, often

Credit: US DoD

***A US Air Force U-2 pilot looks down at a Chinese surveillance balloon as it passed over the Central Continental United States on 3 February 2023. The Chinese aerostat was shot down the next day by a US Air Force F-22.***

known as aerostats, can operate in the stratosphere to provide radar-based surveillance for air defence. Aerostats can be tethered or free flying, and can operate higher than most aircraft, but below satellites, from between 18-30 km above the ground, and can remain over an area of operations for long periods of time.

One leading defence firm involved in military aerostats is the American defence corporation Lockheed Martin. The company was involved in military balloons with the US Navy before World War II and its latest, high-tech models are not your grandfather's blimp. The US used tethered tactical aerostats, at lower altitudes, for surveillance along the southern US border to combat drug trafficking. Since 2013, the Lockheed Martin 420K Aerostat System, with a length of 64 m and payload capacity of 1,000 kg, was the only ISR and communications balloon in daily use in the US until the Biden administration cut funding for the programme in 2021, resulting in eight of the fleet of 12 being grounded by early 2023. Another Lockheed Martin tactical aerostat model, designed for military persistent surveillance and communications at lower altitudes, is the Lockheed Martin 74K Aerostat. The craft is 35 m long and is tethered with a fibre-optic transmission cable. It can carry a payload of 500 kg.

Higher-flying airships can provide significant wide-area surveillance and communications advantages for urban combat operations. Lockheed Martin's High-Altitude Airship (HAA) can operate in the stratosphere and provides the ability for unmanned, persistent, geostationary ISR, electronic warfare, and communications. No tether is required as the HAA can manoeuvre in the airspace as directed from a ground station or satellite relay. Typical payloads for this type of aerostats would include surveillance radars, inertial and/or satellite navigation system, optronic sights, electronic-intelligence systems, and communications intelligence packages. Going beyond sensors and communications, in future armed aerostats could serve as weapons platforms able to conduct precision strikes.

On 28 January 2023, a Chinese intelligence-gathering aerostat penetrated US airspace, and then continued to overfly the continental US to collect information. On 4 February 2023, an F-22 fighter fired an A9X sidewinder missile from an altitude of around 18,000 m, which succeeded in downing the Chinese aerostat, then flying at an altitude of 18,290-19,810 m. China protested the destruction of their aerostat and accused the US of "overreacting" and "seriously violating international practice." In return, the US Government blacklisted several Chinese aviation companies and sent strongly worded messages to the Chinese but took no further action. It is clear that the China has a growing interest in the stratosphere and possesses aerostats capable of operating in this region. According to a BBC article from 26 June 2023, 'New images show Chinese spy balloons over Asia', by Gordon Corera, "Japan has confirmed balloons have flown over its territory and said it's prepared to shoot them down in future."

The race to command the stratosphere and LEO is intensifying. The capacity to launch a large constellation of small internet communication satellites into LEO, is a special capability that can enable terrestrial manned and unmanned combat operations. As the Ukrainians use Starlink to fight Russia, military leaders around the world now understand that LEO and the stratosphere represent an important sphere in warfare. Starlink remains an interesting example of how industry, with the right leadership, is deploying technology that is changing the landscape of war.

# 100 Years of the Republic of Türkiye

## Transformation and Defence Modernisation

**David Saw**

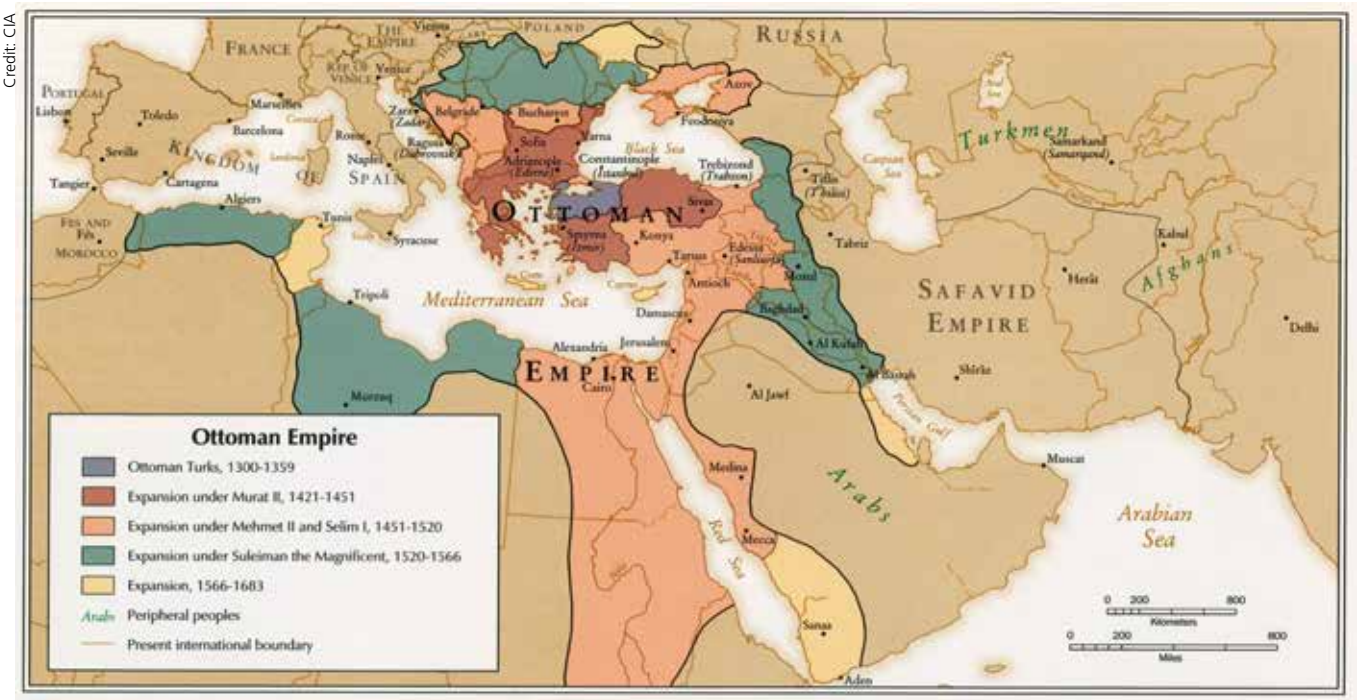
**On 29 October 2023, the Republic of Türkiye celebrated its 100th anniversary. It has been an incredible journey, from conflict and collapse of an Empire, to the development of a modern nation state. This article looks at the evolution of modern-day Türkiye, how its strategic importance has grown, and how Türkiye has developed a comprehensive defence industrial base to not only meet its own equipment needs, but also to meet the needs of export customers. This export success not only enhances the influence of Türkiye globally, it also makes a highly positive contribution to the national economy.**

The story of modern-day Türkiye is said to have begun some 724 years ago with the Osmanli Beylik in the town of Söğüt in today's Bilecik Province in Anatolia. It was here that Osman, regarded as the founder of the Ottoman Empire, started on his path to forging the empire that would eventually emerge as one of the great powers of its age. The rise of the Ottoman Empire, its apogee, years of decline, and eventual fall essential to understanding Türkiye today. The fall of the Ottoman Empire created the circumstances under which the modern Turkish Republic was born. Moreover, the echoes of the Ottoman past remain influential in terms of political and strategic thought in the country today, arguably the greatness of the past provides a vision of what Türkiye might aspire to in the present day. By the mid-1300s, the Ottomans had made territorial gains at the expense of the Byzantine Empire, which then gave them the opportunity to expand into Europe leading to the capture of Thrace and Macedonia and eventually Bulgaria. Ottoman conquests continued, with Serbia, Bosnia, Albania and Greece all subdued by the end of the 1300s. Ottoman expansion continued into the next century, bringing about the final dissolution of the Byzantine Empire with the capture of Constantinople in 1453. By the end of that century, Ottoman territory covered most of modern-day Türkiye; in Europe, it included Greece and the Balkans right up to the outskirts of modern-day Belgrade had been subdued, and Crimea along with most of the surrounding area, being an Ottoman vassal state.

### An Empire Rises and Falls

Ottoman expansion continued throughout the 1500s, with most of the North

Credit: CIA




*This map, from the CIA's 'Atlas of the Middle East', shows the extent of the Ottoman Empire attained under various rulers.*

Credit: BMC

*Recep Tayyip Erdoğan, the President of Türkiye, flanked by two Altay tanks at the Arifiye Campus of the Ministry of National Defense in April 2023, at the ceremony to celebrate the handover of two BMC Altay tanks to the Turkish Armed Forces for testing.*

## VOICES FROM INDUSTRY

# Türkiye Centenary Statement – Otokar

Credit: Otokar

*Serdar Görgüç,*
*General Manager of Otokar*

**With both great enthusiasm and pride, we celebrate the 100th anniversary of Republic of Türkiye.**

Otokar, Türkiye's global land platforms producer, also celebrates its 60th anniversary this year. It is really an honour that since its establishment, Otokar has achieved many firsts in Türkiye and has been one of the leading companies contributing to the industrialisation of the country and development of the Turkish defence industry on a national and international level.

Being a listed NATO and UN supplier, Otokar stands out with its contribution to Türkiye's defence industry exports with nearly 33,000 Otokar military vehicles in active service, with more than 40 countries and nearly 60 end users in different climates and geographies around the world.

The Republic of Türkiye, founded by the great leader Mustafa Kemal Atatürk, constitutes the most supreme legacy, which we will pass on to future generations.

I would like to take this opportunity to extend my sincere greetings on the occasion of the 100th anniversary of Republic of Türkiye, as I commemorate with respect and gratitude our founder, Gazi Mustafa Kemal Atatürk and all the heroes of our War of Independence.

Credit: TLFC

***Turkish Land Forces Command (TLFC) had acquired large numbers of M48 and M60 tanks from the US over the years. Many of the M60s and some of the M48s have been modernised and upgraded by Turkish industry, these will most likely be replaced by the Altay eventually.***

African coast to beyond Algiers also under their control, as was Egypt, with Ottoman possessions also along the Red Sea coast. The modern territory of Lebanon, Syria, Israel and parts of Jordan fell under Ottoman control, with the coastal areas of the Arabian Peninsula and modern-day Iraq Ottoman controlled as well. Vassal states included Transylvania, Wallachia, Moldova, the Crimean Khanate and Georgia. Greece and the Balkans up to and beyond Buda in Hungary were also Ottoman possessions in Europe. Yet this was more than a land-based empire, as the Ottomans were a major naval power and dominated the eastern Mediterranean for extended periods of time.

Historically speaking, arguably the height of Ottoman power came in 1683, when an Ottoman Army besieged Vienna. Had they been successful, the history of Europe might have looked very different. Instead, after their defeat at the 'Gates of Vienna' they were forced to retreat; this represents the apogee of the Ottoman Empire. They still had vast territories, but into the 18th century they found themselves in multiple conflicts with foreign powers, such as Habsburg Austria, Russia and even Iran.

The rate of decline only increased during the 19th century, when uprisings in Serbia saw the creation of the Principality of Serbia, the Greek War of Independence, the Romanian uprising in Moldavia–Wallachia, rebellions in Albania and Bosnia, and wars with Montenegro. Another war with Russia (the Crimean War of 1853–1856), followed by a further war in 1877,

Credit: ASFAT


***A busy day in September for the ASFAT shipyard, with the OPV Akhisar (P1220) launched and a second OPV Koçhisar (P1221) to be launched shortly afterwards, both OPVs are destined for the Turkish Navy. On the same day, PNS Babur (F280), the first of four MILGEM corvettes, was handed over to the Pakistan Navy.***

and wars with Greece, all saw a continuous loss of Ottoman territory.
Fundamentally the problem was that the world had changed, and the Ottoman Empire no longer had military superiority over its potential competitors, nor the ability to compel obedience in the territories it claimed to control. Ottoman leadership grew steadily weaker, and the Empire fell ever further behind in terms of technology. The 19th century was a time of significant technological advancement, though unfortunately for the Ottoman Empire, this coincided with a period of stagnation on their part. This was an era when the Ottoman Empire was commonly referred to as the 'sick man of Europe'.
Matters did not improve into the 20th century – a war with Italy saw the loss of Libya, and the Balkan Wars of 1912–1913 saw the end of Ottoman possessions in Europe, with the exception of Eastern Thrace. Even so, most of modern Iraq, Lebanon, Syria and Israel, as well as the western coastal zone of the Arabian Peninsula remained Ottoman. There were also desperate efforts to modernise, as seen with the Young Turks Revolution of July 1908, but it was all too little and all too late. Then came the eventually disastrous decision to enter the First World War on the side of the Central Powers.
A futile campaign was waged in the Caucasus, though the successful defence of Gallipoli saw Mustafa Kemal come to prominence, but in the end, beset with defeat on many fronts, the Ottoman Government signed the Armistice of Mudros of 30 October 1918. At that point, events within the remaining Ottoman territories began to spin out of control, with foreign intervention, inter-communal violence, a refugee crisis, disorder and a host of other problems emerging.
Ultimately, it was Mustafa Kemal, later known as Atatürk (Father of Turks), who would steer the transition from the Ottoman era to the modern Turkish Republic. This would see the restoration of national sovereignty, and the end of the Ottoman Sultanate with the removal of Sultan Mehmed VI and his departure from the country in November 1922, leading to the proclamation of the Republic of Türkiye on 23 October 1923. The Treaty of Sèvres, signed in August 1920, had previously stripped the country of Ottoman possessions outside of Türkiye, creating the circumstances under which the new Republic was to be built.

## The Modern Era

While Atatürk was undoubtedly the central figure in the birth of the new Turkish Republic, in the modern era, one political figure has come to define Türkiye today, namely Recep Tayyip Erdoğan. This is a politician who has been a transformational figure in the country's modern political era. Previously an Islamist politician and Mayor of Istanbul from 1994–1998, in 2001 he became one of the founders of the Justice and Development Party (AKP), which had a right-of-centre nationalist political position. The AKP would win the National Assembly elections in 2002 and Erdoğan would emerge as prime minister in 2003, a position he would hold until August 2014.
Constitutional change led to a direct presidential election in August 2014, which Erdoğan won, followed by a constitutional referendum in 2017 that agreed with the proposal that the president would be both the head of state

# VOICES FROM INDUSTRY

# How has the Experience of Nurol Makina's Existing Userbase Influenced the Further Development of the Company's Product line?

Credit: Nurol Makina

***Engin Aykol, General Manager of Nurol Makina***

There are more than two hundred 4x4 tactical wheeled armoured vehicle suppliers all around the world, making this segment as one of the most competitive segments of global defence industry. Excluding the suppliers who get easy/direct contracts from their governments and do not need to be competitive to survive, enduring in this hyper-competitive environment requires suppliers to be innovative against constantly evolving threats in the field. The main source of innovation for a company is user feedback.
Nurol Makina has been involved in international sales with their indigenous 4×4 vehicles and for the last six years we have reached more than 20 user countries from four continents. Our users include countries from NATO, EU, GCC and the Far East focusing on conventional warfare, to countries from the Sahel region currently operating under asymmetric warfare conditions. We have vehicles at desert, tropical, continental and Nordic environments for many different missions. Constant feedback from this wide and diverse userbase is an excellent source of innovation and is the main underlying source of Nurol Makina's international success.

Credit: Turkish Air Force

***The Turkish Air Force has a substantial F-16 inventory in service, but future fleet plans are complicated by disputes with the US that has halted the Joint Strike Fighter acquisition. A contract to acquire 40 new F-16 Block 70/72 aircraft should proceed though, while TAI and Aselsan have been awarded contract to modernise Turkish F-16C/D Block 30 aircraft.***

and head of government. Erdoğan would go on to win the June 2018 presidential election and more recently, a third term in the May 2023 election. This last election saw Erdoğan win 49.52% of the vote in the first round, before winning in the second round with 52.18% of the vote, with 84.15% of the electorate voting.

Erdoğan has therefore dominated the politic scene in Türkiye for more than 20 years and he will be in office until at least 2027. Internationally, he is seen as a polarising figure, while in reality he represents a Türkiye that is no longer a peripheral player on the margins of international politics and strategy. The Türkiye of Erdoğan sees itself as having its own national interests and as having an important voice in international security issues. These security and strategic concerns extend further than the areas adjacent to the borders of Türkiye and encompass the areas surrounding the Black Sea, the Middle East and, as a long-standing member of NATO, it wants to see that organisation respect its interests. Erdoğan's Türkiye also looks to represent the interests of expatriate Turkish communities in Europe and elsewhere, as well as becoming a major voice across the Islamic world. Politically, strategically and economically, there is a global vision regarding these interests; Ankara wants its voice heard at the centre of events and rejects the past where the aspirations of Türkiye could easily be ignored by the international community.

Türkiye's role in the ongoing Russia–Ukraine war reflects the confidence of the Erdoğan administration as far as its security and economic interests are concerned. Ankara has successfully sought to mediate between the two parties, while supplying defence equipment to one side and maintaining economic links with both. As the guardian of the Bosphorus straits, Türkiye has also played a key mediation and oversight role in the UN's 'Black Sea Grain Initiative', which allowed Ukraine to export grain and fertiliser from its Black Sea ports of Odesa, Chornomorsk, and Yuzhny – until Russia withdrew from the deal in July 2023. Another example of the Erdoğan administration's confidence in security matters was the 2015 agreement between Türkiye and Qatar to establish a military base in Qatar, and the Qatar–Türkiye Combined Joint Force Command. More than 3,000 Turkish troops have been based in Qatar, with the scope of the base expanded to include both an airfield and a port. Qatar has purchased defence equipment from Türkiye, as well as making substantial investments in the Turkish economy.

If there are clouds on the horizon as far as Erdoğan and Türkiye are concerned, it is the state of the economy. An already fragile economy, coupled with increasing poverty rates and high unemployment, was further damaged by COVID and its aftermath. Inflation remains a major problem; as of September 2023, the inflation rate was running at 61.5%, the highest level for nine months. Poor economic conditions were expected to be an obstacle to an Erdoğan victory in the May 2023 election, but that proved not to be the case. However, Türkiye needs to attract more foreign direct investment (FDI), with the Middle East representing the most likely source. A major concern would be global economic activity going into a major recession, as the Turkish economy would be increasingly hard pressed if this should occur. Improving economic performance remains a critical challenge for the Erdoğan government.

## Türkiye's Defence Industrial Base

As with many other countries, Türkiye has invested in an indigenous defence industry for reasons of national self-reliance. A successful defence industry should not only be able to meet the needs of the military, it would also have a positive impact on the economy overall. As the capabilities of the defence industry increased, the accompanying arrival of advanced technology would stimulate development and production skills across the national economy. Equally, spending defence funds on purchases from domestic companies would have a far more positive impact on the national economy than purchasing from foreign suppliers.

National defence acquisition programmes clearly provide the Turkish defence industry with a sizeable and increasingly

sophisticated long-term procurement marketplace. Arguably though, one of the most important achievements of the defence industry has been its growing success on export markets. Clearly, export sales help to sustain the industry and represent an important source of foreign currency inflows for the national economy. They also meet the strategic objectives of the Erdoğan government to increase the country's international influence.

The international reach of the Turkish defence industry becomes clear when you take into consideration the fact that 21 countries in Africa have purchased defence equipment from Türkiye. The Turkish industry customer base is far broader than that though, as recent export successes include the supply of Roketsan Karaok anti-tank missiles to Malaysia, a USD 35.58 M contract for Aselsan Tolun guided munitions from an undisclosed export customer from Baykar Technology Akinci UAVs and a contract for 12 Turkish Aerospace Industries (TAI) Anka UAV systems from Indonesia. Meanwhile, Otokar has recently supplied Ecuador with 20 Cobra II wheeled armoured vehicles.

One area where Turkish industry has begun to develop an export capability is in naval shipbuilding, where ASFAT have been particularly successful with MILGEM class corvettes, that were originally developed for the Turkish Navy. In September 2023, the Pakistan Navy commissioned PNS Babur at the Istanbul Naval Shipyard, the first of four corvettes it is acquiring from Türkiye. PNS Babur is one of two units built in Türkiye, with the other two units scheduled to be built in Pakistan after a technology transfer programme.

In another naval effort, STM Savunma Teknolojileri Mühendislik ve Ticaret A.Ş. is leading a programme to supply the Ukrainian Navy with two MILGEM corvettes, with the first unit launched at the RMK yard in Istanbul in October 2022, based on a defence cooperation agreement signed in 2020. In August 2023, the keel of the second Ukrainian MILGEM corvette was laid at the shipyard in Istanbul. The original plan had been to complete both corvettes at a Ukrainian shipyard, but this became impossible after the Russian invasion of February 2022. Instead, both units will be completed in Türkiye and then transferred to the Ukrainian Navy.

What impresses most about the Turkish defence industry is the pace of innovation. In the past, defence production in Türkiye was essentially based on local production of foreign equipment, after varying degrees of technology transfer. Now, Turkish industry is capable of rapid innovative developments in areas such as UAVs and loitering munitions. Mention must also be made of the major advances in indigenous missile programmes, both in anti-tank and air defence applications. However, some major national programmes still rely on foreign technology inputs, for example with the TF-X fighter programme, and the utilisation of Korean technology in the Altay tank programme.

The Turkish defence industry represents a new vision for the country, combining advanced technology with an international outlook. Although at this point, the defence industry does not have the full spectrum of products that many of its international competitors offer, where it does have capability though, it is highly competitive. As to the future, the aim is to further develop products and technology to be competitive against a broader spectrum of international requirements. ■

# Dynamic Messenger 2023: Extending the Envelope of Unmanned Capabilities at Sea

**Peter Felstead**

**In a round of related exercises off the coast of Portugal, NATO has been exploring the future potential of maritime unmanned assets.**

Hosted by the Portuguese Navy out of its Maritime Experimentation Operations Centre on the Tróia peninsula and its naval facilities in Sesimbra, NATO has recently conducted two overlapping exercises focused on integrating maritime unmanned assets – unmanned surface vessels (USVs), unmanned underwater vehicles (UUVs) and unmanned aerial vehicles (UAVs) – into naval operations.

The Robotic Experimentation and Prototyping with Maritime Unmanned Systems 2023 (REPMUS 23) exercise, held from 11 to 22 September and co-organised by the NATO Centre for Maritime Research and Experimentation (CMRE), focused on experimentation with concepts, requirements and technological advances in relation to unmanned maritime assets. This year's exercise, for example, achieved a notable first when a team from BAE Systems and Manroy Aeronautics demonstrated the ability of a T-600 heavy-lift multi-rotor UAV to release a Sting Ray Mod 1 lightweight torpedo during a flight mission at sea.

As well as involving 10 mostly Portuguese warships and the British trials ship *XV Patrick Blackett,* REPMUS 23 also gathered more than 40 UAVs, more than 35 UUVs and more than 15 USVs. Beyond Portugal as the host, the participating nations were Belgium, Canada, Denmark, France, Greece, Germany, Italy, Latvia, the Netherlands, Poland, Romania, Spain, the United Kingdom and the United States, along with NATO partners Ireland and Sweden.

Meanwhile, 'Dynamic Messenger 2023' (DM23), held from 18 to 29 September, was more specifically focused on integrating and operationalising those maritime unmanned assets, particularly in relation to mine countermeasures (MCM) operations, where manned assets can be further removed from the danger zone, and on multi-domain operations more generally.

Credit: Peter Felstead

***A Schiebel Camcopter featuring sonobuoy dispensers being controlled by one of DM23's virtual ships.***

Conducted under the joint leadership of NATO's Allied Command Transformation and Allied Maritime Command, the exercise involved assets and more than 2,000 military and civilian personnel from 14 NATO nations (Canada, Denmark, France, Germany, Greece, Italy Norway, Poland, Portugal, Romania, Spain, Turkey, the United Kingdom and the United States), with NATO partner nations Japan, New Zealand, South Korea and Sweden also attending with observers.

Credit: Peter Felstead

***During DM23 the Spanish OPV SPS Furor conducted a passage from Troia to Sesimbra on 26 September 2023 while simultaneously deploying and controlling four unmanned assets.***

REPMUS is an annual exercise, while 'Dynamic Messenger', the first edition of which took place in 2022, will next be mounted in 2025.

## DM23: A Closer Look

Joining DN23 on Troia on 26 September, *ESD* was able to witness a number of the exercise's serials and gain a greater appreciation of its objectives.

The first aim of the exercise was to validate new tactics and doctrine in relation to maritime unmanned systems and to prepare for their integration into NATO's two Standing MCM Groups. A particular second challenge in this respect was presented by the multitude of maritime unmanned systems entering the NATO inventory, requiring the fusion of their many different sensors and the unprecedented volume of data they produce.

A third objective was therefore to test various software solutions related to data conversion, data cataloguing, the displaying of the tactical situation, managing the various assets in play, tasking and reporting, planning and evaluation, and post-mission analysis.

Another objective was to move toward collaborative autonomy between the unmanned systems being deployed and to fully exploit their artificial intelligence (AI) capabilities. With AI harnessed to more effectively identify mines, for example, a key aim of the exercise was to explore how MCM forces can move to being less dependent on human operators to conduct MCM analysis of the data gathered.

The results of the exercise are also intended to inform the support team in charge of developing standards and formats for unmanned systems, with a view to enshrining these within NATO Standardisation Agreements (STANAGs). An additional objective was to capture and analyse the exercise data as a whole. For this purpose a report was generated for any single task completed by any single participant, with performance metrics between systems compared and planning factors analysed in order to improve performance in the future.

Another major objective of the exercise was to demonstrate the ability to use unmanned systems to conduct mine clearance operation from over the horizon. Addressing the threat from drifting mines was a further key aim. This involved serials designed to search for and classify suspicious surface objects using UAVs equipped with optical and laser imagery detection and ranging (LIDAR) sensors, allowing floating mine targets to be acquired and destroyed by explosive ordnance disposal (EOD) units.

Credit: Peter Felstead

***A Kaluga USV from MILTECH Hellas was one of two USVs controlled by SPS Furor during DM23.***

A final challenge for the exercise was to explore how MCM assets could contribute to the protection of critical underwater infrastructure (CUI). For this purpose a three-day serial was devised in which a 700 m-long cable just 18.3 mm wide was laid at a depth of between 30 m and 50 m, with both legacy systems (manned MCM vessels) and unmanned assets used to find and track the cable, conduct change detection in its surroundings and identify any suspicious objects. This particular serial led to a real-life event on 25 September when an actual communications cable was discovered with a significant bend in it, the details of which were forwarded for further examination.

## Passage to Sesimbra

The assets used for DM23 were mostly contained within a Task Group MCM (TG MCM) and a Task Group Surface (TG Surface). TG MCM consisted of assets from Standing NATO MCM Group 2, including its flagship, the Italian replenishment tanker ITS *Stromboli*, along with the Italian minehunter ITS *Gaeta*, the Spanish minehunter SPS *Tambre*, and the French diving tender FS *Pluton*.

TG MCM, meanwhile, included both two real vessels, the Italian frigate ITS *Carabiniere* and the Spanish offshore patrol vessel (OPV) SPS *Furor*, and two virtual ships, known as 'VS London' and 'VS Lisbon', which controlled real unmanned assets out of the Maritime Experimentation Operations Centre on Tróia.

On 26 September, ESD was on board SPS Furor as it conducted a passage from Troia to Sesimbra while simultaneously deploying four unmanned assets: the ship was flanked during the voyage by two USVs – Seadrone's Sead-23 and the Kaluga from MILTECH Hellas – while an Alpha 900 rotary-wing UAV and a fixed-wing M5D-Airfox UAV were

Credit: Peter Felstead

***A Seadrone Sead-23 was one of two USVs controlled by SPS Furor during a voyage from Troia to Sesimbra on 26 September 2023.***

both launched and recovered during the voyage, the former from the ship's helicopter deck while the latter was launched by hand and recovered by a net.

The 6.95 m long Sead-23, which features waterjet diesel propulsion, has a range of more than 322 km (200 miles) at 20 kts. It has a low radar cross-section (RCS) and typically carries day/thermal gyro-stabilised cameras, solid state radar, sounder and five high-resolution pilot cameras, although it can also carry other sensors and even a remote weapon station (RWS) armed with a 12.7 mm heavy machine gun (HMG).

The Kaluga, which Greece's MILTECH Hellas developed with Leonardo Hispania and Spanish company UTEK, is effectively a USV based on a 6.75 m Narwhal 670 rigid-hull inflatable boat powered by a 150HP Mercury Verado outboard engine. It typically carries a MLT-SUR-100RTM thermal surveillance system, but can also mount other sensors or a Leonardo Lionfish Ultra Light RWS armed with a 12.7 mm HMG.

The fuel-powered Alpha 900 UAV has a maximum take-off weight of 25 kg, a payload capability of up to 4 kg and an endurance of up to four hours. The solar-powered M5D-Airfox, which weighs 4 kg and has a wingspan of 2.5 m, carries a high-definition video camera and has an endurance of 10 hours in optimal sunlight conditions (and 1.5 hours on its internal battery).

## NAIAD: The Unmanned Enabler

At the heart of the ability of SPS *Furor* to simultaneously operate multiple unmanned assets is Navantia's Naval Advanced Integrated Autonomous vehicles Defence (NAIAD) system. Designed specifically for the integration of UAV, USV and UUV operations, NAIAD has been designed as a flexible, open system that can be integrated into any combat management system (CMS) or command-and-control (C2) system, either on board a ship or in a control centre ashore. The NAIAD system was first demonstrated during 'Dynamic Messenger 22' (DM22), when it was integrated on the Spanish Navy OPV SPS *Audaz*.

NAIAD allows a ship's crew to both monitor the data and sensor feeds from maritime unmanned assets on their CMS consoles and send missions to those unmanned assets. Communications between NAIAD systems at sea and ashore allows the sensor and data feeds from the unmanned platforms to be transmitted ashore. Additionally, an unmanned platform such as a UAV can be used as a relay between NAIAD systems at sea and ashore to extend the communication range between them, although for DM22 Navantia worked with Spanish company Hisdesat to demonstrate the transmission of NAIAD data via satellite link, thus obviating any range limitations or the need for communications relays.

Speaking to ESD on 25 September, Angelina Cajade Frias, Navantia's European programme director, noted that the company is under contract to the Spanish Ministry of Defence to provide a new baseline configuration for the SCOMBA combat system used by the Spanish Navy's surface combatants. This system update is effectively making these vessels 'NAIAD ready', with the control of UAVs and USVs being followed by the integration of UUVs as well. Cajade Frias added that she expects the NAIAD system will be procured for all of these ships "in the next few years".

Credit: Peter Felstead

***An Alpha 900 rotary-wing UAV was launched and recovered by SPS Furor during its passage from Troia to Sesimbra on 26 September 2023.***

Credit: Peter Felstead

***An M5D-Airfox tactical UAV is recovered into a net on SPS Furor on 26 September 2023.***

Part of Navantia's roadmap also covers integrating the control of unmanned platforms with Spanish Navy submarines. As one of few such systems currently available, Navantia is now starting to market NAIAD to a prospective customer base beyond the Spanish Navy.

"At this time Spain is the unique nation that has NAIAD, but Navantia has the objective to sell it to other navies," Cajade Frias told ESD. "Currently, there are only a few systems similar to NAIAD in the market that have demonstrated its capabilities in real operations. Navantia has received information requests about NAIAD after its participation in 'Dynamic Messenger'.

## The CUI Challenge

The need to protect critical underwater infrastructure (CUI) was a particularly apposite objective for DM23, given that the exercise dates straddled the first anniversary of the 22 September 2022 attacks on the Nordstream pipelines in the Baltic Sea.

Briefing an audience at Sesimbra on 26 September, Thomas Furfaro, a project leader with the NATO Science and Technology Organization's Centre for Maritime Research and Experimentation, outlined a number of questions DM23 was looking to address in the specific area of CUI protection. These were:

- Can acoustic sensors provide sufficient fidelity to allow operators to identify contacts without optical sensing? (which relies on relatively clear water to be effective);
- Can the pace and resilience of MCM operations be improved by broader interoperability between systems?
- How can operators and systems be evaluated in terms of their real and self-estimated performance?

One serial in relation to the latter question involved a mystery target being dropped onto the sea floor, with a UUV's sonar then used to try and determine its shape and characteristics.

Asked by ESD whether maximising the effectiveness of acoustic sensors involved exploiting capabilities such as AI to get the most out of current sensors, or whether new technology was the answer, Furfaro noted that, while DM23 was focusing on the former, the development of new, high-frequency sonars systems could ultimately provide an enhanced capability.

## Manned Versus Unmanned

By the time ESD's visit to DM23 concluded on 26 September, a number of the exercise's objectives had already been met. For example, of 24 mine targets laid, all had been found. With the exercise's conclusion, meanwhile, there will be much data to pore over.

Ultimately, much of the exercise was about whether – using maritime unmanned vehicles in all their forms, relying more significantly on autonomous capabilities and AI, and employing systems such as Navantia's NAIAD – unmanned vehicles addressing the MCM mission can match and eventually surpass the capability of manned MCM assets.

The pitching of manned versus unmanned assets was evident in the maps of the exercise area, which showed that, while legacy manned assets were focused on mine targets in a number of exercise boxes to the southwest of the Troia peninsula, the unmanned assets were focused on an area along the coast below Sesimbra.

According to the commanders in charge of DM23, the current situation is that NATO's unmanned and autonomous capabilities are not quite at the proficiency levels of legacy manned MCM vessels. However, this is precisely the situation that REPMUS 23, DM23 and their subsequent iterations are designed to reverse. ■

Credit: Peter Felstead

***As SPS Furor arrived off Sesimbra on 26 September 2023, an OceanScan Light Autonomous Underwater Vehicle (LAUV) was deployed for an MCM operation as the USVs controlled from SPS Furor patrolled nearby.***

# De-lousing: the Role of ISR in Enabling Maritime Operations

**Dr Lee Willett**

**Intelligence, surveillance, and reconnaissance (ISR) capabilities are an essential, overlaying enabler for naval operations. As the strategic importance of operational tasks such as mine warfare and anti-submarine warfare returns, so does the requirement to expand and enhance ISR capability and its support for such tasks, particularly through enhancing multi-domain command, control, and communications.**

Intelligence, surveillance, and reconnaissance (ISR) is a multi-domain activity. In the maritime domain, assets are deployed in the air, on and below the surface – as well as ashore, in coastal, littoral regions – to conduct ISR tasks, to enhance maritime situational awareness (MSA) and contribute to the development of a common operating picture.

Against the backdrop of returning naval rivalry at sea, crewed platforms are increasingly required to apply their 'exquisite' capabilities to higher-end operational tasking, and/or where human operator decision-making remains paramount. With crewed platform numbers still limited across many Western navies, a consequence of this shift in focus back towards high-end activity for crewed platforms is that there is a pressing operational requirement emerging to bring maritime uncrewed systems (MUS) into service sooner rather than later.

In the near term, while navies' confidence in MUS technology and capability continues to develop, MUS are being introduced to meet two overlapping requirements. The first is to provide mass in terms of assets deployed at sea. The second is to support what are known as the '3-D' operational tasks – tasks that are 'dull, dirty, or dangerous'. Such 'dull' and 'dangerous' tasks encompass ISR requirements as part of building MSA. Here, certain 'dull' and 'dangerous' tasks require MUS to provide sustained ISR capability, often at a fair distance from any host platform. Such tasks include providing sensing capability for anti-submarine warfare (ASW) barriers, or for sanitising (also known as 'de-lousing') deployment routes for high-value assets using mine counter-measures (MCM) operations.

Credit: NATO Maritime Command

***A Light Autonomous Underwater Vehicle (LAUV) used for seabed scanning is pictured being operated by Royal Danish Navy (RDN) sailors at the 'REPMUS'/'Dynamic Messenger' exercise. The RDN also deployed an AUV – a Teledyne Gavia system – to conduct over-the-horizon MCM ISR.***

For NATO navies, the current strategic-level naval rivalry evident at sea across the Euro-Atlantic theatre has heightened the operational focus on core high-end tasks, including ASW, amphibious operations, and MCM, with each of these tasks enabled by ISR.

Russian submarine activity has increased across the theatre, but is particularly significant in Northern Europe and the Eastern Mediterranean. The risk of the Russo-Ukraine war spilling over has sharpened NATO's naval focus on amphibious operations in the Baltic Sea (to secure the Baltic States) and along NATO's northern flank (to deter any risks to Norwegian security). As regards MCM, the strategic importance of the Black Sea in the Russo-Ukraine war has seen the deployment of significant numbers of mines to support defensive and offensive operations across the regions, with such mines – including those now drifting, after becoming detached from their mooring lines – posing a significant risk to commercial shipping.

## Exercise Focus

All these matters have been very much the focus for the Portuguese Navy-led 'Robotic Experimentation and Prototyping augmented by Maritime Unmanned Systems' (REPMUS) and the NATO Allied Maritime Command (MARCOM)-led 'Dynamic Messenger' exercises, which took place in tandem at Troia, southern Portugal across September. The core remit for both exercises is to focus almost exclusively on testing and evaluating MUS systems in operational experimentation that is designed to

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reflect 'real-world' requirements as closely as possible.

The serials around which the exercises were based were designed to reflect such 'real-world' operational requirements for NATO. During the activities, the four primary areas of operational focus were ASW, underwater operations (including the protection of critical underwater infrastructure [CUI]), MCM, and rapid environmental assessment. Effective ISR – either at an overall or an event-specific level – is vital as an enabling capability in all four contexts.

Overlaying these four areas of tactical-level focus, a core operational-level goal for the exercises was to develop multi-domain command, control, and communications (C3) capability. Developing effective multi-domain C3 capability will be essential in underpinning NATO tactical operations at sea, with ISR helping to build the MSA layer that is central to constructing this C3 capability. Together, this develops the integrated capability that enables effective delivery of core operational tasks such as MCM and ASW.

For example, in 'REPMUS 2023', which took place across the first three weeks of September, one of the serials tested – for the first time in a 'REPMUS' exercise – the use of an uncrewed underwater vehicle (UUV) in conducting over-the-horizon ISR to support an MCM operation in advance of an amphibious assault ashore.

An over-the-horizon mission was undertaken because it was the first time that a UUV with the required 'legs' (range and sustainability on station) had been deployed on 'REPMUS'. The UUV was a Teledyne Gavia autonomous underwater vehicle (AUV), brought to the exercise by the Royal Danish Navy. While the serial was designed to prove that the AUV could sustain operations over the required distance and timeframe, it was also designed to demonstrate that the required level of autonomy could be generated for the AUV to ensure effective conduct of the core mission deliverables.

## Operational Requirement

According to a NATO briefing document published online in May 2023, ISR "provides the foundation for all military operations". In the document, NATO defined surveillance broadly as the persistent monitoring of a target, reconnaissance as information-gathering to address a specific military task, and intelligence as the final, fused product derived from combining – together with other forms of information – the surveillance and reconnaissance data collected.

Credit: NATO Maritime Command

***UUVs were deployed on 'REPMUS'/'Dynamic Messenger' to provide ISR imagery of what could be detected on the seabed, including mines and other objects. For example, French Navy and UK Royal Navy systems (France's Alister9 UUV is pictured) collaborated to share, compare, and contrast imagery and information gathered.***

For the exercise serial, over-the-horizon MCM operations using a UUV were required to provide discreet capability to support an amphibious operation, a NATO military official told a media briefing at 'REPMUS', held at the MCM operations 'hub' in Sesimbra, west of Troia. As amphibious operations are often launched from the sea at some distance from shore, from a task group remaining out of range of littoral defences, UUVs are playing an increasingly crucial role in providing ISR to conduct and support MCM activities, in large part because using crewed platforms for the MCM task would indicate the looming presence of the amphibious force.

The exercise serials were designed to support development of how NATO and its navies will conduct MCM operations in the future, bringing "unprecedented change in the way we are doing mine warfare", the NATO official said. This change includes the introduction of a broader variety of systems including uncrewed vehicles, the use of a mix between crewed and uncrewed platforms, increased sensing capacity introduced via the uncrewed platforms, and improved analysis, distribution, and tactical use of the greater data volumes being generated by those sensors.

This new approach adds another layer of complexity to what, in MCM, is already a challenging operational task. "That's why we need experimentation ... to improve our procedures and tactics," said the NATO official.

The UUV was deployed from Sesimbra, and sailed east to the location of the planned amphibious assault, off the Troia peninsula. The UUV conducted a scan of the seabed within the operating area, with this mapping supporting identification of any suspected mine-like contacts, the NATO military official explained.

## Real-World Relevance

In real-world operations, forward-deployed UUVs can conduct discreet ISR and MCM without revealing their presence, by deploying from a host platform over the horizon, conducting a covert transit, undertaking tasking with reduced risk of detection due to their covert operation and smaller size, and initiating timed destruction of any mine-like objects identified by fixing a delayed-fuse charge to any mine target positively identified.

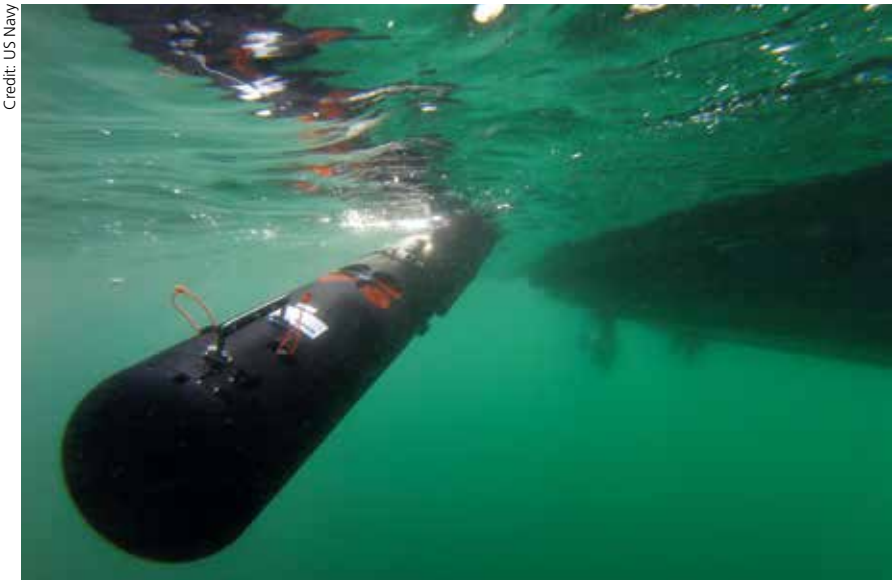
The mission aim in the exercise serial was "to practice .... objectives with regard to specific scenarios. So, long-range [ISR and MCM operations] were tested in the view of conducting covert operations for the specific requirements of amphibious assault," the NATO official said. "If you want to do it covertly, your vehicle needs to be deployed far away and transit underwater [from where] it is safe, over the horizon."

The UUV was deployed from shore for the exercise, the official continued, but it could also be deployed from a ship that would approach the landing area, but stand off at distance over the horizon to avoid detection and observation.

"The idea was to conduct a bottom-mapping scan of the seabed in the landing corridor, without showing the ongoing efforts prior to the landing," the NATO military official said. "So, with uncrewed systems, or UUVs, this becomes more possible because, if they transit underwater, you will not be able to spot them from the landing beach."

"The mission profile was planned so that the vehicle would dive off Sesimbra, make a full transit underwater in a completely

Credit: US Navy



***MCM serials have been conducted at 'REPMUS' for some time. Pictured is a REMUS 100 UUV being deployed for an MCM serial off Sesimbra for 'REPMUS 2019'. In 2023, the exercise tackled an over-the-horizon MCM serial for the first time.***

covert manner, arrive in the amphibious corridor, and do some tracks to do some bottom mapping. Still underwater, it would transit back to Sesimbra, surface, and then [be] recovered," the official continued. "The mission data was downloaded ... and some post-mission analysis software was run in order to classify bottom objects. Some of them were classified as mine-like contacts. So, that means you have an idea of the small objects on the bottom which potentially could be mines."

Such information is then used to inform planning for the amphibious operation. "Either you adjust your route to avoid those possible mines, or you go ... back there to identify and to determine if the possible mines are actual mines or not," said the official.

In this exercise serial, planners then deployed an MCM vessel to the landing corridor, with explosive ordnance divers used to reacquire and formally identify the possible mines classified by the UUV.

Credit: Dr Lee Willett

***CMRE's Biondo AUV is pictured during a 'REPMUS' demonstration serial conducting bottom mapping surveillance work. Such ISR tasking is key to supporting MCM and CUI operations.***

For the exercise, 24 dummy mines were deployed off Sesimbra and 21 off Troia, to test the ability of the assembled operational units to detect seabed mines or moored mines. Three more were deployed in the landing corridor for the amphibious serial.

The purpose of the ISR work and the post-mission analysis was to understand how many mine-like contacts had been located, and how many had been classified as actual mines, the official said.

"The aim is to be very accurate in our ability to classify, because if we have too many mine-like contacts, if you want to identify them to be sure of the nature of the contact, it will be a cumbersome task because it takes time; or if we want to divert the traffic to where there are no mine-like contacts, there are mine-like contacts everywhere and it's impossible to do," the official explained "So, we measure the number of mine-like contacts and the number which were actually mines, and we measure how many mines we may have missed."

"Then, we try to analyse the reason why," the official continued. "We try to determine why the contact has been misclassified, or why the contact was not found .... We try to learn from that."

"One tricky part of mine warfare, in real operations, is you can have some intelligence of the threat, you can have an idea of how many mines have been dropped, but you will never know for sure," the official explained. "What you will know is the number of mines you have found, but you will never know for sure how many mines are still remaining in the water."

"It's important information, because at the end we need to estimate the remaining risk for incoming traffic. So, we have some algorithms to try to determine what is the number of remaining mines and what the remaining risk could be," the official added.

While the operators knew how many mines had been deployed for the exercise, this is not the same in real-world operations – even when working with close allies. For example, in the Black Sea, Ukraine revealed that it had laid defensive minefields in certain locations, but did not disclose mine numbers or mine types, as such information could assist Russian mine-countermeasures efforts.

## Distance Learning

As regards the lessons learned in the combined 'REPMUS'/'Dynamic Messenger' exercises relating to the role of ISR in MCM, the critical element was knowing that the AUV involved had the 'legs' to reach

the operating area, remain on station as needed, and return to its host platform or port – but also knowing that the AUV could complete its mission effectively at distance given the reduced opportunity for operator engagement. In sum, there was a need to demonstrate that the vehicle could provide the required autonomy in delivery of the ISR and MCM taskings.

"At the end, once on the spot in the corridor to be cleared, the AUVs will use the same sensors because the job remains the same," said the NATO official.

The importance of the link between effective ISR and tactical-level MCM operations is underlined in the technology and operational roadmap NATO has set out for how it plans to continue transforming MCM capabilities and operations to keep pace with the changing nature of the threat.

In particular, here, there is a need to make UUVs increasingly smart in order to contribute to improved sensing, information sharing, and co-operative activity, Commander Stefan Pahl – a German naval officer posted at NATO's Belgium-headquartered Naval Mine Warfare Centre of Excellence (NMW CoE) as subject matter expert for MCM doctrine, training, and standardisation, and for the use of robotics in operations – told a media briefing at Sesimbra.

Cdr Pahl – who was deployed to the exercise as a senior staff officer running the MCM serials – said that some of the main objectives of the roadmap include: developing UUV capacity to generate and support dispersed data management, including through designing standards for interfaces to enable such information sharing; and to provide alternative platform/capability options for conducting target identification, other than having to do so through visual means.

ISR also can also make a broader contribution here. Alongside the core requirement to find, identify, and clear potential mine threats, the other key product of MCM is "providing a reduction of risk for the follow-on traffic, [including] providing an estimate of what that risk is actually going to be", said Cdr Pahl. "The risk is determined by the things we didn't see: we're not looking at what we found;

## Marketing Report: W L Gore

# Milipol Paris 2023:

## GORE-TEX Professional Sets New Standard for Military GORE-TEX Combat Boots with EXTRAGUARD Upper Technology

**Innovation at Milipol Paris, November 14-17, 2023 (Booth 5 C110): GORE-TEX Professional (Gore) is introducing EXTRAGUARD, a new upper technology for military GORE-TEX combat boots that for the first time combines the advantages of a robust upper with those of lightweight, flexible and breathable textiles. This enables the specialist in technical functional textiles to produce a completely new class of GORE-TEX combat boots for general infantry and special forces. These are rugged yet lightweight - and stay on easily in wet, muddy terrain and dry quickly afterwards. They are also waterproof, breathable and flame retardant, and feature a significantly low environmental footprint.**

**www.goretexprofessional.com**

EXTRAGUARD upper technology consists of three layers – a highly abrasion-resistant and flame-retardant outer protective layer, a functional layer that provides physical protection and an innovative construction inner layer with low water absorption. This 3-layer upper is sealed with GORE SEAM Tape and integrated into the shoe along with the interior waterproof and breathable GORE-TEX lining (bootie construction). The seam sealing prevents moisture from entering the shoe through the seams. The GORE-TEX bootie construction ensures that the boot is permanently waterproof, even if the water-repellent impregnation has worn off or the upper material is damaged. This keeps feet dry and warm at all times in wet or cold conditions.

Thanks to this unique construction, the EXTRAGUARD upper is 40% lighter than equally strong and dry leather when dry. Since it absorbs less moisture from the outside, it remains lightweight even when wet and dries significantly faster. GORE-TEX EXTRAGUARD combat boots retain their functional properties even after months of use and constant wear in wet environments.

### Comfortable fit, easy cleaning

GORE-TEX combat boots with EXTRAGUARD upper technology fit comfortably from the start, they don't need to be broken in and they retain their shape. Spraying with water is all that is needed for care and cleaning; specific care products are not necessary.

Credit: W L Gore

### Reduced environmental impact during production

EXTRAGUARD upper technology also sets new standards in terms of sustainability: according to the Higg MSI (Higg Materials Sustainability Index, higg.com), the upper is manufactured with less water, CO2 emissions, chemicals and is chrome-free. It is also produced by the roll, so there is less material waste in the production of GORE-TEX EXTRAGUARD combat boots. In sum, all factors significantly minimise labour, material use and overall environmental impact.

Credit: NATO Maritime Command


***Uncrewed surface vessels participate in a critical underwater infrastructure (CUI) security demonstration at 'REPMUS'/'Dynamic Messenger'. The CUI serials were designed to test the role of uncrewed systems in locating, surveilling, and securing seabed cables.***

we're actually looking at what we might have missed." Statistical analysis of what is or is not detected on the seabed, and thus the wider role of the surveillance component of ISR, are critical here.

## Seabed Search

The role and importance of ISR was demonstrated against another key operational requirement put to the test during the exercises – the need to secure critical underwater infrastructure (CUI) on the seabed.

CUI security has become a central issue for NATO, following the occurrence of a range of incidents at sea since 2021. In November 2021 and January 2022 respectively, reports emerged of damage occurring to seabed cables at an environmental monitoring network off Lofoten, northern Norway and at a communications network off Norway's Svalbard archipelago. Then, in September 2022 – amid the wider context of the Russo-Ukraine war – two Nordstream gas pipelines, which traverse the Baltic Sea floor, suffered explosions. The cause of each of the three incidents was assigned as unattributed acts of sabotage.

The relatively sudden, but perhaps not unexpected, emergence of what is now referred to as critical underwater infrastructure warfare (CUIW) is being met by NATO at all levels. At the strategic level, the alliance established the Critical Undersea Infrastructure Co-ordination Cell in Brussels, to provide a hub for countries, militaries, industry, and other stakeholders to engage and co-ordinate in addressing the risk. At the operational level, it is setting up the NATO Maritime Centre for the Security of Critical Undersea Infrastructure at MARCOM, Northwood, UK, to provide a hub for stakeholders to engage on operational tasks like enhancing MSA. Now, as demonstrated in REPMUS/Dynamic Messenger, NATO has now begun testing a range of tactical-level requirements, including technologies as well as tactics, techniques, and procedures, as part of an effort to develop and deploy a 'fight tonight' capability for deterring and defending against CUIW threats.

As a key objective in developing capability for CUI protection, serials were conducted in which UUVs were used to undertake ISR tasking in the vicinity of seabed communications cables, Commander Antonio Mourinha, a Portuguese Navy officer and Director of CEOM – the navy's Maritime Experimentation Operations Centre – told the media briefing in Sesimbra. "We did a lot of experimentation in this area. It is definitely one of the areas where we need uncrewed systems, because this CUI is there, [and] we depend on this infrastructure."

"In order to protect the cables, we need to have the ability to surveil them and to detect any interference," Cdr Mourinha added. As well as conducting surveillance to secure a cable, the serial also included the requirement to use surveillance to find the cable in the first place. This was a challenging task, given that the cable was only 18 mm in diameter, the NATO military official explained.

For CUI serials using MCM assets deployed to Sesimbra, "the aim was to figure out what the contribution of mine warfare assets to the protection of CUI could be," the official said. Crewed mine-hunting assets carrying hull-mounted sonars and AUVs fitted with side-scan sonars were both deployed. The challenge here was searching for a cable that is far smaller than a mine, the official added. AUVs will bring particularly important capability, due to their ability to deploy to the seabed, to close the sensing range to the cable and reduce interference to, and improve definition in, the sonar picture.

The aim of the serials was to provide reconnaissance of the cable target, not only to locate the cable itself but to determine its track – the direction in which it is running – and then to assess its status and determine if any suspicious objects were in the vicinity.

As regards the nature of any suspicious objects, the official explained, "with mines, you know what the threat is. You have intelligence, you know the stockpile of the adversary – what kind of mines it would have. The threat against CUI could be an explosive charge, it could be a surveillance device, or something to connect to the cable to get information."

"CUI is not mine warfare or [ASW]: it's multidomain," the official added. "It's intelligence, it's satellite surveillance, it's MSA, it's force protection, it's a lot of things." Mine warfare plays a key role in shallow waters, as MCM capabilities are designed to surveil the water column and seabed down to a certain depth. In deeper waters, UUV technology will come into its own in conducting CUI ISR.

Some of the testing at the exercises included experimenting with smart cables – cables with embedded sensors that provide in-built surveillance and data-gathering capacity. Such trials work reflected NATO's wider focus in CUIW on building MSA and sharing such information. ■

# Armenia and Azerbaijan – What Happens Next?

**Leonid Nersisyan**

**19 September 2023 marked the start another active military conflict, this time in Nagorno-Karabakh: between the local Armenian troops and Azerbaijan.**

Despite lasting only one day, the conflict led to 412 official causalities for both sides and according to the Armenian Government has led to ethnic cleansing – with practically the entire Armenian population of Nagorno-Karabakh, numbering over 100,000, fleeing from the disputed region to Armenia in the days following the clash. The one-day war also surprisingly resulted in relatively high causalities for both sides.

## Military Imbalance Eroding the Status Quo

Nagorno-Karabakh started to become a conflict region in 1988, when the local Armenian population started to claim the independence of Nagorno-Karabakh Autonomous region from Azerbaijan and demanded to join Armenian Soviet Socialist Republic (SSR). This process triggered the First Nagorno-Karabakh War of 1992-1994, and ended with defeat of Azerbaijan, which lost control not only over the Nagorno-Karabakh Autonomous region, but also of seven ex-Azerbaijani SSR regions around Karabakh, most of which provided a land connection with Armenia, which Karabakh itself lacked. A ceasefire was brokered by Russia, but it never was completely fulfilled. Peace negotiations were mediated by the Minsk OSCE Troika (France, Russia and the USA) for many years without result and continued against the background of continuous violations of the ceasefire along the line of contact in Karabakh and even at the Armenia-Azerbaijan border.

The status quo started to deteriorate in April 2016, when the first large-scale hostilities after 1994 started and resulted in small gains on the line of contact for Azerbaijan. This was the result of the military approach chosen by Baku, which became a much wealthier country after 2005, as it began to export of large volumes of fossil fuels amid higher oil prices. This would resulted in changing the military balance between the two countries'


Credit: Baykar

***The Bayraktar TB2 strike UAV developed by Baykar. The Bayraktar TB2 was procured by Azerbaijan, and rose to considerable prominence in the aftermath of the 2020 Second Nagorno-Karabakh war, in which it was credited with a large number of successful strikes against Armenian targets.***

**Author**

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Credit: Elbit Systems

***The SkyStriker loitering munition, developed by Elbit Systems. The SkyStriker was among the many loitering munitions Azerbaijan procured from Israel, and subsequently used in conflicts with Armenia.***

armed forces, since the Azerbaijani defence budget was several times larger than Armenia's. Baku enacted the large-scale procurement of tanks, artillery, armoured vehicles, air defence assets, combat aircraft and unmanned aerial vehicles (UAVs) in Russia, Ukraine, Belarus, Israel and Turkey starting from around 2005.

A major shift occurred in 2020, during the 44-day Second Nagorno-Karabakh war, where Azerbaijani troops managed to gain a military victory. The 2020 war demonstrated some of the newest components of modern warfare, including the massed use of combat UAVs such as the Bayraktar TB2, and ISR UAVs in combination with artillery and loitering munitions. Azerbaijani Armed Forces were able to conduct a suppression of air defence (SEAD) operation almost without use of manned aviation, relying on the coordinated actions of uncrewed vehicles. Such success was reinforced with a more modern and creative approach in land warfare: the first failed attempts to undertake a 'classical' offensive with tanks and armoured vehicles were replaced with offensives by lighter mobile troops, which were able to disorganise the defending Armenian forces. Many of these modern approaches were taught to Azerbaijani Armed Forces by high-ranking Turkish officers, which Armenia has stated were actively involved in developing and conduction the operation. At the same time, Russian support to Armenia was very limited, despite the two countries being allies.

The war resulted in the Trilateral Statement, made by leaders of Armenia, Azerbaijan and Russia. According to statement, Azerbaijan gained control over territory of seven regions around Nagorno-Karabakh along with Shushi and Hadrut cities which were part of Karabakh, while Russia established a 1,960 personnel-strong peacekeeping mission which became security guarantor for local Armenians and was in charge of guarding the Lachin corridor – the only road connecting Nagorno-Karabakh to Armenia proper. Also, the Statement outlined some bases for peace negotiations, including the exchange of POWs, opening of the transport communications between countries, and various others.

This postwar period was stable for only a few months, and in May 2021 Azerbaijan started to re-assert military pressure – now also directly on Armenia, as well as occupying border territories during limited operations. The most large-scale escalation happened on September 12-13, during which the intensity of hostilities was comparable to Second Karabakh war. Azerbaijani troops occupied more than 140 km2 of Armenian territory and conducted artillery and UAV strikes deep into Armenian territory, destroying some air defence assets and damaging Armenian Armed Forces bases. According to official sources, Armenia lost 202 and Azerbaijan lost 80 servicemen in just two days – more than during the 2016 four-day war in Nagorno-Karabakh. These hostilities showed that the Armenian Armed Forces were still not ready to organise an effective defence against Azerbaijan, especially in the sphere of air defence. As a result of the Azerbaijani attack, Armenia negotiated an EU monitoring mission to the border, which was established for 2 years and could be prolonged further.

Against the background of direct Armenia-Azerbaijan tension, Baku also started to put pressure on Nagorno-Karabakh, despite the existence of the Russian peacekeeping mission and security guarantees. The peacekeepers were shown to be very passive, especially after the beginning of Russo-Ukrainian war, which took a much higher priority for Russian military resource dedication, as well as limited general interest to the region. After several local attacks by Azerbaijani troops, which resulted in almost no reaction from the Russians, Baku started a blockade of Nagorno-Karabakh by blocking the Lachin corridor in December 2022. This also did not lead to any real reaction from Russia and its peacekeepers. This passivity gave Baku the confidence sure that it could run a final military campaign in Karabakh, which started on September 19 and finished on September 20, 2023.

## Success with Surprisingly High Causalities

The launch of hostilities in Karabakh on 19 September 2023 started with massed indirect fires by Azerbaijani troops on military objects and defence infrastructure along the line of contact. Azerbaijani troops used Lora tactical ballistic missiles (TBMs), Harop and SkyStriker loitering munitions, tube and rocket artillery, as well as Spike-NLOS long-range anti-tank missiles. After this, their land forces launched an offensive, planning to cut Nagorno-Karabakh into 3 isolated parts, without entering the large cities, such as the capital – Stepanakert, or Martakert, which was surrounded but not taken. Despite the heavy indirect fire support, Azerbaijani land forces met fierce resistance in most directions and took higher-than-expected causalities. By contrast with their performance in 2020, Armenian forces even conducted several successful drone

strikes, using modified civilian multicopters without encountering many counters from their enemy, which seemed unprepared for such actions.

Despite such innovations, the defenders had no chance of winning, as the region was already cut-off from Armenia and the number of troops was quite limited, with contemporary assessments of Nagorno-Karabakh Defence Army estimating a strength of 7,000-10,000 servicemen. Alongside this, Azerbaijan's pre-war 9-month blockade also diminished their fuel stocks, making their defensive and offensive options more limited. Given this situation, if the war had not been stopped almost immediately by the surrender of Karabakh local authorities, the question would have been how many days it would have last and how many casualties sides would have, but the final result was never in doubt.

Russian peacekeepers did everything to stay out of the conflict, despite that there is evidence of an artillery strike on one of their bases and two cases when Azerbaijani troops opened fire at them. That led to death of six peacekeepers, including Captain First Rank Ivan Kovgan, the deputy commander of Russia's Northern Fleet submarine forces, and deputy commander of the peacekeeping mission. Following his death, an official apology was made by Azerbaijani president Ilham Aliyev over a phone call to Vladimir Putin.

The one-day conflict resulted 192 dead and 512 wounded Azerbaijani servicemen, while local Armenian forces reported 220 servicemen dead and 360 wounded. Yet the most grave outcome of Azerbaijan's offensive was that it resulted in the effective ceding of the self-proclaimed Artsakh Republic to Azerbaijan. Artsakh Republic President Samvel Shahramanyan signed a bill which dissolved the existence of the republic, allegedly with under the condition of threats to both himself and local population. Azerbaijan's seizure of the region also resulted in the entire Armenian population of the former Artsakh Republic fleeing for Armenia, leading Armenia's Prime Minister Nikol Pashinyan to accuse Azerbaijan of conducting the ethnic cleansing of the region. Additionally, several acting and former political and military leaders of the Artsakh Republic were arrested and are being prosecuted in Baku, including an Armenian-origin billionaire from Russia, Ruben Vardanyan, who moved to Karabakh before the blockade of Lachin corridor.

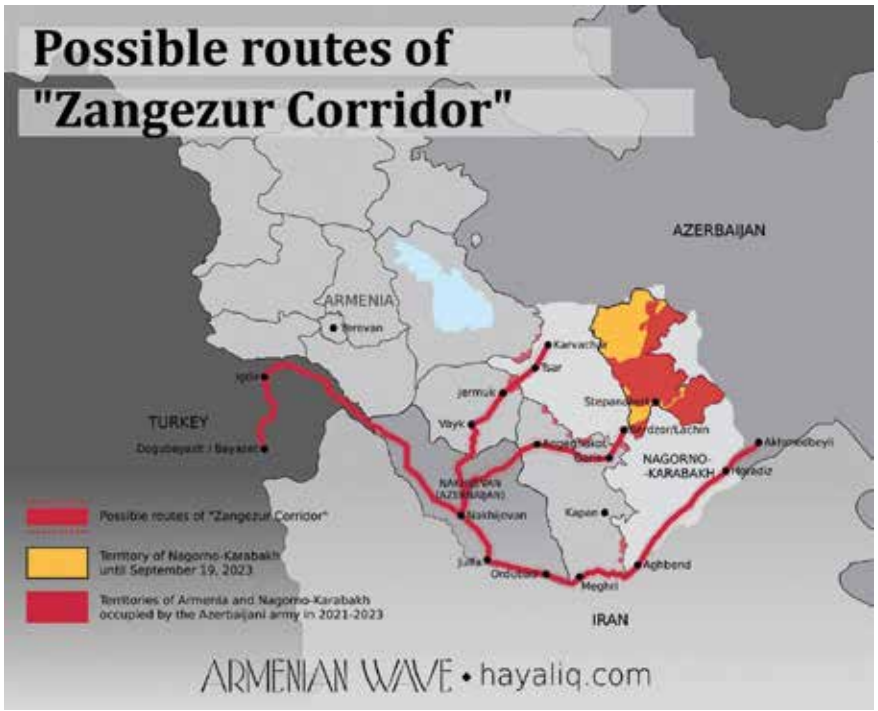
## What Next?

Despite the fact that since 2020 Baku has attained its maximalist goals, and there are no practical obstacles for a peace agreement between Armenia and Azerbaijan, tensions between the two countries is not decreasing. At present, Azerbaijan is seeking to get maximum possible out of negotiations on opening of the logistical routes between the countries. Based on the point 9 of the Trilateral Statement of 9 November 2020, Baku is demanding a railway and highway with special status, which should pass through Armenian territory and connect Azerbaijan's mainland with its Nakhchivan exclave. This is known as the 'Zangezur corridor'. According to the Trilateral Agreement, *"The Republic of Armenia shall guarantee the safety of transport communication between the western regions of the Republic of Azerbaijan and the Nakhchivan Autonomous Republic with a view to organize the unimpeded movement of citizens, vehicles and cargo in both directions. Control over transport communication shall be exercised by the Border Guard Service bodies of the FSS [Federal Security Service – more commonly referred to as the FSB] of Russia".*

Moscow's interest also lies with this 'corridor' idea, as it will provide Russia more on-the-ground presence in Armenia. Yerevan's position in this case is to simply open the route for Azerbaijanis to go to Nakhichevan via Armenian territory, but with no special status road and no Russian FSB guarding the route in place of Armenian customs officers. This position has a certain logic, since de-facto, none of the 'pro-Armenian' points of the Trilateral Statement exist anymore – including security for Karabakh Armenians and the functioning of Lachin corridor, as well as exchange of all POWs – and the agreement has long since been seen as a failure.

Another artificial way of keeping the situation in tension is the issue of enclaves – small pieces of foreign territory which during the existence of the USSR were located in the Armenian and Azerbaijani SSRs. Azerbaijan wants its enclaves back under its control, despite the fact that Armenia also has enclaves with Azerbaijani territory, not counting the >140 km$^2$ of territory occupied by Baku after 2020. The situation is complicated by the fact that an Armenian strategic highway connecting the country to Georgia passes by one of these enclaves. In reality, the only realistic 'peaceful' approach here is to leave the enclave question for a post-peace treaty delimitation and demarcation process, where such territories could be exchanged to benefits either side countries. However, the current tensions over regarding the enclaves represents a possible scenario for a further military incursion by Azerbaijan.

At the moment, there are three Azerbaijani enclaves in Armenia which are located in the Tavush province, located in Armenia's North, and the Ararat province, located North of the Nakhchivan exclave. All are approximately 3-4 km from the border, which theoretically makes them a possible target for a lim-




Credit: Armenian Wave

***This map shows the possible routes for the Zangezur Corridor.***

Credit: Armenaian Wave


***This map shows the overall security situation in Armenia and Nagorno-Karabakh.***

ited rapid operation. However, the parts of the northern border where enclaves exist are both relatively well fortified and are located in mountainous and forested areas. During the 2020 Second Nagorno-Karabakh War, Azeri troops were not able to breach the defences in the northern parts of Nagorno-Karabakh, despite a landing a hard blow at the beginning of hostilities. By contrast, Armenia's southern border is much less fortified, since it never existed until Armenia's defeat in 2020, before which this border was shared with the Artsakh Republic. Additionally the terrain in this area is more permissive, mainly comprising open plains. In a scenario where Azerbaijan would seek to link its mainland to these aforementioned enclaves by force, it would need to conduct an offensive on three axes of up to 8-9 km deep, and would likely result a heavy multi-day war. Such a conflict is more difficult to diplomatically 'sell' as a limited border skirmish, and as such would carry a greater risk of triggering sanctions. Which perhaps serving as a potential dissuasive element, this does not guarantee such a scenario would not come to pass.

Another and perhaps the most probable conflict scenario for the near future would be a limited operation on the 'new' border between Armenia and Azerbaijan, similar to scale and style to one in September 2022. This means, that Azerbaijani troops will have limited time, but not scale or intensity for the attack, with the probable aim being that Azerbaijan's forces take their objectives before an international response can be organised. If successful, this could notably change the tactical situation on the borders, as well as put more pressure on the Armenian leadership to make more one-sided concessions, most probably related to the Zangezur corridor and/or enclaves issue. The real scenario may include the same idea as in September 2022 – to create a feasible risk of encirclement of a relatively large Armenian city which is close to border. If in 2022 it was Jermuk, next time it could be Goris (9 km from border) or toward Vardenis (15 km from border), located on the shores of Sevan Lake.

The third, and least probable scenario is a full-scale invasion to Armenia and attempt to occupy all or a large chunk of the Vayots Dzor and Sunik provinces of Armenia, the latter of which is in the South of the country and shares a border with Iran. Azerbaijan's likely goal here would be to connect its mainland to Nakhichevan and to Turkey, while cutting Armenia off from Iran. However, attempting such an offensive would have serious risks of an international reaction, as well as the the possibility of direct military support from Iran, which is not interested in such scenario coming to pass, as it would dramatically decrease its influence in the South Caucasus.

## Long-Term Consequences

Along with the aforementioned scenarios, it is important to assess the long-term trends for both countries' Armed Forces. At present there is a major capability gap between Armenia and Azerbaijan, which was exacerbated after the former's defeat in 2020.

Following its victory, Azerbaijan has sustained a relatively high defence budget, which is planned to reach USD 3.8 Bn in 2024. Baku is still undertaking on defence procurement and advice for military reforms mostly from Israel and Turkey. The arms deals are now mostly kept in secret, but high numbers of cargo aircraft fights between the three indicates that they are continuing at pace. The most recent news in this sphere is Azerbaijan's selection of Turkish Aerospace Industries (TAI) to upgrade Azerbaijan's Su-25 combat aircraft, and procurement of a 0.5 metre-resolution remote-sensing satellite and possible procurement of Barak MX air defence system from Israel Aerospace Industries (IAI). It can be surmised that Azerbaijan continues to fill its stocks with Israeli and Turkish UAVs and loitering munitions, and is continuing to develop its long-range precision-guided strike capability.

In Armenia, there is more of a shift going on, as the 2020 war saw the devastating of its Armed Forces, especially in Air Defence and Artillery domains. The country boosted its military spending twice, and is due to have a defence budget of USD

1.4-1.5 Bn in 2024. Yerevan tried to rely on Russia, its traditional partner, after the Second Karabakh War, signing a contract worth USD 400 M in August 2021, mostly for air defence systems. The contract has still not been fulfilled, which Russia has justified by citing its own needs in Ukraine. This, along with Russia's aforementioned refusals to fulfil the alliance treaty, has pushed Yerevan to find new partners.

The most significant one at present is India, which according to local media has secured an armament contracts package worth around USD 1 Bn. This includes such major Indian systems as Akash SAMs (with a memorandum of understanding to procure Akash-NG when it is ready), ATAGS 155 mm L52 towed howitzers, MArG 155 155 mm L39 self-propelled howitzers, C-UAV electronic warfare (EW) systems, licensed-produced Konkurs-M anti-tank guided missiles (ATGMs), and other equipment. Interestingly, Armenia made the decision to switch to NATO calibres, and with the number of pieces of artillery being procured, which by some estimations may exceed 150-160, this is a strategic change. Another new partner is France, which is now open to sell NATO-standard weapons to Armenia. First contracts signed on October 2023 include three Thales Ground Master 200 radars, as well as binoculars and sensors produced by Safran. Additionally, memorandum of understanding was signed with MBDA to start the process of procuring Mistral very short-range surface-to-air missiles.

In terms of overall security prospects, the short-term in particular, but also the mid-term currently very much favours Azerbaijan, which lost less equipment in the 2020 war, and has continued to invest a higher amount than Armenia in defence. On the Armenian side, the prospects could look better over the long term, provided the country manages to retain its sovereignty until then. This is because the country is currently undergoing a boom in economic growth, driven in particular by Armenia's IT sector, with the country's GDP growing by 12.6% in 2022, likely reaching 10% in 2023, and looking set to remain high over the coming years. By contrast, Azerbaijan's economy is stagnating and is heavily dependent on fossil fuel exports. The worldwide trend towards decarbonising economies may begin to strongly affect Azerbaijan's economy after 2030, which may allow Yerevan to secure some breathing room. However, 2030 remains further away than is comfortable, and as such Armenia would do well to secure itself in the present. ■

Credit: Press Office of the Government of Armenia

***Armenian Prime Minister Nikol Pashinyan meeting Russian President Valdimir Putin in 2023 during a visit to Sochi. Relations between the two countries have frayed somewhat since 2020.***

Credit: Press Office of the Government of Armenia

***Armenian Prime Minister Nikol Pashinyan meeting India's Prime Minister Narendra Modi in 2019 during a visit by the two leaders to New York.***

# The 19th NATO LCM Conference

The 19th NATO Life Cycle Management (LCM) Conference will take place in Brussels from January 23 to 24, 2024. But before describing what is expected to be presented during this high-level conference a few words on the background for this event might be useful.
In 2003 it was decided by NATO to form a group through which the concept of LCM could be developed and introduced into NATO's and its members' defence systems acquisition processes. The group is AC/327, the Life Cycle Management Group (LCMG). The international standard, ISO/IEC 15288, System Life Cycle Processes, was adopted as the basis for the development of the LCM approach in NATO, which was formalized as the NATO Policy for Systems Life Cycle Management (SLCM) was agreed by the North Atlantic Council in 2006. At the same time, it became obvious that AC/327 needed a link to industry to exchange views and ideas in this high-tech area. In this light, and on the initiative of AC/327, NIAG, the German CALS Forum, and Mittler Report, it was decided to establish a conference giving room for new developments in relation to LCM. Since then, there have been a yearly conference with few exceptions, like in 2021, when the conference was cancelled due to COVID.

## The Conference

The setting for the conference has been more and less the same all over the years, and the 19th NATO LCM Conference will be no difference as it provides a platform for the presentation of innovative approaches and concepts in support of the LCM philosophy. In addition to presentations and papers from experts, the conference provides ample opportunity for the exchange of information between and among experts, program managers and decision makers from the nations' armed forces, defence administration and industry.

## The Theme

For every conference a theme is elected based on contributions from those who are engaged in setting up the conference. This theme is used as baseline when the process for call for papers start. This year the theme will be:

**Life Cycle Management in a Changing World – Ramping up – Delivering Volume, Speed, and Innovation with LCM.**

Taking this into consideration, the ever-evolving landscape of Life Cycle Management (LCM) is currently undergoing a significant shift with the integration of Artificial Intelligence (AI) in LCM tools and in the systems themselves.

## Call for Papers

As we transition into this new era, the conference invites all researchers and practitioners to submit papers that provide fresh insights into the confluence of AI and LCM. The Call for Papers – already sent out by Mittler report - aims to gather leading thoughts, practical implications, challenges, and the visionary potential of merging AI technologies with LCM. On this background those who want to give a presentation can send their abstracts to Mittler Report who will then make the final selection of presenters.

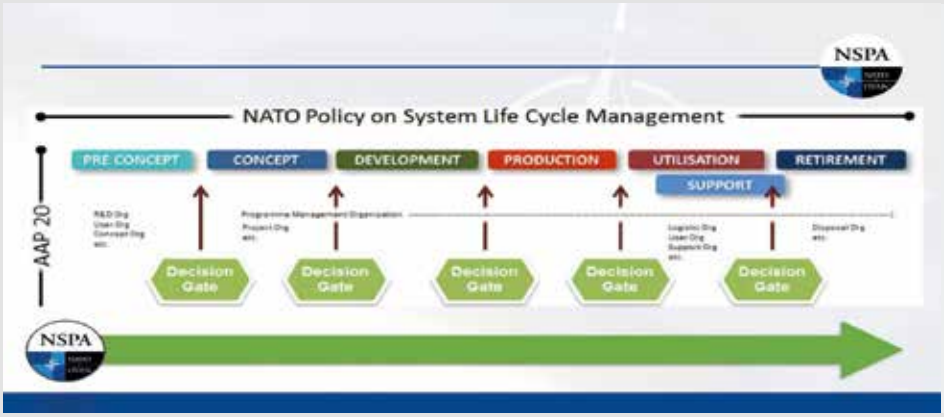
## The Confluence of AI and LCM

The keyword for the 19th NATO Life ycle Conference is confluence. The Science & Technology Trends 2023-2043, issued by the NATO Science & Technology Organisation March 2023, mention three waves in the AI context.
The first wave of AI is represented by expert knowledge or other authoritative sources and encoded into a computer program in the form of an expert system. The second wave of AI is based on machine learning (ML), or statistical learning, and includes voice recognition, natural language processing, computer vision etc. Third wave AI technology combines the strengths of first and second-wave AI, and is also capable of contextual sophistication, abstraction, and explanation.
During the 2022 conference, we had the first presentations touching on those AI waves and therefore we are looking forward to having more presentations on this highly important topic and how the confluence could be envisaged.

## Conclusion

The team behind the NATO LCM Conference can only encourage those who have knowledge or experiences to share, or who want to know more and want to meet experts with their ' finger on the pulse', to join the conference.

Credit: NSPA




*NATO Policy on LCM diagram from the NSPA Keynote Speech during the 18th NATO Life Cycle Management Conference.*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