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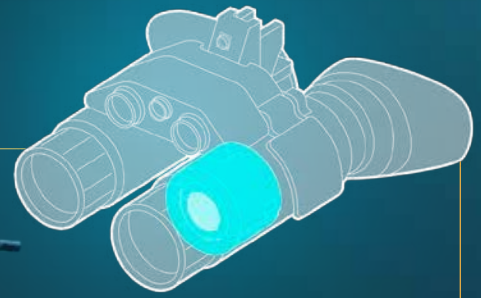
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# Red skies over paradise



It is remarkable how a change in leadership in one country can so radically alter the overall strategic picture for many others, especially when this country is the US. In the wake of the Munich Security Conference, and the disastrous 28 February 2025 meeting between Presidents Donald Trump and Volodymyr Zelenskyy, Europe finds itself at a crossroads. The post-Cold War consensus of the

US as a guarantor of European security is rapidly unravelling in the wake of a transactionist and fast-moving Trump administration. Consequently, European countries are scrambling to examine alternatives to the trans-Atlantic security arrangement, with perhaps the most pressing challenge being the establishment of an alternative to the US nuclear umbrella.

In February 2025, during an interview with German broadcaster ZDF, Germany's Chancellor-in-waiting Friedrich Merz stated: "We must prepare for the possibility that Donald Trump will no longer uphold NATO's mutual defence commitment unconditionally," adding, "We need to have discussions with both the British and the French, the two European nuclear powers, about whether nuclear sharing, or at least nuclear security from the UK and France, could also apply to us."

It is fair to question Merz's statement, since both British and French nuclear doctrine already leaves open the possibility for employing nuclear weapons to protect allies. However, at the same time Merz's statement reflects a valid anxiety among Europe's non-nuclear powers – while there exists the possibility that Britain or France could use their nuclear arsenals to provide deterrence on behalf of allies, this is by no means a guarantee, and policy regarding their use to ensure the security of allies is left deliberately vague. Furthermore, the extent to which the British and French nuclear deterrent is considered sufficiently credible to deter a strategic opponent is up for debate.

For starters, neither the UK, nor France have particularly large nuclear arsenals, at 225 and 290 total warheads respectively, according to the *SIPRI Yearbook 2024* – which is roughly 9% of Russia's inventory of around 5,580 warheads. Added to this, the UK's is not entirely independent, relying on US warhead and missile designs. Consequently, these factors disincentivise nuclear sharing (one of the possibilities Merz raised), and encourage extremely careful consideration of the conditions under which they could be employed.

In the UK's case, all nuclear missiles are hosted aboard its four *Vanguard* class submarines, with the continuous at-sea deterrence policy calling for at least one such submarine to be on nuclear patrol at sea at all times, and the rest based at HMNB Clyde in Faslane, Scotland. Each boat can be armed with up to 16 Trident II D5 submarine-launched ballistic missiles (SLBMs), with

up to eight warheads each, for a theoretical maximum of 128 warheads on any given boat – though the typical figure would be expected to be lower.

While this sounds like a lot, it doesn't leave much room for manoeuvre when considering the nuclear dilemmas which could hypothetically be imposed. For instance, in a worst-case scenario where HMNB Clyde is subject to a surprise nuclear first strike with three boats in port, this would leave the UK with just one boat at sea. Would these warheads be authorised for retaliatory employment at that point? What if further strikes on the UK mainland were threatened? Would allies still be covered? These are the sorts of questions leaders of nuclear powers would have to contend with. Furthermore, the possibility of failure needs to be accounted for, as seen with the UK's last two tests of Trident II; a June 2016 test saw the missile veer off-course and automatically self-destruct, while a January 2024 test saw the missile's first-stage boosters fail to ignite, leaving it to drop into the ocean.

France's force is more versatile, comprising both a sea and air component. The former consists of four *Triomphant* class submarines (each with up to 16 M51 SLBMs, with up to 10 warheads each), with two intended to be at sea at any given time, and the rest at based at Île Longue in Crozon. The strategic air component comprises around 50 Rafale B fighter aircraft (each of which can be armed with one ASMP-A/ASMPA-R air-launched nuclear missile) operated by two squadrons based at Saint-Dizier – Robinson Air Base in Haute-Marne. Faced with a similar worst-case nuclear first strike scenario, France's more diffuse nuclear force would probably have higher odds of preserving capability for a second strike than the UK, but would nonetheless face similar dilemmas on nuclear employment if further strikes were threatened.

Ultimately, there is no real substitute to having one's own nuclear option. It is precisely here, when planning Europe's long-term security architecture in the possible absence of a US nuclear guarantee, that Europe's non-nuclear powers may be tempted to re-examine their stance on non-proliferation. In this vein, with Merz's concerns in mind, Germany joining the nuclear club would make quite a lot of sense, both to guarantee its own security, and to share the burden of wider European deterrence with the UK and France. While Germany is a signatory of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), it is permitted to withdraw under Article X of the treaty.

As little as a year ago, Germany's withdrawal from NPT would have been nigh-unthinkable, however, the Overton window is shifting rapidly, and the public are slowly starting to see things differently, yet some may still require convincing. A common position with many voters has been to oppose nuclear proliferation on the grounds that it would 'paint a target on their country's back'; here it is worth remembering that only four countries have ever given up their nuclear weapons – Belarus, Kazakhstan, South Africa, and Ukraine. One can ask the Ukrainians if they feel doing so has made them less of a target.

**Mark Cazalet**

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## Masthead

ESD [European Security & Defence]

Issue 3/2025, March 2025,

ISSN 1617-7983

www.euro-sd.com

### Published by

Mittler Report Verlag GmbH

A TAMM Media Group company

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Production: Lehmann Offsetdruck und Verlag GmbH,

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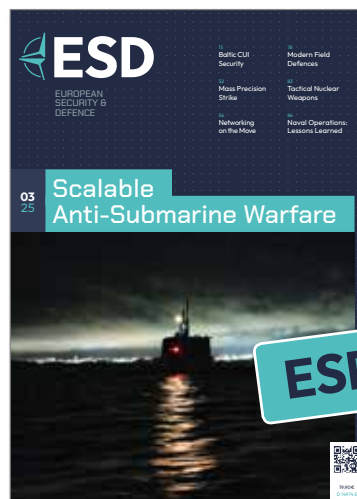
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Cover Photo: A Gotland class (A19) submarine of the Royal Swedish Navy, seen surfaced at night, silhouetted against the light pollution from a settlement in the background. [Försvarsmakten/Ola Jacobsen]

Annual subscription rate: €123.80 incl. postage Reduced annual subscription rate for distribution in Germany: €103.80 incl. postage

**ESD** EUROPEAN SECURITY & DEFENCE



**MITTLER  
REPORT**

Media kit:



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Published monthly,  
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## US military geopolitics appears to have ‘fallen through the looking glass’

(pf) As the third anniversary of Russia’s invasion of Ukraine passed on 24 February 2025, impartial observers could be forgiven for thinking that global military geopolitics – or more specifically the US approach to it – has ‘fallen through the looking glass’.

Europe’s political leadership was first put into a tailspin on 18 February 2025 when US and Russian officials met in Riyadh, Saudi Arabia, to discuss ending the Ukraine War without inviting any participation from either Ukraine or Europe.



[White House press feed]

That same day, during remarks made at his Mar-a-Lago residence in Florida, US President Donald Trump appeared to blame Ukraine for the Russian invasion of the country and called Ukrainian President Volodymyr Zelenskyy a “dictator”.

The latter claim, which appeared to closely mirror the agenda of the political ‘spin doctors’ in Moscow, stemmed from the fact that presidential elections in Ukraine set for the spring of 2024 were suspended, under legislation passed prior to Zelenskyy’s election in April 2019, due to the country being at war.

Russia’s invasion of Ukraine in February 2022, meanwhile, can be traced back to Ukraine’s February 2014 Maidan Revolution: a popular uprising that ousted Moscow-compliant President Viktor Yanukovich in favour of a Western-leaning government and prompted Russia’s initial annexation of Crimea on 27 February 2014.

Then, at the United Nations General Assembly in New York on 24 February, the US disaligned with Ukraine and Europe on two telling votes. Firstly, after a US-drafted resolution calling for an end to the Ukraine conflict was amended, with European nations calling for it to include references to Russia’s invasion and Ukraine’s sovereignty, the US abstained. Then, as the UN General Assembly approved a European-backed resolution from Ukraine that demanded Russia immediately withdraw from the country, the US joined Russia, Russia-compliant Belarus and North Korea in opposing it.

Also on 24 February, Trump’s continued false assertions in relation to the Ukraine War prompted a real-time fact-check by none other than French President Emmanuel Macron. As the two leaders met in the White House, Trump claimed that European

countries were merely “loaning” money to Ukraine and that “They get their money back”, at which point Macron immediately intervened to state, “No, to be frank, we paid 60% of the total effort, and it was, like the US, loans, guarantees, grants, and we provided real money, to be clear.”

Trump’s antipathy toward Ukraine can be traced back to his first presidential term in July 2019, when he attempted to coerce Zelenskyy into opening an investigation into his presidential rival, Democrat Joe Biden, by threatening with withhold military aid to Ukraine. Prior to a whistleblower complaint about this becoming public Trump ultimately released the aid and Zelenskyy declined to open the investigation.

Alongside that is Trump’s barely disguised admiration for the world’s authoritarian leaders who operate free from the guardrails of a US political system that Trump has frequently sought to degrade.

For European nations struggling to deal with the Trump Administration’s attitude to the war in Ukraine, the options are not easy ones. While Macron and UK Prime Minister Sir Keir Starmer are seeking to engage with Trump, other European leaders have adopted a more fatalistic outlook. Following the German federal election on 23 February, chancellor-in-waiting and former Atlanticist Friedrich Merz stated that day, “I would never have thought that I would have to say something like this ... but, after Donald Trump’s remarks last week ... it is clear that this [US] government does not care much about the fate of Europe. ... My absolute priority will be to strengthen Europe as quickly as possible so that, step by step, we can really achieve independence from the USA.”

Meanwhile, back in the US there has been a backlash against Trump’s indifference to Ukraine’s fate on both sides of the US political aisle. A typical example of this was a statement by the Democrat US Representative Mike Quigley, co-chair of the Congressional Ukraine Caucus, who stated on 20 February, “For years, the far right has parroted Kremlin talking points about the war in Ukraine. Now, those same talking points are coming out of the White House. Let me make it clear to President Trump: Putin is a dictator who illegally invaded a sovereign, democratic nation. He has overseen mass atrocities in Ukraine, including the bombing of hospitals; the rape, torture, and murder of civilians; and the kidnapping of thousands of Ukrainian children. This does not make him a ‘smart’ or ‘savvy’ leader. This makes him a war criminal.

“Donald Trump’s betrayal of Ukraine,” Quigley added, “sends a clear message to our allies that we cannot be relied on, we will not stand by our word, and that we choose autocrats over democracy. The President and his cronies should be ashamed.”

The extent to which such voices will be heard, however, remains to be seen.

## UK prime minister announces immediate boost to country’s defence spending

(pf) UK Prime Minister Sir Keir Starmer has announced an immediate upturn in UK defence spending in light of the war in Ukraine and the apparent abandonment of defence solidarity with Europe by the US Trump Administration.



[Parliament TV]

Addressing the UK House of Commons on 25 February 2025, Starmer declared, “Starting today, this government will begin the biggest sustained increase in defence spending since the end of the Cold War. We will deliver our commitment to spend 2.5% of GDP on defence, but we will bring it forward so that we reach that level in 2027 and we will maintain that for the rest of this Parliament. Let me spell that out: that means spending GBP 13.4 billion [EUR 16.2 billion] more on defence every year from 2027.”

Starmer then said that, “On top of the funding of 2.5% that I have just announced, we will recognise the incredible contribution of our intelligence and security services to the defence of our nation, which means that, taken together, we will be spending 2.6% on our defence from 2027.”

While asserting that this additional investment in defence “means that the UK will strengthen its position as a leader in NATO and in the collective defence of our continent”, Starmer acknowledged that it “can only be funded through hard choices”, explaining that, “In this case, that means we will cut our spending on [international] development assistance, moving from 0.5% of GNI [gross national income] today to 0.3% in 2027, fully funding our increased investment in defence.”

In introducing his spending boost statement to the House of Commons, Starmer made four key points, the first of these being that the fundamentals of British defence strategy are unchanged and that “NATO is the bedrock of our security and will remain so”.

“Secondly,” said Starmer, “we must reject any false choice between our allies – between one side of the Atlantic and the other.” While noting that the UK’s relationship with the US “is our most important bilateral alliance”, given that it “straddles everything from nuclear technology to NATO, Five Eyes, AUKUS and beyond”, Starmer asserted that “strength in this world also depends on a new alliance with Europe” and that “now is the time to deepen it”.

Thirdly, Starmer said that “for peace to endure in Ukraine and beyond we need deterrence” and that the UK “will continue to stand behind the people of Ukraine”, adding, “We must ensure that they negotiate their future, and we will continue to put them in the strongest position for a lasting peace.”

Lastly, Starmer said of the UK, “We must change our national security posture because a generational challenge requires a generational response”, even though this would “demand some extremely difficult and painful choices”, and that the country “must also seek unity: a whole-society effort”.

## Ukrainian Air Force receives its first Mirage 2000s and more F-16s

(pf) The Ukrainian Air Force (PS ZSU) has received its first ex-French Mirage 2000-5F fighters along with another batch of Dutch F-16s.

French Armed Forces Minister Sébastien Lecornu stated on his X account on 6 February 2025, “On June 6 2024 [French President] Emmanuel Macron announced the delivery of French Mirage 2000s to Ukraine. The first of them arrived in Ukraine today. With Ukrainian pilots on board who have been trained for several months in France, they will now participate in defending the skies of Ukraine.”

Ukrainian President Volodymyr Zelenskyy posted on X the same day, “Ukraine’s air fleet continues to develop. The first Mirage 2000 jets from France have arrived, adding to our air defence capabilities. I thank Emmanuel Macron for his leadership and support — France’s president keeps his word, and we appreciate it. This is another step in strengthening Ukraine’s security.”

“With the latest deliveries, we are also continuing to expand our F-16 fleet, with the Netherlands fulfilling its commitments to support this effort. I am grateful to everyone who helps and contributes to this.”

Referring to the French Mirage 2000 and Dutch F-16 deliveries as “a long-awaited

reinforcement”, Ukrainian Defence Minister Rustem Umerov stated on Telegram, “These modern combat vehicles are already in Ukraine and will soon begin to perform combat missions, strengthening our defence and ability to effectively counter Russian aggression.”

“I am grateful to France for this strategically important contribution to our security – [the] Mirage 2000 will become a new element of protection of Ukrainian skies,” he said, adding, “The support of the Netherlands is another important step that brings us closer to victory and ensures reliable protection of Ukrainian cities and citizens.”

The Netherlands has pledged to transfer 24 F-16s to Ukraine and delivered the first of these in October 2024.

It is not known how many Mirage 2000-5Fs the PS ZSU is receiving, but Ukraine reportedly requested 12. According to the *FlightGlobal World Air Forces* directory, the French Air and Space Force had 26 Mirage 2000-5Fs still in service at the beginning of 2025. The type officially entered French service in 1999, having been upgraded from French Mirage 2000Cs that entered service from 1983.



[X\_R Umerov]

The Mirage 2000-5F is primarily an air defence platform and was the first French fighter to integrate a 'Fox 3' fire-and-forget missile capability, allowing pilots to engage multiple targets simultaneously and at long range. However, Lecornu has previously stated that the French jets donated to Ukraine were to be upgraded with an air-to-ground capability, which will allow them to carry SCALP-EG cruise missiles and AASM Hammer rocket-assisted guided bombs as well as MICA beyond-visual-range air-to-air missiles.

The PS ZSU received its first second-hand F-16s in August 2024, with Denmark, the Netherlands, Belgium and Norway all committing to donate F-16s to Kyiv as their air forces transition to the F-35.

France's Mirage 2000s are being replaced by the Rafale.

## IDEX 2025: Milrem Robotics unveils Havoc 8x8 RCV concept

(pf) Estonian unmanned ground vehicle (UGV) specialist Milrem Robotics unveiled a new 8x8 robotic combat vehicle (RCV) concept at the IDEX 2025 defence exhibition, held in Abu Dhabi from 17-21 February.

A full-size mock-up of the RCV, called the Havoc, appeared at IDEX on the expansive stand of Emirati defence conglomerate EDGE Group, which owns a majority share in Milrem Robotics.

The Havoc RCV is 6.5 m long, 2.7 m wide and weighs around 12 tonnes without payload. Propelled by all-wheel hybrid electric drive (HED) powertrain that offers near-silent movement capabilities, the Havoc has a maximum road speed of 110 km/h, a maximum off-road speed of 50 km/h and a range of 600 km. Mobility-wise it is stated to be able to negotiate gradients up to 60%, side slopes up to 40%, vertical steps of 0.6 m and can ford waters up to 1 m deep.

The Havoc's roof has been designed to accommodate any payload up to five tonnes. The mock-up presented at IDEX 2025 featured a turreted 30 mm cannon, although a Milrem Robotics video presentation at IDEX 2025 also showed payload modules that included a counter-unmanned aerial vehicle (C-UAV) system, an anti-tank missile launcher, counter-battery and surveillance radar fits and a turreted mortar.



[P Felstead]

Speaking to *ESD* at IDEX 2025 on 18 February, Milrem Robotics Chief Sales Officer Patrick Shepherd noted that the Havoc could accommodate a main weapon up to 57 mm in calibre.

"Weighing substantially less than conventional manned 8x8 vehicles, the [Havoc] RCV boasts superior off-road performance, making it highly effective in rugged terrains," Milrem Robotics stated in a company press release. "Its cutting-edge electric driveline delivers instantaneous torque, enabling faster response times and enhanced mobility. Additionally, the vehicle's pivot steering capabilities allow for a dramatically reduced turning radius, ensuring optimal manoeuvrability in environments ranging from open deserts and urban combat zones to high-altitude mountain passes."

The company additionally noted that, by sharing common subsystems with other Milrem Robotics UGV and RCV platforms, the Havoc has significantly reduced development, procurement and maintenance costs. It also operates on a unified autonomy ecosystem that aligns with Milrem's existing platforms, which Milrem says guarantees compatibility and scalability across a diverse range of autonomous solutions.

Milrem Robotics' Shepherd explained to *ESD* that the Havoc has been designed as a force multiplier especially suitable for smaller forces that have to patrol large expanses of terrain.

"You can cover huge amounts of areas and, with Starlink and other satellite communications, these vehicles can operate far in front of the actual operators," he said. "In Sweden we just did a test with the Swedish Defence Forces where, using Starlink, we were able to communicate to a range of more than 900 km with no delays and no safety concerns. So having that same system in a larger vehicle with a 30 mm cannon, a mortar, or any type of air defence system that could be set up gives you a huge operational advantage over any other land army because you're going to have a forward line of robotic systems that's operating and engaging with targets ahead of critical manned assets."

"What our Ukrainian customers are doing is they're using the robots to identify where are the enemy's critical capital assets, artillery systems, tanks, heavy bunkers," Shepherd added, "and then they use that information to manoeuvre the main elements in a much safer and much more effective manner."

Shepherd said Milrem had already had several customers interested in using an RCV as part of a manned-unmanned teaming formation, an example of this being where an RCV would autonomously move alongside a platoon of tanks to provide C-UAV cover. Such a mission would be especially relevant to the tracked version of the Havoc, called the Vector, which is at a similar stage of development as the 8x8 Havoc.

Shepherd noted that the Havoc and Vector share numerous common subsystems – such as the powerplant, batteries, cooling system, control algorithms and autonomy kit – with the exception of the transmission drivelines, which are fundamentally different between the wheeled and tracked RCVs. The first functional Vector RCV will be up and running in 2026, said Shepherd. With regard to Havoc, meanwhile, he remained

somewhat coy. “We have a system; I don’t know when it’s going to be disclosed to the public,” he said. “Once you see it, you realise what we’re doing. It’s very, you know, we’re all engineers, right? I think we’ll probably show it to the public at IDEX in 2027.”

In the meantime, Milrem is continuing with reliability and functionality testing with both Havoc and Vector to make sure they operate as intended.

## IDEX 2025: T-90MS forms centrepiece of Russian exhibits in Abu Dhabi

(pf) The Russian defence industry took advantage of the lack of an embargo at the IDEX 2025 defence exhibition, held in Abu Dhabi from 17-21 February, to display its latest defence technology.

In a Russian display area at IDEX 2025 that covered almost 1,000 m<sup>2</sup> in which more than 40 Russian defence manufacturers displayed their products, the centrepiece was an example of the T-90MS main battle tank (MBT) produced Uralvagonzavod (UVZ), which was displayed by Russian state export agency Rosoboronexport is ostensibly aimed at the export market.

The T-90MS on display featured a number of upgrades resulting from Russia’s combat experience in Ukraine over the last three years. The most visible of these were a frame over the turret with a woven mesh screen, petal-like PPC panels surrounding the sides and rear of the turret and a post-mounted mesh screen around the rear of the tank to provide protection against attack from so called first-person-view (FPV) drones, which have claimed so many Russian tanks in Ukraine (UVZ literature states that the mesh screens, which also hang around the front of the turret, are additionally protection against high-explosive anti-tank (HEAT) rounds).

A modernised version of the T-90 MBT, the T-90MS was demonstrated in Russia in 2011 and was first displayed internationally at IDEX in 2013. With a combat of 48 tonnes, the T-90MS has as its main armament the 125 mm 2A46M-5 or 2A46M-6 smooth-bore gun served by an autoloader. In addition to standard natures of 125 mm ammunition this can also fire the 9M119M laser-guided projectile out to a maximum range of 5,000 m. As well as a coaxial 7.62 mm PKTM machine gun, the T-90MS is additionally armed with a remote-controlled 12.7 mm 6P7K machine gun on the turret roof.

The T-90MS features a computerised fire control system and the gunner is provided with a stabilised TV/thermal imaging (TI) sighting system with laser rangefinder and missile guidance sighting system, while the commander has a day/night panoramic sight with TV and TI channels and a laser rangefinder. According to UVZ, the T-90MS sighting systems have an identification range for an MBT target of 5,000 m by day and 3,300 m at night.

Propulsion-wise, the T-90MS is powered by a multi-fuel liquid-cooled four-stroke diesel with turbo supercharger that develops 1,130 hp, according to UVZ literature, which lists the tank’s maximum highway speed as 70 km/h. For protection the T-90MS features Relikt explosive reactive armour (ERA) in addition to its main armour and the export-var-



[P Felstead]

iant Arena-E active protection system, although the T-90MS displayed at IDEX 2025 featured additional ERA panels on the turret top and sides and the rear of the hull. According to a Rosoboronexport press release at IDEX 2025 the T-90MS also features a counter-UAV electronic warfare system.

Meanwhile, among the other Russian exhibits was a new version of the Pantsir-S air defence system. Designated the Pantsir-SMD-E, this system features an ammunition loadout that includes “48 TKB-1055 small-sized cost-effective missiles” to protect against all kinds of UAVs alongside the system’s longer-range surface-to-air missiles, according to Rosoboronexport.

Although the significant Russian industry presence at IDEX 2025 was obviously focused on securing new sales of military equipment into the Middle East, with regard to tank production Russia may well have to look to fulfilling its own domestic requirements first. At the International Institute for Strategic Studies’ launch event for its 2025 edition of *The Military Balance* in London on 12 February 2025, the institute’s analysts assessed that Russia lost 1,400 MBTs in the Ukraine War in 2024 and has lost a total of more than 4,000 MBTs since its invasion of Ukraine began in February 2022.

The institute additionally noted that, while Russia’s defence industry has demonstrated resilience, its current rates of production and the refurbishment of stored vehicles will not offset battlefield losses indefinitely, adding that Russia will not have sufficient MBTs to conduct effective offensive operations beyond early 2026 if it maintains the same operational tempo and suffers the same losses as in 2024.

## Japan orders 17 Boeing CH-47 Block II Chinook helicopters

(pf) The Japan Self-Defense Forces (JSDF) have ordered 17 CH-47 Block II Chinook Extended Range helicopters to modernise their fleet, replacing some of their CH-47JA aircraft, manufacturer Boeing announced on 13 February 2025.

The aircraft will be co-produced by Boeing and Kawasaki Heavy Industries (KHI). The two companies have collectively delivered over 100 Chinooks to the JSDF since the 1980s in one of the longest-lasting and most successful licence manufacturing programmes in Japan.



### [Boeing]

The Block II Chinook extended-range aircraft is Boeing's next generation of heavylift, multi-mission helicopter. The aircraft features an advanced digital cockpit, reinforced airframe, enhanced fuel tanks and other improvements, allowing increased performance and commonality with the expanding global fleet of updated Chinooks.

The adoption of a modern aircraft design and avionics architecture enables future technology upgrades and the ability to further expand operational capabilities.

Japan joins the United States, United Kingdom and Germany as the fourth global customer for this advanced configuration of the Chinook.

According to the 2025 edition of the International Institute for Strategic Studies' *The Military Balance*, the Japan Ground Self-Defense Force operates 44 CH-47J/JA Chinooks, while the Japan Air Self-Defense Force operates 15 CH-47Js.

## IDEX 2025: Norinco's SH16A wheeled 155 mm SPH makes its international debut

(Robert Czulda) China's SH16A wheeled 155 mm self-propelled howitzer (SPH) made its international debut at the IDEX 2025 defence exhibition, held in Abu Dhabi from 17-21 February.

The SH16A is a product of state-owned Norinco (China North Industries Group Corporation) that was first unveiled relatively recently, in November 2024, at the China International Aviation and Aerospace Exhibition in Zhuhai.



### [R Czulda]

The SH16A is mounted on an 8x8 VN23 chassis, whereas the earlier SH16 was mounted on a 6x6 truck chassis.

The SH16A's weight, including a full ammunition load, is 36 tonnes. The crew consists of a driver and one or two gunners. According to the manufacturer, the new model features an enhanced hull and better mobility in difficult terrain. Its maximum speed is 110 km/h.

The vehicle is equipped with an adjustable suspension system, allowing for air transport, as well as improved protection against mines and improvised explosive devices. Its armour system, reported rated as equivalent to STANAG 4569 Level 4, provides resistance against some anti-tank weapons as well as shell splinters and small arms fire.

The SH16A features an automatic loading system and a remotely controlled gun, enabling operation of the howitzer from outside the vehicle. The gun is capable of firing a variety of ammunition, including guided rounds, and has a declared maximum range of up to 56 km. The turret can carry up to 30 rounds.

One of the key innovations of the system is its laser ignition technology. According to the manufacturer, this ensures a more stable and synchronised ignition compared to traditional methods. The Chinese report two modes: direct ignition, where the laser directly initiates the charge; and multi-point ignition, where the laser energy is transmitted via a fibre optic system, enabling simultaneous firing of charges at multiple points.

## Saab relaunches third and final Gotland-class boat after mid-life upgrade

(pf) The Swedish submarine HMS *Halland* was relaunched after a comprehensive mid-life upgrade at Saab's shipyard in Karlskrona on 13 February 2025.

Originally commissioned in October 1997, HMS *Halland* is the third and final Gotland (A 19)-class submarine in the Swedish Navy to undergo the upgrade, which includes new technologies and systems of the same type that will be used in Sweden's future Blekinge (A 26)-class submarines.

During the modification more than 20 of the central systems in HMS *Halland* were replaced, including sensors and command systems. These systems are the same as those that will be used in the Blekinge class.

The upgrade means that HMS *Halland* will be able to carry out maritime missions for many years to come with new capabilities, alongside sister submarines HMS *Gotland* and HMS *Uppland*, which have previously undergone similar mid-life modifications.

The first of two Blekinge-class submarines is not expected to be delivered before 2027, but these boats will replace the Swedish Navy's Södermanland-class submarines, of which one remains in operation.

The ability of the Gotland-class boats to operate covertly with great endurance make them a valuable asset in the Baltic Sea, where the layered waters make it particularly difficult to detect submarines.

## Saab UK officially inaugurates new state-of-the-art campus near Fareham

(pf) Saab UK officially inaugurated its new state-of-the-art campus near Fareham, Hampshire, on 4 February 2025.

The site actually began operating several months ago, but was officially inaugurated with a visit from Saab President and CEO Micael Johansson and UK Secretary of State for Business and Trade Jonathan Reynolds.



[Saab]

The site's activities cover two main areas: developing, manufacturing and supporting Saab's radar systems; and providing a new location for Saab's Seaeye business, which is a world leader in developing electric underwater robotics.

As a radar production and maintenance site, the new campus will particularly benefit the UK armed forces, providing in-service support for their Giraffe 1X and Giraffe AMB air defence radars and Taipan (Arthur) artillery-locating radars. It will also double Saab's radar production capacity alongside the company's existing facilities in Gothenburg, Sweden, to respond to new orders.

As a new state-of-the-art facility for Saab's Seaeye business and its range of underwater remotely operated vehicles (ROVs), which are used for defence applications as well as in several commercial sectors, the Fareham site could find itself at the forefront of UK and allied efforts to protect critical undersea infrastructure from malign Russian and Chinese interference.

The radar production at Fareham has been achieved through a technology transfer from Sweden, but Saab also has plans to grow sovereign UK intellectual property out of the Fareham site.

Asked at a press facility at the site on 4 February how Saab will achieve this, Johansson told ESD, "This radar technology that we have transferred here has great potential to improve in terms of functionality: AI [artificial intelligence] algorithms and stuff like that. So you can easily build software IP locally if you have a team doing that. That's why I mentioned this must be an innovation hub as well; not only a manufacturing site.

Andy Fraser, group managing director for Saab UK, added, "The Seaeye business, our underwater robotics centre of excellence, that's a full product life-cycle business: a great example of where we invest in research and development of new products and take them all the way through, get them in hands the user and then support them through their life."

## SpearUAV names Yiftach Kleinman as its new CEO

(pf) Israeli loitering munition manufacturer SpearUAV has appointed Yiftach Kleinman as its new CEO, the company announced on 24 February 2025.

Kleinman, who previously served as the company's deputy CEO and executive vice president commercial, brings over 25 years of executive experience in the global defence sector. He will replace Gadi Kuperman, SpearUAV's founder, who will continue as chief technology officer and chairman of the board. As Kleinman steps into the CEO role, his mission is to accelerate SpearUAV's growth and drive the company toward even greater strategic opportunities in the global market, particularly in the loitering munition field.



[SpearUAV]

Throughout his career Kleinman has led high-profile defence programmes and secured multi-billion-dollar contracts with international customers and leading original equipment manufacturers. As deputy general manager of Rafael Advanced Defense Systems' Land & Naval Division, he managed a multinational portfolio valued at approximately USD 300 million (EUR 287 million), including the company's largest acquisition.

## Cohort completes acquisition of Australian satcom specialist EM Solutions

(pf) UK defence technology group Cohort completed the acquisition of Australian satellite communication (satcom) terminal specialist EM Solutions on 31 January 2025, thus expanding its naval defence offer and reinforcing the group's presence in Australasia.

EM Solutions is a developer of innovative microwave and on-the-move radio and satellite products that help to deliver high-speed telecommunications across the world. EM Solutions' principal activity is the design, assembly test, and support of satellite on-the-move terminals for defence and government customers. The company also provides high-end broadband radio transceivers and other radio frequency subsystems such as low noise receivers and solid-state high-power transmitters for defence and commercial customers.

EM Solutions will become the seventh independent business within the Cohort stable and will report through Cohort's Communications and Intelligence Division.



[Cohort]

# Anti-submarine warfare: A scalable approach

Dr Sidharth Kaushal

**The growing and increasingly-quiet submarine fleets of potential adversaries present Western navies with a resource-intensive challenge using traditional ASW approaches. This article examines a number of more cost-effective and scalable alternative methods that may allow navies to do more with less.**

The prosecution of anti-submarine warfare (ASW) represents one of the most complex aspects of combat at sea. Quiet nuclear-powered submarines and diesel-electric boats present navies with elusive targets which require multiple assets to track a single contact. This is, however, an approach which is difficult to scale against multiple contacts. In theatres such as the Indo-Pacific where China's People's Liberation Army Navy (PLAN) fields 60 diesel electric and nuclear attack submarines, or Europe's high North, where the Russian Northern fleet is regenerating itself after a post-Cold War nadir in strength, these

challenges will be keenly felt. The challenge of mass will be compounded by another factor, namely that newer submarines fielded by likely Western adversaries are increasingly quiet. For example, the Russian *Yasen/Yasen-M* class submarine is comparable in quietness to the most modern western variants. Quietness, in turn, compels the allocation of even more assets to track an elusive contact over a wide area. The purpose of this article is to describe alternative approaches to ASW which are more scalable than current models.

## The challenge with ASW

Presently, the process of tracking a submarine follows a series of well-defined steps. First, an initial contact is provided by an undersea hydrophone network like the US' Integrated Undersea Surveillance System (IUSS), formerly known as the Sound Surveillance System (SOSUS). Although these networks are occasionally capable of generating relatively high-fidelity returns

(at the peak of its performance SOSUS was able to pinpoint submarines to within a 97 km (60 mi) radius) they primarily serve to cue other means of detection. When a fixed array generates a contact, a maritime patrol aircraft will typically be dispatched in order to localise a target. This can be achieved either with sonobuoys or with sensors such as the aircraft's on board magnetic anomaly detector (MAD), though the latter only operates over short distances. An aircraft might attempt to prosecute a target with its own on-board lightweight torpedoes such as the US' Mk 54, or the contact may be passed to another tracking platform such as a frigate or submarine.

The challenge that this model entails is twofold. First, each contact ties up multiple tracking assets in a way that makes scaling difficult. Take maritime patrol aircraft (MPA), for example. To

provide continuous coverage at the GIUK gap, roughly 12-14 P-8 MPA must be kept on station. Between them, the UK and Norway field 14 P-8s, and it should be presumed that not all aircraft will be at readiness at all times. Furthermore, this approach is inherently sensitive to disruption – small losses due to, for example, attacks on airfields with missiles, or aircraft being downed by ship-based surface-to-air missile (SAM) systems, can have a disproportionate impact.



- ▲ **Russia's K-560 Severodvinsk, the first and only vessel of the Project 885 Yasen design, with subsequent boats in the class based on the upgraded Project 885M Yasen-M design. Boats of this class are very quiet, representing a challenging target to track. [Russian MoD]**

### AUTHOR

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operating sonar only in passive mode. For many Alliances such as NATO, frigates are not a capability in short supply (although not all are equipped with LFA sonar), and to some extent the choice may simply be one of accepting a higher loss rate in the pursuit of an operational end.

Improvements in processing power are making it increasingly viable to employ LFA sonar, which has relatively low propagation losses, enabling detection of submarines with accuracy over long distances. The effectiveness of LFA sonar can be enhanced if operated as part of a multistatic array with uncrewed systems. For example, an uncrewed surface vehicle (USV) equipped with

a low-frequency passive towed array receiver, and deployed 50 km ahead of a frigate equipped with an LFA, would effectively double the range of the sonar (in this case, in the forward direction relative to the USV), by reducing the transmission losses of the sound wave, when compared to mounting both transmitter and receiver on the same vessel. Moreover, the more nodes there are in a multistatic system, the more difficult it is to track the emitter, which in turn makes going active somewhat safer.

▲ **A US Navy P-8A Poseidon in flight. While capable, there are limits to where such assets can be employed safely. [US Navy/MC 2nd Class Mike DiMestico]**

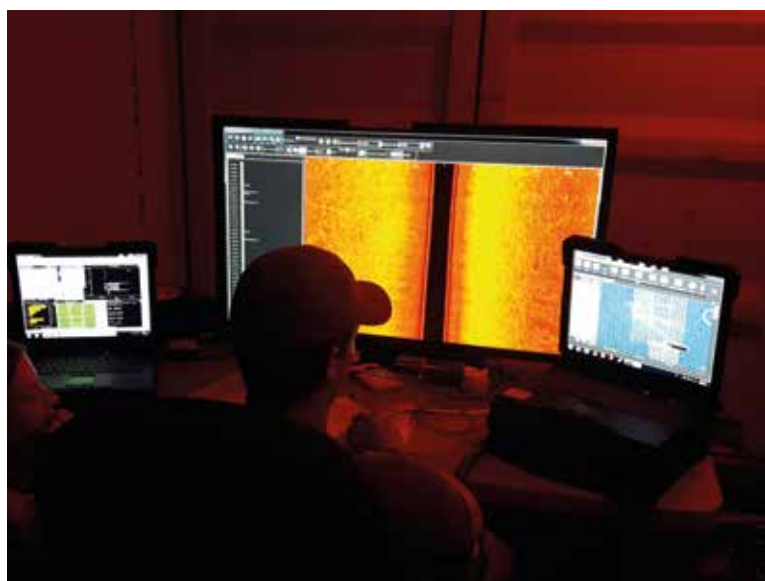
Secondly, the approach described depends on assets which can patrol freely, such as MPA. Yet if a submarine threat needs to be contained near contested airspace, this becomes inviable. This is certainly the case in the Indo-Pacific, where the containment of Chinese submarines at chokepoints such as the Bashi Channel would require US and Allied MPA to operate in airspace which the People's Liberation Army Air Force (PLAAF) may very well dominate in the opening stages of a conflict. In Europe, similarly, the ability to contain Russian nuclear-powered guided missile submarines (SSGNs), such as the Yasen-M class at the Bear Island-Svalbard gap will become increasingly critical if these submarines are to be prevented from launching cruise missiles at key military and civil installations in northern Europe. This, in turn, requires both aircraft and surface vessels to be placed close to Russian bastions, where a range of threats from the Tu-22M3 backfire to the SSGNs' own missiles will likely pose a challenge. This is not to say that vessels cannot operate under these conditions, but they will likely incur losses in a context where a limited number of ship losses (for example) can sink a resource-intensive ASW concept.

There are a number of things that navies can do in order to prosecute submarine contacts in a more cost-effective way. Many of these will, however, require considerable departures from both past practice and the metrics by which success is deemed to have been achieved.

## The importance of an active regime

The task of ASW has often been likened to a cat-and-mouse game between surface vessels built for quietness and submarines, with the risks of emitting high for both. In certain respects, this risk is greater under contemporary circumstances, given that submarines equipped with heavyweight torpedoes and cruise missiles often outrange the surface vessels hunting them.

Despite this, however, an active detection regime may be unavoidable if the number of vessels needed to cover an area is to be reduced. Modelling conducted by the author on the agent-based modelling software NETLOGO suggests that in an area such as the Barents Sea, frigates operating low-frequency active (LFA) sonar on an active basis can systematically defeat the Russian Northern Fleet even with minimal MPA coverage – albeit at the cost of a much higher attrition rate than when



▲ **Royal Netherlands Navy (RNLN) UUV operators, examining sonar imagery to locate possible exercise sea mines in post-mission analysis, during the RIMPAC 2018 exercise. [US Navy/RNLN LT Maurice van Ginneken]**

The uncrewed systems which can be equipped with towed array sensors need not be particularly costly and in many instances commercial-grade systems can serve this role. For example, at least one Chinese firm has advertised the conversion of an uncrewed underwater vehicle (UUV) originally built for oil and gas sector surveillance to the PLAN.

In principle, USVs can also be used as active emitters, but this imposes size and cost requirements given the power consumption of active sonar (with the detection of a submarine type target at 10 km requiring 500,000 W of power, for example). Here,

the use of less-bespoke maritime platforms may make more sense. The containerisation of ASW solutions, such as towed array processing modules can just as easily be applied to active solutions, and can allow for auxiliary vessels taken up from the civilian market to support these functions as well. To be sure, such vessels would be highly vulnerable and the requirements of networking them with a dedicated naval asset are considerable. However, a submarine crew would also have to consider the risks inherent to sinking a relatively cheap ship at the cost of creating a flaming datum – the last known location of the submarine – for more dedicated ASW assets to prosecute. It should also be noted that the integration of containerised systems is never a simple systems engineering task, with requirements for cooling and integration with a vessel's power plant often representing a highly complex activity. Navies would thus likely have to procure and adapt any auxiliaries they intend to use in this capacity in peacetime. The core point, however, is that the quiet ASW frigate, while still the most irreplaceable part of a network, need not be its only surface-based component.

#### ▼ Launch of a Yu-8 long-range ASROC. [Chinese MoD]



Notably, standoff sensors are most useful if the data they generate can be usefully employed quickly. Despite this, many navies have not invested in long-range anti-submarine rockets (ASROC), with key exceptions including China's PLAN, which has fielded the 50 km range YU-8, and the JMSDF which has fielded the 30 km range Type 07. While it is unsurprising that this has not previously been a priority given the short ranges at which a target can be classified as target, as localisation and classification becomes viable at longer ranges, the ability to exploit this will depend on standoff effectors much as it does in surface warfare.

## SIGINT

The use of signals intelligence (SIGINT) to track submarine activity is not new. However, it may gain a new salience due to the growing importance of cruise missiles to submarine activity. Very few modern submarines are incapable of at launching cruise missiles, and in some navies (such as the Russian Navy) older Project 971 *Shchuka-B* (NATO reporting name: Akula) class submarines are being refitted to carry missiles such as the 3M-54 Kalibr (the anti-ship variant of the Kalibr cruise missile family). Tactically, however, this introduced a greater requirement for communication with offboard sources. Submarines can identify the range and bearing of moving targets from long distances, but for target-grade data they require offboard cueing. During the Cold War, for example, the USSR's Project 949/949A *Granit/Antey* (NATO reporting name: Oscar) class nuclear attack submarines (SSNs) were to be cued by the Soviet Tselina electronic intelligence (ELINT) satellites. Land attack missions, while simpler, also require coordination with other missile launchers and in some cases the communication of mission programming data for missiles (though this may be pre-loaded before a submarine departs). This need for offboard communications, coupled with the increasing convergence of SSNs and SSGNs therefore creates new opportunities for ELINT gathering.

In this context, platforms such as medium-altitude long endurance (MALE) uncrewed aerial vehicles (UAVs) can become increasingly useful as a means of gathering data regarding emissions. While the use of UAVs as substitutes for MPA has been mooted, their employment in a SIGINT role is more mature as illustrated by use cases in the land domain. Ground- and space-based SIGINT platforms can also provide wide area surveillance, as illustrated by the ongoing conflict in Ukraine, where the US XVIII Division was able to provide the Ukrainians with a SIGINT and ELINT soak 32 times a day. As submarines increasingly become a deep strike capability, they will have many of the same dependencies and vulnerabilities as other strike platforms.

## A whole-of-society approach

There are a number of sources of data within the ocean which states do not own. For example, the earliest adopters of UUVs have been the oil and gas sector – a point which became apparent to the Norwegian Navy after the severing of a key cable near Lofoten, which prompted it to leverage the 600 or so commercial UUVs operated by the oil and gas sector. Similarly, the Italian Navy recently signed a deal with that nation's largest internet provider to leverage data from undersea cables which are sensitive to, among other things, changes in background pressure.

The data held by private sector actors is proprietary and understandably sensitive, however it is possible to manage these concerns through a number of avenues. One approach, for example, is applying the 'publish-subscribe' model to data fusion. This does not require the underlying source data from a system to be shared; the only information which is critical is the fundamental structure of the data, which allows for the creation of translation layers which can merge it into a shared format. Equally, it should be noted that governments have

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- ▼ **The oil and gas sector was an early adopter of UUVs (such as the Kongsberg Hugin pictured here), providing a commercial fleet which could potentially be leveraged for ASW purposes when urgently needed. [Kongsberg]**



been willing to compel the private sector to share data in the service of counterterrorism, arguably a less-pressing concern than the states which pose credible submarine threats. As such, coercive options cannot be entirely foreclosed, although some companies which represent data sources can fall across multiple jurisdictions, and so would require the coordination of policy across Alliances and coalitions. More incentive-based approaches might be another avenue. In its recent effort to ensure that US company SubCOM was able to participate in a consortium building the SEA-ME-WE cable between Asia and Europe, the US government secured the company credit on favourable terms through the Export-Import Bank of the United States (EXIM). Favourable access to credit could also be used by nations to incentivise the sharing of data, and if a supranational organization (for instance, the EU) led this process, data secured could be disseminated more easily among members.

### Suppression as an alternative to destruction

Many of the most cost effective means of disrupting a submarine's activity may depend on suppression rather than

destruction. Take, for example, many UAVs such as the MQ-9 and the UK's Protector which have been considered for ASW roles. While it is an open question whether these craft can in the near term be equipped with the processing power needed to play a role comparable to dedicated MPA such as the P-8, their persistence is a virtue in of itself. For example, a UAV laying fields of decoy sonobuoys which mimicked the emissions of active sonobuoys, such as the US' AN/SSQ-62 would, at a minimum, force more evasive activity on the part of submariners than would normally be the case. In this vein, a UAV sonobuoy laying capability was recently demonstrated by an MQ-9B SeaGuardian during tests by manufacturer GA-ASI in January 2025.

In a similar manner, minelaying represents a cheap means of complicating submarine activity even when it imposes limited attrition – though it should be noted that mines can be highly lethal at chokepoints, such as those in the Pacific first island chain. This is a major assumption for the PLAN, which intends to use its large fleet of maritime militia vessels to seed minefields near the first island chain as a low-cost means of complicating transit near the first island chain. More sophisticated mines such as the US' Quickstrike series can be cued by the magnetic signature of a nearby boat, as well as by other sensors. It is noteworthy that in the Second World War, mines accounted for the majority of submarine kills on both sides, and even when submarines evaded them, their presence limited the time which a vessel could dedicate to useful activity.

### No panacea, but many effective solutions

There are no straightforward ways of tracking submarines, which remain among the most complex targets in modern warfare. However, efforts to exploit advances in data processing as well as a more risk-acceptant active-sensor-centric approach to employing vessels can limit the challenge posed by submarines. In addition, it must be recognised that to defeat the threat posed by submarines, they need only be kept inactive or focused on evasion, rather than destroyed, even if the latter is optimal. A range of tools, many of which exist in the civilian sphere, can be better-leveraged to allow navies to achieve this.



- ▲ **In January 2025, an MQ-9B SeaGuardian UAV (pictured) demonstrated its capability to deploy sonobuoys via underwing mounted sonobuoy dispensing pods, one of which is visible here. [GA-ASI]**

# Turning the tide: NATO, national, and multinational efforts build Baltic CUI security

Dr Lee Willett

**In mid-January 2025, NATO stood up ‘Baltic Sentry’, an activity designed to build surveillance presence to deter increasing threats to critical undersea infrastructure (CUI) on the Baltic seabed. This move is one of several national, multinational, and wider NATO activities that have been established and integrated to address the Baltic CUI threat.**

CUI vulnerability has been a long-standing theoretical risk for NATO and its member states, with senior military leaders first publicly pointing out this vulnerability around a decade ago. However, the theoretical risk became reality on 26 September 2022, when two Nord Stream gas pipelines were ruptured by explosions off the Danish island of Bornholm in the Baltic Sea. No responsibility for the damage was formally claimed or attributed.

This did not prove to be an isolated incident. What could be construed as a campaign against Baltic Sea CUI perhaps began in October 2023, when the BalticConnector gas pipeline and several communications cables running between Estonia and Finland were damaged. In November 2024, an internet cable connecting Sweden and Lithuania and a telecommunications cable connecting Finland and Germany were cut. On 25 December 2024, the EstLink2 power cable and several nearby internet cables again running between Estonia and Finland were damaged. The cause of all three incidents since October 2023 has not been formally confirmed publicly: however, national and NATO public and political debates have focused on the possible involvement of ‘shadow fleet’ commercial vessels doing the damage by dragging their anchors across the seabed while sailing at speed.

## AUTHOR

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‘Shadow fleet’ ships are commercial vessels that appear to be trying to operate below the ‘registration radar’, running without automatic identification system (AIS) switched on when at sea, and having ownership trails that are difficult to trace ashore. Such ships are often associated with sanctions-busting activities like smuggling oil to and from countries that are under international embargo on such imports and exports.



▲ **Following a succession of CUI incidents in the Baltic Sea between October 2023 and December 2024, NATO stepped up its military presence across the region, for example through ‘Baltic Sentry’.** [Dr Lee Willett]

The Baltic Sea is a very busy shipping environment, with all types of commercial and naval vessels present there, using and securing in turn what are crucial international sea lines of communication (SLOCs) that cross it. It is also a very busy CUI environment, with its seabed criss-crossed by numerous CUI nodes of different types.

Broadly, CUI nodes include: oil, gas, and other natural resource pipelines; communications, data, and power cables; environmental and other monitoring sensors, both civilian

and military; oceanographic/hydrographic research instrumentation; and energy 'hardware' like windfarms, oil rigs, and wave-power generation and other resource platforms.

The Baltic Sea's relatively shallow depths, when combined with its dense CUI and shipping patterns, lends the region to being an area in which rogue state or non-state actors might conduct a campaign of targeting CUI while attempting to maintain plausible deniability.

## Threat response

Following the December 2024 incident, NATO Secretary General Mark Rutte said NATO would increase its military presence in the Baltic Sea region. NATO had been ramping up its regional presence for some time, given the deteriorating security situation there and Finland and Sweden's accession to NATO (in April 2023 and March 2024, respectively).

mander Task Force (CTF) Baltic, the German Navy's newly established tactical maritime headquarters, can conduct tactical control of ships operating under MARCOM command.

General Christopher Cavoli – a US general serving as Supreme Allied Commander Europe (SACEUR) – said in the SHAPE statement that “‘Baltic Sentry’ will deliver focused deterrence throughout the Baltic Sea and counter destabilizing acts like those observed [in December 2024]. It is indicative of the alliance's ability to rapidly respond to such destabilization, and shows the strength of our unity in the face of any challenge.”

The MARCOM-based NATO Centre for Security of CUI (NMCSCUI) was established in June 2023 and made responsible for operational-level networking and expertise support for countering CUI threats, as one of two NATO CUI co-or-



- ▲ **NATO SNMCMG1 flagship HNLMS Luymes is pictured deployed on the Alliance's 'Baltic Sentry' activity. Visible on the horizon is CUI infrastructure that the deployment is there to secure. [Dr Lee Willett]**

While eight Baltic states are now NATO members, the fact that Russia is not means the Baltic remains a contested environment. Baltic Sea maritime access is increasingly significant for Russia in relative terms, with its Mediterranean maritime access more restricted, following Türkiye closing the Bosphorus and Dardanelles Straits to all navies (with an exception for vessels returning to their home port) in the wake of the full-scale Russian invasion of Ukraine in February 2022, and with port access in Tartus, Syria no longer available after the fall of the Assad regime.

For NATO, the establishment of 'Baltic Sentry' was, however, a significant, formal statement of intent to build presence and surveillance deterrence against the CUI threat. Announcing on 14 January 2025 that 'Baltic Sentry' was operational, the Supreme Headquarters Allied Powers Europe (SHAPE) said that Allied Command Operations (ACO) would oversee the multi-domain activity. Under ACO, Joint Force Command Brunssum leads the joint operational element, including synchronising multi-domain activities. NATO Allied Maritime Command (MARCOM) is co-ordinating enduring maritime presence activities throughout the region. Com-

dination cells (the other being the Brussels-based, strategic-level, Critical Undersea Infrastructure Coordination Cell, established in February 2023). The Centre will support 'Baltic Sentry' through providing decision-making and activity co-ordination input relating to CUI protection and response. Such input includes building information sharing to help Allies better understand the operating environment.

Two NATO standing naval forces (SNFs) are committed to supporting the task – Standing NATO Maritime Group 1 (SNMG1), and Standing NATO Mine Counter Measures Group 1 (SNMCMG1). These are MARCOM's North Atlantic-focused SNFs. While their remit is North Atlantic-wide, the increasing Baltic security threats including the CUI challenge mean they are spending more and more time there.

SNMG1 is activity lead. At the time of writing, it consists of: The Royal Netherlands Navy's (RNLN's) *De Zeven Provinciën* class air-defence and command frigate HNLMS *Tromp* as flagship (with the RNLN commanding the group); the Belgian Naval Component's M class frigate BNS *Louise-Marie*; the French Navy's Type A69 *D'Estienne d'Orves* class patrol

vessel FS *Enseigne De Vaisseau Jacoubet* and *Durance* class auxiliary vessel FS *Somme*; along with the German Navy's K130 *Braunschweig* class corvette FGS *Magdeburg*.

SNMCMG1 consists of: the RNLN survey ship HNLMS *Luymes* (as flagship, embarking a Belgium-led command staff); the German Navy *Frankenthal* class coastal mine-hunting vessel FGS *Datteln*; and the RNLN Tripartite/*Alkmaar* class mine-hunter HNLMS *Schiedam*.



- ▲ **An Atlas Elektronik SeaFox remotely operated vehicle is recovered onboard the German Navy *Frankenthal* class mine-hunting vessel FGS *Datteln*, during a 'Baltic Sentry' capability demonstration. NATO's two SNFs deployed on the activity bring a range of surveillance capabilities to counter the CUI threat. [Dr Lee Willett]**

Since 'Baltic Sentry' was launched, Finnish and Swedish naval ships – namely the *Hamina* class fast-attack patrol vessel FNS *Pori*, and the *Visby* class corvette HSwMS *Visby* – have operated within SNMG1. These two navies, plus for example the Estonian Navy, have also been conducting national operations across the region to counter the CUI threat.

Together, the two NATO SNFs bring significant surveillance presence in a multi-domain context, but with particular emphasis on surveilling surface threats, as NATO seeks to build situational awareness and situational understanding (SASU) through enhancing the recognised maritime picture, including assessing who might be doing what, and where, on the surface. SNMG1 also brings deterrence punch in the form of its high-end anti-air, anti-surface, and anti-submarine capabilities. SNMCMG1 brings sub-surface and seabed surveillance capability expertise: the former, in the form of remotely operated uncrewed underwater vehicles (ROVs/UUVs); the latter, in the form of explosive ordnance disposal (EOD) divers.

Overall, across the two SNFs and other national platforms operating alongside them in what is known as 'associated support' – whereby an asset is not committed formally to the SNF, but uses its presence locally to support the group's op-

erations – the 'Baltic Sentry' order of battle (ORBAT) includes surface ships, submarines, satellites and radars, uncrewed systems, and fixed-wing aviation including maritime patrol and fast jet aircraft. In the latter context, the presence of two Royal Netherlands Air Force F-35s overhead of the two SNFs in the eastern Baltic early on in 'Baltic Sentry' may have been designed to send a message to any rogue state actor, perhaps supporting the CUI campaign that NATO is putting high-end military muscle behind 'Baltic Sentry' in both the maritime and air domains.

With this range of capabilities assembled to provide deterrence through presence and surveillance, 'Baltic Sentry' is designed to shine a light onto the activities of the 'shadow fleets' and other rogue elements that may be supporting a CUI threat campaign. "We're the eyes and the ears," Commodore Arjen Warnaar – Commander (COM) SNMG1 – told *ESD* onboard *Tromp* during a media day at sea in the Gulf of Finland, as 'Baltic Sentry' got under way. "We know something has happened. We're increasing our patrols. We're showing ourselves. We're monitoring basically everything here at the moment. That sends a clear message." Cdre Warnaar added, "If something is going to happen here, it's highly likely we'll detect it."

Alongside sending a deterrence message to rogue actors, SNMG1 and SNMCMG1 are present in the Baltic to send a reassurance message to allies. For example, in February 2025, SNMG1 conducted a port visit to Gdansk, Poland while SNMCMG1 called into Liepāja, Latvia. According to MARCOM statements, the two SNF COMs discussed CUI issues in the region and how the SNFs can support NATO Allies.

The SNFs, including those in the Baltic, can also be used to support wider NATO operational capability developments. For example, in late February, *Tromp* – plus Danish and German naval vessels – supported a combined MARCOM/NATO Allied Command Transformation (ACT) capability demonstration involving integrating uncrewed surface vessels (USVs) into SNF operations, as part of the process of preparing the capability to support ACO operational requirements and activities, especially enhanced vigilance presence, across the Euro-Atlantic theatre.

- ▼ **The Royal Netherlands Navy frigate HNLMS *Tromp* – SNMG1 flagship, including on 'Baltic Sentry' – is pictured working with uncrewed surface vessels (USVs) during a NATO capability demonstration in the Baltic in February 2025. [NATO MARCOM]**



It could also be construed that conducting such a capability test was designed to demonstrate to any actors behind a CUI campaign that more capability could now be made available to counter this threat.

## Technical assistance

Alongside providing assurance and operational assistance, NATO is also developing its capacity to counter the Baltic Sea CUI threat and the evolving underwater challenge more widely within the context of NATO efforts to harness autonomy and digital capabilities to improve at-sea surveillance.

NATO's new Task Force X initiative is central to this effort. Created under ACT and announced on 5 February 2025, Task Force X will develop a fleet of autonomous systems to provide persistent surveillance, detect and track threats, and enhance maritime situational awareness (MSA) especially in the underwater battlespace, NATO said in a statement. The Baltic CUI threat is illustrative of this requirement, it added. Underlining the impact of its role, Task Force X provided USVs and other inputs for the Baltic Sea capability demonstration. ACT and ACO work together on Task Force X to develop capabilities that exploit emerging and disruptive technologies like autonomous systems and artificial intelligence (AI) in maritime operations to enhance MSA in support of SLOC and CUI security, the statement continued. Task Force X provides a framework for NATO states to contribute autonomous capabilities to Alliance activities in an integrated manner. A core focus for Task Force X will be capability interoperability and scalability.

Outlining the plan for Task Force X back in January 2025, Secretary General Rutte said *"We have agreed today to launch an initiative to deploy new technologies to this [CUI security] effort, including a small fleet of naval drones, to provide enhanced surveillance and deterrence. We are also working with allies to integrate their national surveillance assets with NATO, ensuring comprehensive threat detection."*

In the NATO statement, Admiral Pierre Vandier – a French naval officer, and Commander (COM) ACT – said *"Task Force X will integrate uncrewed systems with existing naval forces, before transitioning to a fully autonomous fleet operating independently to counter threats and protect critical infrastructure. It will collect data between uncrewed systems and other emergent technologies, fuse that data within a resilient network, and utilize AI to shape MSA."*

## Multinational approaches

Alongside the NATO and national efforts targeting the Baltic CUI threat, non-NATO multinational efforts are playing a part. For example, back in January 2024, the UK-led, 10-country Joint Expeditionary Force – Maritime (JEF-M) task group conducted a large-scale deployment into the Baltic Sea to provide, again, deterrence through presence and surveillance. In the wake of the outbreak of the Russo-Ukraine war, JEF – established back in 2014 – moved to develop JEF Response Options (JROs) to enhance the sub-threshold, non-NATO security contribution it could make for Allies and partners in the North Sea/Baltic Sea region. This particular deployment – JRO 3.2, which involved more than two dozen ships, plus aircraft, from across the JEF membership – covered waters stretching from the western Barents Sea to the eastern Baltic seas. While not being a NATO activity, its focus on maritime security threats such as Baltic CUI was designed to support NATO's enhanced vigilance requirements for the region.

Alongside providing physical deterrence presence in the Baltic, JEF has also moved to counter the activities of 'shadow fleet' vessels looking to operate there. In January 2025, JEF activated for the first time what the UK Ministry of Defence (MoD) referred to, in a statement on 5 January, as an advanced reaction system designed to track potential CUI threats and monitor Russia's 'shadow fleet'. Named 'Nordic Warden', the AI-based system is designed to assess data, including from AIS networks, to calculate the risk



- ▲ **Norwegian assets contribute to Joint Expeditionary Force – Maritime (JEF-M) CUI security patrols in 2024. JEF-M is an example of multinational, but non-NATO, efforts to secure CUI in the Baltic and elsewhere across the Euro-Atlantic theatre. [Norwegian Armed Forces]**

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posed by any vessel entering areas of interest. This included, the statement noted, specific Russian 'shadow fleet' ships. If a particular risk is perceived, the system will send out a real-time warning to JEF participant countries and NATO allies. According to the statement, 'Nordic Warden' covers 22 areas of interest, across the English Channel, North Sea, the Kattegat and Skagerrak Straits, and the Baltic.

Countering threats such as the Baltic CUI challenge requires a range of responses, from strategic, to operational, to tactical. 'Baltic Sentry' in one sense covers all three, being a strategic-level response to what is a clear and present threat to Alliance interests, with the response manifested in operational and tactical activities. From the JEF perspective, its Baltic deployment and the development of 'Nordic Warden' are operational- and tactical-level components. Responses across all three levels must be underpinned by effective, task-relevant capability.

In terms of delivering security across the Euro-Atlantic theatre, NATO is – in a simple sense – a 'hub' around which security can be built. Multi-national constructs like JEF can be seen as 'spokes' that mutually support and reinforce the 'hub'. Another 'spoke' in the North Sea/Baltic Sea region is the Northern Naval Capability Co-operation (NNCC) construct. In 2022, six Northern European countries – Denmark, Finland, Germany, The Netherlands, Norway, and Sweden (Finland and Sweden then as non-NATO members) – established NNCC to assess how to build industrial collaboration to augment naval capability. The first formal meeting was held in Copenhagen, Denmark on 26 September 2022 – the same day the Nord Stream pipelines were blown up. Responding to the CUI threat became an immediate NNCC priority, as the six countries looked to seize the opportunity to 'do something' collectively about the problem – especially through harnessing the 'mass' in uncrewed capabilities and underwater knowledge possessed by the commercial sector, to help build maritime SASU, particularly in the underwater domain. Thus, NNCC established the Seabed Security Experimentation Centre (SeaSEC) in December 2023.

SeaSEC is currently under Dutch lead and headquartered at Scheveningen in The Netherlands. However, plans include options to rotate leadership and headquarters location. SeaSEC is looking to build SASU at a joint and combined level across the North and Baltic seas by exploiting existing technology available in the commercial sector. Collaboration between navies and industry is key. SeaSEC is not setting out to provide an incident response capability. However, it aims to improve collective capability for underwater detection, tracking, data processing, and information transfer,

plus fusing information from different sources, to generate actionable information at the speed of relevance to support response options and increase deterrence against CUI threat actors and activities.

To help build capability to achieve this aim, the SeaSEC headquarters boasts conference, planning, and virtual testing facilities ashore, plus a 26 km<sup>2</sup> area for at-sea testing, including a dedicated 2.6 km<sup>2</sup> exclusive area where objects can be placed on the seabed for training without risk of accidental interference by other sea users. With seabed depths



▲ **A USV is pictured operating off Scheveningen, The Netherlands during a SeaSEC capability demonstration in June 2024. SeaSEC aims to harness commercial industry uncrewed system capabilities to help secure North and Baltic Sea CUI. [Netherlands MoD]**

of up to 20 m offshore, with a sandy bottom, and with other CUI close by, Scheveningen's area is ideal for testing detection of threats such as buried explosive devices, or anchors being dragged across the seabed. SeaSEC calls its combined virtual/real training capability 'sandbox and salt'. This integrated approach is focused on SeaSEC's primary geo-operational task – to help identify small objects on the seabed.

Alongside being a 'hub' for sharing technology and information, SeaSEC is also a 'hub' for sharing ideas. It is a location where navies can test conceptual and operational use cases for securing CUI, and where they can do so in partnership with industry: navies get to know how industry can contribute to meeting the surveillance requirement; and industry gets to know how navies want it to contribute to the surveillance requirement.

In capability terms, SeaSEC focuses on testing systems with higher technology readiness levels (TRLs) – for example, TRL6 or upwards – to test capability that is more developed and perhaps more ready for use. Indeed, the focus on integrating naval and commercial maritime capabilities underlines how addressing the CUI threat is very much a multi-agency function.

Rear Admiral Fredrik Lindén – a Royal Swedish Navy submariner currently posted as Director Naval Systems at Sweden’s defence materiel agency FMV (Försvarets materielverk), told ESD that using the phrase ‘CUI protection’ rather than ‘seabed warfare’ can help clarify which sector or which agency is best suited to tackle which part of the CUI threat. Using the term ‘seabed warfare’ risks it being seen as a naval matter and not as a wider concern that requires a combined, integrated civil-military response.

In purely naval terms, the changing nature of the threat across the Euro-Atlantic theatre, and the outbreak of conventional war, demonstrates that a ‘just in time’ mindset to defence procurement needs to be replaced by ‘just in case’ approach, with NATO countries in a dynamic now of trying to catch up with the threat, said Rear Adm Lindén.

explosive devices, placed around a pipeline; detecting and reporting any anomalies on the seabed in a set area; monitoring a set of transect lines, detecting anything that crosses the line and identifying what it may be (such as an uncrewed system or a diver); and demonstrating the ability to send data back to shore.

SeaSEC is also looking at the role of USVs in providing surveillance and information to counter the CUI threat, noting that USVs will be a central element of future naval force structures and their requirement for surface-based surveillance in dealing with, for example, CUI threats. SeaSEC’s work with industry underlines the extent to which tackling the CUI threat requires a multi-sector, and multi-agency approach. Its model can have relevance to other capability areas across NATO, and European Union (EU), naval operational requirements.



- ▲ **A USV operating off Scheveningen in the sunset. SeaSEC is due to host its next industry event in May 2025, comprising a number of capability demonstrations and challenges. [SeaSEC]**

## Seabed challenge

SeaSEC has already hosted industry capability demonstrations on two occasions, in December 2023 and June 2024, where the use of uncrewed vehicles and the use of information were tested and developed. The next step will be taken in May 2025, when industry will gather at Scheveningen for a 10-day ‘Challenge Week’ period.

Several ‘Challenges’ will be conducted, including: finding, tracking, and identifying unknown underwater vehicles operating in an area; finding small objects, which could be

The Baltic CUI threat, and the political support in place to tackle it, due to the clear and present challenge it poses to NATO and national interests in terms of the risk to key daily societal requirements including access to data or power supplies, is underlining to NATO countries the need to build MSA as a whole, but especially in the underwater domain, as well as the wider importance of using the sea to deter threats to Alliance interests. The response through deploying SNMG1 and SNMCMG1, or the JEF-M task group, plus building capability through SeaSEC, underline that a response can be generated using available technology and sharing available data to tackle the threat.



# Growing affordable mass in the underwater battlespace

Richard Scott

**BAE Systems' Herne extra-large autonomous underwater vehicle (XLAUV) completed initial in-water trials in late 2024, barely a year after commencing development. What was behind this fast-track effort, and how was it achieved?**

A number of testbed systems have been funded for at-sea testing, including the UK's Project CETUS technology demonstrator (being delivered to the Royal Navy [RN] by MSubs) and Anduril's Ghost Shark (co-developed in conjunction with the Royal Australian Navy and the Defence Science and Technology Group).



The US Navy is a step ahead with its Orca Extra Large Unmanned Undersea Vehicle. Boeing was in 2019 contracted to deliver six Orca vehicles to meet a Joint Emergent Operational Need in the Indo-Pacific region. Delivery of the first vehicle (XLE-1) to the US Navy is imminent, with follow-on Developmental and Operational Testing (DT/OT) running through the third quarter of Fiscal Year 2025. After completion of DT/OT, Unmanned Undersea Vehicles Squadron 3 will complete crew certification, and XLE-1 will be ready for deployment.

Seeing a market opening up in the short-to-medium term, the Maritime Services business of BAE Systems has latterly entered the fray with a self-funded XLAUV development and demonstration effort known as Herne (the name commemorating a mythical phantom huntsman). Initially taking the form

of a technology testbed based on an existing commercial vehicle, the company's capability roadmap envisages an 'operationalised' system being ready for market in mid-2026.

## Accelerated schedule

Herne was announced to the world at the DSEI 2023 exhibition in London in September 2023. At that time, BAE Systems set out its ambitious plan to get a technology demonstrator into the water and under test by the end of 2024.

That accelerated schedule demanded that the company think carefully about how it could deliver at pace. Key to this was partnering with Cellula Robotics, a marine technology group based in British Columbia specialising in long-range AUVs for subsea survey, science and security. Cellula's 12 m, 8 tonne Solus-XR modular free-flooding AUV provided an off-the-shelf platform that could be customised to deliver military capability.

"What we saw [with Cellula] was a really agile and flexible company that was very quick in moving to market," said Nick Martin, BAE Systems' Herne project manager. "It brought all the advantages of a commercial business which we could marry with our military knowledge."

▲ **BAE Systems Herne XLAUV began in-water demonstrations in November 2024, little over a year after commencing development. [Richard Scott/NAVYPIX]**

Recent years have seen growing interest in the utility of long endurance, large payload robotic submersibles as 'force multipliers'. This reflects a view that advances in autonomy, navigation, energy systems and sensors have now matured to a point where 'attritable' undersea systems could traverse hundreds or even thousands of kilometres to perform critical and covert missions in often 'non-permissive' environments – think mine laying, special forces support, protection of critical underwater infrastructure (CUI), intelligence surveillance and reconnaissance (ISR), and anti-submarine warfare (ASW). Such XLAUVs would deliver greater coverage and allow large and expensive crewed assets to be freed up for other tasks, while at the same time removing personnel from traditionally 'dull, dirty and dangerous' missions.

### AUTHOR

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▲ **Cellula Robotics' Solus-XR vehicle provides the baseline platform for Herne. [Richard Scott/NAVYPIX]**

Currently depth-rated down to 3,000 m, the Solus-XR AUV offers up to 5,000 litres of payload space. "The vehicle design philosophy adopts a strongback design, with an aluminium structure that free floods," said Martin. "The advantage of that is that it is much more affordable to manufacture than a 'dry' vehicle, and much more adaptable in because you don't have to rate the entire vehicle, only the pressure cans within it."

The Herne demonstrator is configured with self-contained payload modules located fore and aft, each of which can be lifted out as a single unit, added Martin, "Herne is intended to host a wide range of mission-specific payloads. Swap-out takes about 90 minutes, and requires the removal of just four bolts and detachment of two data connectors."

The vehicle design offers the option to relocate or consolidate the payloads. "There is no reason in the future why the payloads couldn't be at the front, or both at the back," said Martin.

Solus-XR is neutrally buoyant, being filled with synthetic foam, and so uses two large forward planes to give control authority to dive underwater. Alongside twin three-bladed propellers aft – used for long distance transit – the vehicle also features horizontal and vertical thrusters, plus X-form control surfaces aft, to allow for high levels of slow-speed manoeuvrability and/or precise station-keeping in the water column. A hard ballast system is incorporated in the AUV design. This compensates for the increased buoyancy arising from the reduced mass should a payload be deployed from Herne.

BAE Systems and Cellula Robotics began engineering work to develop the Herne demonstrator in September 2023, the same month as the teaming was announced at the DSEI 2023 exhibition. "The vehicle did not exist up until that point," said Martin. "The first dive [of the vehicle] was at the end of July 2024 [in British Columbia]. So that was 'whiteboard to water' in just 11 months."

Meeting this timeline demanded a high degree of concurrency in development. In practice, this was relatively straightforward: Cellula Robotics simply shared information on the payload space and interface specifications, allowing BAE Systems to move ahead with its payload development activity in the UK without any need to 'touch' the platform in Vancouver.

What transforms the basic Solus-XR AUV into Herne is the implementation of military-specific autonomy, integration and assurance. In big handfuls, this can be broken down into BAE Systems' own Nautomate autonomous control software; a flexible 'sense, decide and effect' payload integration engineered through mission-specific plug-ins; and system-level assurance – for example IT security and military communications – to enable use in military applications and environments.

"We're trying to embrace COTS, not gold-plate it," said Tim O'Neill, BAE Systems Maritime Services' business development manager. "If we want to enable combat mass, then we understand that this needs to be affordable." He amplified: "Cellula is providing us our baseline platform. What we are then doing is taking our Nautomate 'brain in a box' and putting it into the underwater domain. Nautomate is the core control architecture that drives into the platform...it manages what the platform is doing based on sensing and charting."

Nautomate has been developed as a scalable autonomy architecture for both surface and sub-surface vessels. Its key functionalities include situational awareness (fusing inputs from multiple sensors to improve the accuracy and integrity of its world model); smart collision avoidance (mimicking the way a human considers potential collision risks and identifying safe avoidance manoeuvres); and command and control (C2). Mission-based plug-ins are used to facilitate advanced autonomy behaviours, support payload integrations, and/or quickly update software with new algorithms.

"We want to be flexible, and able to perform multiple missions," O'Neill explained: "The key for us is how to adapt a commercial off-the-shelf vehicle, adapt it for military purpose, and then package and deliver that for a navy to use



▲ **The Herne demonstrator is configured with self-contained payload modules fore and aft. Swap-out takes about 90 minutes, and requires the removal of just four bolts and detachment of two data connectors. [Richard Scott/NAVYPIX]**

and support.” He expounded: *“That’s where we add value, through our deep knowledge of naval platform design. It’s the trust in the autonomy, with no human-in-the-loop. The integrity and reconfigurability of the software. The security of data and communications. The payload integration. And the accuracy of the navigation solution.”*

As an example, the persistence and range afforded by the Solus-XR vehicle led BAE Systems to specify an upgraded inertial navigation system (INS) sourced through Sonardyne. “The navigation system sits within Nautomate, which serves as the core architecture that drives into the platform,” said O’Neill. “It manages what the platform is doing based on sensing and charting.” He added, “At the same time, [Nautomate] it is also managing the payload through the mission plug-ins. Those sit ‘on top’ of the Nautomate core to run the mission.”

Another feature of Solus-XR is its portability. Designed to fit inside a 12 m (40 ft) ISO container on a bespoke skid, it can be transported inside an A400M airlifter or stowed inside a warship mission bay. Deployment is via a standard two-point lift (compatible with a dockside crane, a commercial davit or a standard RN davit). BAE Systems has also looked at submarine hosting and air-drop deployment.

“That launch and recovery piece is key when you are talking about integration into the fleet,” O’Neill observed. “This has to be deployable, whether that’s in an expeditionary setting from a ship, or sailing out from a port. It’s about providing that flexibility for the user.”

The Herne demonstrator vehicle is currently configured with standard Lithium-ion batteries. Located in the mid-section of the vehicle, these offer 2-3 days’ endurance at low speed. Lithium technology already offers scope to push endurance out to 8-9 days, but BAE Systems is already looking at alternative energy solutions, said Martin. “One of the reasons we picked Cellula is because they are working to bring a hydrogen fuel cell to market. This would provide for a submerged range of up to 5,000 km, and that is hitting a sweet spot with a lot of the use cases we have studied.”

## ISR demonstrations

True to its word, BAE Systems performed first in-water demonstrations towards the end of 2024. Undertaken in waters around a commercial port in south England over a two-week period in November, this activity showcased Herne in an operational ‘vignette’ designed to demonstrate an ISR mission. Representatives from 10 nations - including both NATO and Five Eyes partners - were invited to observe.

The ISR vignette required the Herne vehicle to conduct a covert sub-surface harbour entry; navigate autonomously; collect video using an ISR mast and identify a hostile target; and then share ISR data when safe. To enable the ISR mission, BAE Systems has developed a low-profile ISR mast - hosting cameras and communications - which is stowed in a fairing on top of the Herne vehicle. “This actuates upwards above the waterline,” Martin explained. “So what the vehicle



▲ **The Herne XLAUV demonstrator pictured on the surface with its ISR mast extended. [Richard Scott/NAVYPIX]**

can do is hover just beneath the surface, raise the mast and come to what is essentially periscope depth, and just sit there for hours collecting information.”

Three different software plug-ins were demonstrated in the ISR vignette: goal-based mission autonomy (enabling the Herne vehicle to autonomously re-route so as to avoid a series of drag net hazards); machine vision (processing 4K camera imagery to classify ships by type); and track-and-follow (exploiting the camera feed to shadow a rigid inflatable boat ‘target’).

“These demonstrations have sought to showcase where the company has invested, and focused effort,” said O’Neill. “They have also served as a check that we’re going in the same direction as our customers.”

## Next steps

Building on this initial demonstration, BAE Systems now looking at how it further matures Herne. “We’re sitting down with Cellula to explore a number of threads going forward,” O’Neil said. “That will include iterations to the platform, looking at any changes or improvements with regard to power, propulsion, speed, efficiency and signature.” He added, “That said, what Cellula have got - their strongback design, the modularity and the flexibility - is still going to be the core. What we will be doing is layering on top of that.”

BAE Systems is aiming to have an initial production-standard Herne variant ready for market by mid-2026. “In 18 months’ time we want to be able to offer this as an operational bat-

tle-ready configuration,” O’Neill said. “That will include the option for hydrogen fuel cells.”

“That’s a tight timeline,” he added, “and so we’re clearly not going to build three, four or five vehicles in that period. So we will go through some changes, and make those physical instantiations. But a second vehicle is something we are certainly looking at from the platform development side.”

Alongside this, O’Neill noted, “We’re trying to be proactive so that when navies are more confident of their needs, and their concepts of operation, we are ready to respond. And by adapting an existing off-the-shelf [vehicle] platform we can significantly reduce the time and cost to market.”

Further development of Nautomate is continuing in parallel: for example, building additional mission-based plug-ins, and evolving the ‘intelligence’ in the system. BAE Systems will also evaluate overall ‘useability’ aspects such as launch and recovery, in-service maintenance, and through-life support. “If these things aren’t easy to use, and easy to look after, and easy to live with, they are not going to deliver what navies want” said O’Neill, “So there is a delivery of capability to think about in the first instance. But we have to remember that it’s got to be there for an extended period of time. So it’s got to be useable, and we need to look at this a whole system. That includes the whole ‘ecosystem’ around communications, networks, and combat systems.”

As regards future payloads, definition work has already started for an ASW package. Maturing this particular use case reflects growing interest in the role that XLAUVs could play as part of a wider ASW barrier comprising a heterogeneous mix of uncrewed assets.

“We want to have thin-line passive towed array that is reelable within the platform,” O’Neill said, “That makes it covert – you don’t want to have a mother ship attaching a clip-on array and then streaming it. So you would want to have a reeling machine and array integrated into the payload bay”. O’Neill added, “The other ASW piece I’d like to try out, and see if it is feasible, is setting up Herne within a multistatic ASW environment. That is a bigger challenge because of the need to time-stamp data and get that transmitted back to the hub is key.”

Multistatics delivers an enhanced ASW capability by processing the multiple returns from a combined field comprising an active source and several passive receivers. This creates multiple acoustic pathways within the water space, thereby greatly increasing the probability of gaining a detection of an evading submarine.

“It comes back to freeing up crewed platforms to do what they do best,” said O’Neill, “If you’ve got a Type 26 frigate, with a Sonar 2087 active tow, why not use that as your active source and then deploy multiple passive receivers in consort.

“This means that the submariner has no idea in which direction returns from the ‘pings’ are being detected. Yes, he knows where the ‘ping’ is coming from, but there is no way of knowing where his target echo is being picked up. That’s a gamechanger” O’Neill emphasised, “So there are a number of different ASW scenarios we want to look at. And the only way we are going to learn is by getting [Herne] in the water.”

Electronic warfare is an additional use case under study. The thinking here, said O’Neil, is to employ Herne as a covert, forward deployed capability. “Whether that’s interception, deception, disruption or jamming, there are various payloads that we and the scientific community want to try on the masts.”

Networking with other assets is another agenda item for 2025. So too is work on the deployment of a remotely-operated vehicle (ROV). O’Neill explained, “Cellula have already done some work deploying an ROV from Herne. We’d like to revisit that to understand how that could support CNI investigation and protection at depth.”



- ▲ **XLAUVs will allow large and expensive crewed assets to be freed up for priority tasks, while at the same time removing personnel from ‘dull, dirty and dangerous’ missions. [Richard Scott/NAVYPIX]**

# From lab to ship: Portuguese Navy charts course towards integrated MUS operations

Dr Lee Willett

The Portuguese Navy has been leading the way amongst NATO navies in developing maritime uncrewed system (MUS) technologies. Now, including at the national level, it is seeking to accelerate delivery of these systems into integrated maritime multidomain operations (MDO).

Adm de Sousa – who stepped into the Chief of Navy post at the very end of 2024, having previously been in an operational post as Deputy Chief of Staff of Portugal's Joint Operations Command – has a combined vision consisting of maintaining and developing further the Navy's MUS technology, while integrating this with enhanced operational de-



- ▲ **The Portuguese Navy's MEKO 200 PN Vasco Da Gama class frigate NRP *Corte Real* (right) is pictured sailing with Standing NATO Maritime Group 1 in 2022. The Portuguese Navy is a driving force within NATO for developing maritime uncrewed system (MUS) capabilities, and is now pushing to integrate such capabilities more quickly into maritime operations. [NATO MARCOM]**

The drive towards tactical integration of MUS technology is proceeding under the leadership of Portugal's new Chief of Navy, Admiral Jorge Manuel Nobre de Sousa. It builds on the significant technological advances delivered by his predecessor, Admiral Henrique Gouveia e Melo.

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velopment of MUS capability through concepts of operation (CONOPS) and tactical employment. The advances the Navy has made in MUS technology are now enabling the service to drive forward MUS CONOPS and tactics to match the pace of the technology change.

This position was explained to ESD by Captain Antonio Mourinha, in an interview on 16 January 2025. Capt Mourinha is Innovation Adviser to the Chief of Navy, having served until late 2024 as director of the Navy's Centre for Naval Operational Experimentation (Centro de Experimentação Operacional da Marinha: CEOM). CEOM is headquartered in Tróia on Portugal's southern coast, and runs the Navy's operational experimentation (OPEX) programmes including the annual 'REPMUS' ('Robotic Experimentation and Prototyping with Maritime Unmanned Systems') multinational event, produced in partnership with NATO. The first step in delivering MUS op-

erations was to develop the technology, to provide the tools, Capt Mourinha said: now, the focus is on bringing the use of the tools up to speed. “We will keep the speed on both sides ... The emphasis is to balance both,” he explained.

Capt Mourinha has also been appointed as the first commanding officer (CO) of the Navy’s new flagship, Dom João Segundo: due to enter service in mid-2026 and known unofficially as the ‘drone carrier’ the ship is designed to support MUS MDO. The ship illustrates the Navy’s aim of continuing MUS technology development and transitioning this technology into operational capability. It will focus on experimenting with the delivery of MUS use in maritime research, safety and security operations, command and control (C2) for MUS MDO, and tactical-level integration elements such as MUS launch and recovery and human-machine interface. “It is going to be very interesting but challenging,” said Capt Mourinha. “In terms of ship organic MUS use, this is going to be where the rubber hits the road.”

## REPMUS evolution

MDO C2 was a major focus in ‘REPMUS 2024’, and will remain so in ‘REPMUS 2025’. “It is really important to keep advancing this piece of work,” said Capt Mourinha.

‘REPMUS’, held in Tróia each September, is certainly where the rubber hits the road. The exercise has become a mainstay for NATO and member state MUS capability maturation. Its long-established focus on technology development has evolved rapidly in recent years towards applying that technology at tactical and operational levels in OPEX scenarios. ‘REPMUS’ is very much an iterative process, constantly building, refining, and improving not only MUS technology and how to use it, but the process of the exercise itself in order to enhance its outputs. Lessons learned each year are fed straight into the planning process for the following year.

- ▼ **Portuguese Navy’s ‘REPMUS’ exercise provides an annual opportunity for NATO navies to come together and conduct integrated testing of MUS capabilities and concepts in all domains. [NATO]**

One core element put in place in recent years at ‘REPMUS’ is the use of ‘virtual ships’, where a ship’s bridge and command structure is established in a shore facility. Several ‘virtual ships’ were used at ‘REPMUS 24’, including ‘ships’ from Portugal, Spain, the United Kingdom, and the United States. These ‘virtual ships’ are used as real-time, simulated environments into which MUS capabilities can be integrated. For ‘REPMUS 25’, the Navy aims to use a ‘virtual ship’ simulation of *Dom João Segundo*.

The ‘virtual ship’ environment allows the Navy to test how it may conduct integrated MDO involving MUS and crewed platforms, Commander Marco Guimarães – director of the Navy’s MUS technology innovation and development cell (Célula de Experimentação Operacional de Veículos Não Tripulados: CEOV) and CO of ‘virtual ship’ Lisbon during ‘REPMUS 24’ – told ESD during a January 2025 interview. Elements tested, he explained, included running MUS MDO onboard the ship, mixing C2 activities both onboard and offboard the ship (including ashore), using different C2 systems in the same operational environment, and testing Portuguese-made MUS that may be used onboard *Dom João Segundo*.

Central to the testing conducted at ‘REPMUS 24’ was the first use of the Portuguese Navy-developed ‘Mission Sync’ MUS C2 architecture. NATO is developing a common standard – effectively, a technological development blueprint – for MUS C2 operations at a tactical level, including the enabling C2 architecture. This is known as Standardisation Agreement (STANAG) 4817. ‘REPMUS’ has been testing two STANAG 4817-compliant architectures – or C2 ‘languages’: the UK/US-developed I2I (Interoperability to Interchangeability); and NATO in-house research and testing laboratory the Centre for Maritime Research and Experimentation’s (CMRE’s) CATL (Collaborative Autonomy Tasking Layer). Mission Sync – created by CEOV – integrates the key features of these architectures, providing a ‘REPMUS’-wide framework that all participants can ‘plug in’ to. Thus, Capt Mourinha explained that “Mission Sync is actually the first prototype of STANAG 4817.”

Using Mission Sync “was a path that was growing and building itself during ‘REPMUS 24’”, according to Cdr Guimarães. During the exercise, some participants were unaware of the need to use (or how to use) Mission Sync, of its benefits or importance, or of the use and meaning of certain language within it, he explained. This meant Mission Sync could not be used fully across all the exercise serials, with some different C2 formats used instead.

“This ... is something we kept as lessons learned from the exercise, and will try to correct on ‘REPMUS 25,’” Cdr Guimarães added. For example, some serials in ‘REPMUS 25’ will be conducted using only Mission Sync-capable or -compliant MUS, to help conduct experimentation at maximum value and to test and understand fully Mission Sync’s benefits for the serial.





- ▲ Portugal's Type 214 diesel-electric submarine NRP *Tridente* is pictured off Lisbon, Portugal in 2021 during NATO's 'Steadfast Defender' exercise. Portugal's 'REPMUS' testing includes developing NATO capability to build anti-submarine warfare barriers against both submarines and uncrewed underwater vehicles. [NATO]

"One lesson we took from 'REPMUS 24' is that Mission Sync is a very good tool for collecting information that can be used the following years," said Cdr Guimarães. "This information is now organised into different categories so we can make a very good assessment of a serial and how to replicate it in the future."

Capt Mourinha highlighted other lessons learned relating to Mission Sync use and benefits. First, he said, "The most important lesson applies not only for Mission Sync, but for the whole exercise: it is the importance of training and integration." Training for and integration into the exercise are the key points here, he noted: some participants were not ready to use some of the systems, including Mission Sync or other C2 elements. This impacts the exercise, with important time lost in preparation, Capt Mourinha explained. "'REPMUS' may seem a very long exercise when it runs for three weeks ... [but] we need to fully exploit the three weeks," he said. "So, in 2025, we will start earlier and have at least two days for training: we'll have workshops for C2, workshops for Mission Sync, and everyone is going to be there."

Second, Capt Mourinha continued, Mission Sync will bring new developments in information sharing. At 'REPMUS 2023', the MUS was able to connect into the 'virtual ship' network to share basic tactical data such as positioning, course, and speed. In 'REPMUS 24', Mission Sync was used as a common tool for sending and receiving tasking. For 'REPMUS 25', the aim is to add data exchange to the system's capacity, helping for example in changing tasking orders.

Such information-sharing capacity amongst MUS systems and with crewed platforms and C2 nodes will also be used in 'REPMUS 25' for sharing information relating to a new doctrinal development validated in 'REPMUS 24'. This development is called the 'OPSTAT MUS', Capt Mourinha explained. Routinely when a naval unit joins a task group, a message called the 'OPSTAT Unit' is shared with the group's command and C2 nodes, setting out the operational status of the unit's capabilities. An 'OPSTAT MUS' provides the capabilities of the MUS, including for example speed, range, and payload. "So, at 'REPMUS 25', the 'OPSTAT MUS' will flow using Mission Sync. This is also a big advance," said Capt Mourinha.

With Mission Sync, Capt Mourinha continued, "We are moving at pace to create a really important interoperability tool to conduct multi-domain MUS C2." "[It will help provide] the right information to the decision-maker in order to conduct the operation," Cdr Guimarães added.

## High-end impact

Alongside continuing to develop the architecture underpinning MUS capability development and operational use, 'REPMUS 24' also took key steps regarding operational concepts MUS capability support. Here, Capt Mourinha underscored some important capability developments in the underwater battlespace. "We did a lot of experimentation in the underwater battlespace, and we advanced in mine warfare, anti-submarine warfare [ASW], and critical undersea infrastructure [CUI] protection," he said. The mine warfare side saw improvements in tactical development and standardisation terms.

On ASW, 'REPMUS' is a major testing ground for NATO's ASW Barrier concept, which is designed to develop MUS capability for conducting bi- and multi-static sonar sensing for submarine detection. 'REPMUS 24' therefore presented an opportunity to mix ASW Barrier developments with another current NATO focus area – counter-UxV technologies and operations. "For the first time, we created a barrier [providing] detection capability for uncrewed underwater vehicles [UUVs]," said Capt Mourinha. "So, instead of only using the ASW Barrier as a barrier for submarines, we tested a more detailed and more complex construct where we set up a small barrier for UUV detection that could be used in harbour security, force protection, or other contexts."

Another 'first' was conducted in the CUI domain. "For the first time, we did deep-sea CUI protection," said Capt Mourinha. Shallow-water CUI serials were conducted in 'REPMUS 23'; at 'REPMUS 24', serials were conducted at depths beyond 600 m. "We tried to monitor and protect an undersea cable at that depth. We had some successes, some failures, but again we learned a lot," he said.

Counter-UxV concepts and capabilities were also tested on the surface, with uncrewed aerial vehicles (UAVs) used to conduct attacks against frigates to help develop kinetic and non-kinetic (for example jamming) force protection measures. This work is continuing with Spanish Navy involvement in early 2025, with Spain sending ships to test these concepts outside of the routine 'REPMUS' timeframe.

Indeed, Portugal is looking to use CEOM, a government-established 'free tech zone' testing area covering large parts of the region around Tróia, and the broader 'REPMUS' testing

construct to generate more regular technology testing opportunities across the year. Navies are looking to tap into the Tróia-centred testing network more regularly throughout the year, including the UK Royal Navy and the US Navy – the latter, with its US Sixth Fleet-based 'Task Force 66', which drives innovation in asymmetric capabilities to support allies and partners across the European and African theatres. Portugal's defence industry is also looking to exploit this testing capacity, for example developing regular, 'mini-REPMUS'-style events with the Portuguese Navy.



▲ The Vasco Da Gama class frigate NRP Alvares Cabral is pictured while deployed with a US Navy amphibious group in the Atlantic Ocean in 2021. The Navy has been developing counter-UxV capabilities, including defending surface ships against UAV threats. [US Navy]

In the time between 'REPMUS 24' and 'REPMUS 25', delivery will be completed of a new uncrewed surface vessel (USV) that will be central to the Navy's MUS testing and operations. The Trator do Mar (Sea Tractor) USV is fitted with a towed array sonar system to conduct grid-search pattern-based surveillance (this pattern can be thought of akin to a farming tractor ploughing a field).

"We are full steam ahead with Trator Do Mar," said Cdr Guimarães. The first USV was tested at 'REPMUS 24'. Further at-sea testing was conducted with these USVs in early 2025.

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◀ **A Schiebel S-100 Camcopter UAV and the UK's Royal Navy experimental vessel *Patrick Blackett* are pictured off CEOM's testing facility at Tróia, Portugal during 'REPMUS 24'. 'REPMUS' is a core part of the Portuguese Navy's process for building multi-domain operations with uncrewed systems. [Dr Lee Willett]**

By the end of March 2025, the Portuguese Navy is set to have received all four of an initial procurement batch. The new fleet will be readied to contribute to experimentation and serials at 'REPMUS 25', Cdr Guimarães added.

While the Trator do Mar USVs were delivered initially to CEOV, in 2025 the USVs – plus various UAVs – will be transferred to the Portuguese Navy's X31 squadron to add operational capacity, Capt Mourinha explained. X31 – which reports administratively to CEOM, and operationally to the Navy's Fleet Commander – is responsible for integrating the Navy's various MUS capabilities under a single operational unit. For Trator do Mar, Capt Mourinha said "X31 needs to develop the ability to use this."

## Experimentation to operation

For the Portuguese Navy, CEOM and CEOV are two of three centres used for conducting experimentation and testing of naval capability including MUS. The third is the Navy's tactical operations centre, CITAN. Just as CEOV develops the new technology, so CITAN will develop tactics, techniques, and procedures (TTPs) for using the new capability. Covering both organisations, CEOM then conducts certification and delivery of the technology and TTPs to the operational community.

"That's the way we are going to evolve our capabilities from now on," said Capt Mourinha. For MUS, "X31 will be the receiver for both the new equipment and the new TTPs." "X31 will be integrating these with the manned assets, including to build manned/unmanned teaming [M/UMT] concepts and constructs, using both organic and non-organic uncrewed systems," he added. "X31 is quite a small unit, but very powerful in the sense that they are delivering the operational effects and demonstrating the usefulness of uncrewed capabilities," Capt Mourinha continued.

Established in Tróia in 2023, X31 has had a very busy operational schedule to date, both at home and further afield, especially using UAVs. At home, X31 has conducted counter-narcotics tasks in supporting border security operations in southern Portugal. Further afield, it has conducted surveillance and wider maritime security operations in the Gulf of Guinea, including working with local navies. The unit has deployed onboard a frigate within NATO's Standing NATO Maritime Group 1 (SNMGI). Ashore, X31 personnel

and equipment have integrated with Portuguese Marines in Lithuania, supporting NATO's enhanced forward presence and assurance mission there.

Starting in 2025, the next steps for X31 include developing an MDO operational concept. Alongside using UAVs, Capt Mourinha explained, "X31 needs now to move to the operation of USVs and UUVs, all at the same time if possible." MUS multi-domain integration is something the Navy intends to demonstrate at 'REPMUS 25', harnessing CEOM's establishment there of a 'virtual bridge' for Dom João Segundo. X31 will need to be present to conduct integrated MUS MDO with the ship's emerging crew. X31 also will be extensively involved in developing Mission Sync, including use in real operations for MUS C2. For CEOV, it supports X31 with MUS integration onboard ships, as well as X31's at-sea operation of such systems. Here, the Navy is joining legacy platforms and new systems to conduct integrated operations in the form of M/UMT.

*"We will try different technologies and different communications systems integration not only with the assets, but between X31 vehicles and the organic platform, to make progress in having more assets that are organic to the ships, or that can be deployed and retrieved from onboard the ships, to reinforce MUS use onboard the ships we already have,"* said Cdr Guimarães.

Capt Mourinha and Cdr Guimarães both noted that 2025 will be a busy period in the Navy's MUS development, with important hurdles to clear. Yet clearing these hurdles will help deliver integrated operational output. "2025 will be the year we come from the laboratory to be onboard the vessels, to deliver effect onboard our ships," said Cdr Guimarães.

Delivering a new capability like MUS, and then integrating such a novel concept into MDO and M/UMT, is challenging. However, for the Navy, the operational benefits are clear. "It's complicated, but that's the reason we need to do it. We cannot run away from complicated things," said Capt Mourinha. "We need to sort it out, we need to do it well, because the wars of today and the wars of the future are complex", he added, "We need to be able to [operate] within a complex environment and complex C2 structure, to not be confused, to deliver properly, and to get advantage."



# Uncertain future: The deep crisis of Poland's submarine force

Lukasz Stach

The last few decades have been difficult for the Polish submarine force. Despite many plans to modernise the Polish submarine fleet, the Polish Navy currently has only one diesel-electric submarine (SSK) – the ex-Soviet Kilo class ORP *Orzeł*. This vessel is ageing and has not undergone extensive modernisation, meaning its combat capabilities are very limited.

## Plans and 'gap fillers': Poland's submarine force 1991–2023

After the collapse of the Soviet Union, the Polish Navy was in a similar state to the other branches of the Polish Armed Forces – oversized and mostly obsolete. With the country's

economic problems, the ensuing transition period, and the weakening of Russia under Boris Yeltsin's regime, the Polish Armed Forces and defence spending were significantly reduced. For the Polish Navy and its submarine force, the 1990s meant maintaining the status quo. This meant that cuts in defence spending made it impossible to buy new submarines. In 1999, the Polish Navy had the same number of submarines as in 1991 – two obsolete *Foxtrot* class vessels and one Kilo class SSK.

However, the next decade brought some changes: until 2003, two *Foxtrot* class units were withdrawn from service. However, the decommissioned post-Soviet warships were not replaced by brand-new submarines, but by second-hand vessels (so-called 'gap fillers'). These gap fillers came in the form of 4 *Kobben* class submarines received from Norway between 2002 and 2004. All these SSKs were old, though in good technical condition, and thus sufficient for training purposes. For a short time, this was an acceptable solution, but it did not solve the need for modern combatants. In 2008, the purchase of a modern Type 214 SSK from Germany was discussed. The submarine was originally built for the Hellenic Navy, but the Greeks pointed to defects in the boat and refused to commission it. The option of selling it to Poland was examined, but Greece and Germany reached an agreement in the end.

The 2010s can be considered to have been a 'lost decade' for the Polish submarine force. Despite various plans, very little was done to acquire new SSKs, or to modernise the sole submarine – ORP *Orzeł*. The 'Technical Modernisation Plan for the Polish Armed Forces' (three editions: 2013–2022,

2017–2026, 2021–2035), the 'Polish Navy Development Concept' and the 'Poland's Strategic Concept for Maritime Security' all emphasised the need to acquire new submarines. Polish officials maintained the vision of acquiring new submarines as a crucial element for the Polish Navy. In general, the documents (and the policymakers) sounded similar: new SSKs should be acquired immediately. Meanwhile, through numerous papers and statements, the real solution was essentially the same – plans were replicated, but never implemented.



▲ The ex-Soviet Kilo class ORP *Orzeł*, Poland's sole remaining SSK in service.  
[Polish Navy]

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In 2012, a programme for the purchase of SSKs for Poland codenamed Orka (ENG: Orca/Killer Whale) was launched. It assumed that Poland would purchase two SSKs by 2022 and a third by 2030. So far, however, no contract has been signed, and it seems that the Orka programme has been postponed. Moreover the Polish Navy is due to receive three new *Miecznik* multipurpose frigates. Assuming that there are no delays in delivery, these warships will be commissioned between 2028 and 2033. The cost of the programme raises concerns that funds earmarked for naval modernisation will be spent on the frigates rather than SSKs, especially given that the Polish Armed Forces have recently launched many ambitious and rather expensive modernisation programmes. Under these conditions, there are doubts about the affordability of new submarines. In 2019, there was a plan to purchase two second-hand Swedish *Södermanland* class submarines, but the negotiations ultimately failed. Meanwhile, in 2017, one Kobben class SSK was retired, with the remaining three withdrawn from service in December 2021 without any replacement. As things stand, the Orka programme functionally exists only on paper and in political rhetoric, although recently, the discussion on submarines for the Polish Navy has entered a new phase, as the Ministry of Defence announced that the Orka submarine contract would be signed in 2025.



▲ **The Kobben class submarine ORP Bielik. The last three of the class were withdrawn from service in 2021. [Polish Navy]**

The poor condition of the Polish SSK fleet is the result of several factors. Financial realities have played an important role. Indeed, the Polish Navy has always been at the bottom of the list of Polish military expenditures. However, attributing everything to a lack of funds is an oversimplification of a complex situation. Since the end of the 2010s, Polish military spending has increased significantly, and there have been opportunities to modernise the Polish Navy in the recent past, despite the fact that there has been a 'short blanket dilemma' in the Polish defence budget. The main problem, however, was that the Polish political elite lacked a vision as to why Poland needed a navy at all, and the lack of will to modernise this branch was a consequence of such an approach. Moreover, a strong belief that NATO and European Union membership guaranteed Poland's security hampered long-term modernisation programmes, including with submarines. This lack of strategic vision, combined with

a short-sighted naval modernisation policy, has led to the current situation. Indeed, only in the area of mine countermeasures (MCM) can the Polish Navy currently boast modern vessels in the Kormoran II class, and Poland has built up a comprehensive land-based coastal defence system equipped with the Kongsberg Naval Strike Missile (NSM).

## Does Poland need submarines?

When analysing the current situation of the Polish SSK fleet, it is worth considering whether Poland really needs submarines. Firstly, the Baltic Sea is small and rather shallow (only 392,979 km<sup>2</sup> in area, with an average depth of 52 m) and surrounded by various landmasses. At first glance, therefore, it seems unsuitable for submarines. However, further analysis shows that while the Baltic Sea presents a challenge for SSK operations, its salinity and temperature differences, combined with water pollution, make it difficult to detect submarines. Indeed, Baltic Sea states such as Germany, Poland, Russia and Sweden all maintain submarine forces and all have modernisation plans. Second, there are some doubts as to whether SSKs would be useful in a hypothetical high-intensity conflict with Russia. Indeed, some analysts have argued that the usefulness of Polish SSKs would be limited by the fact that the main battles would take place on land, in the air or in cyberspace. Moreover, given that the Russian Baltic Fleet currently has only one SSK in service, does the Polish Navy really need such an expensive weapon of war?

Analysing the usefulness of the Polish SSK solely in the context of a hypothetical military conflict provides an incomplete picture. In fact, the Navy has important tasks to fulfil during peacetime as well. Protecting Poland's maritime interests is important for many reasons, including Poland's increasing dependence on energy resources delivered by sea. In 2015, a major liquefied natural gas (LNG) terminal was opened in Swinoujscie, near the Polish-German border. In October 2022, the Baltic Pipe pipeline will start delivering

natural gas from the North Sea via Denmark to Poland, with both facilities considered crucial for Poland's energy security. There is also an old but fully operational crude oil terminal in Gdansk. Offshore wind farms are also planned for the near future. In addition, Poland's maritime trade is growing and new investments in seaports are planned. Securing maritime interests is therefore important for Poland's economy and energy security. Potential sabotage of *Nord Stream 1* and *Nord Stream 2* has shown that damaging maritime energy transport infrastructure is not fiction. Meanwhile, Poland's ability to respond to such crises is limited. However, the protection of critical underwater infrastructure can also be achieved by surface vessels and unmanned underwater vehicles, not necessarily by expensive submarines.


From a military perspective, submarines are useful platforms for surveillance and intelligence-gathering. SSKs can also act



### ▲ The Kilo class ORP *Orzeł*; will Poland commit to replacing it in time? [Polish Navy]

as a deterrent and complicate an adversary's naval operations. Modern submarines armed with a wide range of weapons could be used against surface combatants, such as enemy SSKs, merchant ships and even land targets. Submarines equipped with submarine-launched cruise missiles (SLCMs) could even become an element of a national deterrent system. Moreover, despite its current weakness, Russia can reinforce its Baltic Fleet with relative ease. If necessary, Russia can redeploy warships from other fleets to the Baltic Sea region. Currently, Poland has very limited anti-submarine warfare (ASW) capabilities, so if a Russian SSK were to enter the Baltic Sea, the Polish Navy would not be able to track it if submerged. A modern, fully operational submarine fleet can mitigate such risks. On the other hand, with Sweden and Finland now in NATO, Russia is at a major strategic

disadvantage in the Baltic, and there are doubts about whether the Russian Baltic Fleet poses a real threat to Poland.

In conclusion, there are good arguments both for and against the maintenance of a submarine force by Poland. However, for almost two decades, Polish governments (regardless of their political camp) have adopted a strategy of postponing a decision on the problem, despite the fact that the Orka programme has attracted the interest of major companies from Germany, France, Italy, Sweden, Spain and South Korea. The SSKs on offer are of modern design and could be tailored by the manufacturers to meet a buyer's requirements. As things stand, however, no decision has been taken, and the Polish SSK fleet is slowly dying. 

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# Canada's submarines: Bridging the gap

Dr Lee Willett

**Canada continues to invest in its submarine capability, to offset increasing underwater threats in its areas of responsibility and interest and to build more operational output, as it transitions from its current boats to a planned new fleet under the Canadian Patrol Submarine Project.**

and impacts it brings, at everything from the tactical to the strategic levels. For all the overt cost a submarine programme carries, the covert effects it delivers are in many ways second-to-none in politico-military terms compared to many other platforms. The simple reason for this is that a submarine comes unseen.



- ▲ The Royal Canadian Navy (RCN) *Victoria* class submarine HMCS *Windsor* is pictured sailing off Halifax, Nova Scotia. The RCN is procuring a new submarine class under the CPSP programme, and in parallel is modernising and upgrading the *Victoria* boats to assure capability transition between the two classes. [Canadian DND]

The submarine remains a pre-eminent naval – and national – instrument for projecting influence and protecting interests. A relatively small number of navies possess a submarine capability, but those who do recognise and value the outputs

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Possession of such covert stealth, when combined with an already highly-capable platform, can deliver disproportionate effect across the spectrum of military operations. This combination thus has significant politico-strategic effect, too. In whatever part of the world the possessor of the submarine may have strategic interest, others will know that the possessor has the capability to deliver strategic influence at sea and from the sea – and doing so unseen, too.

The ongoing Russo-Ukraine conflict and the wider insecurity it is generating across the Euro-Atlantic theatre underlines the impact a submarine can bring in terms of shaping events. Russian Kilo class diesel-electric submarines (SSKs) have been used to launch Kalibr conventional land-attack submarine-launched cruise missiles (SLCMs) from the Black Sea against targets ashore in Ukraine, in an overt display of the

covert capability a submarine offers. However, the impact of submarine activity in the current Euro-Atlantic security crisis is perhaps more clearly reflected in unseen activities underway in the Eastern Mediterranean and North Atlantic.

In the Eastern Mediterranean, NATO naval forces protecting Alliance interests in the region, including the Black Sea, have been closely monitoring – and deterring – the activities of Russian submarines trying to interfere with the operations of those NATO naval forces. In September 2022, Naval News reported the possible deployment of Russian nuclear-powered submarines (SSNs) to the Eastern Mediterranean, noting that the region may form an outer ring of defence for Russia for its Black Sea operations, with Russian naval forces deployed to the Eastern Mediterranean being part of Russia's deterrent strategy against NATO efforts to exert influence in the Ukraine conflict.

submarine-operating navies to maintain and renew their submarine capabilities. This is illustrated in the NATO context, for example, by the fact that of the 14 NATO submarine operators, 12 are somewhere along the procurement path towards renewing that capability with brand new boats. One such navy in the process of renewal is the Royal Canadian Navy (RCN).

### Canadian transition

The RCN's submarine fleet – in the form of its four in-service *Victoria* class SSKs, HMCS *Victoria*, HMCS *Windsor*, HMCS *Corner Brook*, and HMCS *Chicoutimi* – generates regular presence in the Euro-Atlantic theatre, in support of both NATO and national requirements, including under the Operation 'Reassurance' tasking, representing Canada's national contribution to NATO's collective assurance, deterrence, and defence measures in the Euro-Atlantic.



- ▲ **HMCS *Windsor* (centre) is pictured with German (left) and Norwegian submarines during the NATO exercise 'Dynamic Mongoose' in the North Atlantic in 2016. These three navies are amongst many NATO submarine operators recapitalising their flotillas with new boats. [NATO MARCOM]**

In the North Atlantic, Russian Kalibr-capable SSNs present a 360° challenge for NATO navies by seeking to roam from their Barents Sea bastions out into the Norwegian Sea and wider North Atlantic to project influence – including deterrent effect – against NATO countries through the implicit threat generated by the capability to strike targets at sea and ashore across northern Europe with their SLCMs. In turn, NATO submarines are pushing northeast through the Greenland-Iceland-UK (GIUK) and Bear Island Gaps in order to pin Russian submarines back in their bastions and keep their SLCMs out of range of key European targets.

So – and never mind the continuing covert intelligence, surveillance, and reconnaissance (ISR) activity a submarine delivers – these examples demonstrate that the role of submarines is alive and well in modern military operations, underlining the need for

However, Canada's strategic requirement for using its submarine capability – and its navy, more widely – is relatively unique in NATO terms, in that its geographic sphere of interest and influence encompasses three oceans – the Atlantic, the Pacific, and the Arctic.

For the RCN, its requirement to operate its SSKs across this vast oceanic range goes hand-in-hand with a requirement to operate the boats across a broad range of tasks, for example from conducting maritime surveillance in the Arctic, to countering maritime smuggling in the North Pacific, to contributing to NATO anti-submarine warfare (ASW) activities and wider deterrence posture in the Euro-Atlantic.

Given this range of task requirements across such a considerable geographic space, and with security risks in each area

increasing, on paper, the RCN requires a fairly substantial submarine force in numbers and capability terms. However, both maintaining and expanding a four-boat flotilla is an expensive business in financial terms. Canada is addressing the question of how to expand but afford its submarine force for the future, to meet the demand to provide enhanced presence across its area of operations to project national influence and deter threats to national interests in a planned programme to renew its submarine capability – the Canadian Patrol Submarine Project (CPSP).

CPSP was established in 2021 to inform the decision-making process regarding timely replacement of the in-service *Victoria* class submarine flotilla in order to avoid any gap in capability. On 10 July 2024, Canada's Department for National Defense (DND) formally launched the CPSP procurement

Reflecting the strategic requirement set out in Canada's most recent defence strategy ('Our North, Strong and Free', published in May 2024) to explore options for renewing and expanding the submarine fleet to enable Canada to better detect and deter threats and to better control its maritime approaches, in light of both the emerging threats and the ageing nature of the *Victoria* class fleet, the DND statement confirmed Canada is taking the first steps in renewing this capability by formally engaging industry in this procurement process.

The statement added that Canada wishes to procure "a larger, modernised submarine fleet to enable the RCN to covertly detect and deter maritime threats, control [Canada's] maritime approaches, project power and striking capability further from [its] shores, and project a persistent



▲ **HMCS *Victoria* is pictured conducting task group operations. Canada's submarine capability requirements include generating high-end operations across the Arctic, North Atlantic, and North Pacific oceans. [Canadian DND]**

process, with a statement announcing Canada's plan to buy up to 12 new SSKs. Highlighting the role of a submarine capability in addressing the 'three ocean challenge' Canada faces, the DND said "Canada is the country with the largest coastline in the world," adding "An underwater surveillance capability is crucial to our security and sovereignty."

Outlining the specific geostrategic issues Canada faces that underscore the requirement for a submarine capability, the DND said that climate change will make the Arctic more accessible, meaning both that commercial shipping volume moving between Europe and Asia via the Arctic may increase, but also that other actors who have growing capacity to pursue growing ambitions in the region may see more opportunity to do so.

In a more current military context, the statement underlined the growing threat to critical undersea infrastructure (CUI), against which a submarine capability plays a key 'deter and defend' role. It also pointed specifically to Russian and Chinese growth in submarine activity as a whole.

deterrent on all three coasts". It highlighted the requirement for stealth, lethality, persistence, and Arctic deployability – including in the latter context, emphasising under-ice capability. Consequently, the new boats delivered under CPSP will need extended range and endurance. Indeed, with the RCN's increasing emphasis on Arctic operations, including right up into the High North, the new boats seem likely to have a requirement for significant under-ice capability.

The need to provide effective operational capability in all three oceans was underlined clearly in the DND statement, in the context of both combining stealth, lethality, persistence, and deployability and so doing with sufficient capacity – up to 12 boats – in the force level. In sum, it said, "Canada's new fleet will need to provide a unique combination of these requirements to ensure that Canada can detect, track, deter and, if necessary, defeat adversaries in all three of Canada's oceans, while contributing meaningfully alongside allies and enabling [Canada] to deploy this fleet abroad in support of [its] partners and allies."

Alongside operational output terms, working with allies and partners, industry, and other navies will sit centrally in the CPSP process in capability development terms. According to the DND statement, “This procurement will enable Canada to develop closer ties with its allies and partners and establish a strategic partnership that not only delivers the submarines themselves, but creates a durable relationship between Canada and its strategic partner(s) to support personnel training and the sharing of information.”

The DND statement was followed on 17 September 2024 by the formal announcement of a request for information (RFI) phase in the procurement process. The RFI headline was Canada’s need to gain from industry “Further information on the availability of submarines that are currently in service or in production, and the industry’s capability and capacity to build and deliver up to 12 submarines to Canada.” The announcement also noted that Canada was engaging with officials from allied and partner countries, and companies and navies in Europe and Asia that currently have, or are in the process of, building submarines that could meet Canadian requirements. In capability terms, the RFI announcement underlined that the new boats must provide “superior underwater surveillance capability to maintain [Canada’s] security and sovereignty”.

The RFI also set out briefly the timeframe within which the CPSP needs to deliver a new submarine fleet in order to maintain overlap with the *Victoria* class SSKs and transition to the new fleet with no gaps in capability. With the *Victoria* boats due for decommissioning from the mid-2030s, the RFI stated that Canada was anticipating a contract award by 2028 to enable delivery of the first replacement boat no later than 2035. According to the details set out in the RFI documentation, initial submissions in response to the RFI were scheduled to be submitted in mid-November 2024.

## Defence vision

Naturally, the requirements set out in the RFI reflected the vision for Canada’s defence requirements as set out in the 2024 government document ‘Our North, Strong and Free’. This noted that Canada would need greater presence, reach, responsiveness, and surveillance, including in the Arctic, and

added that submarines – along with hypersonic and cruise missiles – would be crucial to protect Canada’s northern and Arctic regions against emerging and existing threats. It also noted the need for underwater surveillance capability in the north (as well as elsewhere).

Capabilities such as sensors and missiles and outputs like responsive reach, surveillance, and presence can all be delivered, of course, by a submarine. The paper also underlined Russia’s growing submarine presence in the Arctic, and China’s steady growth in sub-surface platforms and capability within its wider naval development.


## Bridging the gap

Canada has committed to continue operating the *Victoria* class boats out to the mid- to late-2030s, and consequently to modernising them over this timeframe via the *Victoria* Class Modernisation (VCM) programme. With CPSP being a procurement priority for Canada too, the emphasis on both programmes is designed to ensure a continuous transition from the outgoing to the incoming capability and to build a bridge across any potential capability gap.

Vice Admiral Angus Topshee, the RCN’s Commander, has set out three clear priorities around which to develop the navy: people, platforms, and being ready to fight. This is reflected in the prioritisation being developed within the VCM programme. As regards ‘platforms’, with delivering extensive upgrades for ageing submarines often being a lengthy and complex process, the navy is prioritising items within the overall VCM capability uplift plan that potentially offer more immediate operational output return on the time and money investment delivered in the VCM programme. For example, work on the boats’ hullform and propulsion to improve acoustic quieting is set to get underway in the coming fiscal year (after 1 April 2025). The boats will also be fitted with optronics masts, replacing their optical periscopes. This workstrand was initiated with a request for proposals (RFP) released to industry, closing in April 2025. Optronics masts are designed to provide more rapid capture and assessment of the operational picture on the surface. The VCM programme is also upgrading living quarters, messes, and amenities to enhance habitability for submarine crews.



◀ **HMCS *Windsor* is pictured in the Mediterranean, alongside Crete. RCN submarines make a core contribution to national and NATO deterrence and defence requirements in the Euro-Atlantic theatre on Canada’s Operation ‘Reassurance’ tasking. [Canadian DND]**

With only four boats in the current fleet, reducing the work time involved in the VCM upgrades will help optimise boat availability at a time when the capability is needed at sea, in order to meet the ‘ready to fight’ requirement. Moreover, having boats available for operations will also deliver on the ‘people’ part – keeping the underwater operations expertise current amongst the RCN’s submariners, again as part of the process of bridging across to the CPSP platforms. 

# Developments in infantry night vision systems

Sidney E. Dean

## NATO nations are procuring several state-of-the-art night vision systems to provide their infantry forces with a tactical advantage for night fighting.

For millennia, the dark of night provided sufficient cover for armed forces to advance or redeploy undetected. That all changed with the introduction of night vision systems (NVs). The first infrared (IR) scopes for surveillance and targeting were introduced during World War II, but these systems were cumbersome. Man-portable night vision goggles (NVGs), which amplify ambient light became operational in the 1960s and were deployed by the Army during the Vietnam War. Today, such systems have become standard issue to ground forces around the world. Modern NVs can work on the basis of thermal imaging (TI) or image intensification (I2).

TI systems detect heat signatures radiated by persons or objects and create images based on temperature differences; they function even in total darkness or and can see through many common types of obscurants encountered on the battlefield, such as smoke. Though in the latter case it should be noted that this relates to common smoke rather than the specialised aerosols used in many modern vehicle-mounted obscurant smoke grenades, which are often precisely intended to obscure thermal signatures. TI systems also tend to be costlier than their I2 counterparts.



### ▲ [The USMC's SBNVG. \[Elbit America\]](#)

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By contrast, I2 systems require at least some ambient light to function – starlight and near-infrared (NIR) light are sufficient. Ambient light photons are collected through the device's objective lens and channelled into the intensifier tube, where they strike a photo-cathode and are converted into electrons; these are amplified by a micro-channel plate and directed onto a phosphor screen, where they form a visible image. If green phosphorus is used, a green monochrome image is produced. White phosphorus produces a grayscale image.

Alongside TI and I2, more recently, 'fusion' night vision has become available, which applies algorithms to overlay and merge thermal and I2 data into a single digital image, providing greater clarity and detail.

NVS configurations can be monocular or binocular, hand-held or helmet mounted (tripod- and weapon-mounted devices are also common, but are beyond the focus of this article). At present, there are a number of key NVS procurement programmes being carried out by NATO members.

## United States

The US Army and the US Marine Corps (USMC) are acquiring three modern NVs.

### ENVG-B

The Enhanced Night Vision Goggle – Binocular (ENVG-B) entered service with the US Army in 2019 under the designation AN/PSQ-42. It combines several technologies and capabilities in one instrument, including third-generation white phosphor-based I2, a 40° TI field of view (FoV), image fusion, as well as a 3× zoom capability, and augmented reality capabilities, including an integrated heads-up display (HUD). According to Army figures, the system has a minimum 80% chance of detecting a man-size target at 150 m and a 50% chance at 300 m, outperforming legacy NVGs.

Additionally, the L3Harris Smart Battery Pack provides the goggles with power, but also acts as the conduit for wireless communications. This permits the device to receive real-time video including full-colour map overlays for situational awareness. The wireless connection can also transmit the image from the zeroed weapon sight reticle and the FWS-I (Family of Weapons Systems – Individual) thermal sight to the goggles; this permits the soldier to remain under cover while exposing only the weapon for rapid target acquisition. Due to this combination of attributes, the ENVG-B is considered the most advanced set of goggles ever fielded by US ground forces.



▲ **Fusion mode enables various display formats, including the outline mode seen here through the ENVG-B. [US Army/Dean Johnson]**

The Army has procured the ENVG-B from both Elbit Systems of America and from L3Harris Technologies. Following several years of LRIP orders, the Army awarded Elbit an indefinite delivery/indefinite quantity (IDIQ) contract for ENVG-B deliveries in 2023. The latest order under that contract was announced in January 2025; it covers continued delivery of ENVG-B units plus parts and logistic support, and is valued at USD 139 million. In April 2024, the Pentagon awarded L3Harris a full-scale production IDIQ contract for ENVG-B deliveries, with an estimated value of nearly USD 1 billion over ten years. The first partial delivery order valued at USD 256 million was also placed in April 2024, followed by the second order (valued at USD 263 million) in January 2025. According to L3Harris, the firm has delivered 18,000 units to the Army through January 2025.

### **SBNVG**

The USMC's Squad Binocular Night Vision Goggle (SBNVG) incorporates fewer features than the ENVG-B, but is a significant improvement over the Corps' legacy AN/PVS-14 monocular NVS, providing increased depth perception and improved clarity. The lightweight SBNVG can be hand held or clipped to a helmet. It incorporates white-phosphorus based I2 as well as TI capability, and has an integrated IR illuminator. The latter is analogous to a flashlight, albeit shining a beam of IR light which is visible only through the night vision device. This permits the user to see in tunnels or other enclosed spaces without any ambient light. When not in use, the helmet mounted NVG can fold upward like most such devices. Unlike most NVGs, it can also fold to the side of the helmet. The Marines specifically required this option to facilitate operations in low-ceiling environments.

The USMC awarded Elbit Systems of America an IDIQ contract in 2019 with the first infantry units equipped in 2020. In December 2023, Elbit received another five-year ID/IQ contract for continued SBNVG deliveries, with a potential total value of USD 500 million.

### **IVAS**

The third US acquisition programme, the Integrated Visual Augmentation System (IVAS), has been troubled nearly since its inception. Initiated by the Army in 2018, the programme seeks to introduce a multi-capability device based on the Microsoft HoloLens augmented reality/mixed reality (AR/MR) headset. A five-year development and evaluation contract was issued to Microsoft in 2021 with the goal to enhance soldier situational awareness and decision-making under all operational conditions. The system consists of a visor-like HUD, a body-worn computer known as the 'puck' and a networked data radio. The HUD combines direct view day vision, I2 and TI capability, with augmented reality supported by situational awareness software. The puck and radio enable wireless connectivity between the HUD and a weapon-mounted digital sight, permitting soldiers to peer or even aim and fire around corners without exposing their heads.

Three variants, designated IVAS 1.0, 1.1 and 1.2 have been presented to date. Results from soldier evaluation of IVAS 1.0 and 1.1 were mixed to negative, with frequent complaints of head- and neck-pain, spatial disorientation and nausea, as well as some performance issues. IVAS 1.2 was designed to address these complaints. Testing of the new variant proceeded through the end of 2024, with a company-level user assessment scheduled for early 2025. A positive assessment could clear the way for a full-scale production decision by autumn 2025. If the assessment is negative, it is widely expected to preclude an IVAS 1.2 transition to a procurement programme of record.

On 22 January 2025, the Army Contracting Command issued a new Integrated Visual Augmentation System (IVAS) Next request, "seeking information from industry regarding capabilities to develop and manufacture the IVAS Next system" with a response deadline of 26 February 2025. While the Request for Information (RFI) was explicitly "issued solely for information and planning purposes" and "does not constitute a Request for Proposal (RFP) or a promise to issue an RFP in the future", it has fuelled speculation that the service would re-compete the programme rather than continue with the current devices.

On 11 February 2025 Microsoft and Anduril Industries announced that the latter company would assume control over the current IVAS program, pending DoD approval. Specifically,



▲ **A US Army squad leader training with the IVAS 1.2. [US Army/Frederick Shear]**

Anduril will assume oversight of production, future development of hardware and software, and delivery timelines. As part of the “advanced partnership agreement,” Microsoft will continue to support the program through AI development, and Anduril will use Microsoft’s Azure cloud infrastructure for all workloads related to IVAS. Anduril is not completely new to the IVAS program. In September 2024 the firms collaborated to integrate Anduril’s Lattice software onto IVAS 1.1 and 1.2 devices; the software improved collation of sensor input from numerous external sources, enhancing threat detection and situational awareness for the IVAS operator. Anduril replacing Microsoft as project leader is considered the best option for salvaging the current program and preventing further delays in fielding.

## Europe

Various European armed forces are also procuring sophisticated NVSs.

### Mikron-D

The intergovernmental European procurement agency Organisation for Joint Armament Cooperation (OCCAR) is acquiring the Mikron-D NVS for the armed forces of Belgium and Germany. The joint procurement and service contract is being fulfilled by Cyprus-based Theon International in consortium with Germany’s Hensoldt Optronics GmbH. Nearly 50,000 units have been procured since the signing of the original contract award in 2021, with roughly 80% going to the German Bundeswehr. In December 2024, OCCAR issued a contract amendment which will provide an additional 25,000 units for the Bundeswehr. A final option for approximately 25,000 more units still remains to be exercised.

The German armed forces, in particular, aim to streamline their supply and maintenance system by replacing the various legacy NVSs with one versatile device. Weighing less than 415 g, Mikron-D is considered the most lightweight full mil-spec stereoscopic, I2 binocular. The 16 mm aperture tubes are optimised to match the performance of heavier 18 mm tubes, and provide a 40° field of view.

German airborne troops have praised the comfortable and secure fit as well as the integrity of the helmet-mounted system during jumps. The device includes an integrated IR illumina-

tor for operations in complete darkness. It can operate helmet-mounted, head-mounted or hand-held and gain can be adjusted automatically or manually. The binoculars can attach to a wide variety of helmet types, as well as to visual augmentation system (VAS) shrouds. Each tube can be individually flipped away, permitting the soldier to continue using a monocular NVS while retaining night vision with the other eye and avoid being blinded by sudden flashes. When both tubes are flipped up, the system aligns closely with the helmet’s contours, reducing silhouette and minimising the risk of damage. The device accepts a single AA battery which powers up to 24 hours of service; it can optionally be connected to an external battery pack mounted at the back of the helmet for longer endurance.

### JIM Compact

Germany is also procuring hand-held infrared multifunctional binoculars from Safran Electronics & Defense Germany, which announced an order for the Jumelle infrarouge multifonction (JIM) Compact binoculars on 20 January 2025. The binoculars are provided with three channels: cooled medium-wave infrared (MWIR), a low-light camera, and high-definition (HD) day TV camera. The binoculars weigh under 2 kg, and are powered by a rechargeable COTS battery providing 4 h of endurance, which can be increased to 6 h with an alternate power pack.



### ▲ JIM Compact infrared binocular. [Safran]

The capabilities profile includes up to 4x zoom, day and night see-spot function, real time photo/video recording and streaming, image fusion mode, image stabilisation, and new specific mission packages for long-range fires, sniper support, close air support and artillery spotting roles. The embedded laser rangefinder and pointer can locate targets at 12,000 m and mark/hand over targets at 2,500 m distance. Target coordinates can be identified and transmitted even under GPS/GNSS-denied conditions. NATO-standard connectivity includes multiple interfaces including USB, Wi-Fi, Bluetooth and Ethernet for data exchange with other devices.

The JIM Compact is currently in use by 18 NATO nations, having been introduced in 2016 to complement Safran’s larger JIM LR (long range) binoculars. Both devices offer sophisticated capabilities, with electronics and software upgraded regularly. The manufacturer specifically lauds the intuitive interface and ergonomic design which facilitate completion of complex surveillance and target identification missions under adverse environmental conditions.



### ▲ The Mikron-D NVS during testing by the German Army. [Bundeswehr/Torsten Kraatz]

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### BPS14 and Brolis Twins

The Lithuanian firm Brolis Defence produces various optical systems including the Brolis Personal System 14 (BPS14) monocular and the Brolis Twins binocular NVSs. Both devices are based on I2 tubes, and have similar performance parameters, albeit the binocular achieves a wider field of view. An IR illuminator is optionally available to permit visibility in complete darkness. Like many I2 NVSs, the BPS14 and Brolis Twins feature auto-gating and automatic power cut-off when exposed to high-intensity light. Auto-gating rapidly switches the voltage feed to the image intensifier tube on and off, adjusting the amount of light reaching the intensifier. This ensures consistent image clarity despite fluctuating light levels, and protects the I2 tube from damage caused by sudden bright light. The battery permits up to 50 h of continuous use. As with other I2 devices, the Brolis BPS14 and Twins enable the wearer to see near-IR laser beams projected by various devices such as targeting or pointing systems.

In 2024, the Lithuanian Armed Forces ordered approximately EUR 17 million of equipment for night fighting, which includes the BPS14 monocular and Brolis' LP5X laser aiming device, with deliveries slated to run through 2025. The BPS14 is also in service with Ukraine's armed forces.

### XACT nv33

The British Army introduced the AN/PVS-14 monocular into service in 2008, where it was known as the Helmet-Mounted Night Vision System (HMNVs). While the HMNVs remains in service for the time being, it is being supplemented by the newer XACT nv33.

In 2021, under a USD 16 million contract, the British armed forces began procuring the helmet-mounted binocular XACT nv33, produced by Elbit Systems UK through its subsidiary Instro Precision Ltd. Follow-up orders were awarded in November 2022 (worth USD 19 million) and October 2024 (worth USD 19.9 million). The XACT nv33, which is also in use with several other armed forces, is a compact device weighing 450 g. The NVGs are suitable for dismounted operations as well as driving under blackout conditions, parachute operations, or diving to a depth of 25 m. An integrated IR illuminator permits operations in the absence of residual light. A single AA battery enables 20 hours of operation. The device features hands-free

- ▼ **The XACT-33 NVG is currently fielded with Very High Readiness and High Readiness units of the British Army. [Elbit Systems]**

activation or shut-off via specific head-tilt motions, permitting soldiers to maintain a secure grip on their weapon or other equipment.

Through early 2025, Instro had delivered 3,500 units of the XACT nv33 to the British armed forces, where they are currently used by high-readiness units including the Ranger Regiment, 16 Air Assault Brigade, and also operated by the RAF Regiment. The MoD's Defence Science and Technology Laboratory (Dstl) has confirmed that, as the British Army continues to modernise under the Future Soldier programme, the XACT nv33 will continue to be scaled to eventually replace the HMNVs.

### Expectations

As technology develops, more attributes become mainstream, leading to ever increasing expectations for the next-generation systems. Data overlays, augmented reality, and networking with external sensors – including weapon-mounted scopes, IR systems and laser-targeting capability – are rapidly becoming the norm for higher-performance NVSs. Future NVSs will be expected to produce high-resolution images under all light conditions, and provide even greater situational awareness through wider fields of view, sensor fusion, as well as more sophisticated HUD-like data displays and augmented reality features, such as blue-force tracking and the ability for soldiers to 'mark' detected hostile positions on their own display and feed that data to nearby friendly forces. Increased networking bandwidth, speed, and hardening against electronic warfare (EW) will be essential for these to reach their potential on the networked battlefield. Automation features, such as automatic target/threat detection functions, for instance for spotting UAVs, will also be increase survivability on the future battlefield.

Frequent current complaints focus on size and weight of head- or helmet-mounted NVSs. Prolonged wear leads to neck strain, with the risk of chronic injury with extended use. Head mobility and overall agility can both suffer from the weight, the narrow field of view (40° to 60° in most cases) and the unnatural visual display. To overcome these issues, the US Defense Advanced Research Projects Agency (DARPA) initiated the Enhanced Night Vision in Eyeglass Form (ENVision) programme. As the agency stated in January 2022: *"ENVision seeks to leverage recent advances in planar optics and transduction materials to develop NV systems that don't require bulky image intensifiers, provide wider FOV, offer enhanced visual access across infrared bands, and are lightweight to reduce neck strain caused by today's technology."*

The goal is to enable development of advanced NVGs to the size and weight of regular eyeglasses. Ten industry and university research teams were selected in January 2022 to develop the scientific and technical means necessary to realise this goal. Specifically, one team was tasked with developing multi-band, wide-FOV planar optics and planar image intensifiers to demonstrate advanced NVS imposing near-zero torque on the wearer's neck; the other was to explore new methods to amplify photonic up-conversion processes from any infrared band to visible light to enable future 'intensifier-free' NVSs. To date, DARPA has not announced progress or further pursuit of the programme, but the ultimate goal of miniaturising NVS components to enhance comfort and mobility remains valid.



## Viewpoint from Kyiv

# Ukraine ponders lifting its arms exports ban

Alex Horobets



[Alex Horobets]

Since the outset of Russia's full-scale invasion, Ukraine has maintained the ban on arms exports, naturally directing all supplies to sustain its own effort to repel Moscow's onslaught. Now, three full years into the war, there are more and more voices highlighting the need to lift the restrictions.

In October 2024, Ukrainian Defence Minister Rustem Umerov said he didn't rule out a greenlight for defence exports since some countries had already expressed interest in buying Ukrainian missiles, drones, and other weapons. However, according to the Ukrainian defence chief, it's up to a collective decision by the state leadership. So is Ukraine moving towards easing export restrictions?

Most often, the discussion revolves around allowing the export of at least Ukraine's own uncrewed systems. Why drones? One of the reasons is that unmanned aerial vehicles (UAVs) have become one of the most lethal tools against enemy manpower and armour at this stage of the war. However, this also means there is a need for their mass production, since it is quite difficult to keep pace with Russia's defence production in this area (considering their ties with China). This is where exports can potentially help, providing financial resources to further boost production. The problem is some manufacturers in Ukraine are currently unable to operate at full capacity, since government contracts fail to cover 100% of production volumes. As some manufacturers note, the government lacks the money to purchase all the necessary types of weapons systems and finance further research and development, while the Ukrainian military constantly requires wider supplies of various types of UAVs to perform effectively. In theory, Ukrainian companies can produce weapons worth USD 20 billion annually, while the State can pay only up to USD 6 billion. Under

these conditions, manufacturers are exploring opportunities to export products in order to obtain additional resources for production and modernisation. According to Oleksandr Marikovsky, chair of the parliamentary economic subcommittee, the export of UAVs alone could bring Ukraine up to USD 20 billion annually.

The situation related to UAV manufacturers is especially telling, since without the ability to export their products and sell them internally, drone producers, even fairly large ones, are beginning to move capacity out of Ukraine, mainly to Eastern Europe and the Baltic states. If the ban remains in place, this process may speed up because the demand for Ukrainian products, conceived and adapted amid a full-scale war, and sold at a lower price compared to those offered by European and American competitors, is not expected to drop.

So, lifting the ban on exports seems rational, but only if it's done in the right way. Executive Director of the National Association of Ukrainian Defence Industries Serhiy Honcharov shares this opinion. Relaunching arms exports is necessary, but it should be controlled, and first of all, it should be available to partner countries, since selling products to Russia's allies while the war wages, is off the table, he stressed, despite the obvious fact that this narrows the trade potential. In any case, Ukraine's government should start exploring export opportunities as soon as possible, so that Ukraine will be able to secure a place in the international arms market after a long absence. Signing defence contracts is a complex process that takes time, and of course, in this process it is necessary to take into account certain risks that the export of Ukrainian weapons may carry, including the threat of such weapons falling into the hands of adversaries.

According to the Commander of Ukraine's Unmanned Systems Forces Vadym Sukharevsky, the export of weapons should be reopened to a limited number of countries. One approach is to create sales strategies, identify the types of weaponry eligible for export, and compile a list of countries where they can be sold. In lifting the export ban, the most important aspect of this process will be to properly communicate with the public and partners, in order to explain the urgency of the matter and the possibilities of attracting additional funds to sustain the army, as well as reducing dependence on external financial assistance for the purchase of weapons for Ukraine's own needs. Weighing all the pros and cons of lifting the ban, an unconditional advantage is that the export of weapons would improve Ukraine's financial prospects, giving the country greater freedom to pursue its geopolitical interests. It remains to be seen whether the voices calling for lifting the ban will be heeded, and the idea brought to fruition.



# Hanwha signals even stronger push into international defence market

Peter Felstead

**South Korea's Hanwha is seeking to further deepen its international defence footprint with US stalwart Michael Coulter as the group's newly named President and CEO of Global Defense. Speaking to *ESD* at IDEX 2025, Coulter outlined the path ahead.**

With the appointment of US defence sector veteran Michael Coulter into the newly created position of President and CEO of Hanwha Global Defense – the first foreign CEO of a South Korean defence company – Hanwha is signalling an even bolder push into the international defence market.

- ▼ **Michael Coulter, newly named as President and CEO of Hanwha Global Defense, will seek to further establish the company as a multi-domestic global aerospace and defence prime. [Hanwha Aerospace]**



#### AUTHOR

**Peter Felstead** a UK-based journalist who joined ESD as News Editor in February 2023. Before pursuing a freelance career and joining ESD, Peter had worked for Janes for almost 33 years, editing titles such as Janes Defence Weekly and Janes Intelligence Review.

In keeping with that bold strategy, Coulter's remit in this newly created position will be an expansive one; he will be responsible for not only overseeing the global defence business of Hanwha Aerospace, but also those of subsidiaries Hanwha Ocean and Hanwha Systems.

Coulter's CV, however, certainly shows he has the requisite experience for this challenge. He most recently served as senior vice president of corporate business development for Leonardo DRS and president of Leonardo DRS International, but before that his career spans multiple key roles within US national security organisations. At the US Department of Defense Coulter has served as Assistant Secretary of Defense (Acting), Principal Deputy Assistant Secretary of Defense for International Security Affairs, and Principal Deputy for Strategic Plans and Policy with the US Joint Chiefs of Staff. Within the US Department of State, meanwhile, he has served as Deputy Assistant Secretary of State for Political-Military Affairs and Coordinator for Coalition Operations, as well as National Security Advisor in the US Senate. Rounding out Coulter's experience in the defence arena is his service as a US Navy reserve officer with command and combat experience across multiple regions worldwide.

Speaking to *ESD* in Abu Dhabi on 17 February 2025, on the first day of the IDEX 2025 defence exhibition, Coulter outlined how his past experience will be brought to bear.

"I've lived as a customer, I've lived as a government official and I've lived as an industry leader, which has caused me to spend a lot of time observing the market and reflecting on the market," he said. "And I think we're at a point in the global security market right now where customers are demanding innovation. They're demanding speed of capability because the requirements are urgent. They are demanding scale of capability, so they're less interested in a few exquisite items and more interested in mass capability. And they are also interested in cost-effective solutions. So that I would say is my observation from my background as far as how I hope to help Hanwha."

With regard to Hanwha's heritage, Coulter acknowledged that South Korea's military-geopolitical situation, existing as it does with the continually belligerent communist Democratic People's Republic of Korea (DPRK) to its north, has presented a fundamental requirement to support a strong defence sector.

*“Because [the DPRK] has been sitting on a war footing for 70 years, the industry in South Korea in general, and Hanwha specifically, has had to make sure that it is on a war footing as well, so it has been investing in its technology, its capabilities and very notably its ability to scale products for the South Korean customer,” Coulter noted. “That strength domestically in South Korea created capability that was desired globally, so for many years now South Korea has been exporting very successfully into the global market ... so I do think it is that industrial footprint that has driven Hanwha to be a leading aerospace and defence company.”*

Coulter added, though, that in recent years Hanwha, in addition to its defence export focus, “has begun showing serious commitment to becoming an industrial partner with customers around the world”.

Prior to its acquisition by Hanwha in June 2015, Samsung Techwin, the original developer of Hanwha’s K9 self-propelled howitzer (SPH), concluded licensed-production deals for the K9 with India, Poland and Türkiye. Hanwha Aerospace has subsequently secured K9 export and licensed-production deals with Australia, Egypt and Romania as well as successfully exporting the SPH to Norway, Estonia and Finland.

Hanwha Aerospace is now building on this success, most notably in Australia, where in August 2024 the company officially inaugurated the Hanwha Armoured Vehicle Centre of Excellence (H-ACE) in Geelong, Victoria, as the first overseas production base established by a South Korean defence

company. H-ACE is producing both the K9-derived AS9 Huntsman SPH and its associated AS10 armoured ammunition resupply vehicle, 30 and 15 of which respectively were ordered for the Australian Army in December 2021. Additionally, the Redback infantry fighting vehicle (IFV), 129 of which were ordered for the Australian Army in December 2023 after extensive trials, will be manufactured at H-ACE after 2026 following the successful delivery of prototype IFVs.

“The next stage for Hanwha,” said Coulter, “is leveraging that strength and evolving those capabilities, continuing to be the leading Korean aerospace and defence company but also being a leading, multi-domestic global aerospace and defence leader.”

One key upcoming opportunity for the K9 SPH is in Coulter’s native United States, where the US Army has decided to abandon its Extended Range Cannon Artillery (ERCA) prototyping effort in favour of an off-the-shelf SPH procurement. Coulter, however, noted that there are numerous US opportunities for Hanwha Aerospace.

“There are a lot of requirements in the United States right now,” he said. “The evolving howitzer requirement is certainly one of our priorities, but there are other priorities in the US market as well. The US Navy has been requesting our

- ▼ **Taking pride of place on the Hanwha Aerospace stand at IDEX 2025 was the company’s widely exported K9 self-propelled howitzer. This example was fitted with a South Korean-designed powerplant to maximise its export potential. [Peter Felstead]**



assistance and growing capacity to do naval shipbuilding, so we recently acquired Philly shipyard". Acquisition of the yard was finalised in December 2024 and it is now called Hanwha Philly Shipyard.

"There are requirements across the services in the United States where they are seeking innovative capabilities, investment at scale and cost-effective solutions, and we believe we are uniquely positioned to help in the United States across all of those fronts," said Coulter. "So conversations range from

Following on from its Romanian K9 SPH contract, signed in 2024, Hanwha Aerospace is scheduled to start constructing a state-of-the-art armoured vehicle manufacturing facility in the country this year, which will be the company's first production facility in Europe.

The Romanian facility will have the capacity to produce Redback IFVs, should the IFV contract in Romania be secured in addition to the manufacturing of K9 and K10 vehicles, contributing to Romania's defence modernisation and industrial growth.



▲ **Given the current global interest in air and missile defence capabilities, Hanwha Aerospace exhibited models of its M-SAM and L-SAM air defence systems at IDEX 2025. [Peter Felstead]**

the howitzer programme, the path forward for which is still being determined, to shipbuilding, and in the munition space as well there are urgent requirements to develop capacity in the United States, both in technology and in volume."

Meanwhile, Hanwha Aerospace has active campaigns in Poland and Romania with regard to its Redback IFV. "The success of the Redback programme in Australia – both the capability of the platform itself, but also Hanwha's ability to create industrial capacity in Australia – has created a pull for that around the world," said Coulter. *"Poland and Romania are two countries that have expressed an interest in that capability, both the infantry fighting vehicle itself and the idea of becoming more self-sufficient from an industrial standpoint, so I won't go into more technical details on those opportunities, but just to say that interest is there and we are having discussions with them."*

The Hanwha Aerospace Chunmoo multiple rocket launcher is also a prime candidate for exports. The system has been offered for Norway's current long-range precision fires requirement and has also been bid into Asian countries such as Malaysia and the Philippines.

Turning to the Hanwha presence at IDEX 2025, Coulter added that the company is very focused on the Middle East market. "We've been doing business here, mostly on an export basis, for 15 years," he said, "but given Hanwha's technology, innovation and interest in becoming industrial partners, we have conversations throughout this week, with Middle Eastern militaries but also with Middle Eastern industry about how Hanwha can partner to help meet requirements in in the Middle East."

Lastly, Coulter emphasised how his remit as global defence CEO will see him "working across both traditional Hanwha Aerospace, but also with Hanwha Systems and the naval portion of Hanwha Ocean".

He pointed out, for example, that, given the current global interest in air defence capabilities, the Hanwha Aerospace stand at IDEX 2025 included models of the company's L-SAM and M-SAM long- and medium-range air defence systems, which he noted "has significant content both from Hanwha Aerospace but also from Hanwha Systems in the form of the radar", adding that "as we look to grow globally, I'm very interested in opportunities where we can leverage the strength of Hanwha's defence capabilities across the whole of our defence businesses".

Examples of this are Hanwha campaigns in both Canada and Poland where the KSS-III submarine designed by Hanwha Ocean is looking to address the Canadian Patrol Submarine Project (CPSP) and Poland's Orka submarine programme.



# Long-range rocket artillery munitions: A market overview

Sidney E. Dean

**Demand for long-range rocket artillery has increased with the return to great power conflict. The Ukraine war is demonstrating the utility and power of this weapon category on the modern battlefield.**

The definition of long-range rocket artillery is fluid on two axes, so it is necessary to set some parameters for this review since different nations may draw different lines between medium- and long-range systems. For the purpose of this article, however, long-range will be applied to systems capable of striking targets at a distance of 70 km or more, although the majority of weapons discussed will have a notably greater range. Likewise, some nations distinguish between rocket and ballistic missile systems. As the boundary between high-end large rocket artillery and lower-end ballistic missiles becomes increasingly blurred – in part by imbuing rocket artillery with greater range, size, and precision guidance capabilities – this review will treat the differentiation between the two weapon classes as academic. The decisive factor for inclusion will be the operational employment of the weapon system as conventionally-armed indirect surface-to-surface precision fires suitable to neutralising high-value, time-critical targets at extended range.

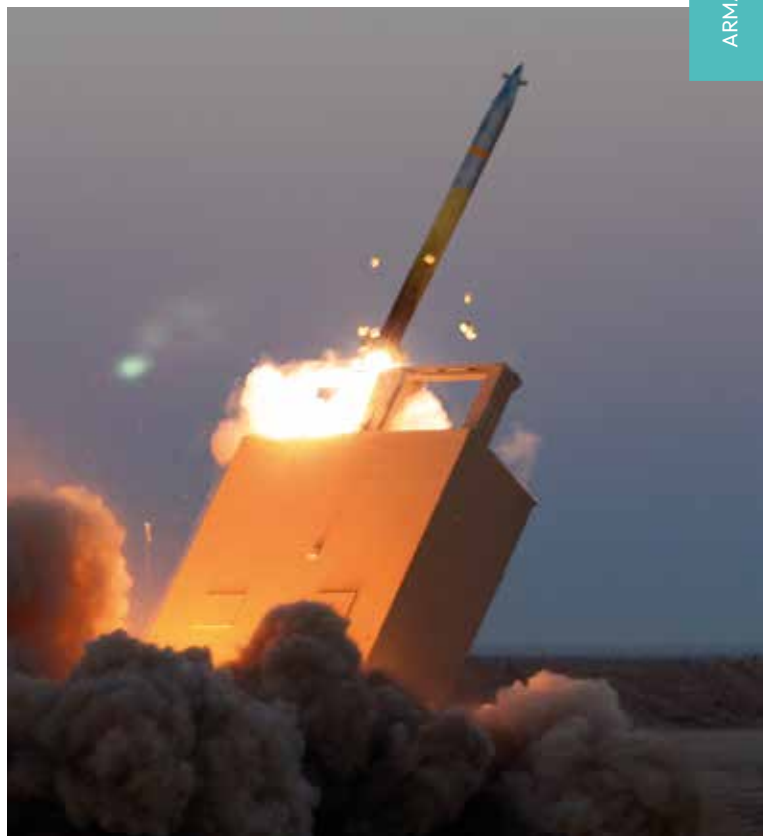
## GMLRS

The guided multiple launch rocket system (GMLRS) developed and produced by Lockheed Martin can be launched from the M270 Multiple Launch Rocket System (MLRS) and M270 derivative launchers, as well as from the M142 High Mobility Artillery Rocket System (HIMARS) launcher system. They are currently in service with 16 nations including ten NATO member countries. Donations from the United States and European partners have made Ukraine the 17th operator.

GMLRS illustrates major development trends regarding rocket artillery. The M270 MLRS initially deployed the M26 family of medium-range unguided rockets which were fielded as of 1983. The United States and the various European users phased these unguided weapons out between 2007 and 2017. They were replaced by the GMLRS which was approved for low-rate initial production (LRIP) in 2003 and first used in combat in Iraq during 2005.

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▲ **An M270 launches a GMLRS round at a building that insurgents were using to store explosives, and a nearby weapons cache, near Bayji, Iraq, on 27 December 2007. [US Army/Rick Rzepka]**

Several improved GMLRS munitions were developed over the last two decades. These precision-strike guided weapons are currently produced in two variants, both of which utilise an inertial navigation system (INS) paired with Global Positioning System (GPS) for guidance. The M30A2 rockets carry an area-effects payload consisting of a 90 kg high explosive (HE) warhead surrounded by two layers of pre-fragmented inert tungsten projectiles. This payload is designated as the Alternate Warhead (AW), which detonates in airburst mode. The height of burst (HOB) is adjustable. By contrast, the M31A2 rocket mounts a 90 kg unitary HE warhead in a steel casing for low-collateral precision strike against point targets. The unitary warhead permits attacking targets in urban settings. Three detonation options are available: HOB, point detonation on impact, and delayed detonation following impact.

Both the M30A2 and the M31A2 utilise the improved Insensitive Munitions Propulsion System (IMPS) motor and achieve a range of 84 km, a notable improvement over the M26A1's roughly 45 km range. However, in future war scenarios surface-to-surface rocket artillery will require significantly greater range in order to deny the enemy safe havens for marshalling forces, stockpiling

ordnance, or launching airstrikes. Since 2018, Lockheed Martin has been developing the Extended Range (ER) GMLRS capable of striking targets located over 150 km from the launcher. Like the current system, the extended-range rockets will come in two variants, the M403 with the AW payload and the M404 with the unitary payload. The ER munitions have a redesigned body, a larger motor, and a tail-driven control system that enhances manoeuvrability when compared to current GMLRS rockets. The rocket will adjust the attack trajectory to vertical at select ranges to target. It also has a new side-mounted proximity sensor (SMPS) designed to enable an optimal height of burst (HOB) for both the AW and unitary warhead variants of ER GMLRS.

First flight of the ER GMLRS was conducted in March 2021. Since then several successful test launches from the HIMARS have been conducted, validating the rocket's ability to complete a 150 km flight trajectory and demonstrate flight accuracy from launch to impact on designated target sets. As of January 2025, the Army plans to conduct another five flight tests, including two launches of multiple rockets, through the autumn of 2026. A full-rate production (FRP) decision is expected by the end of 2026. Foreign military sales of the ER GMLRS have already been approved.

## ATACMS

Lockheed Martin's MGM-140 Army Tactical Missile System (ATACMS) can be launched from either the M270 MLRS or the HIMARS launching system. It was first used during Operation Desert

### ▼ Launching the US Army's M57 ATACMS from a HIMARS launcher. [US Army]



Storm in 1991, providing a long-range, precision-guided missile system crucial of striking targets deep within enemy territory. Currently, it is in the inventory of 11 nations, including Ukraine, with five additional nations contracted to procure the ATACMS. The most recent configuration of the ATACMS carries the US Army designation M57E1 MOD, which achieves up to 300 km range and has a 227 kg unitary warhead. The warhead can be programmed to detonate on impact or, using a proximity sensor, in airburst mode. The M57E1 MOD is created by modifying older ATACMS variants. This modification process is accomplished by replacing older missiles' M74 anti-personnel and anti-materiel (APAM) bomblet payload with the unitary warhead, re-graining the propellant in the motor to enhance performance, and upgrading navigation and guidance systems.

## PrSM

Ultimately, ATACMS will be replaced by the Precision Strike Missile (PrSM) currently being developed by Lockheed Martin, which the Army initiated in 2016. The PrSM is to be fielded in four sequential increments, each endowed with additional or enhanced capabilities. While offering considerably better performance parameters than ATACMS, the PrSM will be launched from the M270 MLRS and the M142 HIMARS, and will be utilised much the same way as ATACMS is now, albeit two PrSM missiles will fit per launch pod, in place of the one per pod with ATACMS. As defined by Lockheed Martin, PrSM's mission is to deliver enhanced capabilities for neutralising, suppressing and destroying targets at depth, supporting units and operational commands from the brigade level upward and contributing to multi-domain operations (MDO).

Flight testing began in 2019 and has maintained a high success rate. Following the successful fifth production qualification test (PQT) in November 2023, the Army accepted delivery of the

### ▼ Test flight of the PrSM, on 1 December 2023. [PEO Missiles & Space/Darrell Ames]



first four units of the Increment 1 Early Operational Capability (Inc 1 EOC) production run in December 2023, with an additional 22 missiles to be delivered through 2024. “From [December 2023] forward, we have been focusing on more ground testing and flight testing to make sure that the system we put in the hands of soldiers had been vetted through all the safety things that need to be done,” said Lt. Col Zack Lewis, PrSM Inc 1 programme manager, in October 2024. In December 2024, the Army conducted the first Limited User Test (LUT) performed exclusively by military personnel. Two missiles were launched from a HIMARS in a long-range test against a target set, proving system readiness.

Increment 1 has a unitary HE warhead equivalent in size and effects to ATACMS; an insensitive munition (IM) energetic payload and propulsion system; and an INS/GPS guidance system. The Pentagon and Lockheed Martin have, to date, been intentionally vague regarding the new weapon’s range. According to the Pentagon, Inc 1 is considered the PrSM baseline capability with a threshold lethal range of 400 km. Lockheed Martin has in fact confirmed that the missile has demonstrated 499+ km range in testing. Lockheed Martin further stated that the system’s open architecture ensures the capability to “easily spiral” the missile’s capabilities to achieve longer ranges.

Additional Production Qualification Tests of Inc 1 are expected through June 2025 and an acquisition Milestone C decision is expected by the end of Fiscal Year 2025 (30 September 2025); a declaration of IOC is also anticipated in 2025.

Development of Inc 2 began in 2020, with the Army planning to begin procurement in Fiscal Year 2026, with deliveries due in 2027. Army budget documents indicate that Inc 2 will have a multi-channel guidance system that will enable engagement of moving targets including naval vessels, but also high-value relocatable land targets. Future plans call for an Inc 3 which will

focus on enhanced lethality, and an Inc 4 which could achieve up to twice the range of Inc 1. According to Army statements, work on Inc 4 is in the science and technology phase.

### Europe seeks to diversify

Many European nations utilise the M270 MLRS (or derivative launchers modified to local standards) and/or the M142 HIMARS. Consequentially, they rely largely on the GMLRS or, to a lesser extent, the ATACMS for long-range rocket artillery munitions. Several have already announced plans to adopt the PrSM when it enters service. According to Brig Rory Crooks, head of the US Army Futures Command’s Long-Range Precision Fires Cross-Functional Team, the UK and Australia have even expressed interest in co-development of future PrSM increments.

At the same time, European nations are also seeking to diversify their rocket artillery capabilities as they upgrade their arsenals for high-end future warfare. Several bi- and multi-national projects and studies are underway to modernise the currently operational modified MLRS launchers or, alternately, to develop new launchers which will permit deployment of a greater variety of rocket munitions. This latter initiative would reduce reliance on US-designed or manufactured rockets and missiles. European nations are already planning to source some weapon systems from third-party vendors outside the United States. Additionally, France in particular is pursuing domestically developed long-range rocket artillery options.

### CGR-080

In 2022, Poland placed an order for the K239 Chunmoo MLRS system produced by Hanwha Defense. First units were delivered in August 2023, with field trials conducted in 2024; a follow-up order was announced in December 2024. The Polish Army designates the truck-mounted system as the Homar-K MLRS, and plans to use the new weapon system side-by-side with the existing fleet

#### ▼ [Launching a CGR-080 rocket from the K239 Chunmoo launch system. \[Hanwha Defense\]](#)



of HIMARS. With the K239 able to accommodate a variety of munitions, Poland has ordered the CGR-080 239 mm guided missiles which carry an HE warhead and have a range of up to 80 km. Additionally, Poland is acquiring the CTM-290 ballistic missile which is also launched from the Homar-K; this 600 mm missile has a 290 km range and carries either a 500 kg penetrating warhead suitable for attacking bunkers and other hardened targets, or a thermobaric warhead.

## EuroPULS

In February 2025, Germany announced that it would become the fourth European nation (after Denmark, The Netherlands and Spain) to procure the Precise and Universal Launching System (PULS) produced by Elbit Systems; additional European nations are considering the system. For this new market, Elbit and partner firms, including KNDS Deutschland, are integrating German command and control (C2) systems to produce the EuroPULS variant. Serbia for its part is purchasing the original PULS system.



▲ **A launch of the EXTRA munition from the PULS launcher. [Elbit Systems]**

PULS and EuroPULS can deploy a wide range of munitions, including third-party weapons, reducing reliance on a single supplier. Most European operators have yet to announce their intended loadout. However, Elbit has announced that at least one European customer has included rockets with the PULS acquisition contract. In September 2024, Diehl Defence and Elbit Systems Land announced a partnership to “deliver rockets and advanced training rockets for the PULS and EuroPULS, specifically designed to meet the European rocket artillery requirements and those of the German armed forces in particular”.

Two Elbit Systems munitions would have significant potential for European nations’ long-range rocket artillery mission. The Extended-Range Artillery (EXTRA) missile has been offered since the mid-2000s, and has a range of up to 150 km, with a circular error probable (CEP) of 10 m. Four missiles can fit per PULS launch pod; the 120 kg warhead is available as a unitary HE-FRAG warhead or a penetrating warhead for hardened targets. Alternatively, Elbit’s Predator Hawk missile has a 300 km range,

striking targets at maximum distance within eight minutes of launch with a CEP of <10 m. Up to two missiles can fit per PULS launch pod; this munition carries a 140 kg unitary warhead.

Uncertainty remains regarding the compatibility of the EuroPULS and GMLRS munitions. While Elbit has maintained that the American rockets could be integrated with the Israeli launch system, Lockheed Martin’s vice president for strategy, Howard Bromberg, has explicitly stated that the two systems were incompatible. “The MLRS family of munitions cannot be integrated into the PULS system,” Bromberg said during Eurosatory 2024. Should there be no technical workaround, countries such as Germany would ultimately be forced to maintain two launch systems or divest themselves of their remaining GMLRS stocks.

## Feux Longue Portée-Terre (FLP-T)

France plans to phase out its remaining nine M270 derivative Lance-Roquettes Unitaire (LRU) launcher systems (which no longer receive maintenance support from Lockheed Martin) and replace them with a (preferably) domestically developed system. The Feux Longue Portée-Terre (FLP-T) long-range ground fires programme calls for fielding the new system by 2027, a timeline the Chief of Staff of the French Army, Gen Pierre Schill, now concedes is not realistic. Schill has called for intense maintenance to keep the LRU operational past their 2027 end-of-service date and acquire LRU-compatible rockets able to “shoot deep within the 100 kilometre range” while the FLP-T programme goes forward.

The Military Programming Law (LPM) 2024–2030 calls for the FLP-T programme to acquire 13 new missile artillery systems by 2030 and a total of 26 systems by 2035. Performance goals call for fielding rockets with 150 km range during the programme’s first phase (2024–2030),

with range extended to 500 km during the second phase (2030–2035). Two consortia are currently competing for the contract to develop both the new launcher and new munitions. One partnership consists of Arianespace, which is pursuing missile propulsion and warhead development, and Thales, which is responsible for guidance systems.

The second consortium is composed of Safran Electronics and Defence and MBDA France. Here, MBDA is responsible for munitions propulsion and warhead design while Safran is responsible for guidance systems. The partners have already presented their Thundart guided artillery rocket as a FLP-T solution during Eurosatory 2024. The model displayed at Eurosatory appears to show a 227 mm diameter body. The Thundart is compatible with the LRU, and achieves the 150 km range required for phase 1 of the long-range ground fires programme.

The INS/GNSS navigation and guidance system will be based on the Armement Air-Sol Modulaire (AASM) family of air-



▲ **A model of the Safran/MBDA Thundart munition on display at Eurosatory 2024. [Mark Cazalet]**

launched bombs, albeit configured to withstand the shocks associated with aircraft carrier catapult starts and arrested landings. Matthieu Krouri, head of the Battlefield sector at MBDA, emphasised that Thundart could strike movable but not moving targets, at least during the first increment. According to Krouri, “The machine must be able to strike with precision fixed or movable targets up to a distance of about 150 km. The idea here is not to strike moving targets, which would require a more complex and much more expensive guidance system, but to be able to ensure a certain form of saturation both against fixed infrastructures and against targets of opportunity [...] thanks to the rocket’s deployment and movement speed.”


## Changing times

Moving forward, two noteworthy trends for future rocket artillery include moving target engagement capability, and the use of air-breathing munitions. In this vein, MBDA has recently showcased two designs with such capabilities.

The UK is pursuing moving target engagement at more traditional rocket artillery ranges, in the form of the Land Precision Strike (LPS) programme. The solution being developed by MBDA comprises a turbojet-powered munition flying at high subsonic speeds, with a sophisticated active radar seeker capable of independently scanning for targets in flight, performing automatic target recognition, and manoeuvring to intercept the target, even against moving targets. The round is smaller than many others mentioned in this article, at 190 mm in diameter, roughly 3.5 m long, and weighing under 140 kg. While smaller than many missiles in this class, the expectation here is that the munition’s very high precision offsets the need for a large warhead. While certainly a very promising programme, it remains to be seen whether or not the UK will elect to proceed with it following the publication of the Strategic Defence Review (SDR) due out later in 2025.

The second noteworthy design from MBDA is the Joint Fires Support Missile (JFS-M), first showcased at the ILA 2022 exhibition. The munition is significantly larger than the LPS munition, and is essentially a surface-launched cruise missile, though MBDA specifically refers to it as an ‘artillery’ system compatible with the German Army’s Future Indirect Fire System programme. JFS-M is capable of deploying from mixed-load multiple rocket launchers including M270 derivatives and EuroPULS. The operational concept presented by MBDA would deploy the cruise missile in precisely the same manner as the solid-fuel artillery rockets, attacking the same target sets to achieve the same goals.

According to MBDA, JFS-M is expected to have a range of over 300-500 km and a scalable-effect warhead capable of eliminating point targets or small area targets. The missile can be deployed on kinetic attack, electronic warfare, or reconnaissance missions (depending on payload), and employ variable flight patterns and low-level flight to minimise detection and maximise survival. Missiles can be networked with one another or with other weapon systems and command centres, maximising situational awareness and the ability to adapt to changing circumstances. The combination of GPS and image-based navigation and guidance systems, augmented by an AI-supported Automated Target Recognition capability, are expected to allow engagement of moving targets, and provide redundancy against electronic warfare countermeasures.

MBDA is currently self-financing the technology maturation for the JFS-M. The German Army’s expansion plan calls for acquiring the ability to strike targets at 300 km distance by the early 2030s. Jochen Dehner, MBDA’s head of army systems marketing, has expressed confidence that his firm could provide the capability, with the caveat that the start of a development programme would depend on when a selection decision is made and on the level of budget allocation. 



▲ **Mock-up of the JFS-M ground-launched cruise missile at the Berlin aerospace expo in 2022. [MBDA Deutschland]**

# Mass precision strike: The best of both worlds

Dr Sidharth Kaushal

**While neither as reliable as high-end bespoke munitions, nor as overwhelming as traditional massed artillery, the growing array of affordable precision strike options offers militaries a third way forward.**

The tradeoff between mass and precision has often characterised discussions regarding warfare. Militaries can either achieve statistical effects (for example that a given weight of fire will deliver lethal effect with a certain probability), or they can increase their likelihood of defeating a specific target by employing more precise munitions. During the latter stages of the Cold War, for example, the Soviet second echelon was to be engaged with a range of emerging deep strike capabilities as part of the US' Second Offset Strategy,

- ▶ **The Izdeliye-52 (Z-52) model of the ZALA Lancet family (pictured) has since been supplemented by the longer-range Izdeliye-51 (Z-51) and the more autonomous Izdeliye-53 (Z-53) models. [RecoMonkey]**

while on the other side of the Iron Curtain the Soviet Chief of General Staff Marshal Nikolai Ogarkov saw the portents of a "military technical revolution" driven by a combination of pervasive intelligence, surveillance, and reconnaissance (ISR) and deep strike capabilities. One consequence of this would be that the first echelon would have to fight at ever greater depths, and on the assumption that it alone would be decisive.

However, in truth, the precision age never truly existed when it came to war at scale. It tends to be forgotten that as even during the 1980s the then-Supreme Allied Commander Europe (SACEUR) General Bernard Rogers estimated that he had the capacity for a week of conventional warfighting before he would have to rely on tactical nuclear weapons. Similarly, for all his interest in military technical revolutions, Ogarkov was most concerned with quickly overrunning NATO's tactical nuclear weapons in-theatre. This was reasonable, since the most important effect of deep strike would have been not to cripple the Soviet second echelon,

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but to fix it in place by temporarily disrupting its command and control (C2), and thus setting the conditions for tactical nuclear weapons to be employed against it. Precision, then, never truly undid the logic of statistical weaponry.

Today, a third category of weapon has entered the repertoire of many militaries – capabilities which can be used en masse but which are relatively precise. Many of these capabilities are not nearly as reliable as precision strike at either the tactical or operational level, and most of them have systematic vulnerabilities. However, they provide a greater likelihood of effect than traditional conventional statistical weapons such as unguided artillery. The question for many militaries will be how mass precision strike is integrated into force structures in a manner that leverages its strengths while accounting for the weaknesses of many of the systems which can be described under this rubric.

#### What do we mean by 'mass precision strike'?

The concept of mass precision strike deserves further elaboration, since oft-used terms such as 'kamikaze drone' can apply to anything from a USD 200 quadcopter uncrewed aerial vehicle (UAV) fitted with a PG-7V warhead, all the way up to the IAI Harop one-way attack (OWA) UAV, which costs almost as much as many cruise missiles. Broadly speaking, there are three categories of weapon which can be grouped under this broader label – commercial off the shelf (COTS) systems, simplified versions of existing capabilities and older precision strike capabilities.



- ▲ **A typical example of a common FPV drone design. These are often fairly crude, but have also proven highly effective under permissive operational circumstances. [Russian MoD]**

The first type of system, COTS capabilities, has received the most attention, given the widely distributed videos of first person view (FPV) UAVs (typically Chinese made DJI Mavic drones originally built for civilian use) scoring kills against Russian tanks in Ukraine. This does have an element of selection bias, since only hits are recorded. In fact, FPV drones are highly susceptible to jamming and spoofing, and given their small payloads, only around 20% of these UAVs reach their targets. Moreover, losses remain high – by way of example, both Russia and Ukraine have employed over 10,000 UAVs per month, most of which have been lost. Additional complications arise from the fact that massing these UAVs saturates control frequencies, while workarounds such as using a single larger UAV as a control hub creates a point of failure within the system. Even so, however, these systems have proven highly lethal in permissive contexts and have served as an important gap-filler when dedicated tactical missiles such as anti-tank guided missiles (ATGMs) were not available, with FPV drones accounting for the majority of kills on Russian armour in 2023.

The second category of system comprises bespoke military systems in which some components or capabilities are substituted for less-expensive or more available parts in order to enable scaling. Examples of this include the Iranian Shahed OWA UAV family, in effect a propeller-powered cruise missile, which is made scalable by sacrificing both terminal phase sensors and by using a Serat-1 Wankel rotary engine. Similarly, the Russian Lancet loitering munition family, costing roughly USD 30,000 per unit (depending on model), is scalable partially because of commercial inputs such as Light Detection and Ranging (LIDAR) from automobiles.

These systems have a higher probability of achieving a desired effect than COTS systems, although they still fall well short of the standard demanded of dedicated military systems. For example, based on what can be gleaned from open source data, Russian-made Lancets were documented to have scored roughly 193 kills in in 2023, when Russia was known to have manufactured roughly 900 lancets – implying a single-shot probability of kill (SSPk) of 0.25. This is shy

of the effectiveness demanded of most western complex weapons (which are typically expected to have an SSPk of around 0.8 or so), but considerably higher than that of unguided weapons (for example, typical artillery kills roughly 8 people per 100 rounds fired). In this category are also functional equivalents of existing platforms which rely on bespoke military manufacturing but sacrifice some element of performance in order to make a system more scalable. For example a Bayraktar TB2 UAV can play a close air support role comparable to a manned fixed-wing aircraft but can do none of the other things that manned aircraft can do, and is much more vulnerable in contested airspace.

Finally, older precision strike capabilities can be employed to provide additional mass. We might consider, for example, how Russia has employed the Tochka-U tactical ballistic missile (TBM) and Kh-22 air-launched cruise missile (ALCM) in this role, along with North Korean missiles, such as the Hwasong-11A (KN-23), Hwasong-11B (KN-24), and KN-25 short-range ballistic missiles (SRBMs), which though not old per se, are comparable to older Russian systems. The scale of the global arms market over the last few decades means that there are large numbers of systems which are no longer state-of-the-art operated by militaries around the globe. For example, France has exported 2,000 older models of the Exocet missile in the last two decade.



- ▲ **Older precision-strike systems, such as the Soviet-era Tochka-U (pictured), are often sufficiently cheap and numerous to allow their use as a form of low-cost precision strike capability. [Russian MoD]**

## Combining mass and precision

As will be evident from the earlier discussion, none of the three categories of system described will replace truly bespoke military capabilities any time soon – they are all subject to limitations which preclude this. However, it remains the case that there is no immediately-available equivalent in Western arsenals to the tactical nuclear weapons of the Cold War – a statistical weapon that would have multiplied the effects of precision strike. As such, it is worth considering how second-tier precision strike can be combined with more

bespoke systems to provide both statistical effect and to solve the challenge of scaling military capabilities.

The first role that second-tier strike capabilities can play is as a means of unmasking an opponent's systems. For example in Ukraine, Russian UAVs are often used in advance of cruise missiles as a pathfinding capability, which forces Ukrainian radar to unmask in order to track them. While a reliance on passive sensors can potentially help militaries obviate this challenge in the future (particularly as acoustic sensors become more effective against UAVs) but the very fact of an engagement taking place can assist in localising a sensor and shooter (such as an air defence system) for engagement by a more complex system. Another example might be the way in which triplets of Orlan-10 UAVs (one typically equipped with a jammer) are used as to unmask systems for strikes using the Iskander-M system's 9M723 SRBM).

defence network during the Second Nagorno-Karabakh War as a proxy for what this might look like. This is of particular salience for Western militaries, since exercises repeatedly show them succeeding at achieving objectives but at a prohibitive cost. For example, wargames and modelling by NATO militaries suggest a brigade would achieve its objectives but at the cost of 80% of their strength.

Similarly, the weight of historical experience suggests that even a loss rate of around 4% per sortie can cripple an air force over time, with most Cold War modelling suggesting that the task of suppression of enemy air defences (SEAD) was achievable, but at the cost of a significant degradation of available airpower. Western militaries face a second echelon problem – they can, if properly equipped, seriously damage an opponent's first echelon including their integrated air defence system (IADS), but cannot easily exploit the opportunities that this provides. It is here that second-tier strike capabilities in the hands of po-



▲ **Low-cost UAVs such as Orlan-10 have acted as critical enablers for longer-range strike systems, such as the Iskander-M (pictured) SRBM system. [RecoMonkey]**

The second role which second-tier precision strike capabilities can play is as a means of exploitation. In contact between the first tier elements of two forces, both are likely to be heavily attrited. As a consequence, however, many of the threats which make a second-tier system less survivable than a first-tier system are mitigated. For example, assuming both air defences and electronic warfare (EW) systems are attrited during first contact, a system such as the Bayraktar TB2 can be highly effective. We might, for example, consider the impact of the TB2 against Armenia's obsolescent air

potentially less-capable second line units (for example mobilised reservists) might add greatest value. To use an example, given the relatively short training times for many second-tier strike systems (certification on the TB2 takes about four months, for example), these systems can be used primarily by reservists, who could be mobilised as an exploitation force in a context where they would be far more lethal.

The third role second-tier strike capabilities can be employed in is for the simple purpose of saturation. This has




▲ **Owing to their relatively low cost and short time required for training, second-tier strike capabilities such as the Bayraktar TB2 (pictured) represent a fairly simple means to boost capability among second-line units. [Baykar Technologies]**

been evident in Ukraine, where the scarcity of air defence interceptors has been a major consideration – one exacerbated by the need to employ them against targets which are often cheaper than the interceptor. While the layering of sensors on the modern battlefield can partially alleviate the challenge by allowing some targets to be distinguished from others (for example UAVs can be more readily distinguished from cruise missiles by their acoustic signatures), it remains the case that many target types are indistinguishable (an example being cheap and expensive ballistic missiles). Furthermore, sensor layering and operator discipline cannot always be relied upon.

This leads to a final use case for mass precision strike capabilities, which is as a competitive strategy. The systems and skills needed to defend against these capabilities are often not cheap and furthermore impose requirements for skilled personnel. For example, Russia has had to deploy the Pole-21 EW system down to the company level in Ukraine. Not only does this impose costs, since every unit generated has to be enabled in this way, but it also imposes dependencies on smaller numbers of skilled personnel such as EW operators, who cannot be quickly trained or easily replaced. Even comparatively cheap solutions such as obscurants impose a logistical cost. An M58 obscurant

dispenser, for example, has about 90 minutes' worth of visual obscurant and 30 minutes' worth of infrared (IR) obscurant in it, after which it must be replenished. The more enablers a unit needs to operate, the smaller the deployed element of a first echelon force must become since equipping a force for the defence involves both costs and the introduction of dependencies. Second tier strike and the ubiquity of the risks it poses, then, can be a means of shaping the way in which an opponent can generate forces and limiting his capacity to use the forces theoretically at his disposal since against poorly defended or trained second echelon troops the effectiveness of these systems increases drastically.

### A balanced approach

When examining the utility of mass precision strike, it is important to avoid both the extremes of technology-driven euphoria and an excess of conservatism. On the one hand, it is the case that many of the systems which can be described under this label have significant limitations which preclude their being used as substitutes for existing capabilities. However, they can be used in tandem with existing systems to provide a degree of mass which is presently lacking from many Western arsenals. 

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# Movement is life

Thomas Withington

**The US Army is moving ahead with efforts to ensure that manoeuvre forces enhance their mobility with requisite on-the-move networking and command-and-control capabilities.**

One of the key takeaways from the ongoing war in Ukraine sounds like one of the most obvious, particularly for land manoeuvre forces: Movement is life, staying still is death. Manoeuvre formations must keep moving as much as possible. Simply put, stationary targets are easier to locate and attack unlike mobile forces, with the latter continually covering ground and hopefully manoeuvring to a position of physical advantage vis-à-vis the enemy. The need for mobility can challenge the signaller. Notionally, battlefield tactical networks are designed to be survivable and mobile.



- ▲ **Units from the 2nd Armoured Brigade Combat Team participated in the AFN OTM initiative in 2022 at Fort Stewart, Georgia. Lessons learned from this event have fed into the AFN OTM pilot 2 which is expected to take place later in 2025. [US Army/Capt Detrick Moore]**

In response to this critical need for movement, the US Army is reducing its static command posts and infrastructure and investing in modular, highly mobile command posts (CPs). These mobile CPs will enable freedom of manoeuvre for commanders to execute command-and-control (C2) at a time and place of their choosing. This effort, which began with prototyped integrated network and communications technologies in tactical vehicles at division and brigade echelons, is informing armour formation experimentation.

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## MANET foundations

Mobile Ad Hoc Networking (MANET) is a tactical communications technique which has movement at its core. Radios are transmitters, receivers and nodes in large tactical voice and data networks. Very/Ultra high frequency (V/UHF: 30 MHz to 3 GHz) MANET radios transmit and receive voice and data traffic to other MANET radios across line-of-sight (LOS) ranges. Nonetheless, radios beyond LOS ranges in the same network can send and receive traffic. Each MANET radio in the network is a node. Traffic is forwarded from one radio to another until it reaches its intended recipient.

MANET is not new. Initial work on so-called 'packet switching' began in the early 1970s with the sponsorship of the US' then Advanced Research Projects Agency (ARPA), now Defense Advanced Research Projects Agency (DARPA). An article dedicated to packet switching could be written in its own right. For the sake of brevity, it works as follows: A radio receives traffic from either a human voice or a computer, and then divides this into several small packets of data. As well as containing the data, these packets convey other details such as their intended recipient. This latter information helps radios in a packet switching network direct traffic to its destination. Once they reach the receiving radio, the packets of data are reassembled into the voice traffic, or whatever information the original radio was transmitting.



- ▲ **Flashback to 1998: vehicles are seen here equipped for a demonstration of the US Army's Near-Term Digital Radio initiative, a ground-breaking advancement of MANET technology which also fed into the UK's High-Capacity Data Radio programme. [US Army]**

ARPA sponsored the development of the Packet Radio Network (PRNET), which was an early example of a MANET network. Research into MANET continued in the United States and elsewhere into the 1980s and 1990s. In fact, the US Army was instrumental in developing a prototype MANET system via the near-term digital radio (NTDR) initiative, according to the service's official history. The NTDR effort commenced in the 1990s and involved companies including ITT (now L3Harris) and Bolt, Beranek and Newman (now part of Raytheon). Work completed on the NTDR fed into the realisation of the High-Capacity Data Radio (HCDR). HCDR formed a key part of the UK's Bowman tactical communications, and C2 system. Bowman remains in service today and the HCDR component provides a 225 MHz to 450 MHz internet protocol tactical communications backbone on the battlefield. According to the historical record, ITT's UK/VRC-340 was the original HCDR transceiver. This radio could carry data at rates of between 288 kbps and 750 kbps, depending on whether 500 kHz narrowband or 4 MHz wideband channels are used. One HCDR MANET network reportedly comprises a maximum of 200 radios. Each radio has a range of up to 15 km (9.3 miles).

## Armoured Formation Network On-The-Move

The US Army continues to take mobile, resilient network communications to the next level. In January and February 2022, the force conducted the first phase of the Armoured Formation Network On-The-Move (AFN OTM) pilot. The service is exploiting lessons learned therein to conduct phase 2 of the pilot this fiscal year. Lieutenant Colonel Marquessa Keith, mission network product manager and tactical network project manager, assigned to the Programme Executive Office for Command, Control, Communications, and Network, says that the AFN OTM "is not a separate network, but a US Army effort to equip armoured formations with new and emerging commercial OTM and At-The-Quick-Halt (ATQH) network communications capabilities".



- ▲ **As well as experimenting with technologies to enhance mobile connectivity, AFN OTM work is looking at how C2 mobility can be enhanced. [US Army/Amy Walker]**

As noted in a US Army article published in September 2022, AFN OTM efforts are intended to dovetail into multi-domain operations (MDO). Broadly speaking, MDO is a military philosophy which emphasises the inter- and intra-force connectivity of all military assets (personnel, platforms, weapons, sensors, bases and capabilities) at all levels of war to fight synchronously across all domains. The goal of MDO is to foster better-quality

and faster decision-making than one's opponent. When properly executed, MDO should force opponents into being continually reactive. The US Department of Defense (DOD) is realising MDO via the Combined Joint All Domain Command and Control (CJADC2) initiative. CJADC2 will federate the disparate C2 systems and networks currently used by all US armed forces.

Given the core role connectivity plays in the MDO approach and CJADC2 manifestation, it makes sense for the Army to look closely at manoeuvre force connectivity. Interestingly, the answers to these challenges may not be found within the offerings of conventional defence suppliers. We are all aware of the connectivity we take for granted in our everyday civilian lives facilitated by the internet and smartphones. As the September 2022 article makes clear, AFN OTM leverages commercial technologies and their application. The piece stated that both commercial C2 and communications capabilities "could enable mobility, increase survivability, and ensure lethality at the decisive point, across all warfighting domains".

To be fair, the Army is not approaching this problem from a cold start. Much as MANET fosters secure intra-force mobile connectivity, initiatives such as the Integrated Tactical Network (ITN) harness commercial offerings. The ITN is a US Army programme which exploits technologies like civilian-standard smartphones and tablets, and connectivity protocols such as Wi-Fi and fifth-generation (5G) cellular communications. The ITN can be deployed by the manoeuvre force and used for the transport of sensitive, but non-classified, data within the force, and between allied and coalition units.

According to the Army, the ITN is already up and running. Network functionality is being introduced through a series of year-numbered Capability Sets (CSs). As an example, Army documents state that CS21 introduced the wherewithal to



- ▲ **The US Army's work via the AFN OTM initiative should eventually yield a modular AFN capability which can equip vehicles and be configured according to the mission in hand. [US Army/Amy Walker]**

integrate augmented reality NVGs. This Capability Set also enhanced satellite communications (SATCOM) deployed by expeditionary signals brigades. The follow-on CS23 is deepening ITN and CJADC2 connectivity while enhancing low/medium Earth orbit (LEO/MEO) SATCOM connectivity. Capability sets are being introduced into the ITN, and hence manoeuvre force, roughly every two years.

The first AFN OTM pilot in February 2022 was supported by the 2nd Armoured Brigade Combat Team (2nd ABCT) of the 3rd Infantry Division. Taking place at Fort Stewart, Georgia, the AFN OTM pilot was intended to “inform operational and technical concepts, requirements, technological maturity and affordability”. The goal was to support the design criteria and plans to enhance on-the-move network capabilities for US armoured formations to make them more survivable and lethal.

During the 2022 AFN OTM Pilot I, the US Army evaluated technology from over 20 companies that were integrated into some of the 2nd ABCT’s vehicles. A set of questions serves as guidance for the overall AFN OTM effort:

- Will the systems being introduced enhance lethality and survivability?
- Do the technologies enhance the commander’s common operating picture and decision-making cycles?
- Are technologies easy to use and reliable?
- Do they support and enhance unit Primary, Alternate, Contingency and Emergency (PACE) safeguards for network resilience?

SATCOM is particularly important for PACE. The diverse set of emerging commercial OTM and ATQH pilot capabilities for the 25 AFN OTM Pilot Phase II, include high-throughput low-latency SATCOM systems that operate in both geosynchronous orbit (GSO) and LEO. The kit also includes multi-band, high-capacity, line-of-sight backhaul and mesh networking capabilities. Additional capabilities comprise commercial 5G LTE (fifth-generation long-term evolution) cellular, and secure Wi-Fi base-band systems. These capabilities include a Secure But Unclassified-Encrypted (SBU-E) enclave to enable integration of ITN data exchange.

## Taking AFN OTM forward

The Army’s 2025 AFN OTM Pilot II will integrate lessons learned from the 2022 pilot initiative. According to an Army statement, the 2025 AFN OTM will be supported by the 1st Infantry Division (1st ID) and will take place later in 2025 at the

National Training Centre, Fort Irwin, California. The 1st ID has already gained some familiarity with AFN OTM capabilities. The unit used them during a command post exercise at Fort Riley, Kansas in November 2024 as part of its preparations. The 1st ID headquarters, the Division Artillery Brigade and the 1st BCT headquarters will be among the 1st ID units supporting the pilot.

The document further mentioned that technologies to be evaluated for this year’s event include 5G and secure Wi-Fi. Multi-band, high-capacity line-of-sight links will be examined along with secure-but-unclassified systems permitting ITN data exchange. A key focus is ensuring the network remains resilient in heavily congested and contested electromagnetic environments. The pilot II commercial technologies were integrated into the division’s HMMWV and JLTV 4x4 wheeled vehicles. The eventual goal is for AFN OTM capabilities to be provided in modular form for integration into multiple vehicle platforms, also including BAE Systems AMPV tracked and GDLS Stryker 8x8 wheeled platforms. Modularity will let users insert and remove capabilities according to their mission. The AFN OTM kit will include numerous automatic PACE contingencies, meaning that network transport options will automatically switch should one suffer congestion or attack.

The 2025 AFN OTM pilot is not only focused on network communications that enable C2, but also on improving CP mobility “by making command posts more mobile through expeditionary rapid set-up/tear-down ATQH network transport systems ... OTM network capability will also provide the flexibility for commanders to fight disaggregated or collected regardless of geographic or mission constraints”, Lt Col Keith stressed. Key considerations for C2 node survivability include mobility, resiliency, dispersion, electromagnetic signature, as well as hardware size, weight and power (SWaP). The latter point is a key consideration vis-à-vis armoured vehicle space limitations, Lt Col Keith explained. Additionally, the Army will own the emergent AFN OTM architecture design, helping the force to avoid proprietary solutions and hence vendor lock.

Lt Col Keith emphasised that AFN OTM assessments are not occurring in a vacuum. The technologies realised via the initiative will fully integrate with the Army’s Unified Network, which integrates disparate and stovepiped tactical and enterprise Army networks, consolidating these into a single architecture. Tactically, these efforts improve Army C2: “In potential future large scale combat operations against advanced enemies, mobility and OTM C2 are crucial elements to survivability and lethality.” Ensuring C2 execution while mobile “enables commanders to be present at decisive points on the battlefield, whether physically or digitally, to make and execute rapid informed decisions”.

While the Army continues to transform how it communicates, the force is facing a changed geopolitical landscape. The first two decades of the 21st century saw the US military


- ◀ **AFN OTM kit will be integrated into some JLTVs of the 1st Infantry Division during the forthcoming AFN OTM pilot at the National Training Centre, Fort Irwin, California.** [US Army/Maj Edgardo Rivera]





- ▶ **Prototype AFN OTM equipment has been installed inside this US Army HMMWV 4x4. This platform, and its AFN OTM equipment will be used during the 2025 AFN TOM Pilot-II experiments. [US Army/Amy Walker]**

involved in counter-insurgency operations, but it is now preparing for potential future large-scale combat operations with near-peer adversaries. As Lt Col Keith noted, Army manoeuvre force networking and C2 have changed accordingly. The work pioneered via the AFN OTM Pilot II will inform a “networking capability baseline (to) replace the current

OTM and at-the-halt systems that armoured formations use today”. The benefits heralded by the AFN OTM work will be seen beyond the manoeuvre force, enhancing the Army’s operational, and ultimately strategic, posture. As the embrace of MDO and its CJADC2 manifestation moves forward, the Army is helping these aspirations become reality. 

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# Bridging: Keeping up with rising MLC

Tim Guest

**Over more than a century of operational deployments, military vehicles of all descriptions have evolved in shape, size and weight, with military bridging and gap-crossing systems keeping up with those changes in order to safely bear in-service vehicular platforms across obstacles to maintain force mobility on the battlefield.**

the load-carrying capacity of the bridging or gap-crossing equipment and the effect produced by a particular military vehicle crossing them, factoring into any calculations such parameters as vehicle weight and geometry, as well as differing characteristics for tracked and wheeled platforms. This assessment ensures the vehicle's capability to use a particular piece of gap-crossing equipment, without it catastrophically failing, with the potential loss of vehicle,



▲ **Pictured: Medium Girder Bridge. Industry is ensuring the MLCs of military bridging systems are keeping pace with latest armoured vehicle weight and design changes. [KNDS UK]**

Through the eyes of leading industry players, this article looks at how the military bridging sector is addressing the need to ensure the military load classifications (MLCs) of their gap-crossing equipment are keeping pace with latest armoured vehicle weight and design changes, and potentially altering the MLCs of new vehicles, themselves.

The procedure and information required for vehicles and bridging systems to calculate their respective MLCs are complex, and space precludes detailed consideration of the process to calculate MLCs here. In the context of this article on military bridging, the MLC number is representative of

or vehicles crossing it, or simply causing damage to the bridging system in any way. An accurate MLC allows users, or assigned combat engineers, to determine, which appropriate and available gap-crossing systems can be used to support a particular mission safely.

The MLC calculation procedure is conducted according to NATO Standard AEP-3.12.1.5. It is worth stressing the point that when calculating a vehicle's MLC, whether tracked or wheeled, its final MLC is dependent not only on the vehicle's weight, but also on its geometry.

## Keeping inventory MLCs on track

With that brief MLC explainer in mind, and in order to find out a little about how the military bridging sector is keeping its inventories on top of latest armour trends and how MLC requirements might be changing in the face of current tracked and wheeled-vehicle developments, *ESD* spoke with leading

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- ▶ **Pictured: DSB deployed in Korea. At KNDS UK, one of the solutions used in the design of its bridging systems, such as its dry support bridge (DSB), is finite element analysis. [KNDS UK]**

military bridging manufacturers, General Dynamics European Land Systems–Bridge Systems (simply GDELS for the purpose of this feature) and KNDS UK.

While armoured vehicle designs continue to change and are, in some, though not all, cases getting heavier, military bridging makers are having to ensure their bridging portfolios can meet any new MLC requirements. A spokesperson for GDELS told *ESD* that this is not really a new trend, as gap-crossing assets have always needed to keep pace with the growing weights and design changes of the vehicles they were supposed to carry, adding that load capacity is influenced by a variety of construction factors. To ensure bridge qualification even for the heaviest loads, the calculated specifications are verified through extensive tests by manufacturers, customers, and neutral test authorities.

At KNDS UK, one of the solutions used in the design of its bridging systems, such as its dry support and medium girder bridges, is finite element analysis (FEA). Communications and marketing lead for the company, Emma Livingstone, told *ESD*, that to maximise the capability of tactical bridging, KNDS UK has employed the use of FEA to gain a full insight into the strength of the bridge. “By using computer simulation,” she said, “we’ve been able to gain a full understanding of the most highly loaded sections of the bridge and improve the design as necessary.” Through the simulation of various operational scenarios and different loads, FEA – which is just one example of the solutions employed by KNDS to mitigate any trends for increased vehicle weight – examines such active parameters as deformation, stress, and the dynamic behaviour of a bridging system.

## Floating heavy armour

Having come through all those qualification stages, GDELS said that its main floating and dry-gap bridges, such as the M3 and the Anaconda, are designed and qualified to carry the heaviest MBTs in use with NATO. This has been practi-

cally proven in several customer tests, including recently by the US Army’s Engineer Research and Development Centre (ERDC), which tested the Army’s in-service Improved Ribbon Bridge (IRB) with the latest configuration of the M1A2 Abrams main battle tank (MBT), the M1A2 SEPv3. At 9.7 m long, 3.7 m wide, and 2.4 m high, the new variant weighs in at 66.8 tonnes (though can be heavier with additional components added), an increase compared to the earlier M1A2 SEPv2, which weighs 64.6 tonnes. The GDELS IRB passed all the Army’s tests and is now approved to carry the new M1A2 SEPv3 in both the IRB’s bridge and ferry configurations.

Another GDELS example is its M3 amphibious bridge and ferry system, which won a competitive trial in South Korea during 2021 against international competition, and more recently began deliveries to the Swedish Defence Materiel Administration (FMV) in November 2024. The M3 is engineered to bear the weight of some of the heaviest European MBTs, such as Challenger 2, which when including its different combat armour configurations can go up to around 75 tonnes; the Leopard 2A7V at some 66.5 tonnes is also approved for carriage by the M3 system. GDELS told *ESD* that its M3 amphibious bridging system is being further developed at this time, February 2024, “to carry even higher loads in its next generation”.



- ▶ **GDELS’ Improved Ribbon Bridge (IRB) is now approved to carry the M1A2 Abrams SEPv3 in both the IRB’s bridge and ferry configurations. [GDELS]**

As to whether it’s always feasible to re-engineer existing bridging systems to increase their load-carrying capabilities, or if it’s simply a case of having to design new higher-MLC systems from scratch, the GDELS spokesperson said that, indeed, it is sometimes feasible to re-engineer, citing the M3’s original MLC 70 classification, which was increased to MLC 85 for the British Army, through engineering modifications. In addition, the company’s former Biber/Beaver system, which had a maximum MLC of 80, depending on its configuration/variant, was re-designed and upgraded to MLC

80-100, and is now known as Anaconda. The GDELS spokesperson said: *“it’s important to note that the MLC of bridges that were designed and built 30 years ago were calculated on a rather conservative basis and with high safety factors. Today, modern computerised calculations allow a more precise classification, and even these older bridges can usually carry higher loads than originally calculated.”*

On this same subject of re-engineering and modification of existing systems to change MLCs, KNDS’ Livingstone told ESD that, *“There is potential to modify our current bridge systems, with key considerations such as weight, build time, build complexity and ease of transportation taken into account. Retrofitting equipment to existing bridges presents significant growth potential in our current tactical bridge portfolio and upgrades to current systems would allow continued interoperability with the existing fleet.”*

### Adapting to the latest armour

While European military armoured vehicle designs are changing, weights are not necessarily always increasing – as can be seen with the US Army’s recent decision to backtrack on completing development of the M1A2 Abrams SEPv4 variant. Indeed, GDELS’ spokesperson said that they believed today’s MBTs had reached practical weight limits and that future combat vehicles are likely to become lighter once more, due to new technologies, including active protection systems (APs) and unmanned subsystems. This will help avoid the severe limitations to mobility imposed by increasing vehicle weight.

The new trend towards speed and mobility on the battlefield is a clear one and not only contributes to a vehicle’s survivability, but also, as GDELS emphasised, illustrates the importance of getting a vehicle to where it’s needed in the first place. Without the right bridging, that vehicle is almost worthless; and that’s without factoring in the many restrictions to size and weight that will be encountered along the way in Europe’s civilian infrastructure, which is often ill-prepared for MBTs.

For its part, according to Livingstone, KNDS UK’s R&D team continuously appraises developments in the armoured fighting vehicle (AFV) market to ensure that the company’s portfolio remains at the forefront of the tactical bridging sector. She said that looking at the MLCs for current MBTs,

it appears that tactical bridging will be able to traffic these systems without the need for upgrades, adding that each of the company’s four main bridging categories – assault bridging, tactical bridging, LOC bridges and wet gap crossings – has a technology leader with whom most NATO partners operate, which provides interoperability between the users. *“In the case of our dry support bridge (DSB) in the tactical bridging sector, current interoperability can be sustained whilst catering for the latest AFVs coming into service.”*

### Versatile inventory

As for GDELS’ bridging product range, its systems, some already mentioned, can handle payloads and MLCs ranging from 100 kg to 120 tonnes. The Anaconda wheeled tactical bridge-laying system, for example, incorporates the earlier Beaver bridge’s proven design, re-engineered and carried onboard either 8x8 or 10x10 trucks, with the two available Anaconda variants – 1x22 m span and 2x12 m spans – tailored to NATO’s payload/MLC requirements and, according to the company, able to carry all vehicles currently in use by Alliance forces. GDELS presented the Anaconda on an 8x8 HX truck from RMMV at Eurosatory 2024, although other



▲ **Pictured: Anaconda, based on the earlier Beaver system. Re-engineering is one way to upgrade and increase bridging MLCs. [GDELS]**

platforms are capable of carrying the bridge; the use of 10x10s allows for crew cab protection to be integrated into the design.

Another system with two alternative bridge variants – a 15 m span MLC 90 version, or 9 m span MLC 120 system – is GDELS’ Cobra, with a modular, front-launched design that can be mounted either permanently or temporarily on a variety of different base platforms, including medium-weight wheeled or tracked armoured vehicles, and launched or retrieved in about two minutes under full protection for the crew; once disconnected from the bridge, the base

platform can be used for other purposes, while the bridge itself remains in use. A Boxer Cobra front-launching vehicle version was demonstrated by Rheinmetall in early 2024. GDELS has also integrated Cobra on a Fendt Vario 900 farming tractor, an innovative approach, though again with essential battlefield mobility in mind. GDELS' spokesperson noted: *"Tractors are already being used by engineers as versatile construction vehicles, combining good off-road mobility with outstanding usability, their small turning circle and 180° swivel seat for reversing, making the tractor a particularly suitable variant for use in confined spaces, such as might be encountered in urban or wooded terrain, that would otherwise hinder the manoeuvrability of heavier bridge-laying vehicles."*

When it comes to the hundreds of major rivers snaking their way throughout Europe, for wet-gap crossing GDELS' M3 and IRB floating bridge systems are an essential part of NATO's military mobility backbone. The M3 is the most agile available amphibious bridge and ferry system for such applications in the Alliance, although many more M3s are ideally needed across member nation inventories for the Alliance to be truly prepared in the event of a major Europe-wide conflict. M1A2 Abrams, Challenger 2, and Leopard 2 main battle tanks (MBTs) are just some of the armour the MLC 85(T)/132(W) M3 is capable of carrying in its bridge or ferry configurations.

While pontoon bridges such as the IRB are less expensive, though slower to deploy, than amphibious bridge and ferry

systems, they also remain a flexible and valuable asset, especially for rear-area operations. The MLC 80(T)/96(W) IRB is in use with seven users today, and according to the GDELS spokesperson, the M3, IRB, and the IRB's SRB/FSB predecessor systems are fully and safely interoperable through a specifically designed coupling adaptor. The spokesperson added that with limited (national) capabilities available across the Alliance, this interoperability is of major importance and holds especially true for floating bridges, both pontoon and amphibious. Indeed, with wet gap crossing near a frontline riskier today than ever – as has been played out on the battlefields of Ukraine – such crossings must be carried out as fast as possible.

## Adapt or die

Among the inventories of NATO members and in the portfolios of Europe's military bridging industry sector, there are undoubtedly advanced bridging systems displaying the right MLC characteristics to handle even the highest vehicle load classifications across European military fleets. Their ability to adapt to new vehicle requirements is clear. The problem is, there simply are not enough of them already in the hands of Allied forces. So, it's not just a growing variety of new-generation tracked and wheeled armour that's driving NATO's need for more bridging systems with the appropriate MLCs, it's also because many more bridging systems, of all kinds, are needed across the Alliance, period. These assets need to be pre-deployed at scale among member nations, particu-



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- ▲ **The M3 amphibious bridging and ferry system's original MLC 70 classification was increased through engineering modifications to MLC 85 for the British Army. The M3 is fully and safely interoperable with the IRB and the IRB's SRB/FSB predecessor systems. [GDELS]**

larly on the Alliance's eastern flank, in order for combat engineers to have all the systems they need at a moment's notice.

Without these resources, the engineers just can't make that happen, and that makes military bridging systems about as essential as the armour they're designed to carry. While doctrine is developed by armed forces and not by industry, it should be unsurprising that GDELS advocates for high availability of bridging assets, with the spokesperson noting, *"Wherever manoeuvre elements go, combat engineers need to be able to support them without delay, using more systems in quantity, but also with a flexible and diversified toolbox. It is, however, up to the users to define their needs and implement respective procurement programmes."*

While not ubiquitous, increases in armoured vehicle MLC remain widespread, despite some trends towards lighter, more agile platforms. For its part, KNDS is exploring a number of ways to increase the capability of its bridging systems to address these continued increases. Livingstone said that the various development projects the company has in progress at present aim to use a combination of computer simulation, laboratory testing, and its experience to meet customer requirements. At this time, KNDS UK is looking to increase the capability of its current systems and is also designing additional equipment that could potentially increase the MLC ratings of its bridging systems. It is also looking at different materials and manufacturing methods that will allow it to optimise the strength-to-weight ratio of any of its bridges, the aim being to provide additional strength in key areas, whilst keeping weight increases to a minimum. 



- ◀ **Pictured: DSB. KNDS UK is looking to increase the capability of its current bridging systems, including designing additional equipment to potentially increase their MLC ratings and at different materials and manufacturing methods that will allow it to optimise the strength-to-weight ratio of any of its bridges. [KNDS UK]**

# Assault rifle programmes: Continuity and change

David Saw

**From outsourced versus domestic production, to collaborative procurement, to the introduction of a new calibre – the story of modern assault rifle procurement reveals the divergent paths being taken by various NATO members, Ukraine, and the US.**

In the past, the capability to design, develop and manufacture a complete range of small arms was considered to be a fundamental part of a national defence industrial capability. Even a nation that could not design and develop small arms would have the capability to produce weapons in this class locally under licensed production terms. A national defence industry would also have the capability to produce ammunition for whatever small arms were in the inventory. That was the situation that lasted for more than a century in Europe; however, since the end of the Cold War, small arms manufacturing capabilities in Europe have entered a period of decline.

France is a prime example of this phenomenon, as France was once a world leader in small arms and related ammunition technology. It designed, developed and produced pistols, rifles and light machine guns – the complete range of small arms systems and their associated ammunition. One might argue that this was not a critical defence industrial capability in the post-Cold War world, especially since the size of ground forces was shrinking. In 1996, the French government suspended compulsory military service, officially ending conscription in 2001. If you are not going to be building hundreds of thousands of weapons for a large conscript Army, is there really need for a small arms industry?

France decided it did not need large-scale small arms manufacturing, which presented a problem when it sought a replacement for its FAMAS assault rifle under the 'Arme individuelle futur' (AIF) programme. The AIF called for a rifle in standard 5.56

× 45 mm NATO, with only European manufacturers being considered. After a full evaluation of numerous systems, in September 2016, the Direction générale de l'armement (DGA) announced that Heckler & Koch (HK) were the preferred contractor and that the HK416F and the shorter barrel HK416F-C, as well as HK269F 40 × 46 mm grenade launchers had been selected. A total of 117,000 HK416F were ordered, with some 93,000 for the French Army and the remainder for the Air Force and the Navy. First deliveries to the DGA were made in May 2017 and by the end of 2025, 94,000 rifles will have been delivered; deliveries will conclude in 2028.

Germany also conducted an assault rifle programme known as the System Sturmgewehr Bundeswehr to replace its existing inventory of HK G36 rifles. In contrast to France,

Germany had maintained its small arms industrial base. At the end of 2022, funding was released covering the acquisition of 118,718 HK416A8 rifles, in two variants; the G95A1 with a 16.5-inch barrel and the G95KA1 with a 14-inch barrel, with 2026 the in-service date. German Special Forces had previously acquired the HK416A7, with the official designator being G95. Outside of France and Germany, the HK416 has also been supplied to Ukraine where it has seen combat service.



▲ **French troops on patrol in the centre of Paris on Christmas Day 2024 as part of anti-terrorism measures. They are equipped with HK416F-C rifles with the Aimpoint CompM5 sight. By the end of 2025, France will have received 94,000 HK416 rifles. [Chef d'état-major des armées]**

#### AUTHOR

**David Saw** has been a defence journalist for over 40 years, writing for and editing magazines in Asia, Europe and America. His interests include defence industrial developments in Asia, current conflicts and the role of artillery and infantry on the modern battlefield.

## Ukraine's frontline

Put simply, it would be surprising if there is a modern or relatively modern assault rifle that has not been supplied to the Ukrainian military. The HK416 and its civilian version the semi-automatic MR223 have been supplied to Ukraine, HK416A2 models with 10.4 inch and 14.5-inch barrels, supposedly supplied via The Netherlands have been seen, as have HK416A5 rifles. Other weapons supplied to Ukraine include G36 and HK433 rifles, while 'official' German military assistance has included Haenel MK556 rifles, some 4,005 of which have been supplied to Ukraine.

Belgium has also supplied assault rifles to Ukraine; as might be imagined, these are all FN Browning weapons. Around 5,000 ex-Belgian Army FNC 5.56 × 45 mm rifles, a small number of F2000 weapons, a very limited number of SCAR-L rifles in 5.56 × 45 mm and even FAL rifles have been delivered. Former French Army FAMAS weapons have been delivered, while Steyr AUGs have also arrived in Ukraine; according to some, these are ex-Australian, while others suggest supply from Austria. Elsewhere, Thales Australia has supplied their recently developed Australian Combat Assault Rifle (ACAR) in both 5.56 × 45 mm and 7.62 × 51 mm in limited numbers.

Canada has been a major source of assault rifles for Ukraine, supplying Colt Canada C7 and C8 systems, the M5 carbine and even M16A4 and M4 weapons acquired via the US. The Netherlands has also supplied C7 weapons to Ukraine. French manufacturer Verney Carron, via its Lebel brand, also struck a deal to supply Ukraine with AR pattern rifles. Spanish CETME L rifles have also been exported to Ukraine. Poland has also been a major supplier of assault rifles to Ukraine, including ex-Polish Army AKMS weapons, the Tantal rifles in 5.45 × 39 mm previously used by the Polish Army, as well as the current issue MSBS Grot in 5.56 × 45 mm.

One of the most significant assault rifle developments in Ukraine occurred in December 2024, when local assembly of the CZ BREN 2 rifle commenced. Previously the CZ BREN 805 had been supplied and this was followed by the direct supply of the BREN 2 from the Czech Republic in both 5.56 × 45 mm and 7.62 × 39 mm calibres. Hopefully, local assembly of the BREN 2 will allow more small arms standardisation in Ukraine. Mention should also be made of other weapons supplied to Ukraine: these include old Czech vz.58 rifles and Serbian Zastava M70 rifles, both in 7.62 × 39 mm. While the US has supplied Ukraine with M4 carbines, it has also supplied Iranian-origin AK-47/Type 56 rifles in 7.62 × 39 mm captured while being smuggled to Iranian surrogates in the Middle East.

It is also well to remember that Ukraine was awash with assault rifles even before the supplies received in the current conflict. Large numbers of AKM/AKMS rifles in 7.62 × 39 mm, as well as large numbers of AK-74/AKS-74 rifles in 5.45 × 39 mm. There were also post-Soviet era weapons such as the Fort 221 and 224, a locally licensed version of the Israeli IWI Tavor in 5.56 × 45 mm. Another locally-produced weapon is the Vulcan-M 'Malyuk'; this is a bullpup design based on the AK action and used by Ukrainian Special Forces, and is available in 7.62 × 39 mm, 5.56 × 45 mm and 5.45 × 39 mm. Reportedly there is also an M4 clone being produced in Ukraine.

Ukrainian forces have also captured a large number of Russian assault rifles during the current conflict and are quick to use them against their former owners. Captures cover the complete range of Soviet-era small arms, up to the current issue AK-12. One aspect of the conflict in Ukraine is just how quickly small arms systems such as assault rifles can be lost, damaged or be beyond economic repair due to combat action. So, despite the fact that Ukraine has been supplied with large quantities of assault rifles, operational wastage means that a constant supply of weapons needs to be available, hence the importance of BREN 2 production in Ukraine.

- ▼ **The Vulcan-M, also known as 'Malyuk' (shown here in centre, and on right) is a Ukrainian domestic bullpup design which has joined the country's vast array of in-service rifles. [InterProInvest]**





- ▲ **The standard assault rifle of the Polish Land Forces is the MSBS Grot in 5.56 × 45 mm NATO, produced by Fabryka Broni Lucznik Radom. In December 2024, the Polish Armament Agency ordered a minimum of 46,000 Grot rifles. [Polish MND]**

## Recent acquisitions

In addition to assault rifles supplied by Poland to Ukraine, assault rifle developments in Poland are worthy of further discussion. Having used standard Soviet weapons, Poland moved to develop its own assault rifle solutions in the post-Cold War era. Work on the wz.88 Tantal rifle in 5.45 × 39 mm had started at Fabryka Broni Lucznik Radom (FB Lucznik) towards the end of the Soviet era as a replacement for the AKMS. The weapon entered service in the early 1990s, but it had a very short operational life with most weapons put into storage or sold off in the 1990s.

The next phase in Polish assault rifle development saw FB Lucznik develop a new weapon in the form of the wz.96 Beryl, though the reality was that this was an evolution of the Tantal in 5.56 × 45 mm. The weapon entered service in the Polish military towards the end of the 1990s, with three variants of the standard rifle, wz.96A/B/C eventually produced, as well as the wz.96 Mini Beryl, a carbine variant of the rifle. A version of the Beryl in 7.62 × 39 mm was exported to Nigeria with some 3,000 units acquired, with licensed production of the weapon being agreed.

Poland later developed a new a new small arms solution in the form of the MSBS Modular Small Arms System, primarily in 5.56 × 45 mm calibre. Initially the idea was that the weapon would come in two formats, one conventional and the other a bullpup for special forces. The bullpup variant was subsequently dropped and the programme emerged as a weapon available in multiple formats featuring interchangeable parts. There would be a standard assault rifle variant, a carbine, and a magazine-fed Squad Automatic Weapon equivalent (all of these available in 5.56 × 45 mm, with 7.62 × 39 mm as an option); also discussed was a Designated Marksman Rifle (DMR) variant in 7.62 × 51 mm. A civilian semi-automatic version of the system would also be made available.

At present, the primary Polish Army variant of the system is the MSBS Grot C assault rifle, the Grot C16 FB-A1 variant was

the first production batch, and after minor modifications the Grot C16 FB-A2 second production batch came into service. In December 2024, the Polish Ministry of National Defence announced a set of major small arms orders, with deliveries between 2026 and 2029. As part of this, there is a confirmed order for 46,000 Grot C16 FB-A2 rifles, with an option on additional purchases. An unknown quantity of MSBS Grot rifles in 7.62 × 39 mm have been sold to Rwanda.

## Scandinavian solutions

With both Finland and Sweden joining NATO, there is added impetus to collaborative defence procurement between the two nations. If one country has a suitable weapon system solution, it makes sense for the other to consider adopting it, delivering interoperability and reducing costs. This was certainly the case as far as Sweden and Finland were concerned, when both found themselves seeking a new small arms solution.

Back in 2020, the Finnish Defence Forces (FDF) had begun working with Sako (part of Beretta Holding) in Finland on the development of a new DMR and a sniper rifle. In December 2021, the FDF signed a contract with Sako covering the acquisition of two 7.62 × 51 mm weapons, the KIV 23 DMR and the TKIV 23 sniper rifle. Both of these weapons formed part of the M23 family, with that family also including an assault rifle option, which the FDF would purchase eventually. The FDF strategy was to purchase M23 systems in phases as part of “a controlled and cost-effective phase out of the current system(s)”.

Sweden had become interested in the potential of the M23 system and in April 2021 signed an information sharing agreement with Finland; in October 2021, it officially joined the programme. The Swedish requirement was to replace the AK4 (HK G3) battle rifle and DMR in 7.62 × 51 mm, the AK5 (FN Browning FNC) assault rifle in 5.56 × 45 mm that had first entered service in 1986, and the Psg 90 sniper rifle (Accuracy International Arctic Warfare) in 7.62 × 51 mm. They wanted an assault rifle in 5.56 × 45 mm, a battle rifle/DMR in 7.62 × 51 mm and a sniper



- ◀ **The Automatkarbin 24 (AK24) is the new 5.56 × 45 mm NATO assault rifle for the Swedish Armed Forces, replacing the old AK5 (FN FNC). The weapon is manufactured by Sako in Finland and is also used by the Finnish Defence Force as the M23. [Swedish Armed Forces]**

### A revolution or not?

Thus far, most of the weapons discussed here have been in the standard NATO calibres of 5.56 × 45 mm or 7.62 × 51 mm for DMR or battle rifle applications. Considering that the US essentially forced most of NATO to adopt the 7.62 × 51 mm round and then, not so long afterwards, went and selected a new assault rifle with a 5.56 × 45 mm round, there are fears that history might be repeating itself. The reason is the US Army Next Generation Squad Weapons (NGSW) programme.

system in .338 Lapua Magnum (8.6 × 70 mm). The sniper system will be the Sako TRG M10, a multi-calibre system switchable between 7.62x51 mm and the Lapua Magnum round.

The Automatkarbin 24 (AK24) programme to replace the AK5 with the M23 began in 2024. Initially, 200 test and evaluation weapons were delivered, followed by a series production delivery of 7,500 AK24 weapons in 2024. The target for 2025 is the delivery of 15,000 weapons, with 15,000 more arriving in 2026 for a total of 37,500. The DMR variant of the weapon was originally due to be delivered in 2025, but at this point quantities and actual delivery schedules are unclear.

Under NGSW, the US Army is looking for an M4 carbine replacement with the Next Generation Squad Weapon-Rifle (NGSW-R) and an M249 replacement with the Next Generation Squad Weapon-Automatic Rifle (NGSW-AR). The state of play with this programme is that SIG Sauer was selected as the winner of the programme in 2022, providing the XM7 for the NGSW-R and the XM250 for the NGSW-AR requirements. The round for the new weapons will be the SIG Sauer developed 6.8 × 51 mm Common Cartridge, also known as .277 SIG Fury in commercial applications.

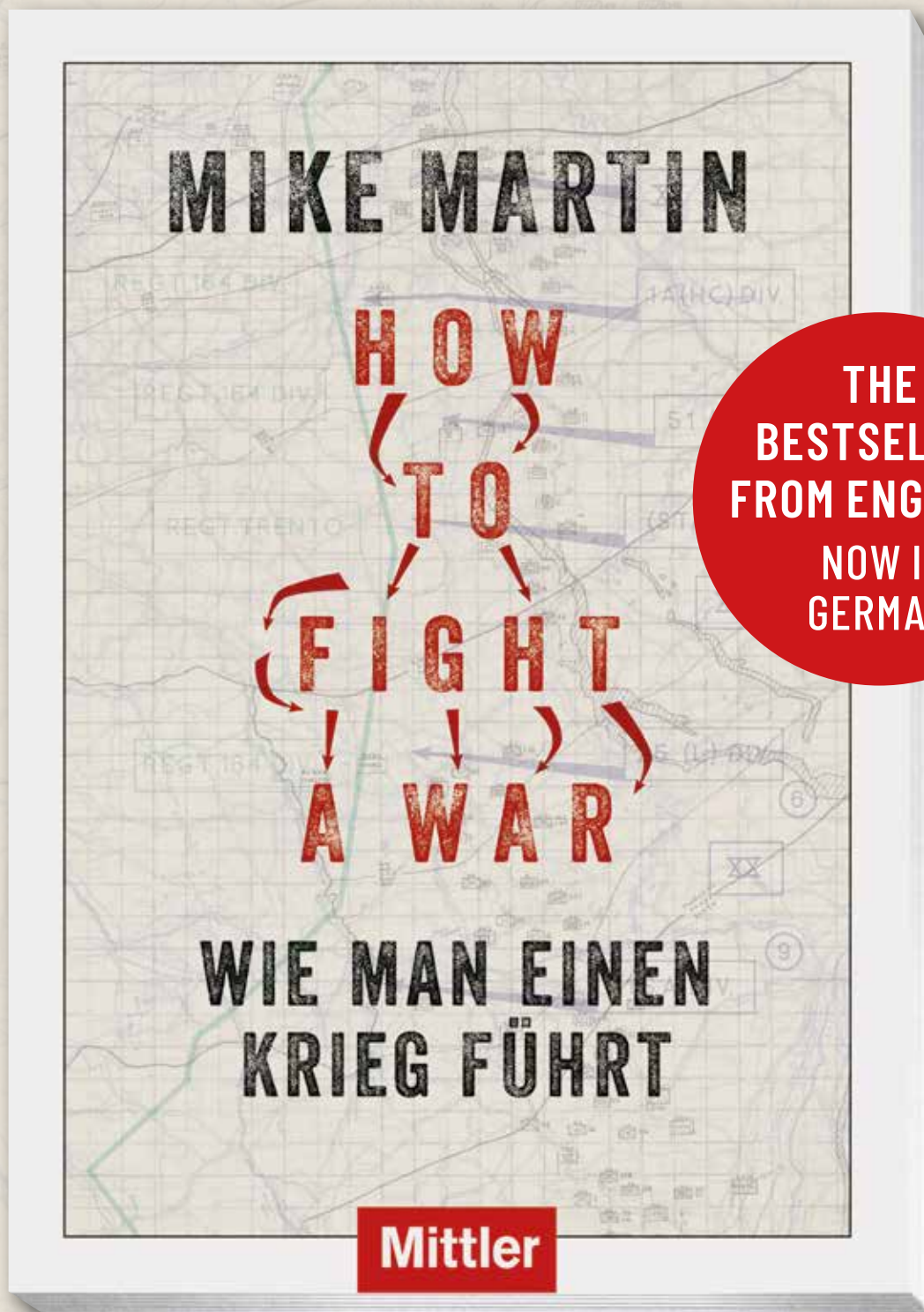


- ▶ **The 101st Airborne Division (Air Assault) took part in New Equipment Training (NET) in the first quarter of 2024 with the XM7 rifle, which is being acquired as a part of the US Army Next Generation Squad Weapons (NGSW) programme to replace the M4 carbine. [PEO Soldier]**

Both the XM7 and the XM250 are in the trials process with US Army and National Guard formations and, at this point, these are weapons that seem to have much to offer, with the new 6.8 × 51 mm round supposedly delivering performance beyond that achieved by current 5.56 × 45 mm and 7.62 × 51 mm NATO rounds. As an aside, there are also thoughts of replacing the 7.62 × 51 mm round in light/medium machine gun applications with weapons employing the .338 Norma Magnum amongst various manufacturers – what would be the price for NATO cartridge standardisation then?

The fact of the matter is that if the US Army officially adopts the XM7 and the XM250 weapons, along with the 6.8 × 51 mm round, and issues these weapons in numbers, then everything changes in terms of assault rifles and calibres. For example, the British Army has Project Grayburn to replace its L85 assault rifles, but when the project eventually gets underway, will they follow the US lead and go 6.8 × 51mm or stick with a 5.56 × 45 mm weapon citing compatibility with European allies as a factor? If we assume that the US Army does fully embrace the XM7/XM250 and the new round, it will be very difficult to turn down this small arms solution.





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# French special forces equipment

Jean François Auran

**In the current fast-paced technological landscape, defence equipment is experiencing rapid advancements. The French Special Forces, who assess new equipment annually, must stabilise their inventory to effectively develop operational concepts.**

(BFSA) commands the CPA 10 and 30 Air Parachute Commando, the 3/61 'Poitou' transport squadron, and the 1/67 'Pyrénées' helicopter squadron. The 2025 edition of SOFINS, a key event for France's SF community, addresses the following challenges: enhancing the effectiveness of operators and their equipment; ex-

panding the range of options; and reducing the time spent in the field. An overview of their current equipment is provided following these key ideas.

## Improving the efficiency of operators and their equipment

Enhancing SF capabilities involves utilising a variety of equipment to improve their performance. The French military programming act (LPM 2024-2030) includes provisions for equipping SF with new intervention capabilities, tailored to their diverse missions in various environments, enabling operations in challenging conditions.

Specialists in action, human intelligence, and counter-terrorism use standardised

weapons such as the HK416A5 assault rifle and Glock 17 pistol, equipped with optics, laser designators, and suppressors. Some (such as Mountain Commando and some Parachute Commandos) also use the SIG MCX VIRTUS assault rifle, while the SIG SG 553 assault rifle is used by divers. Helicopter crews have HK MP7A1 personal defence weapon (PDW), while marksmen use HK417 rifles, which were previously procured for operations in Afghanistan. In terms of sniper rifles, Air Force special forces employ Sako TRG-42 rifles in .338 Lapua Magnum (8.6 × 70 mm) and recently the Cadex CDX-40 SHDW in .408 Chey Tac (10.4 × 77 mm), while Marine commandos use Barrett M107A1 rifles in .50 BMG (12.7 × 99 mm). Special Forces are equipped with various machine guns including the FN Evolys, and vehicles, boats, and helicopters now mount the Dillon Aero M134D minigun. The 1st Marine Infantry Parachute Regiment (1er RPIMa) and 13th Parachute Dragoon Regiment (13e RDP), action teams, also use grenade launchers such as the HK GMG.



▲ The French Special Forces consist of around 4,000 personnel from all service branches. [Armée de l'Air et de l'Espace]

The French Special Forces (SF) are made up of the Commandement des Opérations Spéciales (COS; ENG: Special Operations Command) and units from the Army, Navy and Air Force. The Commandement des Actions Spéciales Terre (CAST; ENG: Command for Special Operations on Land) is the army's specific command, comprising three regiments, command and support elements with 2,500 soldiers and 45 helicopters. The Naval Special Forces (Commandos Marine) have seven specialised commands, including two special operations support commandos and 700 operators. The Air Force Special Forces Brigade

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The Military Air Expertise Centre (CEAM) is working with an industrial partner on a very low-altitude tracking radar, along with air-dropping French Naval Commando ZH-930 Rigid Inflatable Boat (RIB), known as ECUME. The unit operates two C-130H Hercules and two DH-6 Twin Otter aircraft. The recently renovated C-130s are equipped with an MX-20 optronic system, newer communication systems, and the Remotely Operated Video Enhanced Receiver (ROVER) system for Joint Terminal Attack Controller (JTAC) communication. There are options for arming the C-130 with Armement Air-Sol Modulaire (AASM) family guided bombs, which could be installed under the wing instead of additional fuel tanks. The Commandement des Opérations

- ▲ A Joint Terminal Attack Controller (JTAC) participates in a targeting exercise conducted by CPA10. The operator is armed with a Sako TRG-42 precision rifle. [Armée de l'Air et de l'Espace/Morgane Vallé]

For anti-vehicle or anti-tank missions, operators use the Saab AT4CS and the Nammo M72 LAW for their compactness. Army special units have also been using the Akeron MP anti-tank guided missile (ATGM) since 2018. In this context, the ability to launch Akeron MP ATGMs from the SF vehicle is a real operational asset, since missile can be launched and then switch to fire-and-forget mode, allowing the team to leave the area. Mortars are also part of their equipment, including Austrian Hirtenberger Defence Systems 60 mm mortars and plans to acquire the Alakran mortar platform from Spanish company Milanion NTGS.

SF units, as well as the wider armed forces, are set to receive the new Bariolage Multi-Environment (BME) camouflage. This newly designed pattern will replace the existing desert and Central Europe camouflage designs. This change is being implemented despite the widespread use of multicam. According to its designers, the BME decreases the visual signature of a combatant, increasing detection time by 25%. Following the Army, 700 Naval special operations personnel are scheduled to receive their uniforms starting in March 2025, with a slight delay anticipated for the French Air and Space Force. The land special forces utilise a highly versatile plate carrier known as the G3P. This equipment is fully modular and lightweight, designed to accommodate plates that provide protection against armour-piercing rounds.

## Renewing air and helicopter capabilities

In May 2022, the French Air and Space Force retired the last C-160 Transall, which had been modernised in 2019 with Command, Control, Communications, Computers, Intelligence, Surveillance, Target Acquisition and Reconnaissance (C4ISTAR) and Link 16 capabilities. The ET 3/61 "Poitou" squadron now uses the Airbus A400M transport aircraft, validated for all-terrain landings since 2021. The aircraft is also equipped with Link 16, which allows it to be integrated into air operations.

Spéciales also works with Air Force fighters, the MQ-9 Reaper unmanned aerial vehicle (UAV), and intelligence, surveillance, and reconnaissance (ISR) assets such as the Avion Léger de Surveillance et de Reconnaissance (ALSIR; ENG: Light Surveillance and Reconnaissance Aircraft).



- ▲ The Caracal remains the preferred helicopter for Air Forces Special units. [Armée de l'Air et de l'Espace]

The 4th Special Forces Helicopter Regiment (4e RHFS), based in Pau in the South of France, consists of seven Special Operations Squadrons and a detached unit based in Villacoublay near Paris. The fleet includes ten new-generation AS 532 Cougar helicopters, ten SA 342 Gazelle helicopters and eight EC665 Tiger helicopters. In addition, the Ministry of the Interior uses seven SA 330 Puma for rapid movement within the country. The situation regarding the equipment plan is evolving. The French Air Force will receive the entire fleet of 19 H225M Caracal helicopters on order, while the 4eRHFS will receive all 18 NH90 Standard 2 helicopters. These new helicopters, based on the NH90 TTH variant, will have a trans-

port capacity of 14 to 20 passengers, a Distributed Aperture System (DAS) and a new-generation Helmet Mounted Sight Digital Display (HMSD-DD). The aircraft features a Safran Euroflir 410 optronic sight, a new digital map generator, the installation of a third crew member and new, enlarged sliding rear windows capable of accommodating MAG58 machine guns. Flight testing of the prototype began in June 2024, and entry into service is planned for 2025. The unit will also receive 11 H160 M Guépard helicopters under the Hélicoptère Interarmées Léger (HIL; ENG: Joint Light Helicopter) programme. The programme integrates specific equipment, such as communication systems, and kits to specialise the aircraft. This approach has already been used on the NH90.

## Operations at sea

The increase in the armed forces' budget has enabled the modernisation of submarine incursion equipment. The PSM3G swimmer delivery vehicle, designed for marine commandos, is now in service and deployable on Suffren class submarines. It will be housed in a composite fairing to maintain hydrodynamics and discretion. The system is also air-transportable by C-130 aircraft, allowing it to be deployed to remote operating zones with minimal port stops or directly out at sea. Additionally, a third training module has been ordered, alongside two Dry Deck Shelters (DDS).

## Land mobility

Special forces must maintain their edge over conventional forces, which have ever more advanced resources and specialised units that cultivate a higher level of excellence. In France, these include the parachute and mountain commando groups (GCP and GCM) and the amphibious engagement support group, the 9eBIMa. The SF's level of innovation must therefore be considerably higher compared with recent commitments in the Sahel. In addition to the air vehicles already mentioned, land mobility is a source of progress. In-service Land Rover and Mercedes G-class vehicles are being phased out, with a new generation of vehicles in the process of being introduced.

The Poids Lourds des Forces Spéciales (PLFS; ENG: Special Forces Heavyweight) and Véhicule Léger Forces Spéciales (VLFS; ENG: Light Vehicle for Special Forces) Light Vehicles Programme (PLFS/VLFS) is now being delivered to the French armed forces after experiencing delays and technical challenges. The final allocation will consist of 151 PLFS and 206 VLFS vehicles. These numbers have been adjusted due to the procurement of additional vehicles outside the original programme. As a result of the programme delays, the Commandement des Opérations Spéciales has acquired 45 VOS-APP 6x6 vehicles produced by Technamm, based on the Toyota Land Cruiser AZJ 79, as well as around 20 Masstech



▲ **Members of the French Navy's Commando Hubert using the ECUME during a training exercise.**  
[Marine Nationale/Jonathan Bellenand]

SF units use various boats for sea operations, with the French Navy employing the aforementioned ZH-930 ECUME (9.35 m long), equipped with a NAZDAC autonomous navigation system from Safran, and carrying 12 commandos; and the Etraco (7.33 m long) carrying 14 operators. The Army's SF uses the Squalo RIB9.4 WJ, built by UFAST shipyards. For inland waters, the 1er RPIMa operates the Styx fast river craft.

Commando vehicles for the BFSa. In addition, TECNAMM will also supply around ten armoured VOS-MEDs designed around the Masstech T6 (VOS-APP), for medical evacuation.

French SF will soon receive Serval armoured vehicles modified by the Section technique de l'Armée de terre (STAT; ENG: French Army Technical Section), with two variant based on



Despite the standardisation of vehicles, there are still small fleets acquired according to their specific requirements. The Land Special Forces also evaluated the Haulotte Ultralight Tactical Platform (HUTP), produced by French company Haulotte. Equipped with a 160 hp diesel engine and a five-speed automatic gearbox, it can carry a payload of 1.2 tonnes, reach a top speed of 150 km/h and have a range of at least 1,000 km. Additionally, electric motorcycles and mountain bikes have been tested by the French SF for several years, such as the LMX 161 electric motorcycle.

- ▲ **The VOS-APP is a vehicle built on a Toyota 6x6 chassis, designed for high mobility. [Armée de l'Air et de l'Espace/Morgane Vallé]**

the infantry and command post versions of the Serval. Modifications include adding AN/PRC-152 and RF-9820 handheld radios, and the AN/PRC-117 portable networking radio. The command post version will feature a Satellite communication on the move (SOTM) terminal, and the Delta Suite C2 system.

At the light all-terrain vehicle end, the 1st RPIMa uses the Polaris MRZR, with some planned to include the Alkaran mobile mortar system. Units also operate quad bikes such as the Polaris Sportsman MV850 and MV700. The first units were delivered at the end of 2022. Alongside these, 60 Fardier light vehicles and 34 trailers are planned to support medical evacuation, logistics missions and carry 120 mm mortars. These vehicles have a top speed of 60 km/h, and are aircraft/helicopter-transportable, as well as air-droppable.

## Specialised ISR

Night vision binoculars are standard equipment for SF operators. The Thales Bonie HP NVG is a widely used model. The Commandement des Opérations Spéciales requirements were communicated to Thales in 2014, leading to deployment with units in July 2015 and serial production in 2018. Some task forces use L3 GPNVG four-tube goggles, while Thales Sophie and Safran JIM LR binoculars are used for long-range observation.

Alongside the above, the Commandement des Opérations Spéciales uses small drones to ensure timely observation, such as the Teledyne FLIR Black Hornet and the AeroVironment Puma 3 AE. The 61st Artillery Regiment (61e RA) of the French Army can also provide drone-based night observation capabilities if required. In terms of loitering munitions, the French SF are using the AeroVironment Switchblade 300, ordered in 2023, and are awaiting French equipment currently in development, including a drone based on Delair's UX11, and the container-launched R2-120 Raijin being developed by Fly-R and MBDA.



## Concluding remarks

The era of asymmetric warfare against terrorist groups in the Sahel is over, at least temporarily, and France's SF achieved very significant results in this mission. Yet more than ever, SF operations require discretion and superior firepower. SF are preparing for a more complex potential Ukraine scenario. Recent exercises such as 'Gorgon' and now 'Perseus' are adapting to this new situation and are also focusing on a previously marginalised aspect – the security and protection of information systems.

- ▲ **A briefing conducted by 13th Parachute Dragoon Regiment members during an exercise. [13e RDP]**



# Transformation through training

Dr Trevor Nash

**Ever since the NATO Prague summit in late 2002, NATO has fundamentally changed. This change can be witnessed by the addition of new members and the transformation of the alliance that has strengthened its deterrence posture. As an intrinsic part of the transformation process training has had a major part to play and this role will only continue in the coming years.**

In 2024, NATO celebrated its 75th anniversary following the signing of the North Atlantic Treaty on 4 April 1949. Initially comprising 12 founder members, today the alliance has grown to embrace 32 countries that are referred to as NATO Allies. In a complex world, NATO's mission is quite simply, "to safeguard the freedom and security of all of its members." A simple mission in theory but one that has grown in complexity since the fall of the Iron Curtain.

It achieves that aim through collective defence and that means that an attack on one member is considered an attack on all 32 members. This concept is embodied in Article 5 of the North Atlantic Treaty. The key element of Article 5 is all NATO Allies, "will assist the Party or Parties so attacked by taking forthwith, individually and in concert with the other Parties, such action as it deems necessary, including the use of armed force, to restore and maintain the security of the North Atlantic area."

If deterrence fails, then conflict is the likely outcome. In a multipolar world and a world where great power competition is growing, the military strength and efficacy of NATO becomes ever more critical. The 32 NATO Allies must work, deploy and seamlessly operate together to provide a credible response to third-party aggression. The key to achieving that goal is both political and military. Politically, individual nations should have fully funded and equipped armed forces and a clear willingness

to use them. Militarily, NATO Allies must be well trained and use common techniques, tactics and procedures (TTPs) where appropriate.

Considering purely the military aspects, NATO has three main methods by which to train its troops: exercises, deployments, and the use of NATO schools and Centres of Excellence (COE). Although this feature will concentrate on the education and training options provided by schools and COE, it is worth briefly mentioning exercises and deployments because as well as providing opportunities for military training, they are increasingly being used to send political messages to potential foes, chief of which is the Russian Federation.

An example of this 'exercise messaging' could be seen during exercise Steadfast Defender 2024, which involved over 90,000 troops from all 32 NATO Allies. The main exercise encompassed a number of smaller exercises such as Saber Strike 24 that took

place in Poland's Bemowo Piskie training area and involved troops from Germany, Spain, Italy, Poland and the US.

Speaking before the exercise, NATO's Supreme Allied Commander Europe, Gen Christopher Cavoli said that, "Steadfast Defender 2024 will be a clear demonstration of our unity, strength and determination to protect each other, our values and the rules-based international order."



- ▲ **As well as its COE and official training centres, NATO benefits from joint exercises to assist interoperability and training. [NATO]**

## AUTHOR

Following a career in the British Army specialising in air defence, **Dr Trevor Nash PhD** spent four years in the T&S industry before becoming defence journalist concentrating on training, simulation

This message was clearly reinforced during Saber Strike with the final phase seeing participants deploying to defensive positions in the Suwalki Gap, the corridor of land between Poland, Lithuania, Belarus and the Russian enclave of Kaliningrad. In early 2025, NATO troops forming the Allied Reaction Force (ARF) deployed to reinforce Bulgaria and Romania as part of Exercise Steadfast Dart. It is clear then that NATO takes deterrence very seriously and is keen to advertise its defensive capabilities to antagonists such as Russia.



- ▲ **An exercise underway at the Civil-Military Cooperation COE (CIMIC), located at Den Haag in The Netherlands. [NATO]**

Another example of deterrence can be found in NATO's operational deployments. An example of this posture can be found at Šiauliai Air Force Base in Lithuania where NATO's Baltic Air Policing force is based. NATO Allies deploy here on a four-month rotation. These aircraft are integrated with the German Air Force's deployment to Lielvarde Air Base in Latvia and both are controlled by a Combined Air Operations Centre (CAOC) at Ämari in Estonia.

This Enhanced Forward Presence (EFP) posture is also reflected in NATO's deployments to the Baltic states and Poland as well as Bulgaria, Hungary, Romania and Slovakia. Such deployments provide an ideal opportunity to conduct training at national and coalition levels.

## Schools & training centres

Before looking at the NATO COE structure, mention should be made of the NATO School in Oberammergau (NSO), the Joint Forces Training Centre (JFTC) and the Joint Warfare Centre (JWC). Like the COE, these organisations come into the bailiwick of Allied Command Transformation (ACT) that is based in Nor-

folk, Virginia and is one of two strategic commands in NATO; the other being Allied Command Operations (ACO).

ACT was created following the reorganisation of NATO's military command structure following the 2002 NATO Summit in Prague and became responsible for, "transforming NATO into a more efficient and balanced organisation that was better able to face new global challenges through improved training and a greater emphasis on interoperability." The way to achieve this transformation was recognised as improving training through the cross-fertilisation of ideas and knowledge.

In essence, ACT has four major functions: the development of strategic thinking; the development of capabilities; education, training and exercises; and finally, cooperation and engagement. Nowhere is this more apparent than at the NSO. Formed in March 1953, the NSO hosts some 10,000 students and conference attendees every year. Around 115 different courses are offered that cover six main areas: intelligence, cooperative security, joint operations, joint planning, protection and non-commissioned officer (NCO) programmes. As well as residential courses, NSO offers advanced distance learning opportunities as well as deploying staff as part of Mobile Education and Training Teams (METT) to deliver training in Allied Partner countries.

Turning to the Bydgoszcz, Poland-based JFTC, this organisation's role is neatly summarised in its motto to lead, 'Transformation Through Training'. It provides joint pre-deployment training to support current operations and future requirements, and by offering a platform for experimentation, testing, and interoperability. Its focus is on tactical level operations. Currently with a staff of 170 soldiers and civilians that represent 22 NATO

- ▼ **Using live chemical agents for training is unique to the Joint CBRN Defence COE in the Czech Republic, offering a chance for participants to experience the psychological challenges involved in handling them. [NATO]**



Allied countries, JFTC is organised into a Command Group which is responsible for three divisions: Training and Exercise; Training and Exercise Enabling; and HQ Support that together, provide live collective training.

Complimenting JFTC, NATO's JWC in Stavanger, Norway provides training that focuses on full-spectrum joint operational and strategic-level warfare that sits above the tactical level that is championed by JFTC. With a staff drawn from 18 NATO members, JWC provides collective training but uses the constructive domain to provide Computer Aided Exercises (CAX) to support collective defence and crisis response.

Another major initiative developed by ACT is its development of wargames. Unlike CAX, wargames provides what JWC refer to as, "a highly responsive, low-cost, and low-impact alternative to other training activities and can help provide a cognitive foundation upon which to guide future training." These is no doubt that NATO is a prime mover in the current wargames debate. It has published the NATO Wargames Handbook and provides input to many conferences around the world.

Although not a training centre in itself, NATO's Joint Analysis & Lessons Learned Centre (JALLC) provides the data to drive the future training that is provided by JFTC and JWC. Located in Lisbon, Portugal, and although fundamentally focusing on analysis to identify

▼ **There are a total of 30 accredited NATO COE that can be found in Europe and North America. [NATO]**

trends and their strategic implications, the organisation does provide a number of training courses as well as hosting exercise support through the JALLC Advisory and Training Team (JATT).

An example of JALLC's work can be found in its 'Two Years of Lessons Relating to Russia's War Against Ukraine'. The report covers aspects such as command and control, joint effects, the use of UAVs, EW and cooperation with national and international bodies. The report concludes that, "it is critical that NATO continues to develop and incorporate new technologies into modern warfare, traditional/conventional methods and materiel remain relevant and are often used in conjunction with their modern counterparts. As such, modern warfare will require superiority across the spectrum of modern and conventional warfare."

### Centres of excellence

NATO's COE were created to train and educate subject matter experts and commanders from NATO members and partner countries. As well as this pedagogical function, COE help in doctrine development as well as verifying that doctrine alongside operational concepts. They also provide an all-important expert-focussed source of knowledge for specific subjects.

They were first proposed in a paper entitled The NATO Military Command Structure (MC 324/1) dated 14 May 2003. By the end of 2003, the concept had been refined and criteria drawn-up for their establishment.





▲ **The Cold Weather Operations COE is located at Elverum in Norway and teaches Allied troops how to survive and thrive in snow and ice cold conditions. [NATO]**

The first organisations to achieve accredited COE status were the Air Power Competence Centre in Germany and the Defence Against Terrorism Centre of Excellence in Türkiye in 2005 and 2006 respectively. Since then, dozens of COE with NATO accreditation have been established across Alliance territory. The most recent COE to receive accreditation was the Climate Change and Security COE that was created in Montreal in 2024.

Each of NATO's 30 accredited COE concentrates on a specific function or area of expertise. On a visit to JWC in late 2024, Admiral Pierre Vandier of the French Navy, NATO's new Supreme Allied Commander Transformation (SACT) highlighted that transformation is not a simple one-time goal but an ongoing process. He said, "what makes us better as an Alliance is training" and then emphasised how essential training and warfare development are in ensuring NATO stays ahead of emerging threats. Around 20,000 personnel have graduated from COE over the years having benefitted from 150 different courses.

There are three different levels of COE participation. Framework Nations, Sponsoring Nations and Contributing Nations. In basic terms, a Framework Nation agrees to take on the responsibility of developing the concept and implementation of the COE. In addition, it agrees to provide physical space for the operation of the centre, as well as personnel to run the organisation. Sponsoring Nations contribute financially to the COE and provide personnel, whose salary they cover. Contributing Nations may provide financial support or some other service that is of use to the operation of the facility.

As part of the establishment process, the Framework Nation submits an initial proposal to ACT. Once this initial process

is underway, staff from the Framework Nation discuss their proposal covering areas such as syllabi, training resources and staffing. Once this stage is complete, the Framework Nation then submits an official application to SACT.

If the offer is accepted, the Framework Nation then draws up an Operational memorandum of understanding (MoU) that is sent to potential Sponsoring and Contributing Nations. Discussions lead to the creation of what is referred to as the Functional MoU and that is the trigger for ACT to define its accreditation criteria. If successful, the Military Committee of the North Atlantic Council approves the accreditation before courses can begin.

"The COE have proven themselves to be indispensable assets in strengthening our collective defence capabilities," opined Admiral Vandier. "...these centres have become increasingly vital in an era defined by Multi-Domain Operations (MDO). Their growing importance is evident in their contributions to doctrine development, lessons learned, education and training, exercise participation, and experimentation – all critical tools for implementing NATO's transformation."

It should be noted that although accredited COE have been established by SACT, they do not come under NATO command authority; however, according to NATO's Military Committee Policy For Centres Of Excellence (MC 0685), COE do "have a functional relationship with HQ SACT."

The authority of numerous NATO's COE has become world renowned and liaison takes place with many countries throughout the world. The Joint Air Power Competence COE (JAPCC) that is based in Kalkar, Germany is an example. Sponsored by 14 nations and headed by the US Air Force's Gen James Hecker, who is also Commander, US Air Forces in Europe and Commander, US Air Forces Africa, JAPCC, it is referred to as 'NATO's air and space power think-tank.'

JAPCC is currently engaged in an effort that is studying MDO that examines processes, command functions and technologies. As well as military input, industry and academia are involved in the project. JAPCC publishes 'The Journal of JAPCC' twice a year along with a number of white papers. In addition, an annual conference is held, normally taking place in late-September.

## Conclusion

The NATO Prague Summit that concluded in November 2002 recognised the "grave new threats and profound security challenges" facing the alliance. This resulted in the acceptance of seven new members and the desire for a raft of new capabilities to boost deterrence. In short, NATO was planning for transformation and the key to achieving that was through better training.

The effects of the Prague Summit have certainly seen the enhancement of NATO's posture and a continuing strengthening of its doctrine of deterrence. Russia, and its activities in Georgia and Ukraine, as well as its relationship with North Korea and Iran, have all combined to reinforce the threat that it poses. As well as training, forward deployments and exercises are now being widely used by NATO to signal its intent to defend its NATO Allies.



# Holding ground: A review of modern field defences

Sam Cranny-Evans

**When it comes to holding ground, some military fundamentals never change. From trench systems to urban fortifications, this analysis examines how armies are protecting their forces in an era of contested logistics and persistent surveillance.**

“It takes a land force to defeat a land force,” Amos Fox, a retired US Army officer and now lecturer in political science at the University of Houston told this author in November 2024. We were discussing emerging trends in C4ISR and the West’s apparent obsession with deep-strike capabilities. “If territory is the question, then a land force is the answer, and the bigger the land force the better,” he added, before moving on to

discuss what infantry will tend to do when subjected to air strikes. “They will just go into cover, or underground, they’ll be more aware of things flying overhead,” he said.

It is hard to argue with his observations, and there is no denying that a land force is needed to stop a land force. We can see this in conflicts from the Middle East to Ukraine; in Mosul during 2016, the Iraqi Security Forces (ISF) had no choice but to clear ISIS forces from the city one building at a time, despite an abundance of Western air and artillery fire support. In Ukraine, two vast land forces are fighting to take and control territory, trading lives for land. The flood of drones has driven adaptations in infantry tactics, with small teams now commonly infiltrating forward to congregate

close to their objective and conduct a coordinated attack, but infantry on both sides have been digging trenches and elaborate earthworks designed to shield them from artillery, drones, and air strikes since 2014. Both conflicts are defined by the extensive use of land forces and the use of fortifications. Trenches in Ukraine, and fortified buildings and structures in Mosul. Alongside these, the International Security Assistance Force (ISAF) in Afghanistan frequently constructed sangars, using gabions and sandbags, as the ground was often unsuitable for trench digging, and the added height of these structures provided a tactical advantage.

So, if land forces are key to defeating another land force, then field fortifications and defences are a necessary and critical component of land warfare. This article will explore the topic of field defences, and the factors that shape their use and effect.

## Contested logistics

In the 2020 Nagorno-Karabakh war, both the Azeri and Armenian forces fought from a series of trenches and earthworks prepared over many years. The Azeri success in defeating Armenia’s air defences, or perhaps Armenia’s failure to hold Azerbaijan’s Bayraktar TB2s and various strike assets at bay, led to hundreds of videos showing precise drone strikes on Armenian forces. There were two broad categories – frontline and rear echelon strikes. The rear echelon strikes are worth pausing on for what they indicate about land warfare and the use of trenches and field fortifications.



▲ **A member of Iraq’s 9th Army fires a KPV 14.5 mm heavy machine gun from a Technical during a battle with ISIS fighters near Al Tarab, Iraq, in 2017. Despite the US wielding overwhelming air power and artillery during the Battle of Mosul, it was the hard-fought battles led by the Iraqi Security Forces that cleared ISIS from the city. [US Army/Staff Sgt Jason Hull]**

### AUTHOR

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In Nagorno-Karabakh, Armenian logistics were laid bare to Azeri drone strikes, leading to extensive losses of forces, equipment, and supplies before they ever reached the front-line. This is an immense challenge for forces in contact with an enemy since a lack of supplies like ammunition means that you cannot fight effectively. Losing reserves before frontline forces can be rotated or replenished may set the foundation for the defeat of those forces holding the trenches. Martyn Beardsell from B+SL, an engineering and design company in the UK, believes this is one of the primary challenges facing modern field logistics. “Being an infantryman is a really scary place, I think scarier than it’s ever been. If a fortification is in place before the fighting starts, then it will be targeted from the outset and, after the fighting starts you may end up in a logistics-denied environment,” he told ESD in an interview on 15 January 2025.



▲ **A soldier takes a moment’s pause during the Battle of Bakhmut, while sheltering in what appears to be a hastily-prepared trench with a parapet providing some cover from sight. [Ukrainian MoD]**

“Being in a logistics denied environment will lead to a focus on 35 Mike Mike logistics, with anything else a distant secondary consideration,” he added. 35 Mike Mike is a US Army mnemonic referring to fuel and lubricants (class 3), ammunition (class 5), maintenance of equipment, and medical supplies. The Ukraine war also shows the impact of contested logistics with forces typically operating out of bed-down locations some distance behind the frontline and only

moving forward to the ‘zero line’ as it is known, for relatively short durations. The routes to and from the zero line are scoured by drones and, when the frontline moves closer to a town creating a cauldron, by artillery and even tanks. This means that only essential supplies and soldiers are brought forward to the frontline. Ukraine is not alone.

This is important to note because building field defences requires supplies and materials. If the defences are not established when the fighting starts, then they are unlikely to take on any form other than that which the soldiers can dig themselves.

## A shovel is your best friend

In September 2022, shortly after Russia had begun mobilising its population to resource the war in Ukraine, but before drones had become prolific, Aleksandr Kots, a Russian war journalist, wrote an article advising new recruits on what to expect once they reached Ukraine. “Your main friend in positional battles will be a shovel...The deeper and better you dig into the ground, the safer you will be to wait out the artillery attacks,” he told them.

At the time, Russian reports indicated that as much as 90% of casualties were caused by artillery, which means that trench digging, and digging deep is a relatively smart move. Martyn Beardsell noted however that: “Trench digging is a thing of diminishing returns: you can dig a hole and go as deep as you dare, shore the sides up with plywood and you’re pretty safe. But to do anything more than that, the cost sky-rockets.” Choosing to do more than this should be informed by several factors: Soil type, the nature of the threat, and the time and resources available.

The goal of digging a trench – be that for a vehicle or infantry – is to place the centre of mass below the surface of the ground, out of harm’s reach. In Ukraine, for much of the war, the primary threat has been artillery fire, which primarily produces lethal effects through fragmentation, rather than the energy released by its explosion. Each artillery shell is made of a steel casing filled with up to 30% of its weight in an explosive like RDX. The more energetic the explosive, the better, however, this tends to increase cost. More energy is better because it moves the resulting fragments at higher speeds. Ideally, the blast of a shell should create fragments weighing between a fraction of a gramme and up to 6 g, although 1 g is arguably optimal as it balances the lethality of each fragment, with a high quantity of fragments (thus increasing the likelihood of scoring a ‘hit’), each of which will have lower range than a heavier fragment (since heavier fragments tend to have a higher ballistic coefficient than lighter fragments), and therefore allowing the shells to be used in closer proximity to supporting infantry.

It is common to use a pre-formed or pre-scored fragmentation sleeve, both of which are intended to generate the optimal fragmentation pattern upon detonation. The shell will explode either as it hits the soil, or slightly above it, depending on the type of fuze. The resulting fragmentation pattern will depend on the angle of the shell in its terminal phase,

but will generally develop a roughly 'wing-shaped' pattern out from the point of detonation. If infantry are standing in the open and within the radius of effective fragmentation, they are very likely to be wounded. If, however, they are mostly below ground in a trench, then the likelihood of being wounded is reduced considerably. That is not to say that the psychological effects of a barrage, nor the concussive effects are completely mitigated, but it helps illustrate why a trench is an essential element of land warfare.

It is important to understand the mechanics of soil if you are about to dig a trench into it, or even drive a vehicle across it. Soil types technically range from rocks, through to clay, and up

to sand. They are defined by factors that include the size of the particles that make up the soil, as well as the moisture content and cohesiveness. This might mean that digging a four-man fire trench can take an hour with a shovel and one soldier, or all day with shovels, picks, and four soldiers. Beardsell's company has designed the Universal Battle Trench (UBT), a system designed to be quickly emplaced to provide maximum protection from the outset. It helps address several challenges by increasing the structural strength of the trench and the ease with which it can be built compared to sourcing plywood, corrugated iron, and other materials. The system is carried on pallets with one pallet providing enough material for 8 m of trench, including 4 m of firing bays, and 4 m of trench with overhead

cover. It includes a suspended floor and reinforced parapets. "It can be built into a worst-case soil – like talcum powder sand – and you could drive a tank over it. It would have to literally be blown out of the ground to destroy it, but the cost is much higher than the trench with plywood," Beardsell explained. The system has been developed with pre-deployment and prepositioned stocks in mind, so that UBTs could be held in storage and quickly deployed to provide trenches in the event of war. Importantly, as Beardsell noted, this would have to happen before the logistics routes to the frontline become contested.

There is, of course, always the option to source materials locally to build and fortify trenches, but this too comes with its downsides. "Digging is a skill – it's not hard to learn, but you can be bad at it," Beardsell remarked. Indeed, efficient digging and being physically used to preparing a trench is an important skill that not all of an armed force will necessarily have upon going to war. This, in part, is because trench digging can be difficult to accomplish on training ranges that must be used often and protected to some extent, so opportunities to practice are rare. Yet digging is not the only skill required; Cold War soldiers carried saws and axes on their vehicles, as does the Australian Army of today, and they are taught how to correctly saw down trees and prepare a defensive structure from them. Saws may seem a relatively simple tool, and they are, but they still require training to avoid injuries and broken saws. In the past, these tools could be coupled with equipment such as the Individual Protection Kit (IPK), a small bag given to British soldiers in the Cold War. It contained a sheet of tarpaulin, a set of aluminium stakes and a length of paracord. The paracord was arranged over a prepared trench in a certain manner, with the tarpaulin added on top and covered with a layer of soil; this arrangement would then provide some protection from fragmentation. While well-intentioned, the IPK seems to have received mixed reviews from British soldiers, who felt that while it would provide some protection from fragmentation, the greatest risk seemed to be that the structure could collapse on them in their sleep.



▲ Prepared defences in Ukraine's Zaporizhzhia Oblast in 2024, likely built some way behind the frontline, out of reach of Russia's artillery and drones. [ArmyInform, via Wikimedia Commons; CC BY 4.0]



▲ The Universal Battle Trench shown here is designed to be carried on a standard pallet and added to pre-positioned equipment so that it can be quickly deployed in the event of war. It provides greater protection and structural strength than a standard trench. [B+SL]

Nonetheless, images and videos of heavily camouflaged vehicle hides used in Ukraine, with some large enough to hide entire artillery vehicles from view, highlight the importance of soldier or vehicle-level camouflage and concealment. Small things such as the IPK help a section or vehicle crew to make the most of their surroundings and work to hide entries to dug-outs and vehicle bed-down locations. Yes, it is always possible they will be found, especially when different forms of intelligence, surveillance, and reconnaissance (ISR) are reviewing a position, but this arguably the nature of war – it is about finding and killing the enemy, while making it as difficult as possible for the enemy to do the same. So, it is clear that trench-digging remains key, and there are even engineering solutions to help make trenches safer and more effective than ever before, as long as there is enough time and money to establish them before the shooting starts.

## Building up and urban warfare

When you can't dig down, perhaps because the soil is too hard or has been replaced with concrete, the general solution is to build up. The British use of the word 'sangar' began in the 1800 and 1900s, when they may have learned the concept from Indian and Afghan forces, who are known to have built fortifications that consisted of a small parapet of stones typically built around a hollow. Sangar is derived from the Persian 'sang', meaning 'stone', and has grown – in British military parlance – to mean a temporary fortification protected by gabions, sandbags, and even watchtowers. Sangars were used by the British armed forces in Iraq and Afghanistan, although the basic structure was broadly employed by most forces deployed to those conflicts. The Hesco gabion was the basic building block of British sangars, although they also used shipping containers and repurposed Soviet fortresses from the 1980s.

A Hesco gabion is a wire box lined with a heavy-duty fabric that can then be filled with rocks, gravel, or soil by an earthmover. Hesco has developed the concept to include Hesco Raid, which is an ISO container full of gabions that is dragged along the ground, deploying the gabions as it goes. This system can quickly deploy a wall up to 333 m long,

- ▼ [A US soldier with the 124th Engineer Company, South Carolina Army National Guard, attached to the 206th Engineer Battalion, adds dirt to a Hesco barrier at Al Asad Air Base, Iraq, 23 January 2020. \[US Army/Spc Derek Mustard\]](#)



which would then need to be filled. The process is relatively fast, and two personnel with a front loader tractor could build a 10 m wall in 20 minutes, according to Hesco. The same wall built from sandbags would take eight hours and eight personnel, the company claims. Hesco also offers sangar kits, which can be elevated or ground-based observation points using the Hesco gabion concept as well as roof cover and protective glass if required.

There are other prefabricated field fortifications such as the Modular Protective System from MH International, an engineering company, which has developed a lightweight structure designed to be embedded under- or above-ground, depending on the location. It consists of metal supports designed to carry up to 1.2 m of soil on the roof providing concealment and protection from large-calibre artillery rounds. It can also be fitted with emergency lighting and acoustic dampening, as well as with Kevlar screens to limit the path and spread of fragmentation. The system fits in an ISO container and is intended to be used as a command post or medical centre, as well as a fighting position.

Some of the solutions already mentioned – the Hesco and the Modular Protective System – can also be used to fortify an urban environment. However, there is much that can be done without prefabricated solutions. “In an urban environment, we need to move away from thinking about Pavlov's house,” Beardsell said, referring to the legendary house in Stalingrad that was held by a small garrison of Soviet soldiers against successive and ultimately failed German assaults. “Instead, we need to think of resilience by hardening neighbourhoods using mouse holes and tunnels, sandbags, and disguising HQs inside buildings,” he continued.

Indeed, the efficacy of modern weapons make a prolonged struggle for a single building unlikely, assuming that permission to release large enough weapons can be granted, but it is worth noting that effective tactics – as used by Islamic State in the Philippines (IS-P) fighters during the 2017 Battle of Marawi – can derail an offensive urban operation, especially against unprepared troops. However, the general concept does appear valid, at least in situations where the defending force lacks the firepower and resources to hold the attacking air force and artillery support at bay.

Mouse holing is an effective way of turning a block of buildings into a fortification. It involves creating passages between buildings by blowing or breaking a hold through a dividing wall. This allows the defending force to move from one house to another, without leaving the building and exposing themselves to fire. This technique was used by the Islamic State during the 2016 Battle of Mosul, as well as by IS-P in the 2017 Battle of Marawi. Mouse holes allow fighters to reposition before they were overwhelmed or subjected to aerial bombardment. It also means that soldiers are not confined to moving down roads and streets, which make movement through a city predictable and risky. “If there is time and resources, you can also reinforce a building's structure. For instance, you can add Acrow props to support a ceiling and add sandbags, supports, and wire to the building's exterior,” Beardsell noted.




- ▲ **A bomb explodes on the hideout of an IS-P fighter during the Battle of Marawi. The ability of state forces to bring very large ordnance onto a building in a short space of time makes the prospect of a single house controlling an area for a long time less likely than was the case in WWII. [WikiEditor56783, via Wikimedia Commons; CC BY-SA 4.0]**

In Gaza, Hamas of course had its extensive tunnel networks – claimed to be more than 500 km in length – which had been built over many years. While many urban battles have had some element of subterranean warfare, including Mosul, Marawi, and Mariupol, the Israeli operation in Gaza faced the most concerted effort to fortify a space using tunnels. There were different types of tunnels, with those for commanders generally deeper and better-equipped in terms of ventilation and concrete reinforcement than those built for fighters. They were used to cache weapons, for command and control (C2) nodes, and for manoeuvre around Israeli units. The tunnels became a significant challenge, especially when paired with above-ground manoeuvres, as they required specialised systems and soldiers to locate and map them, and special forces to clear them.

Even without prepared tunnels, such as those used by Hamas in Gaza, if a defending force is likely to be subject to air strikes or be observed constantly during a battle, then it will typically seek shelter underground. This might be in the form of trenches where the terrain allows, but in cities, using cellars or basements is a common feature. Many videos from Ukraine show drone command posts operating from cellars, and some accounts from Russian soldiers indicate that they use cellars for bed-down locations away from the frontline. Chechen fighters in Grozny during 2000 also used basements and a network of tunnels to move underground, concealed from Russian forces. They also conducted extensive mouse holing, enabling them to manoeuvre through buildings and

re-emerge in new, previously-cleared locations, in much the same way that Israeli forces experienced in Gaza.

## Holding ground

Overall, the state of modern defences shows some signs of innovation; systems such as the Universal Battle Trench, and the well-proven Hesco gabions appear to be capable of quickly providing forces with effective defensive structures often better than the hand-made alternatives that they would be able to produce. However, the basics of modern field defences are essentially the same as they were in the 1800s. The focus is on protecting friendly troops and denying the enemy the ability to manoeuvre while retaining or even enabling the defending force's ability to manoeuvre as seen in some recent urban battles. This makes them a valuable skill-set to learn and maintain, especially in terms of basic soldiering skills such as digging and camouflaging a trench. Finally, it is also worth noting that fortifications or fortified positions, even those that use prefabricated defences, may be quickly destroyed by precision guided munitions (PGMs). Russian glide bombs in Ukraine, for example, can be capable of levelling a large apartment block, or otherwise overwhelming the soldiers defending it. In Mosul, MQ-9 Reaper UAVs and M109 self-propelled howitzers (SPH) were able to bring precision fires to bear very quickly, destroying even well-prepared buildings. This may not always happen, but remains a distinct possibility and, with the increase in drones, Western forces must now plan to a much greater degree for aerial and drone-delivered munitions. 

# Weighing the threat of tactical nuclear weapons

Dan Kaszeta

**The Russian aggression against Ukraine has a bitter twist to it – one of the belligerents, Russia, is the world's largest holder of small 'tactical nuclear weapons', along with its more publicly-discussed strategic nuclear deterrent force. As this conflict continues to rage, it is worth discussing these tactical nuclear weapons and their implications.**

Tactical nuclear weapons are miniaturised nuclear warheads intended for use with carrier munitions such as artillery shells, mortar shells (the Soviet Union had a 240 mm nuclear mortar), demolition charges, rocket and missile warheads designed for battlefield use, aerial dropped bombs, depth charges, and torpedoes. As a general rule of thumb, these are weapons of less than 10 kt yield – translating to an explosive force of  $\leq 10,000$  tonnes of the conventional explosive TNT. Russia is believed to still maintain an arsenal of many hundreds of such weapons, although their inventory is the subject of much speculation.

- ▼ **The Soviet Union made small nuclear mortar bombs for their M-240, a 240 mm mortar. [ShinePhantom, via Wikimedia Commons; CC-BY-SA 3.0]**



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The Cold War saw vast inventories of tactical nuclear weapons evolve on both sides. The USSR, USA, France, Britain, and China all had such weapons, and it was rumoured that India and Pakistan also have such weapons, with Israel and North Korea possibly also possessing these. The end of the Cold War (or, speculatively, a hiatus in the Cold War) led to the US getting mostly out of the tactical nuclear weapons business. Britain had foregone such weapons earlier, while France's arsenal of weapons comprises systems too large to be considered tactical nuclear weapons. The Soviet Union and its successor, Russia, reduced its arsenal of such weapons but maintained them as a category.

The US Army and US Navy got entirely out of tactical nuclear weapons, with the remaining US weapons in this category currently in the hands of the US Air Force. These consist of a few hundred B61 aerial bombs, some of which are forward deployed at US bases overseas. The B61s are 'variable yield' weapons and if you (literally) dial the yield to the lower options, they could be used as tactical weapons. At the upper end of their yield, they are too big to be considered 'tactical nukes'.

## Aspects of small nuclear weapons

Non-specialists have simplified notions of nuclear weapons. After all, few people alive have ever seen one go off. TV, film, and popular literature have spread both correct and incorrect notions of how they work and what sort of effects they have. Let there be no mistake about it, the strategic nuclear weapons that sit on intercontinental ballistic missiles (ICBMs) or in stealthy submarines are city-enders. They are many times more powerful than the crude-but-effective nuclear weapons that demolished Hiroshima and Nagasaki. Tactical nuclear weapons on the other hand are much smaller. The strength of weapon that destroyed those two Japanese cities is basically at the far top end of the scale for tactical nuclear weapons. We are talking about weapons that range from perhaps half the yield of those original weapons down to yields that measure in the tens of tonnes of TNT equivalent. By way of example, the smallest tactical nuclear weapon yield in the US arsenal was the W-54 (retired decades ago), which had yields as low as 10 tonnes of TNT equivalent. A conventional explosion of that magnitude could easily be made by a payload towed by a commercial semi-trailer truck. There have been, and no doubt will be, conventional explosions that are larger in explosive yield than small nuclear weapons.

What does this mean in practical terms? First of all, the radius of total or partial destruction from heat and blast is much smaller than many people assume. For example, the US B61 bomb, set to its lowest yield of 0.3 kt, will only physically destroy buttoned-up tanks at a radius of about 100-120 m. For the smallest of nuclear

► **The 72nd Test and Evaluation Squadron test loads a B61 nuclear-capable gravity bomb for the B-2 Spirit bomber at Whiteman Air Force Base, Missouri, on 13 June 2022. [USAF/Airman 1st Class Devan Halstead]**

weapons, less than about 2 kt, the biggest radius of damage is not blast or heat, but direct gamma and neutron radiation. This is the sort of thing that is mitigated by, say, being in a bunker or in a tank. Another factor is the electro-magnetic pulse (EMP). Long associated with nuclear weapons employment, given the yield and altitude of tactical weapons, the EMP is very small compared to strategic weapons detonated at high altitudes.

The physical size and design of tactical nuclear weapons poses interesting issues. The entry point into nuclear weapons is, literally, 1945 technology. To get a larger or smaller explosion than the first-generation weapons used in 1945 requires a lot of technical sophistication. Making a really small 0.2 kt warhead that fits into a 155 mm artillery shell took many hundreds of man-years of PhD-level labour and billions of dollars. The resulting product in the US Army was extremely maintenance-intensive. As a broad rule of thumb, the smaller a nuclear weapon, the more of a maintenance burden it will be and the shorter the shelf-life would be. A vast and expensive infrastructure, euphemistically called 'special ammunition maintenance' evolved in the US Army to service thousands of such weapons during the Cold War. One must question whether an economically degraded and corrupt country such as Russia has sufficiently kept up with all the maintenance requirements. Is Putin's arsenal full of duds? Or at least containing enough duds that it might be a bit speculative to use it?

## Offensive doctrine

The continued existence of tactical nuclear weapons in the hands of a party (Russia) to the largest ground war in recent decades means that there needs to be some consideration of offensive tactical nuclear doctrine. What are these weapons actually meant to be used for? While the finer details of Russian offensive doctrine remain secretive, we can draw some conclusions from old Soviet and American doctrine.

First and foremost, the existence of tactical nuclear weapons can arguably serve as a deterrent much in the same way as strategic nuclear weapons. Though the extent to which this is true is debatable as, from a technological standpoint, the entry point into nuclear weapons are the larger weapons more suited to strategic aims.

From a more tactical perspective, small nuclear weapons are meant to serve as a replacement for much wider and deeper use of conventional weapons. In other words, a single nuclear aerial bomb or artillery shell replaces thousands of conventional shells or bombs in some scenarios. It might take a serious artillery



campaign involving dozens or hundreds of howitzers to blunt the advance of a tank brigade, or a series of bombing sorties to take out a key bridge, but a small handful of sub-kiloton nuclear warheads might save an awful lot of time. For both the US Army and the Soviet Army, Cold War doctrine often treated tactical nuclear weapons as very large munitions, their sheer explosive yield acting as substitutes for precision. In naval terms, lest we forget maritime affairs, they are basically the only type of payload that can assuredly take out a US aircraft carrier or large amphibious ship. Modern military doctrine often talks about 'shaping' the battlefield, but use of nuclear weapons against bridges, dams, and airfields literally does shape the battlefield.

## Passive defensive tactics and techniques

One of the things that this correspondent learned as a young CBRN defence officer in the early 1990s was that the idea that you cannot defend against tactical nuclear weapons is, in fact, a defeatist fallacy borne out of ideas of scale that apply more to strategic weapons, which are truly city-busters. As noted above, lumping all nuclear weapons into the same bin is not actually a helpful approach. There are numerous tactics and techniques to reduce an army's vulnerability to tactical nuclear weapons.

Various passive defensive techniques, while seemingly dull, are surprisingly useful in protecting against the immediate and delayed effects of tactical nuclear weapons. One of these is dispersal of forces. If an army keeps its key mobile assets (such as artillery, tanks, mechanised infantry, and command centres) both dispersed and moving, it changes the calculus of nuclear weapons employment. The radius of practical destruction of tanks for a small nuclear artillery shell is surprisingly small if the tanks are buttoned up, literally a roughly 100-200 m radius. If you keep tanks 50 m apart, a single nuclear artillery shell is only going to take out four or five tanks and damage a dozen more. This is an appallingly low rate of return for nuclear escalation. For purposes of protecting against prompt radiation from small nuclear weapons, there are things that can be done to improve the radiation protection factors of armoured vehicles. In theory, substances such as Boron Carbide, a good insulator against neutrons, could be added as a layer. Indeed, it is known that Boron Carbide is used in some types of armour.

In terms of infantry forces, the old tactic of entrenchment, particularly with overhead soil cover or sandbags, greatly reduces the radius of vulnerability for soldiers. A lethal dose of radiation at, say, 600 m, can be mitigated down to a nuisance level of ra-

◀ **Detonation of a 3.5 kt tactical nuclear weapon in Nevada, on 28 October 1951. [US National Archives]**


Finally, there is the prospect of nuclear explosive ordnance disposal (EOD). Given the sophistication of tactical nuclear weapons and the daunting maintenance burden that they incur, there is a non-trivial chance that some of the Russian arsenal fails to function. In this vein, the prospect of tactical nuclear duds is something that needs to

be addressed; this is an area where robotics holds more promise than a long stick – though the long stick still has a surprising number of uses in EOD scenarios.

### Active defence

Passive defence increases the ability of the target to endure damage, but an active approach to preventing the use of such weapons is probably preferable. Obviously, air and missile defence systems are a logical countermeasure against air-dropped bombs, missiles, and rockets. Robust use of such systems works as both a direct countermeasure and a deterrent.

Another factor is counter-battery fire. If the prospect of tactical nuclear weapons being used becomes of direct concern, NATO doctrine will more or less drop every other category of target and the delivery systems for nuclear weapons become the primary target class. Dumping every category of firepower into targeting a fairly narrow number of delivery systems would be very effective if combined with thorough situational awareness and target acquisition. Even in a disproportionate conflict, there would only be a finite number of rocket launchers, artillery tubes, airfields, and the like that could deliver such weapons. Furthermore, it is exceedingly unlikely that tactical nuclear weapons are routinely lurking around in the ammunition trucks. Special transport from secure storage, with special security, may be something that intelligence and surveillance assets could discover and target; alongside this, conventional strikes to degrade the transport network to get weapons to the firing units would also be of value. Electronic warfare (EW) would be of value too – disrupting the ability to send orders to units, geolocation of firing units, and general erosion of command and control (C2) are within the remit of EW.

Finally, there is the prospect of deterrence. Is the use of nuclear weapons in a tactical sense the thin end of a wedge that leads to strategic nuclear warfare, and thus ending modern civilisation as we know it? For decades this was the arms control argument against tactical nuclear armaments and one embraced by many governments, both left and right of centre. Indeed, it was George Bush senior who started the process of getting the US mostly, but not completely out of the business of tactical nuclear weapons, largely for this reason. In this day and age of ‘red lines’ observed more in their breach than in practice, perhaps this is an area where countries with strategic weapons, such as France, Britain, and even China can lay down a firmer red line. 

radiation exposure by just a metre of soil. Dispersal and entrenchment can, quite practically, make the tactical nuclear artillery shell a substitute for hundreds of conventional shells, not thousands, thus calling into question the logic of their employment. Entrenchment with overhead cover and dispersal of key forces until they need to be concentrated together is already a lesson learned in the Ukraine conflict due to conventional lethality; in fact, some such countermeasures against drone warfare, also provide nuclear hardening as a second-order effect.

Military CBRN defence has often, in recent decades, neglected the R and N, but good CBRN defence equipment and practices are part of a good casualty-reduction strategy. Good awareness of weather conditions (which you need anyway for small drone operations and precision artillery) gives commanders an idea where the fallout (if any) from nuclear weapons employment will end up. Combined with well-established hazard prediction schemes, both manual and automated, this gives the defender an idea where and when post-attack hazards will be significant. For tactical weapons, many of which need to operate as air-burst weapons to maximise their immediate radiation, blast, and thermal effects, downwind fallout might even be negligible or only a matter of a few kilometres. Yet skilled CBRN specialists have the tools to estimate where those few kilometres will be.

Contamination avoidance is backstopped by radiation detection and dosimetry. Military radiation detection (discussed in issue number 1-24 of this magazine) lets commanders know where a hazard may be, and the magnitude of the hazard. It also can tell if equipment is contaminated or not, allowing judicious use of decontamination assets. Dosimetry, often neglected in recent decades, allows for monitoring of just how much radiation troops have been exposed to. In theory, this allows for judicious decisions on rotating troops or taking defensive measures. Armies serious about the tactical nuclear threat can and should dust off their radiation detection and dosimetry technology.

Finally, there is medical treatment of radiation injuries. This is still an evolving and under-resourced area. Interesting work at places including the (US) Armed Forces Radiobiology Research Institute (this correspondent is, in fact, an alumnus) provides prospects for better treatment of radiation injuries, and the prospect of biological dosimetry (taking a blood sample to analyse radiation exposure) and even prophylaxis (preventative treatment). Are there medications that could mitigate radiation sickness or even reduce long-term cancer incidence? There are intelligent people working on these questions.

# Naval operations: Lessons from recent conflicts

Conrad Waters

The last three years have seen navies involved in the most intensive maritime conflict of recent decades. The outbreak of the Russo-Ukrainian War in February 2022, followed by the commencement of attacks on Red Sea shipping by rebel Houthi forces in Yemen in November 2023, have provided 'real world' evidence of the impact of technological progress on naval operations. Some of the resulting lessons are likely to have a marked influence on fleet structures, equipment and doctrine for years ahead. However, the distinctive nature of the hostilities that are currently underway suggests that it might be unwise to extrapolate their significance too widely.

- ▼ A test launch of a prototype of Ukraine's R-360 Neptune ACSM in April 2019. Navies operating in both the Black and Red Seas have operated in range of a potent, land-based missile threat. [Office of the President of Ukraine]

## The operational context

Despite the differing aims of the relevant protagonists, the ongoing maritime hostilities in the Black and Red Seas share some notable similarities. Both are taking place in relatively enclosed, littoral regions where geography inevitably exerts a considerable influence on the threats posed to naval forces. In essence, the Russian Black Sea Fleet (BSF) and the allied navies deployed in the Red Sea have been operating close to hostile shores against forces seeking to prevent them attaining their objectives. After some early, limited successes, the Russian Fleet has essentially failed to achieve its goals, notably leaving Ukraine's strategically important grain trade largely free from blockade. Meanwhile, whilst the US Navy and its allies have gained tactical victories in protecting the passage of shipping in the Red Sea through a crucial chokepoint, they have been unable to prevent a material dislocation of maritime trade that has had real, if to date limited, economic costs. The overall picture arguably validates the focus on littoral operations that



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was a major feature of post-Cold War naval developments, whilst simultaneously demonstrating some of the limitations of this littoral strategy.

The two conflicts have also been noteworthy in the marked asymmetry of the naval forces involved. The bulk of Ukraine's modest fleet was swiftly neutralised after the commencement of Russia's full-scale invasion, and the country has subse-

quently been unable to deploy any major naval combatants. Equally, the Houthi rebels in Yemen have never fielded a navy of note. As such, neither the Russian BSF nor the US Navy and its allies have been confronted by significant conventional naval opposition. Instead, the nature of operations in both wars has been typified by the need to face down a potent land-based, missile threat that has been supplemented by an increasingly wide range of drone technologies. At best, this threat has proved difficult to counter in the absence of effective options to neutralise the risk 'at source', whether through occupation or elimination of the enemy's base infrastructure.

## The rise of the drone

The conflicts in the Black and Red Seas have seemingly been where the role of the uncrewed vehicle in maritime warfare has come of age. Drones have previously had a material impact in specific aspects of naval operations, such as their role in mine clearance during the 2003 invasion of Iraq. However, their presence in the current wars has been much more pervasive. A well-publicised development has been Ukraine's use of uncrewed surface vehicles (USVs) such as the indigenously-developed Magura V5 to destroy a significant number of Russian warships, both in port and at sea. Ukraine's ability to achieve the rapid deployment of these low-cost USVs, as well as to overcome some of the targeting challenges inherent in their use, has undoubtedly been a major achievement. Despite limitations in range and speed, such vessels have proved difficult to detect and to counter, for example when used in coordinated or swarm attacks.

In addition to being used as weapons in their own right, uncrewed vehicles have also been increasingly widely used to confuse and saturate warship defences as part of more broadly coordinated operations. There have been various, unconfirmed reports that Ukraine used uncrewed aerial vehicles (UAVs) to distract the combat management team aboard the Russian cruiser RFS *Moskva* prior to the ship's destruction by R-360 Neptune anti-ship cruise missiles (ASCMs) in April 2022. In the Red Sea, Houthi engagements against allied warships have also sometimes combined aerial drones, cruise and ballistic missiles in coordinated assaults. For example, a complex engagement in early January 2024 saw 18 one-way attack (OWA) drones, two cruise missiles and a single ballistic missile destroyed by a combination of American and British warships, as well as carrier-based aircraft. These tactics have, to date, failed to inflict damage to any warship, arguably endorsing the heavy investments made in air and missile defence by the US Navy and other partner fleets over many years. Nevertheless, they have still imposed significant challenges – in terms both of crew fatigue and munitions depletion – on thinly spread allied forces. Moreover, it is difficult to exclude the possibility that the use of similar tactics by a better-resourced adversary benefitting from more advanced technology might achieve more material results.

A less remarked-upon role of the drone in the conflict in, particularly, the Black Sea had been the use of a wide range of UAVs to provide persistent intelligence, reconnaissance, and surveillance (ISR) across the maritime domain. Just as on the land battlefields, the ready availability of large numbers of attritable drones that are often equipped with commercial-



▲ Pictured: Flyeye 3.0 in Poland, on 14 October 2022. **The ready availability of large numbers of attritable drones is revolutionising the provision of persistent in ISR information across the littoral domain. [US Army/ Sgt Andrew Greenwood]**

real time information over inshore and coastal waters. This information has undoubtedly contributed to some of the Ukrainian successes previously mentioned. In any event, the expansion of information provided by UAVs has become yet another challenge faced by any navy seeking to impose its will in an opponent's littoral waters.

The response to the rise of the maritime drone remains work in progress. In some cases, it seems that old approaches are being successfully adapted to meet the new threat. A good example is the Russian Navy's deployment of helicopters to detect and engage USVs, thereby exploiting their vulnerability from the air. This is reminiscent of the similar adaptation of rotorcraft to counter the danger posed by the advent of missile-armed fast attack craft during the course of the Cold War. The intelligence advances gained by the widespread use of surveillance drones may be much more difficult to overcome when operating in littoral waters. However, the use of visual stealth, as well as careful control of electronic emissions, is likely to remain relevant.

## Logistical vulnerabilities

Another interesting, if not altogether unsurprising, aspect of recent maritime operations in the Black and Red Seas is the extent to which logistical considerations have played their part. One of the most pertinent revelations has been the vulnerability of the BSF's homeport of Sevastopol to attack by drones and precision-guided munitions such as Storm Shadow cruise missiles, despite the presence of extensive air defences. The extent of the damage and destruction caused to ships and other facilities has significantly limited the port's

viability as an operational base. This has, in turn, enforced the dispersal of the BSF's warships further afield and thereby restricted their overall effectiveness. This vivid demonstration of the limited security afforded by even well-defended fixed infrastructure within practical striking distance of enemy forces has important implications for both expeditionary and defensive naval operations. Potential responses include a greater focus on dispersed naval forces along the lines of the US Navy's Distributed Maritime Operations (DMO) concept and increased reliance on mobile base infrastructure.

outfit of Sea Viper/Aster surface-to-air missiles after two months of active service. It would seem that the challenge is not so much that an individual attack will saturate the defensive shield, so much as the totality of assaults will eventually deplete magazine capacity.

There are various potential solutions to this conundrum. Certainly there is a trend towards expanding missile capacity aboard surface warships; the aforementioned HMS *Diamond* is to receive 24 additional CAMM surface-to-air



- ▲ **The Russian Project 775 'Ropucha' class landing ship RFS *Kaliningrad* pictured operating with Royal Navy landing craft in happier days. Logistic support assets have proved particularly vulnerable during naval operations in the Black Sea. [Crown Copyright 2008]**

The war in the Black Sea has, however, suggested that logistical support shipping might prove particularly exposed to developing technologies, at least in a littoral context. Many of Ukraine's naval successes have been achieved against the BSF's landing ships and other support vessels, with a combination of missile strikes and drone attacks effectively destroying much of the fleet train. This has made the Russian Armed Forces far more reliant on civilian shipping and land-based infrastructure such as the Kerch Strait Bridge to meet their logistical needs, both of which come with their own vulnerabilities. The Western nations' own logistics vessels, few of which are particularly heavily-armed, would seem to be equally liable to destruction in a similar conflict. This might have particular relevance to the DMO strategy referenced above, given a distributed force's greater requirements for logistical support – particularly in terms of fuel.

The influence of logistics has also been highlighted by the defensive operations carried out against the Houthi rebel attacks in the Red Sea. A much-reported aspect of this campaign has been the heavy demands made by these attacks on the limited stocks of sophisticated and expensive air defence missiles carried aboard ship deployed to the region. For example, the Royal Navy destroyer HMS *Diamond* temporarily departed the theatre for the over 5,556 km (3,000 NM) voyage to Gibraltar in February 2024 to replenish her (maximum 48)

- ▼ **The Combat Information Centre (CIC) onboard the *Arleigh Burke* class destroyer USS *Carney* (DDG-64) on 19 October 2023, during an action against a combination of Houthi missiles and unmanned aerial vehicles in the Red Sea. Red Sea operations demonstrated the effectiveness of air defence systems on NATO warships but have also highlighted important questions. [US Navy]**



PETER NEUMANN

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missiles (SAMs) for her Sea Ceptor system, as part of previously-planned upgrades to the British Type 45 destroyer class. The US Navy's use of carrier-based airpower to supplement ship-based missiles as part of the defensive umbrella against drone attacks has also proved to be of utility. This is indicative of the value of a fully integrated combat management capacity, including the fleet-wide synthesis of weapons and sensors heralded by the US Navy's Cooperative Engagement Capability (CEC).

However, the mismatch between limited numbers of expensive air defence missiles and cheaper threat missiles and drones endorses the current investment being attracted into directed energy weapons (DEWs) such as high-energy lasers (HELs). These hold out the potential of providing warships with essentially a self-replenishable magazine, coupled with a cost of operation that rated at a few dollars' worth of electricity per engagement.

### Training, readiness and survivability

The recent naval operations in the Black and Red Seas also provide lessons in the fields of training and readiness. For reasons that will be easily apparent, there is little first-hand knowledge of BSF readiness at the start of the Russo-Ukraine War. However, American and European commentary following the loss of RFS *Moskva* pointed to deficiencies in situational awareness and damage control procedures, exacerbated by lack of a balanced non-commissioned officer corps and over-reliance on short term conscripts, as material factors in the ship's destruction. Certainly, the relatively high level of losses subsequently experienced by BSF units in the course of the war suggests that it has taken time for the Russian Navy to adjust to operational realities.

The allied navies operating in the Red Sea have, to date, managed to avoid a catastrophe on the scale of *Moskva*'s loss. However, their own experience has not been entirely

plain sailing. A salutary lesson was provided by the premature withdrawal of the Danish air defence frigate KDM *Iver Huitfeldt* from the theatre of operations. This followed a broadly successful engagement against a drone attack in March 2024 that, nevertheless, revealed a number of deficiencies in her equipment and crew training. Problems encountered during the action included the emergence of a defect in the ship's Evolved Sea Sparrow missile (ESSM) launcher that rendered it temporarily unusable, the premature detonation of up to half of the 76 mm ammunition fired from the frigate's guns, and crew errors in the operation of the command and control (C2) system. Concerningly, it seems that there were concerns about the extent of crew experience and training, as well as about the reliability of some equipment, before *Iver Huitfeldt* commenced her deployment.

Many of these deficiencies can likely be traced to the general complacency that often permeates a peace-time environment, as well as the hollowing out of capabilities as a broad consequence of the immediate post-Cold War era. The greater focus on readiness that has accompanied the increase in East-West tensions will likely serve to dissipate some of this malaise. It is noteworthy that navies that have maintained a relatively high operational tempo in recent years – the US Navy and Royal Navy are amongst a number that spring to mind – have generally experienced fewer glitches than their less-active peers in adjusting to wartime conditions.

One interesting, little discussed, aspect of the recent conflicts relates to the seemingly impressive survivability of modern combatants. With the exception of the obsolescent and ill-prepared *Moskva*, no major surface combatant has been destroyed in the course of operations. By contrast, Russia's BFS has lost numerous smaller combatants and – as previously noted – support vessels. The relatively good track record of larger warships in both surviving and sustaining operations arguably runs contrary to the proponents of fleet structures comprising larger numbers of cheaper vessels.



▲ The deployment of the Royal Danish Navy frigate KDM *Iver Huitfeldt* – pictured here operating in the Baltic in 2018 – to the Red Sea revealed deficiencies in her equipment and crew training. [US Navy]



- ▲ **Chinese PLAN frigate at sea. The lessons of the recent asymmetrical maritime conflicts in the Black and Red Seas can have only limited relevance to operations where substantial navies are engaged on both sides. [Crown Copyright 2017]**

## Limited lessons

The recent naval operations considered in this article hold many important lessons for both practitioners and industry to consider. However, it should also be noted that there are limits to what can be learned. As previously noted, the maritime elements of both current conflicts have been taking place in littoral waters in an environment where land-based systems enjoy significant advantages. The warships of Russia's BSF have been operating under constant surveillance in confined waters that are within range of a myriad of missiles, drones and other weaponry. In these circumstances, it is hardly surprising that it has suffered material casualties. Similarly, the allied navies in the Red Sea are protecting shipping passing through a well-defined choke point in constant range of a broad spectrum of land-based weapons. Their ability to eliminate these threats is also constrained by practical and political considerations. The results arguably have limited application to environments where a different geography applies. The constant ISR picture provided in the littoral environment by plentiful drones will progressively degrade as naval operations are performed further out to sea. Similarly, the advantages of USV swarms deployed in, say, the confined waters of the Black Sea will have little application in more open waters. Here their limitations in terms of range, speed and seaworthiness will inevitably come to the fore.

Equally significantly, the asymmetry of naval forces that is a marked feature of both operations considered by this article means that they have only limited relevance to a conflict where substantial navies are engaged on both sides. Neither the war in the Black Sea nor its counterpart in the Red Sea has

seen engagements between opposing surface vessels. Equally, submarine missions in the Black Sea have essentially been confined to long-range strikes against land targets performed by 'Kalibr' cruise missiles launched from Russian 'Kilo' class (Project 877) boats. Although the Russian BSF's flotilla of amphibious vessels was significantly reinforced in advance of Ukraine's invasion, there have been no significant amphibious landings of note. The experiences of the Black and Red Sea conflicts therefore leave many questions about the future direction of naval operations that remain unanswered.

## Concluding remarks

The naval operations that have taken place, first, in the course of the Russo-Ukrainian War and, subsequently, during protection of trade deployments in the Red Sea provide important opportunities to analyse the practical consequences of evolving naval technology and doctrine. The hostilities have demonstrated many of the practical challenges inherent in sustaining protracted operations in littoral waters against a well-armed, land-based opponent. These difficulties have been exacerbated by the ISR and saturation potential provided by the increasing availability of attritable drones. The importance of training and readiness, particularly when transitioning from a peacetime to wartime environment, has been demonstrated yet again. However, the distinct geographical nature of both operations, as well as the marked asymmetry of the forces involved, place inevitable limitations on the extent of their relevance to other maritime scenarios. The student of, for example, potential 'blue water' conflict across the open expanse of the Pacific Ocean may need to look elsewhere to inform their research.



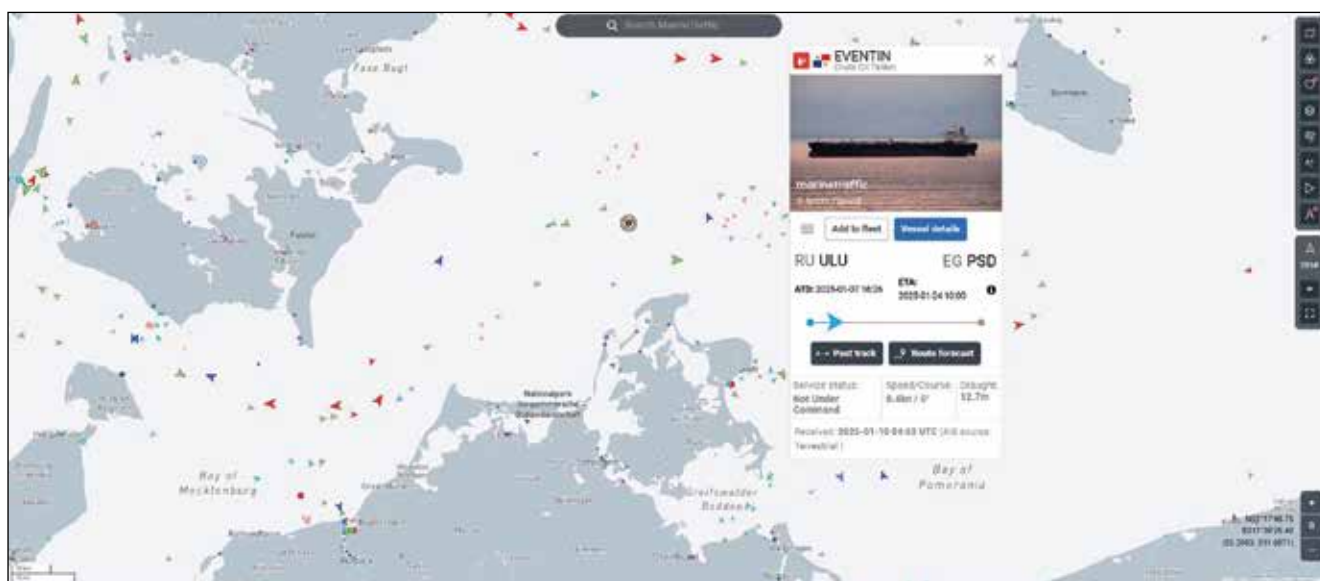
# Reaction time

Thomas Withington

**Russia is violating hydrocarbon sanctions introduced because of Moscow's continued occupation of Ukraine. A new initiative by the UK-led Joint Expeditionary Force may help to combat Russia's illicit oil exports.**

It was easy enough to see that the MV Eventin was not doing much in the Baltic Sea on the [marinetraffic.com](https://www.marinetraffic.com) vessel tracking website. As of 11 January 2025, the Panamanian-flagged oil tanker appeared to have lost all power and steering, stuck in Germany's territorial waters. Tugboats had reached the scene and secured the stationary ship. However, the MV Eventin was not perhaps all she seemed. Consider her voyage: According to [marinetraffic.com](https://www.marinetraffic.com) she left the Russian port of Ust-Luga, on the Baltic coast close to the Russo-Estonian border on 7 January 2025.

This cargo may be far from innocent. On 11 January 2025, the German government hinted the ship maybe part of Russia's so-called 'shadow fleet' used to circumvent sanctions. Russia has been subject to sanctions on her oil exports since her full-scale invasion of Ukraine in February 2022. In September 2022, the G7 group of industrialised democracies, which includes the EU, agreed a price cap on Russian oil and petroleum exports. The price cap was intended to restrict Russia's ability to finance its war in Ukraine through the sale of hydrocarbons. The price was set at USD 60 per barrel for oil transported by sea; while oil transported through land pipelines was left exempt. The extent to which these sanctions have been successful in reducing the money Russia has to continue fighting are debatable. Nonetheless, one consequence is that Russian oil exporters are using the shadow fleet to evade such oil sanctions.



- ▲ **MV Eventin as seen on the [marinetraffic.com](https://www.marinetraffic.com) website on 13 January 2025. Her position is illustrated by the circled red dot in the upper centre of this screenshot. The ship is thought to form part of Russia's shadow fleet. [[marinetraffic.com](https://www.marinetraffic.com)]**

The website revealed that she was heading to Port Said on Egypt's Mediterranean coast, at the mouth of the Suez Canal. At the time of writing, she had been detained by German authorities, reportedly due to her drifting off course and being unable to manoeuvre, and towed to Sassnitz on Germany's Baltic coast, where she has remained since, along with her cargo comprising 99,000 tonnes of crude oil.

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## Shadow fleet

Russia is working hard to outflank the EU and G7's hydrocarbon export sanctions. Part of Moscow's approach has been to establish a shadow fleet of ships which "(make) use of flags of convenience and intricate ownership and management structures while employing a variety of tactics to conceal the origins of (the ships') cargo", according to a briefing on this subject written for the European Parliament. Sanctions covering the Russian oil sector prevents G7 members from "providing shipping, brokering, technical assistance or insurance services to facilitate the trade of Russian crude oil and petroleum products across the globe, unless the trade is verifiably below the price cap", the briefing continued.

The issue for Moscow is that the price cap is supposed to prevent Russia from benefiting from fluctuations in the global oil price. Should the price fall below USD 60 per barrel, Russia will make a profit, but her oil will be comparatively more expensive. On the other hand, Russia cannot benefit from typical increases in the global price of oil. The *statista.com* website noted that the average per-barrel price for Brent Crude, the international standard benchmark, was USD 80.53 in 2024. Moscow was thus selling oil at a loss last year. The European Parliament briefing noted that G7 members dominate the global market for shipping services and maritime insurance. For example, Lloyds of London remains the world's leading marketplace for marine insurance. G7 member companies are prevented by sanctions from providing Russian oil exporters these services and insurance.

Russian exporters are thus forced to look beyond G7 member nations for shipping services and marine insurance. One approach taken by the exporters is to charter vessels from so-called 'flag of convenience' states such as Panama. Ships registered to these states may benefit from a relatively lax enforcement of vessel safety or environmental regulations,



- ▲ **A digital rendering of an oil tanker registered in a flag of convenience nation. Vessels such as these are being used by Russia's shadow fleet. They may not be maintained and crewed to adequate levels to carry oil cargoes, and hence risk polluting the environment should they run into trouble. [Thomas Withington]**

the European Parliament briefing says. Vessels may not maintain adequate insurance, may avoid inspections, and may have poor crew safety and welfare standards. Shadow fleet ships may also have highly opaque ownership and management structures. Just as billionaires undertake efforts to conceal the location of their wealth to avoid tax, so ship owners can hide behind front companies.

As the briefing notes, the key motivation for Russia's shadow fleet is to "continue trading Russian oil at market prices by avoiding G7/EU vessels, ports and financial and maritime services." Analysis by Kyiv School of Economics estimates

Russia may have spent circa USD 10 billion since March 2022 on the shadow fleet. Up to 90 tankers owned by Sovcomflot, Russia's largest shipping company, are thought to have had their management relocated to countries such as the United Arab Emirates. Another technique involves buying ships that had Protection and Indemnity (PI) insurance from the International Group (IG). PI insurance is mandatory for vessels navigating through international waters. The insurance covers the harm the ship might do to the environment, people and/or property should she sink, for example. The IG is a network of PI providers funded and managed by shipowners. Up to 90% of global shipping tonnage is provided by the IG. The shadow fleet buys vessels that did hold PI insurance from the IG, but which are now beyond the insurable age limit of 15 years. The report says that Russia also buys ships older than 20 years. Buying old vessels may help to keep the financial exposure of the owners to a minimum should the ship be impounded for sanctions busting: An older ship is cheaper to buy than a new ship, and less of a loss if impounded and eventually scrapped.

The problem with Russia's shadow fleet is that its ships may be unsuitable for hydrocarbon export. Vessels may be kept in an inadequate state of maintenance meaning they might be unseaworthy. This raises the danger that tankers could suffer mechanical problems, which may have been the case for the MV Eventin. Crews may also have inadequate levels of training, and working conditions may be un conducive to personnel working in a safe and responsible manner. These factors could cause shadow fleet ships to experience difficulties or even court disaster. A badly-maintained and crewed vessel is more likely to sustain damage that could risk the release of large volumes of oil into the sea. Opaque vessel ownership structures, and inadequate insurance, could make it difficult, if not impossible, to determine who is responsible. This could hamper efforts to hold people or organisations criminally or financially liable.



- ▲ **Transmissions from marine navigation radars, such as Furuno's M Series shown here, can be useful for detecting and locating a vessel. Determining any difference between the radar, and hence the ship's position, and her reported AIS data can help determine if the latter is inaccurate. [Furuno]**

## Chasing shadows

Fortunately, it is becoming increasingly difficult for merchant vessels to hide nefarious activities. G7 members are deepening their abilities to keep tabs on what ships are doing on the high seas. All vessels need to carry radars for navigation and radio communications. Merchant shipping uses very high frequencies (VHF) of 156-157 MHz, and 156-162 MHz, reserved by the International Telecommunications Union (ITU) for radio communications. The ITU is the UN body which globally regulates the radio spectrum. The ITU also makes several ultra-high frequency (UHF) wavebands from 457.525-467.825 MHz available for marine radio communications. Ships can use high-frequency (HF) radio across frequencies of 4-8.815 MHz. Medium-frequency communications on wavebands of 405 kHz to 2.850 MHz supplement HF. Satellite communication (SATCOM) is used extensively by merchant shipping. A myriad of service providers including Thuraya, Iridium and Inmarsat use SATCOM frequencies spanning from 1.525-1.646 GHz. Ships need navigation radar which typically transmit radio signals in S-band (2.3-2.5 GHz/2.7-3.7 GHz) and X-band (8.5-10.68 GHz).

Vessels displacing 300 tonnes or more are obliged by the International Maritime Organisation (IMO) to use the Automatic Identification System (AIS). All passenger ships regardless of size on international passage must also use AIS. The AIS transmits a host of information about a ship and her voyage to AIS receivers in range. Information can include the ship's identity, details of her voyage and cargo, and her location. The vessel's position is usually derived from her global navigation satellite system (GNSS) receiver. The receiver calculates the ship's location by using incoming position, navigation and timing (PNT) signals transmitted by a GNSS satellite constellation. AIS information is sent by the ship across VHF frequencies of 161.975 MHz and 162.025 MHz. This information may reach an AIS receiver co-located on a coastal surveillance radar antenna. As the antenna detects and tracks targets at sea, corresponding AIS information

regarding those targets is overlaid on the radar screen. One shortcoming of AIS data is that it must be set by the crew. This means that false information can be intentionally or accidentally input. AIS transponders can also be switched off as a safety precaution. This may be necessary if a vessel is navigating through an area with a high risk of piracy. Advertising her voyage and/or cargo in such areas via AIS transmissions could be risky.

All these radio emissions from a merchant ship can be detected with an Electronic Support Measure (ESM). The ESM could be located at a coastguard station, equip a vessel or maritime surveillance aircraft or even be onboard a satellite in space. The system will detect radar communications, radar and AIS transmissions, provided the vessel is in a line-of-sight range from the receiver. At the very least, the ESM will detect a bearing from itself to the source of the transmission. Find the source of the transmission and you find the vessel. The ESM may be able to triangulate the source of the transmissions, giving even more detailed information on the ship's location. The first indication that a vessel maybe acting suspiciously is that its AIS maybe switched off or transmitting false information. It may make sense to restrict AIS transmissions transiting through the Gulf of Aden, a piracy hotspot, but inactive or inaccurate AIS data may seem more suspicious in the relatively peaceful Baltic. For example, a vessel's AIS may indicate that she is underway off the coast of Chile, carrying a cargo of timber bound for the Chilean port of Concepción. Yet closer inspection by a maritime surveillance aircraft may reveal the ship is in fact in international waters close to Rostok on Germany's Baltic coast, and resembles an oil tanker.

## Baltic monitoring

Given Russia's desire to flout oil sanctions using potentially unsafe vessels in European waters, the UK Government announced in January 2025 it was activating the Joint Expeditionary Force (JEF) Reaction System. According to the government, the JEF is "a pool of high readiness, adaptable forces




◀ The MV *Eagle S* seen here in the port of Porvoo Anch, Finland. The ship is thought to have been involved in an incident on 25 December 2024 during which an undersea electricity cable between Finland and Estonia was damaged. Like the MV *Eventin*, this oil tanker may form part of Russia's shadow fleet. [HTF]

... designed to enhance the UK's ability to respond rapidly, anywhere in the world, with like-minded allies, or on behalf of international organisations such as the UN or NATO." The UK leads the JEF, which includes Denmark, Estonia, Finland, Latvia, Lithuania, the Netherlands, Norway and Sweden. The JEF's primary goal is "protecting northern Europe". The new reaction system is to "track potential threats to undersea infrastructure and monitor the Russian shadow fleet".

The Baltic Sea has witnessed multiple instances of critical underwater infrastructure (CUI), such as undersea cables, being damaged, likely deliberately by ships which may form part of the shadow fleet. For instance, on 25 December 2024, the Estlink-2 electricity cable linking Finland to Estonia suffered a power outage. The incident occurred shortly after the MV *Eagle S* oil tanker had crossed over the cable. The ship was travelling from Ust-Luga in Russia, carrying petroleum, possibly either to Türkiye or Egypt. The Finnish authorities impounded the ship and crew which, as of mid-January 2025, remain in the Finnish port of Porvoo Anch. The MV *Eagle S* is reportedly registered in the Cook Islands, a flag of convenience state, and is operated by a company registered in the UAE.

The JEF Reaction System will also track suspicious vessels using AIS data alongside other data "from a range of sources", according to a statement regarding the initiative published by the UK government on 6 January 2025. The system will use artificial intelligence (AI) software to analyse and aggregate data from these disparate sources to build up

as accurate a picture as possible regarding a vessel's identity, voyage and behaviour. UK MoD sources shared with the author that the reaction system is built around a computer programme which uses AI software licensed from Palantir Technologies. The computer system forms part of the JEF headquarters based at the UK's Permanent Joint Headquarters (PJHQ) in Northwood, northwest London. The MoD declined to provide additional detail on the other data sources that feed into the JEF Reaction System. However, the source continued that other sources the system could draw upon include publicly-listed details about individual ships. Should a vessel be determined as operating suspiciously, a notification is generated which can be checked and shared with JEF members. Personnel from JEF nations are based at the PJHQ, so the sharing of information is easily done. Nations can then take appropriate action regarding the vessel.

The JEF Reaction System will not stop the activities of Russia's shadow fleet by itself, but it will help to ensure that G7 members can continue to apply pressure to Moscow's illicit oil exports. Data from the system may also prove useful in future legal action concerning shadow fleet activities. It is reassuring that, despite the damage it may have caused, the MV *Eagle S* is languishing in a Finnish port. Finnish law enforcement is reportedly investigating the crew. Meanwhile, the MV *Eventin* seems unlikely to complete her voyage anytime soon. In the long game of combating Russian oil sanctions evasion, initiatives like the JEF Reaction System will prove invaluable. 



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# Laser-focused training

Dr Trevor Nash

**The adoption of improved laser-based tactical engagement simulation for military collective training continues to grow. Alongside this growth, technology is enabling new capabilities to be added to aid training realism. A case in point is the use of geometric pairing to provide simulation of indirect fire weapons such as artillery and mortars.**

The cornerstone of any land force live training activity is a laser-based Tactical Engagement Simulation System (TESS). As the name suggests, laser-based TESS features laser emitters fixed to weapon systems, and laser receptors fitted to personnel and vehicles. This is supported by an overarching instrumentation system to monitor and record player activity as well as a range of pyrotechnic and non-pyrotechnic battlefield effects to aid realism.



▲ **The British Army's TESS capabilities in the UK are provided by Cubic Defense and Saab. [Saab]**

#### AUTHOR

Following a career in the British Army specialising in air defence, **Dr Trevor Nash PhD** spent four years in the T&S industry before becoming defence journalist concentrating on training, simulation

In basic terms, live training features real people, operating real weapon platforms in a real environment with only the ordnance being simulated; in this case, that ordnance is mainly simulated by a coded laser beam and the special effects described above. The TESS system is enhanced still further through a soldier-worn harness communication system that informs participants if they have been engaged and killed or engaged and wounded.

Compared to virtual training, where only the people are real and the weapon platforms, ordnance and environment are simulated, live training offers significant advantages. Chief amongst these are the psychological and physiological stresses that the participants are subjected to. The physical stress of an infantry soldier carrying a full load of equipment over difficult terrain in extremes of temperature whilst hungry and tired and then having to overcome the mental challenges of having to map read, issue orders and maintain battlefield situational awareness cannot be simulated in the virtual world.

This is not to say that virtual training is worthless. Far from it. Virtual training prepares the individual soldier and teams to operate personal and crew-served weapons; to call for and correct indirect fire; and to operate sensors and communications systems. Once completed, these individual and crew training processes provide the basis for operating in the live environment to conduct meaningful collective training.

Like any military training system, developments continue to occur to reflect real-world challenges although such changes can only take place if technology is available to allow them to be implemented. For example, when TESS systems were first fielded in the late 1970s with products such as the first generation US Multiple Integrated Laser Engagement System (MILES), training was limited to direct fire force-on-force engagements involving infantry and armour participants.

“Times have changed and military forces are facing new threats and the experience from ongoing conflicts that create demands for new training capabilities,” Saab Training & Simulation’s Head of Business Development Hans Lindgren tells ESD. “These threats include UAVs and indirect fire and the key here is to use interoperability and realism to create effective training.”

Over recent years more capabilities have been added to TESS to aid realism and to integrate indirect fire weapons including field artillery and mortars, chemical, biological, radiological and nuclear (CBRN), medical simulation, counter-improvised explosive device (C-IED) procedures and unmanned aerial vehicles (UAVs), but there are still gaps;

most notably in simulating fast-jet Close Air Support (CAS) and air defence. Significantly though, as TESS-based live training develops still further, there is an increasing trend for the system's instrumentation system to provide a conduit to add new capabilities.

An example of this is Cubic Defense's Light Gun Simulation System (LGSS) that, according to the company's President, Paul Shew, provides the British Army's Royal School of Artillery, "with a fully immersive training system [that] when integrated into collective training allows formations to train in the orthodoxy of coordinating artillery fires and manoeuvre."



- ▲ **One of the latest developments to occur in collective land training has been the introduction of meaningful indirect fire simulation by companies such as Ravenswood, Saab and Cubic. Shown here is the Cubic Blueshell system used for the British Army's 105 mm Light Gun. [Cubic Defense]**

Named Blueshell, the system is fully interoperable with Cubic's Live, Virtual and Constructive (LVC) training system, known as SCOPIC, and their tactical engagement system. SCOPIC provides what is referred to as a 'synthetic wrap' that enables users to integrate the virtual and constructive domains with live TESS exercises. For example, a live exercise can integrate indirect fire, UAV feeds and targeting pod downlinks from CAS aircraft.

Although welcome additions, perhaps the only downside to such capabilities are the unrealistic terminal effects. Looking at a tablet and seeing that 105 mm artillery rounds are landing 100m away is different to experiencing it for real and so there is the potential for negative training to occur. This issue is being addressed by the US Army at Fort Johnson in Louisiana in a number of trials known as the Live Training System Operational Demonstration.

"It's much more challenging to replicate the training environment in the terrain that is found in Fort Johnson," said BG William Glaser, director of the Synthetic Training Environment Cross-Functional Team (STE CFT). "We went to the hardest place first," he said. "If it works there, it will work anywhere."

Glaser's comments on terrain refer to the undulating and wooded topography found at Fort Johnson. The complex terrain and vegetation "posed a unique challenge, making it an ideal testing ground," he said. These trials, referred to by the US Army as 'touchpoints', have taken place at a number of locations, including Fort Hood in Texas. Here, Cubic Defense highlighted its mortar simulator that has been developed in conjunction with General Dynamics Mission Systems.

At Fort Johnson meanwhile, the trial concentrated on four main weapon systems: hand grenades, Claymore mines, mortars and the FIM-92 Stinger shoulder-launched air defence missile. Although companies such as Saab, Cubic, Ravenswood, Lockheed Martin and Thales have long been able to offer TESS products for grenades and Claymores, and more recently mortars, Stinger simulation in the live domain has been largely absent. The notable exception in the provision of TESS air defence products being US specialists, Inter-Coastal Electronics (ICE).

In mid-2024, ICE was awarded a USD 94 million, five-year Indefinite Delivery Indefinite Quantity contract from the Orlando-based Program Executive Office for Simulation, Training and Instrumentation (PEO STRI) to provide Combat Training Centers Home Station Aviation Force on Force (CHAFF) training support. The US Army says that the contract will enable it to provide, "a more realistic Air Defense Threat to support Force on Force training exercises utilizing rotary aircraft and ground forces at Army CTCs and home stations."



- ▲ **Developed by RUAG before being purchased by Thales, shown here is a mast from the Gladiator mobile CTC system as used by the Swiss Army. [Trevor Nash]**

According to ICE, CHAFF will include Training Aircraft Survivability Equipment Stimulation Suite (TASS) components on US Army aviation aircraft that interface with ground threat systems and simulate air defence systems by activating visual and auditory cockpit warnings and indicators of an engagement that requires pilots to take appropriate action to avoid being engaged.

## Indirect fire

There are currently two approaches to simulating indirect fire during a TESS exercise. The first is through a hand-held device that, “provides real-time trajectory visualisation and GPS coordinate-based fire resolution, with the aim of enhancing the effectiveness of mortar and artillery units,” explains Björn Linderö, director for live training at Saab.

Users can either opt for a simple solution that sees the mortar officer simply inserting firing data into the tablet that is then sent to Exercise Control (EXCON) via the combat training centre’s (CTC’s) instrumentation system. Terminal effects are transmitted to individual soldiers within range of the exploding mortar bomb and heard via the speaker on the soldiers TESS harness or vehicles speaker system. These effects can also be seen on a tablet and may be enhanced by Observer Controllers (umpires) throwing Thunderflashes.



▲ **The increased adoption of TESS equipment allows allied forces to train together; a strategy fostered by Saab’s International User Community initiative. [NATO]**

Linderö said that customers who want a more elaborate solution than that provided by the simple tablet version can add a simulated mortar tube to their real sight, bipod and base-plate. Sensors in this modified mortar tube feed data such as bearing, elevation, ammunition type and charge, directly to EXCON. Saab has developed the simulator in conjunction with the Royal Netherlands Army as part of an upgrade provided for the latter’s MCTC in Marnehuizen.

Another adopter of mortar simulation is the British Army, where as part of a Post Design Service contract for the Tactical Engagement System In Kenya (TESIK) programme,

Ravenswood Solutions has added an 81 mm mortar training capability. The new capability has been developed in partnership with fellow US company, Cole Engineering Systems.

The new system is based on a training barrel that fires simulated rounds over a short distance to provide added training value to the mortar crew. The sensor components in the training barrel then communicate with the TESIK instrumentation system and ‘kill’ instrumented entities in the simulated impact area.

According to Ravenswood, “soldiers gain valuable experience in executing mortar drills, adjusting fire, and coordinating with infantry units—all within a controlled and data-rich environment that maximizes learning and preparation for combat scenarios.”

The technology to assist this is known as geometric pairing, or geo-pairing, and uses the Global Positioning System (GPS) to fix the position of the target and weapon system, and then calculate the impact point once the weapon is fired. Initially considered too expensive to incorporate in Combat Training Centres (CTC), geo-pairing and laser-based TESS are now increasingly supporting each other to provide added realism.

This approach of bringing different technologies together to improve live training was echoed by Saab’s Hans Lindgren at last December’s Interservice/International Training, Simulation and Education Conference (I/ITSEC) in Orlando. “Interoperability and realism are the keys to create effective training,” he said. “Technology should be agnostic with the focus on training value and delivering effective and measurable training outcomes.”

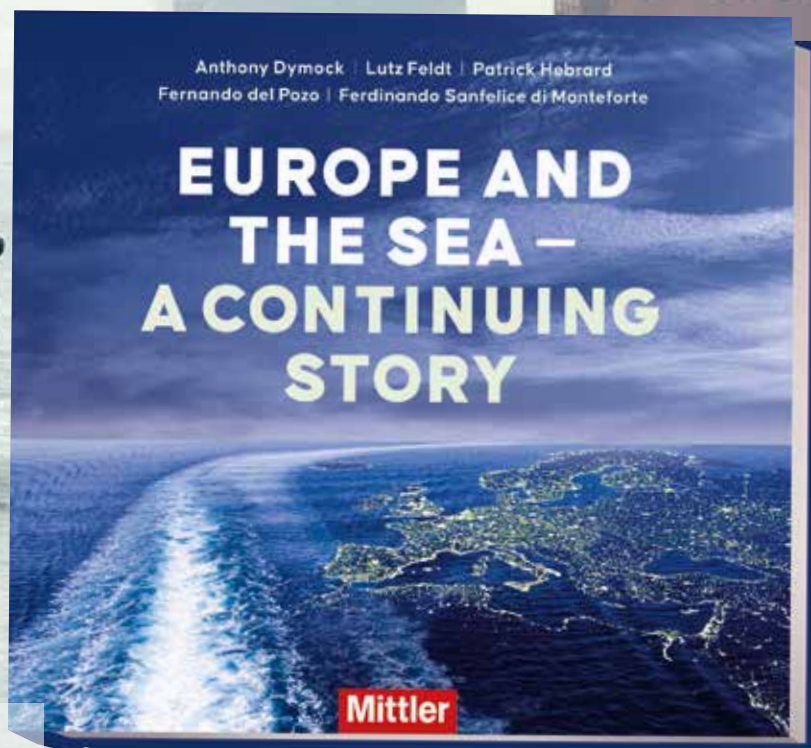
## TESS adoption continues

One of the largest TESS programmes underway at the present time is the US Marine Corps Training Instrumentation Systems (MCTIS), an offshoot of the US Marine Corps’ Force-on-Force Training Systems – Next (FoFTS – Next) initiative. This new Saab training system is designed to replace the older MILES TESS equipment used by the US Marine Corps. The contract will provide MCTIS equipment for 10 battalion training sets, and the establishment of support operations at five Marine Corps locations: Twentynine Palms (4), Camp Pendleton (2), Camp Lejeune (2), Hawaii (1) and Quantico (1). So far, four kits have been deployed to Twentynine Palms in California, two to Camp Pendleton and one each to Hawaii and Quantico. Depending on usage, acceptance and funding availability, additional MCTIS kits may be procured for Okinawa and Guam.

In 2024, the US Marine Corps used MCTIS in a major Air Ground Task Force (MAGTF) Warfighting Exercise (MWX) at Twentynine Palms that saw the deployment of three USMC regiments. Initially, 19 buildings were instrumented for military operations in urban terrain (MOUT) training, but this was later increased to 28. In addition, 300 vehicle kits were fitted, along with the instrumentation of 2,900 Marines. The aim of the exercise was to obtain user feedback and make modifications if appropriate. Reflecting on the improvements offered by MCTIS compared to the earlier MILES equipment, Lt Col Rory Herman, product manager for Range Training Systems (RTS) at the US Marine

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procurement authority, Program Manager for Training Systems (PMTRASYS) said, "I can tell if a Marine is standing up, lying down, running, walking or being carried by an aircraft...This gives us the ability to look at not just how Marines fight in a tactical engagement but how they move logistically in a tactical environment from point-to-point."

One of the major benefits of TESS-based live collective training is that it can be conducted with allies. This approach cements relationships, aids interoperability and provides a potential deterrent effect to possible adversaries.

A recent initiative in this field has seen Rheinmetall complete tests to support German troops that are being deployed to Lithuania. Up to 4,800 troops that form 45 Armoured Brigade and combat support units are to be deployed to two bases later in 2025, with a full operational capability set for 2027. To enable these German troops to train alongside their Lithuanian colleagues, a 'reach-back' network has been established to allow joint exercises to be conducted with units in Lithuania and those at the German Army's Gefechtsübungszentrum (GÜZ) at Letzlingen/Altmark. The tests featured Rheinmetall's Legatus Mobile CTC and its AGDUS TESS equipment.

A vital component of coalition warfare collective training using TESS is interoperability. Saab established its Interoperability User Community (IUC) a number of years ago and today the group has 16 members from an overall customer list of more than 50 countries. An example of such coalition collective training was witnessed during Exercise Nordic Response 2024. The exercise had its focal point in northern Norway, Sweden, and Finland. Over 20,000 service personnel from 13 allied nations took part in the exercise. Of these, approximately 10,000 soldiers undertook exercises on land with the US, Finland, Norway, Sweden and Germany using TESS equipment from Saab.

As with the German deployment to Lithuania, NATO efforts to show its resolve against Russian bellicosity in northern

- ▼ **Rheinmetall is currently instrumenting a 'reach-back' link for its soon to be deployed forces in Lithuania with its GÜZ CTC in Germany. [Rheinmetall]**



- ▲ **A Swiss Army Duro III 6X6 vehicle fitted with Gladiator TESS receptors during an exercise at Walenstadt. [Trevor Nash]**

Europe and the Nordic region saw troops from Estonia, France, UK and the US conduct joint exercises during Exercise Winter Camp. This exercise again featured Saab's TESS equipment and the company's Hans Lindgren believes such cooperative exercises, along with the growing adoption of live training systems will continue to grow. "Live training provides a realistic, scalable, affordable and reliable training medium that promotes partnership, multinational training and interoperability," he told ESD. "Taken together, this creates armed forces that provide a coordinated and rapid response to any level of threat."

Historically, TESS systems could not interact with each other due to the use of different communication and coding protocols. Through the excellent work of NATO's Urban Combat Advanced Training Technologies (UCATT) task group and its development of Live Simulation Standards (LSS), a set of international standards have been identified, "to allow live simulation systems to interoperate in a multinational training environment..."

## Conclusion

The capabilities of collective live training systems have advanced considerably over recent decades. With conventional TESS capabilities of older systems having been greatly improved through the work of companies such as Saab, Rheinmetall, Ravenswood, Cubic and Thales. Many of these additional capabilities have occurred through new digital instrumentation technologies and the GPS-based geometric pairing system that is now being increasingly adopted to simulate indirect fire.

Although these additions should be welcomed, less progress has been made with simulating the terminal effects of weapons. Although a difficult challenge that must also take safety into account, this is an area that is currently lacking realism and is a challenge for the future. One thing is certain and that is that the live collective training market continues to grow and this is good news for the many defence companies that support it.



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