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A large number of white model aircraft are scattered across a dark, textured background, creating a sense of a vast, busy sky. The aircraft are of various sizes and orientations, some appearing to be in flight. The overall composition is dense and dynamic.

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New year, new look



As we kick off the new year, what should be immediately apparent to long-time readers is that ESD has undergone a major redesign. We spent a large portion of 2024 working on this for both ESD and our German-language sister magazine ES&T, and are excited that we can finally present the fruits of this work. The changes are intended to provide a much fresher, cleaner,

and more modern look and feel to the magazine, while also improving readability, and adding a dash of flair.

Yet this is only the beginning – under the ESD roadmap, the redesign first takes effect with the print magazine, followed shortly afterward by an interim minor design update for the website in the early portion of the year, and culminating with a much more comprehensive remaking of our website, due later in the year. We hope you all like the new look as much as we do!

Aside from the new look, ESD remains committed to providing the most accurate and detailed information on all aspects of the defence space. In this regard, we have some very exciting plans for topics we plan to cover in-depth over the course of this year.

Looking at the year ahead, 2025 promises to be truly historic in many ways, ranging from the prospect of a peace agreement to finally end the War in Ukraine, to the ways US–European foreign and economic relations will be tested by US President Donald Trump’s second term, to the ongoing reshaping of the geography of power in the Middle East. Alongside this, the year ahead will see a number of key elections take place, with those in Australia, Belarus, Canada, Germany, Poland, and Romania being some of the key ones to watch.

Many fundamental questions remain to be decided. In the case of Ukraine for instance, if the war does end by mutual agreement, how will the peace be enforced? Will European countries, many of whom have struggled with sluggish economic growth and internal crises, step up to the task of rebuilding Ukraine, both militarily and economically? Or will more European leaders choose to deal with competing problems, and so turn to policies serving a narrow form of national self-interest? In many ways, the answer to these questions will serve as a key litmus test of Europe’s capacity for solidarity and cooperation, likely setting the scene for the remainder of the decade.

Elsewhere, Donald Trump’s recent statements announcing his desire for the US to control Greenland and the Panama Canal, along with his subsequent refusal to rule out the use of military force to annex either, were unexpected to say the least, and have already started causing headaches in Europe prior to his inauguration. While a war between the US and any European country is probably not on the cards this year, such statements have highlighted both how unpredictable President Trump can be, and the palpable lack of what an obvious and credible European response would even look like if the threat were genuine.

All this and the year has barely even begun. Strap yourselves in, this looks like it’ll be a wild one.

Mark Cazalet

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Cover Photo: Ajax reconnaissance vehicle, undergoing trials near Bovington Training Area, on 7 January 2023.

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China uses Mao's birthday to reveal substantially sized sixth-gen fighter

(pf) China stunned the aerospace world on 26 December 2024 when footage appeared on social media of a new sixth-generation fighter conducting a daytime test flight that bears little resemblance to anything that has come before it.



▲ **At around 21 m long, the new Chinese sixth-generation stealth fighter, which is possibly designated the J-36, appears as a substantially sized aircraft in flight.**
[X/@TWZ]

Featuring a tailless, modified delta-wing design, the new aircraft is around 21 m long – with its delta wing form thus making it appear as a substantially sized aircraft in flight – and is propelled by three powerplants.

The aircraft's daytime test flight – which was no doubt meant to be seen (26 December is the birthdate of Mao Zedong: the founder of the People's Republic of China) – saw it accompanied by a Chengdu J-20S fifth-generation fighter. The Chengdu Aircraft Corporation has apparently referred to the new aircraft as the J-36.

While the new aircraft's sheer size and lack of a tailplane mean that it is unlikely to be particularly manoeuvrable, features such as the absence of a tailplane and the fact that the powerplant exhaust outlets are mounted on the upper side of the rear fuselage show that significant design considerations in relation to stealth have been made. The aircraft's size also suggests substantial capabilities in relation to its weapons payload and fuel capacity/range, while the three engines could indicate high-altitude operations were a major design driver.

Other features initially noted on the aircraft by analysts include five trailing-edge control surfaces per wing (to compensate for the absence of a tail) as well as two sets of large apertures on each side of the nose. These are likely to be for both electro-optical sensors and side-looking radars, with the latter significantly extending radar coverage beyond the usual front-mounted radar array.

At this stage it is unclear whether the new aircraft is just a demonstrator, although if it has, indeed, been designated as the J-36, then that would suggest that it constitutes a full-on sixth-generation fighter programme.

As if to significantly disturb the Christmas holidays of Western aviation analysts, footage also appeared on 26 December of a smaller tailless combat aircraft, apparently from the Shenyang Aircraft Corporation (SAC). This aircraft has a swept-wing design and twin engines, but a lack of detailed still or video imagery have so far not allowed analysts to determine whether this smaller tailless aircraft is a manned platform.

Ukraine's GUR claims Russian Mi-8 kills using missiles fired from MAGURA V5 USVs

(pf) The Main Directorate of Intelligence of the Ukrainian Ministry of Defence (GUR) has claimed to have destroyed two Russian helicopters and damaged a third in an operation that used MAGURA V5 unmanned surface vessels (USVs) armed with surface-to-air missiles (SAMs).

The operation, conducted by the GUR's Group 13 special forces unit, took place in the Black Sea near Cape Tarkhan-kut off the western tip of the Russian-occupied Crimean Peninsula on 31 December 2024.

The SAMs used by the MAGURA V5s were identified by the GUR as "R-73 'SeeDragon' missiles": ground-launched variants of the Soviet-designed R-73 short-range air-to-air missile. Each USV can carry two R-73s mounted on launch rails.

The GUR initially claimed on its website on 31 December to have destroyed one Russian Mi-8 helicopter and to have damaged another. However, in an update on 2 January 2025 the GUR revised its report to claim that two Mi-8s had been destroyed and a third helicopter damaged.

The GUR posted video imagery on its website on 31 December, taken from the MAGURA V5s' infra-red cameras, to corroborate its claims. The footage clearly shows the MAGURA V5s coming under machine gun attack as well as multiple Russian helicopters and one fixed-wing aircraft. The USVs are seen to launch multiple missiles, with at least one Mi-8-type helicopter being struck before crashing into the sea.



[GUR]

Ukraine's 5.5 m long MAGURA V5 USVs have typically used by Ukrainian special forces as 'suicide drones' to conduct explosives-laden ramming attacks on Russian shipping in the Black Sea. However, Ukrainian literature disseminated at the Eurosatory 2024 exhibition in Paris in June 2024 noted that the USVs could be used for a variety of missions – such as surveillance, patrolling and reconnaissance operations, mine countermeasures missions and search-and-rescue operations – and be armed with weapons such as SAMs, machine guns and surface-to-surface missiles.

For the 31 December operation it is possible that the MAGURA V5 feigned an approach to the Russian port at Sevastopol, which is about 100 km further to the southeast of Cape Tarkhankut, to lure out and then ambush Russian aviation assets responding to their presence.

Finnish Border Guard boards Russian tanker following latest act of underwater sabotage



[Finnish Border Guard]

In an act of what the Finnish government has called “aggravated sabotage”, *Eagle S* is accused of dragging its anchor to break the Estlink 2 submarine cable, which carries electricity from Finland to Estonia. The Finnish patrol ship *Turva* intercepted *Eagle S*, which was flying the flag of the Cook Islands but is part of Russia’s ‘shadow fleet’ of sanction-busting tankers, to interview the crew and gather evidence. Finnish investigators said the ship’s anchors were not on board the vessel.

The incident on 25 December was the latest in a series of attacks on Western undersea infrastructure.

On 17 and 18 November 2024 a Chinese bulk carrier, *Yi Peng Three*, is suspected of severing two undersea cables – one linking Sweden to Lithuania and the other between Finland and Germany – by deliberately dragging its anchor along the seabed for more than 160 km.

In October 2023 an undersea gas pipeline between Finland and Estonia was shut down after it was damaged by the anchor of the Chinese cargo ship *Newnew Polar Bear*.

On 26 September 2022 a series of underwater explosions and consequent gas leaks occurred affecting the Nord Stream 1 and Nord Stream 2 natural gas pipelines within the economic zones of Denmark and Sweden. Both pipelines were built to transport natural gas from Russia to Germany via the Baltic Sea.

In August 2024 it was reported that German authorities had issued a European arrest warrant for a Ukrainian national suspected of having used the sailing yacht *Andromeda* along with two others to sabotage the Nord Stream pipelines, although some sources have suggested this might have been a Russian ‘false flag’ operation.

To counter these acts, in May 2024 NATO launched a new Maritime Centre for the Security of Critical Undersea Infrastructure within the alliance’s Maritime Command in the United Kingdom, while on 4 December 2024 NATO foreign ministers wrapped up two days of meetings in Brussels by vowing to address the increasing incident of sabotage and other hostile actions being inflicted on NATO countries.

NATO Secretary General Mark Rutte stated at the time that “both Russia and China have tried to destabilise our countries and divide our societies with acts of sabotage, cyber attacks and energy blackmail”.

(pf) On 26 December 2024 the Finnish Border Guard boarded the Russian oil tanker *Eagle S* after it was suspected of breaching an undersea power cable linking Finland to Estonia the previous day.

In an act of what the Finn-

ish government has called “aggravated sabotage”, *Eagle S* is accused of dragging its anchor to break the Estlink 2 submarine cable, which carries electricity from Finland to Estonia. The Finnish patrol ship *Turva* intercepted *Eagle S*, which was flying the flag of the Cook Islands but is part of Russia’s ‘shadow fleet’ of sanction-busting tankers, to interview the crew and gather evidence. Finnish investigators said the ship’s anchors were not on board the vessel.

While Finland acted decisively to board *Eagle S*, effectively countering such sabotage is complicated by the fact that it is ostensibly being conducted by civilian vessels that are simply using their anchors as a weapon. Moreover, moves by NATO to counter attacks on the allies’ undersea infrastructure – whether by active patrolling, monitoring of suspect shipping or increased physical protection for undersea cables and pipelines – is likely to become an expensive undertaking.

Eurofighter closes 2024 with new Spanish and Italian orders and signing of LTE contract

(pf) Eurofighter closed out 2024 with two news orders totalling up to 49 jets for Spain and Italy and the signing of a contract to secure the Eurofighter Typhoon’s long-term development.



[Eurofighter]

On 20 December 2024 it was announced that the leaders of the NATO Eurofighter and Tornado Management Agency (NETMA) and Eurofighter had signed a contract for 25 additional jets for the Spanish Air Force. Known as Halcon II, the Spanish order continues the modernisation of the Spanish Air Force’s Eurofighter fleet and follows the first Halcon order for 20 fighters, made at the ILA show in Berlin in June 2022. The contract covers 21 single-seat and four twin-seat jets, to be delivered between 2030 and 2035, that will replace part of Spain’s legacy F-18 fleet, based in Torrejon and Zaragoza, bringing the total number of Typhoon aircraft in the Spanish Air Force to 115.

The new Spanish Eurofighters will be equipped with advanced avionics, electronically scanned-array (E-Scan) radars, an enhanced weapon suite that includes MBDA’s Brimstone III ground attack missile and Meteor beyond-visual-range air-to-air missile, new sensors and improved connectivity.

Also on 20 December it was reported that Giancarlo Mezzanatto, chief executive of Eurofighter, and Air Vice Marshal (ret) Simon Ellard, general manager of NETMA, had signed the contract for Part 1 of the Eurofighter’s Long Term Evolution (LTE) Technology Maturation Phase (TMP).

The LTE programme will boost the growth capacity of the Eurofighter through the development of new cockpit, mission computing and flight control computing capabilities, along with new communications equipment and armament controls. In addition, it will be a key enabler for the delivery of future production aircraft, as well as facilitating continued capability enhancements for the remaining life of the Eurofighter.

“LTE will be the major midlife technology upgrade for the Eurofighter, bringing several major enhancements to the jet – specifically to its avionics architecture,” noted Mezzanatto. “There will be an evolution of the cockpit configuration and human machine interface and an expansion in its ability to handle large amounts of data, much faster.

“The signature of the LTE contract demonstrates the commitment of our customers to continue the effectiveness of the Eurofighter aircraft and programme for many years to come. It will also meet the evolving needs of our air forces,” Mezzanatto added.

Then, on 23 December in Rome, the leaders of Eurofighter and NETMA signed a contract covering up to 24 new Eurofighters for the Italian Air Force, which will replace Italian Tranche 1 Typhoons currently in service.

As with the new Halcon II Spanish order, the new Italian Eurofighters will be equipped with advanced avionics, enhanced weapon systems capable of operating Brimstone III and Meteor, new sensors and improved connectivity.

The Eurofighter Typhoon fleet is slated to have a service life that will extend well beyond 2060, with technical enhancements that will allow the aircraft to be fully integrated into Europe’s future air combat environment.

GCAP partners announce joint venture to deliver the programme



[BAE Systems]

(pf) The three main companies behind the trinational Global Combat Air Programme (GCAP) announced on 13 December 2024 that they have reached an agreement to form an equally owned joint venture to take the programme forward to fruition.

The UK’s BAE Systems, Italian company Leonardo and the Japan Aircraft Industrial Enhancement Co (JAIEC) will each hold a 33.3% shareholding in the new joint venture, bringing together the combined strengths and expertise of the three companies and marking a pivotal moment for the programme. The agreement is subject to the usual regulatory approvals.

The new joint venture will be accountable for the design, development and delivery of GCAP, including the Tempest sixth-generation fighter, and will remain the design authority for GCAP for the life of the product, which is expected to be in service beyond 2070.

The joint venture will have operations and joint teams working in each of the partner nations. It will be headquartered in the UK, to ensure maximum alignment and collaboration with the GCAP International Government Organisation (GIGO), which will also be headquartered in the UK. Both entities will work together to support cost-effective and timely programme delivery, including a 2035 aircraft in-service date.

The trilateral GCAP effort, announced by the governments of the UK, Italy and Japan on 9 December 2022, merged two previously separate sixth-generation fighter projects: the UK-led Tempest programme, developed with Italy, and the Japanese Mitsubishi F-X programme. A treaty cementing the agreement was signed in December 2023.

Putin apologises for ‘tragic incident’ in downing of Azerbaijani airliner

(pf) On 28 December 2024 Russian President Vladimir Putin came as close as he was ever likely to in admitting that Russian air defences had mistakenly shot down Azerbaijan Airlines Flight 8243 three days before.

A statement from the Kremlin noted that, in speaking to Azerbaijani President Ilham Aliyev, Putin “apologised for the fact that the tragic incident occurred in the Russian airspace”.

Flight 8243 was an Embraer 190AR that was on a scheduled flight from Heydar Aliyev International Airport in Baku to Kadyrov Grozny International Airport near Grozny in Russia on 25 December. While on approach to Grozny it was severely damaged by what are now understood to have been Russian surface-to-air missiles (SAMs) before diverting towards Aktau International Airport in Kazakhstan and crashing before it could land there. Of the 62 passengers and five crew on board, 38 died in the crash, including both pilots and a flight attendant, while 29 people survived.

Russian authorities initially claimed Flight 8243 had suffered a bird strike, as the crew had initially reported at the time, but numerous survivors recalled multiple explosions, while imagery of the aircraft wreckage clearly revealed fragmentation damage consistent with a SAM attack.

The Kremlin subsequently conceded that Russian air defences were repelling Ukrainian unmanned aerial vehicle attacks at the time. These actions would have been combined with GPS jamming, exacerbating an air picture already confused by fog (having lost the use of aircraft’s navigational aids, the crew twice tried to land at Grozny but were thwarted by fog in the minutes before the aircraft was struck).

Azerbaijani government sources told news outlets on 26 December that a Russian Pantsir-S1 self-propelled air defence system was responsible for downing Flight 8243.

Denmark and Sweden place major order for new CV9035 IFVs

(pf) Denmark and Sweden have ordered new CV90 infantry fighting vehicles (IFVs) from BAE Systems in contracts worth a total of around USD 2.5 billion (EUR 2.36 billion), the company announced on 6 December 2024.



[BAE Systems]

The contracts come under BAE Systems’ framework agreement with the Danish Ministry of Defence Acquisition and Logistics Organisation (DALO) and the Swedish Defense Materiel Administration (FMV) to expand the acquisition of new CV9035MkIIIC IFVs for both countries.

Denmark is procuring 115 new CV9035MkIIICs, while Sweden has agreed to acquire a total of 50 new vehicles, although the

agreement also includes further CV90s for Ukraine financed by the two governments.

The contracts reach a value of around USD 2.5 billion with the inclusion of spares, support, logistics and training.

“The infantry fighting vehicle is an essential component of the heavy brigade we are currently building,” Major General Peter Boysen, chief of the Royal Danish Army, was quoted as saying in a BAE Systems press release. “The 115 new vehicles will significantly enhance Denmark’s contribution to collective security and international operations. With the 44 existing vehicles, we will have a total of 159 vehicles, providing us with substantial strength – also from an international perspective.”

The new version of the CV9035MkIIIC is built to the same standard as the latest CV90 mid-life upgrade programme for the Netherlands. The vehicles will be equipped with a new CV90 turret, which “provides a leap forward in design and functionality”, according to BAE Systems.

The company additionally noted that the CV90 is built on years of combat-proven experience, continuous improvements and data gathering from the CV90 User Club, which comprises the 10 nations operating CV90 fleets. The commonality of the CV90 platform offers the users interoperability within as well as between nations.

CV90 variants weigh between 23 and 38 tonnes and can integrate a range of weapon systems. While previous CV90s have usually been armed with a 30 mm or 40 mm cannon, the CV9035MkIIIC, which weighs around 32 tonnes, is armed with a 35 mm Bushmaster cannon.

A total of 1,900 CV90s have been ordered in 17 different variants, with the vehicle selected by 10 European nations.

NATO Secretary General implores allies to shift to wartime mindset and spend more on defence

(pf) NATO Secretary General Mark Rutte has highlighted the critical need to ramp up defence spending and defence production amid an increasingly turbulent security climate.



[NATO]

Speaking on 12 December 2024 at an event hosted by Carnegie Europe in Brussels, Rutte called on the NATO allies to “shift to a wartime mindset and turbo charge our defence production and defence spending”.

Starting out by noting that Ukraine, where “Russian bombs are falling”, is just a day’s drive from Brussels, Rutte said of Russian President Vladimir Putin’s invasion of that country, “Putin is trying to wipe Ukraine off the map. He is trying to fundamentally change the security architecture that has kept Europe safe for decades. And he is trying to crush our freedom and way of life.”

Rutte then went on to note that past incidences of Russian belligerence had gone unchecked.

“His pattern of aggression is not new, but for too long we did not act. Georgia in 2008. Crimea in 2014. And many did not want to believe he would launch all-out war on Ukraine in February 2022,” said Rutte, who then asked rhetorically, “How many more wake-up calls do we need? We should be profoundly concerned. I know I am.

Rutte then went on to point out that the Russian economy is on a war footing, accompanied with a warning for what that means.

“In 2025, the total military spending will be 7 to 8% of GDP, if not more. That’s a third of Russia’s state budget – and the highest level since the Cold War,” he said. “And Russia’s defence industry is producing huge numbers of tanks, armoured vehicles, and ammunition. What Russia lacks in quality, it makes up for in quantity – with the help of China, Iran and North Korea. This all points in one clear direction: Russia is preparing for long-term confrontation: with Ukraine, and with us.”

Rutte also warned that the NATO allies “need to be clear-eyed about China’s ambitions”, pointing out that China is substantially building up its military, including its nuclear forces. “From 200 warheads in 2020, China is expected to have more than 1,000 nuclear weapons by 2030,” said the secretary general. “Its space-launch investments are skyrocketing. China is bullying Taiwan, and pursuing access to our critical infrastructure in ways that could cripple our societies.”

While noting that the NATO allies had increased their defence spending, have more forces at higher readiness, exercise more, have more troops and hardware in eastern Europe and now have more allies in Finland and Sweden, Rutte warned that “our deterrence is good – for now – but it’s tomorrow I’m worried about. We are not ready for what is coming our way in four to five years. Danger is moving towards us at full speed. We must not look the other way; we must face it.

“We can do that,” he continued. “We can prevent the next big war on NATO territory, and preserve our way of life. This requires us all to be faster and fiercer. It is time to shift to a wartime mindset, and turbo-charge our defence production and defence spending.”

Rutte cautioned, however, that “there is a lot that needs to be done to ensure long-term deterrence and restore peace. We are not where we want to be.”

With a direct message to the allies’ governments with regard to their defence orders, Rutte said, “Give our industries the big orders and long-term contracts they need to rapidly produce more and better capabilities. Buying only big-ticket items that are delivered too late will not keep us safe. We also need modern capabilities that use the most advanced technologies, and we need them now. So embrace risk and invest in the pool of innovators across our countries.”

Identifying the issue of defence spending as the main point he wanted to address, Rutte said, “It is true that we spend more on defence now than we did a decade ago, but we are still spending far less than during the Cold War, even though the threats to our freedom and security are just as big – if not

bigger. During the Cold War Europeans spent far more than 3% of their GDP on defence. With that mentality, we won the Cold War. Spending dropped after the Iron Curtain fell. The world was safer. It is not anymore.

“A decade ago, Allies agreed it was time to invest in defence once again. The benchmark was set at 2%. By 2023, NATO Allies agreed to invest ‘at least’ 2%. I can tell you: we are going to need a lot more than 2%,” Rutte warned.

Eurofighter consortium invests in BAE Systems’ Striker II HMD

(pf) The Eurofighter consortium has awarded BAE Systems a GBP 133 million (EUR 161.6 million) contract to further develop its Striker II helmet-mounted display (HMD), the company reported on 11 December 2024.

Under the new contract the four-nation Eurofighter consortium – which combines companies from Germany, Italy, Spain and the UK – has tasked BAE Systems with continuing to mature the helmet’s capability alongside a programme of flight testing.

Eurofighter combines BAE Systems, with its 33% stake, with Italy’s Leonardo (21%) and the German and Spanish entities of Airbus Defence and Space (46%).

One of the world’s most advanced fighter aircraft helmets, the Striker II HMD uses the latest technologies to integrate its all-digital night vision system and daylight readable colour display. Data is displayed directly onto the pilot’s helmet visor, providing mission-critical information right before the pilot’s eyes.

BAE Systems is already developing the Striker II under a GBP 40 million contract announced by the UK Ministry of Defence in September 2023, which will see the helmet undergo flight trials in the coming months. The latest investment will fund the next stage of development, ensuring the helmet achieves a production-ready standard.

“The Striker II helmet aims to give the next generation of Typhoon pilots a crucial advantage in what is an increasingly congested and contested battlespace,” Richard Hamilton, managing director for Europe and international business at BAE Systems Air, was quoted as saying in a company press release. “This continued investment by the Eurofighter nations secures highly skilled jobs and enables our teams to further develop the helmet’s capabilities and move it another step closer to production.”

“Eurofighter has always been at the forefront of technological advancement and this contract – to further develop Striker II – will ensure that Typhoon pilots continue to fly a world-leading aircraft, wearing a world-leading all-digital helmet,” added Giancarlo Mezzanatto, chief executive of Eurofighter. “The contract award is also great news for the programme, as the international commitment to the development of the helmet will provide full synergies across our air forces.”

The contract is expected to secure more than 200 highly skilled jobs at BAE Systems’ combat air facility in Warton, Lancashire,

and its Electronic Systems site in Rochester, Kent, which specialises in developing HMDs.

British Army personnel conduct live-firing with Raytheon UK’s laser weapon demonstrator

(pf) Raytheon UK’s High-Energy Laser Weapon System (HELWS) has completed a successful live-firing with the British Army directed against moving aerial targets, the company announced on 11 December 2024.

The recent trial, which was conducted in October 2024 at the Radnor Range in Wales, is the latest stage of the UK Ministry of Defence’s (MoD’s) Land Laser Directed Energy Weapon (LDEW) demonstrator programme and saw British soldiers operating Raytheon’s HELWS by successfully tracking and neutralising moving mini-unmanned aerial vehicles (UAVs).

The experiment marks the first time the British Army has tested a high-energy laser weapon mounted on an armoured vehicle, in this case a Wolfhound 6x6 protected patrol vehicle. The same vehicle/HELWS first fired its laser to successfully neutralise targets back in mid-2024, but at the time was not in the hands of British Army personnel. In the latest trials soldiers from the army’s 16th Regiment Royal Artillery were trained on the weapon’s targeting and tracking technologies. The regiment the British Army’s only one equipped with a medium-range is air defence capability.

The vehicle-mounted laser trials are part of a joint programme between Raytheon UK and Team Hersa: the joint LDEW enterprise between the UK MoD’s Defence Science and Technology Laboratory and Defence Equipment and Support organisation.

The HELWS operates by directing an intensely amplified beam of light toward its target, using advanced sensors and tracking systems to maintain lock-on and accuracy in real time. It has already proved effective in real-world conditions, validating its potential as a game-changing technology in modern warfare.

“Our High-Energy Laser Weapon System has been used in operations globally, and now the British Army is experimenting with this game-changing capability”, James Gray, chief executive and managing director of Raytheon UK, was quoted as saying in a Raytheon press release. “The success of this test is the result of the skill, dedication, and vision of our scientists and engineers, who have collaborated with the British Army to help fulfil its commitment to staying at the forefront of technological innovation.”

In a video about the latest trials posted by DE&S on X/Twitter, technicians noted they were particularly impressed with how quickly the HELWS was able to take down its mini-UAV targets. Given that a laser weapon essentially has a limitless magazine compared to missile and gun-based systems, the HELWS thus shows significant potential as an effective counter to swarming UAVs as well as other air targets.



[Crown Copyright]



[Eurofighter]

Jorge Tamarit Degenhardt named as new CEO of Eurofighter

(pf) Jorge Tamarit Degenhardt was announced on 7 January 2024 as the new CEO at Eurofighter.

Degenhardt, a dual Spanish/German national, joins Eurofighter from Airbus Defence & Space, where he has spent the past two decades rising through the company's management to hold several international executive roles.

Degenhardt's appointment follows the Eurofighter three-year partner-company rotation policy. He succeeds Giancarlo Mezzanatto, who took up the Eurofighter CEO post on 1 May 2023 and now returns to Leonardo.

"We are delighted to welcome Jorge to Eurofighter as the new Chief Executive Officer," stated Richard Hamilton, chairman of the Eurofighter Supervisory Board, in a company press release. "We also offer sincere thanks to Giancarlo Mezzanatto for his dedication and commitment to Eurofighter during his term as CEO. Giancarlo's leadership brought many successes to the programme and we wish him the very best on his return to Leonardo."

Degenhardt has extensive Eurofighter experience, having recently been the programme head for Spain and leading all activities related to the Airbus contribution within the Eurofighter consortium.

Rheinmetall completes acquisition of US vehicle specialist Loc Performance Products



[Rheinmetall]

(pf) Germany's Rheinmetall announced on 2 December 2024 that it has completed the takeover of the US company Loc Performance Products LLC, which will now operate under the name American Rheinmetall Vehicles.

The Düsseldorf-based technology group announced the purchase of the renowned vehicle specialist, which is based in Plymouth, Michigan, in August 2024. Following approval by competent supervisory authorities, the transaction was closed on 29 November 2024.

The agreed purchase price for Loc Performance Products was based on an enterprise value of USD 950 million (EUR 907 million).

The investment follows Rheinmetall's drive for growth in the United States, which will be an important domestic market for the group in the future. The acquisition also strengthens Rheinmetall's production capacity in the United States, with a view to targeted high-volume major orders for US Army vehicle programmes.

Founded in Plymouth, Michigan, in 1971, Loc Performance Products provides drivelines, suspensions, track systems, rubber

products, armour products and fabricated structures for vehicle platforms and is the original equipment manufacturer for most military ground vehicle track systems in US service.

US Army Europe and Africa welcomes new commander

(pf) US Army General Christopher Donahue was welcomed as the new head of US Army Europe and Africa (USAREUR-AF) during a change of command ceremony at Clay Kaserne in Wiesbaden, Germany, on 10 December 2024.



[US Army]

General Darryl Williams, the outgoing USAREUR-AF commander, who will officially retire from the army early in 2025, relinquished command of the organisation to Gen Donahue in a ceremony officiated by US Army General Christopher Cavoli, the US European Command commanding general and Supreme Allied Commander Europe for NATO, and US Marine Corps General Michael Langley, Commander of US Africa Command (AFRICOM).

Gen Donahue's assumption of command of USAREUR-AF marks a return to Europe, as he previously served as the commander of the 82nd Airborne Division and later the 18th Airborne Corps as they deployed to Europe as part of USAREUR-AF's initial response to Russia's full-scale invasion of Ukraine in 2022.

As commander of USAREUR-AF, Gen Donahue will take on the unique task of leading the army's only service component command that campaigns on two continents.

Gen Donahue will also assume command of NATO's Allied Land Forces Command in Izmir, Türkiye. This unique role helps facilitate deeper integration of US and NATO forces in support of NATO regional defence plans.

Israel Aerospace Industries appoints two new senior executives

(pf) CEO of Israel Aerospace Industries (IAI) Boaz Levy and the company's board of directors appointed two senior executives at the end of 2024. Yaakov Berkovich was appointed vice president and general manager of IAI's Aviation Group, while Oded Jacobowitz was appointed as general manager of the Defense Plant in IAI's Missile and Space Systems Group.



[IAI]

Berkovich began his tenure at IAI in 2009 and. He served in various positions in the Aviation Group and in international marketing. In his most recent position, he was general manager of the Conversion and Upgrade plant within IAI's Aviation Group.

Jacobowitz began his tenure at IAI in 2018, serving in various positions at the Defense Systems plant, including as head of the Directorate of Land Systems and plant deputy general manager.

APS and ERA developments

Alexey Tarasov

Emerging threats observed in the ongoing Russo-Ukrainian conflict and a series of conflicts in the Middle East from 2022 to 2024 have sparked renewed interest in armoured vehicles and their protection.

Contemporary solutions include various layers of protection designed to increase the survivability of armoured vehicles against multiple threats on the battlefield. Among other measures, these include newer models of explosive reactive armour (ERA) and active protection systems (APSs). Over the last two decades, the development of defensive solutions for armoured fighting vehicles (AFVs) has been influenced by several factors.



▲ **T-90M protected by a combination of Nakidka camouflage system, Relikt ERA, RPG netting, overhead protection, and a drone jammer. [Alexey Tarasov]**

After the end of the Cold War and the beginning of the Global War on Terrorism (GWOT) in 2001, many theorists envisioned future warfare as a series of high-speed operations enabled by the Network-Centric Warfare (NCW) doctrine and precision weaponry, while extended large-scale conventional conflicts with peer or near-peer adversaries were considered unlikely.

This point of view led to a substantial reconsideration of the size and role of ground forces, specifically armoured fighting vehicles. As a result, large armoured formations were widely considered obsolete or excessive, while smaller, professional armies – compared to their Cold War-era counterparts – capable of rapid global deployments were now seen as effective tools for fighting low-intensity conflicts, typical of the 2000s to early 2010s.

AUTHOR

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In addition, the most common threats to armoured vehicles in low-intensity conflicts, were man-portable anti-tank weapons and improvised explosive devices (IEDs), with advanced anti-tank guided missiles (ATGMs) being less prevalent.

In most cases, the protection of existing armoured vehicles was deemed sufficient to withstand the majority of threats, while additional protection was provided through the extensive use of ERA – as seen with Russian and Chinese AFV fleets – or specialised kits combining ERA with appliqué passive armour. Examples include urban warfare kits such as the Tank Urban Survival Kit (TUSK) and the Bradley Urban Survivability Kit (BUSK), both used by the US Army.

These factors, combined with tight post-Cold War budgets, have made armies worldwide less interested in APSs. With few exceptions, countries with large AFV fleets focused on cost-effective solutions, such as passive protection, leaving more advanced systems for limited adoption and experimentation. The only hard-kill APS to enter active service between 2000 and 2020 was Rafael's Trophy APS, which was accepted into service by the Israel Defense Forces (IDF) in 2011.

During the same period, a few other countries adopted and procured soft-kill APSs. For example, Germany procured the Multifunction Self-Protection System (MUSS) for the Puma IFV, while Russia integrated the Shtora-1 soft-kill APS into the T-90 family of main battle tanks (MBTs).



▲ **A Puma in VJTF-2023 configuration, showing its MUSS soft-kill APS mounted above the commander's sight. [Bundeswehr/Panzergranadierbataillon 112]**

Gradual changes began in the late 2010s, with new threats emerging and lessons drawn from combat experiences in Lebanon, Iraq and Syria. The new threat environment was shaped by the proliferation of tandem-charge missiles, advanced ATGMs, and the widespread use of reconnaissance and weaponised UAVs, including models designed for top-at-

tack missions. In addition, the possibility of future large-scale conflicts with peer adversaries returned to the agenda.

The experiences drawn from ongoing conflicts have shown a controversial situation: on the one hand, armoured vehicles have proven their indispensability in combat, being the only tool capable of operating under fire and in close contact with the enemy. On the other hand, armour has demonstrated its vulnerabilities against new threats and in certain combat scenarios.

This controversy was described by Valery Mikhailovich Kashin, the chief designer of the Russian State enterprise, Machine-Building Design Bureau (KBM), in January 2017: *“The conflicts in the Middle East have shown, first of all, that tanks are indispensable, and second, that it is no longer possible to provide them with adequate protection using traditional methods, including ERA – tanks are being hit, and they are burning.”*

The evolving threat environment prompted an increasing number of nations to revisit the issue of improving the survivability of armoured combat vehicles. The period between 2016 and 2022 was characterised by growing efforts in this field.

For example, in 2016, the US military was already experimenting with several APSs for the Army and United States Marine Corps (USMC), including the expedited non-developmental item (NDI) APS programme and the Modular Active Protection System (MAPS) programme. During this period, the US military considered various APSs of both domestic and foreign origin, including Israel’s Trophy and Iron Fist systems, Raytheon’s Quick Kill system, ARTIS’s Iron Curtain system, and Rheinmetall’s Active Defence System (ADS), now marketed as ‘Strikeshield’.

Earlier, in 2015, Russia publicly unveiled its new armoured platforms: the Armata, Kurganets-25, and Bumerang 8×8. Some of these platforms were equipped with Afganit, a new-generation APS. A year later, on 19 January 2017, KBM’s chief designer Kashin announced that the Arena-M APS would be integrated into the T-72 and T-90 families of MBTs, although testing was still ongoing.

In August 2017, China unveiled its domestically designed GL5 APS during the Armor and Anti-Armor Day event. In January 2018, the US military selected the Trophy APS for further tests



▲ **Arena-M shown fitted to a scale model of a T-72, displayed at IDEX 2023. [Alexey Tarasov]**

and integration with the M1 Abrams platform, and within a year Germany announced its intention to join the ‘Trophy club’ and integrate the Trophy APS into the Leopard 2 MBT.

It is worth noting that, while by the late 2010s many countries had recognised the growing need to improve AFV survivability, the pace of procurement and implementation has remained relatively slow.

Since then, Russia’s full-scale invasion of Ukraine in 2022 and various conflicts in the Middle East in 2023 have provided a substantial amount of new experience gained in diverse combat environments and scenarios, once again reshaping the threat environment. Yet what exactly has changed?

An evolving battlefield

Over the course of the 2020s, there have been significant changes to the threat landscape.

- AFVs are now threatened from all directions, including from above through top-attack munitions. The modern battlefield for armoured vehicles is increasingly three-dimensional rather than ‘flat’. Older concepts of focusing protection on the 60°, or 180° frontal arc, or even 360° all-around protection now seem less relevant.
- The battlefield has become more transparent with the proliferation of reconnaissance unmanned aerial vehicles (UAVs). Previously, the ‘Survivability Onion’ concept emphasised that the physical protection of an AFV was one of the last layers of defence, prioritising measures to avoid detection and targeting in order to prevent being hit. Now, with the proliferation of low-cost sensors such as UAVs, the role of physical protection has increased – since an active AFV is likely to be detected, prompting the enemy to concentrate all available fire assets against it.
- The threat spectrum for AFVs has expanded, with a wider variety of weapons now targeting them from multiple directions, including top-attack capabilities. This shift, driven by advances in precision-guided weapons, drones, and loitering munitions, necessitates a re-evaluation of protective measures across all classes of vehicles.

During the Cold War, the different militaries, and specifically engineers, had a clear understanding of which threats were most probable for specific classes of armoured vehicles at certain distances. For example, they recognised that MBTs were likely to face RPGs, ATGMs, or armour-piercing rounds in close combat scenarios involving direct fire over relatively short distances (roughly 1-5 km). As a result, MBTs were primarily designed with to prioritize protection over vehicle’s the frontal arc. Similarly, the engineers understood that self-propelled howitzers (SPHs) required lighter protection, sufficient to withstand shell fragments or small arms fire. It is important to emphasise that this understanding had a significant impact on AFVs design between the 1970s and 1990s.

Today, tanks can still face armour-piercing tank rounds and RPGs over the frontal arc. However, they now also require protection against precision-guided munitions, high-explosive anti-tank (HEAT) and tandem-charge HEAT munitions,

various drones, and loitering munitions, which can attack from all directions, including from above. SPHs, in turn, have also become increasingly exposed to long-range loitering munitions.



- ▲ **An up-armoured T-72B3M on display at Armiya 2024. The protection package includes additional ERA covering weak spots, rubber mats around the turret rear, thermal and visual camouflage coating, RPG nets, overhead protection, and a drone jammer. [Alexey Tarasov]**

There have been several key factors driving changes to AFV protection requirements:

- AFVs can be attacked using combinations of various means, increasing the need for multi-layered protection, ranging from passive armour to jammers and APSS.
- The combat zone has now expanded and sometimes extends tens of kilometres beyond the line of contact. What was previously considered a close rear and relatively safer area is now within reach of enemy intelligence, surveillance, and reconnaissance (ISR) and fire support assets, making it unsafe. In scenarios such as urban warfare in Gaza, the so-called 'safe zone' may be surrounded by hostile territory or positioned outside the main operational area.
- The expansion of combat zones has increased the need for protection for light and medium armoured vehicles, as well as for soft-skinned vehicles. This includes classes such as SPHs, logistics and resupply vehicles, or specialised ISR and C2 vehicles.

In summary, every vehicle on the modern battlefield now requires some form of protection against multiple threats. This requirement has largely shaped the evolution of AFV protection, including components such as ERA and APSS.

ERA developments

How have changes in the threat environment prompted developments in ERA, and what trends can be highlighted?

- 1) Where previously ERA had been largely restricted to MBTs, now combinations of passive protection and ERA are now being introduced to new classes of armoured and soft-skinned vehicles.**

This trend emerged as a response to the growing threat to high-value but lightly-armoured vehicles, such as self-propelled artillery, air defence systems, recovery and engineering vehicles, to name a few. In some cases, vehicles fitted with additional ERA kits have already entered service, while in others, they have only been unveiled recently or are undergoing trials.

For example, on 13 August 2024, Russia's Uralvagonzavod (UVZ) plant delivered a batch of upgraded BREM-1M ARVs equipped with Relikt ERA elements. On 5 November 2024, UVZ reported the delivery of another batch of TOS-1A heavy thermobaric multiple launch rocket systems (MLRS), also equipped with Relikt ERA modules. Earlier, on 31 October 2023, a Russian BREM-1M ARV with Relikt ERA modules was spotted somewhere in the operational area of the Russo-Ukrainian war. Further armoured vehicles equipped with ERA, were showcased at the Russian Army's annual exhibition 'Armiya' between 2022 and 2024, including the BREM-1M and BREM-80U armoured recovery vehicles, as well as the BMP-2M and BMP-3 IFVs, though the latter two were only presented to the public as scale models. In April 2024, footage of a BMP-3 IFV equipped with an NKDZ protection kit featuring 2S24 ERA modules was published on social media. Allegedly, the vehicle was filmed in Ukraine; however, it is unclear whether NKDZ kits for IFVs are being procured by the Russian MoD or undergoing further trials.



- ▲ **Pangolin ERA on a prototype of the RAK M120G SPM, at MSPO-2024 [Mark Cazalet]**

Meanwhile, the Pangolin ERA package was presented on a prototype of the RAK M120G tracked, turreted self-propelled mortar (SPM) at the MSPO 2024 exhibition in Poland. Pangolin ERA had previously been unveiled by Wojskowy Instytut Techniczny Uzbrojenia (WITU) at MSPO 2022, where it was presented as a successor to the Erawa-1 and Erawa-2 series ERA. According to the manufacturer, the new ERA can be adapted to meet the user's expected level of protection, incorporating various levels of explosives, including low-sensitivity, as well as different types of non-explosive materials. At MSPO 2024, the Pangolin ERA was showcased in two variants: a heavier ERA for use with the PT-91 Twardy MBT and a non-explosive reactive armour (NERA) variant suitable for medium and light armoured vehicles.

It can be also expected that more modular ERA/NERA kits for more classes of combat and auxiliary vehicles would emerge in the near future as demand will likely increase

2) ERA is becoming increasingly customisable and is offered as part of modular protection solutions.

As recent combat experiences suggest, protection capable of defeating or withstanding a broad range of threats is preferable. This understanding drives manufacturers to develop and offer multilayered, modular solutions that can be adapted based on the operator's requirements.

An example of one such system is the ASPIS (Advanced Shielding Platform Integrated System) Modular NG, unveiled on 10 May 2023 at the DEFEA exhibition in Greece. According to manufacturer EODH, the system was designed to enhance the protection of Greek Leopard 2A4 MBTs. The ASPIS system includes two types of protection modules. The first consists of passive elements and modular ERA tiles, designed to protect the front arc and sides of the tank against kinetic energy projectiles and shaped charges. Modules of the second type are designed to protect the roof of a tank against top-attack munitions and drones; these consist of a radar sensor and static high-explosive fragmentation effectors, which function similarly to proximity-fuzed mines.

In a broader view, EODH's 'holistic' approach to protection combines mine protection with various passive armour solutions, ERA, and both soft-kill and hard-kill countermeasures. Notably, solutions based on ASPIS can be adapted for light and medium combat vehicles.



▲ ASPIS ERA and hard-kill top-attack protection shown fitted to a Leopard 2A4. [EODH]

This approach, under different names, is shared across the industry. For example, Dynamit Nobel Defence (DND) offers adaptable ERA solutions against a broad variety of threats, ranging from kinetic energy penetrators and ATGMs to IEDs and roof protection against bomblets and submunitions. As with the previous case, the ERA solutions can be customised for different types and classes of AFVs. Other manufacturers, such as Rafael, Elbit Systems, Rheinmetall, and others, largely follow this trend by offering integrated and adaptable solutions.

3) New survivability enhancement packages are expected to emerge for both modern and older AFV designs.

As the War in Ukraine illustrates, almost every AFV fielded by the belligerents, regardless of its age or country of origin, has eventually been equipped with additional protection. Furthermore, ERA configuration patterns designed prior to the conflict have been upgraded, and their evolution continues.

For example, Russia entered the war with several models of MBT, with the T-72 forming the backbone of its fleet, supported by smaller numbers of T-80 and T-90 tanks. These tanks were most commonly equipped with second-generation Kontakt-5, along with smaller quantities using first-generation Kontakt-1, third-generation Relikt ERA, or configurations combining modules from various packages. Combat experience from the initial phase of the war has revealed a number of vulnerabilities, including unprotected sights and observation devices and weak spots in ERA arrangement. The latter issue proved especially critical during urban combat scenarios. From 2022 through 2024, manufacturers such as Uralvagonzavod (UVZ) and Omsktransmash have addressed these issues through incremental upgrades to both serially-produced and refurbished MBTs. Among other improvements, the upgraded versions of the T-72, T-80, and T-90 families of tanks received rearranged ERA kits, now designed for 360° protection, covering weak spots on the turret roof, gun mantlet, sides, and rear hull and turret.

Importantly, recent research on AFV employment in combat acknowledges that tanks not equipped with ERA or those with weak zones are extremely vulnerable to enemy fire. Additionally, certain lightly armoured AFVs, such as the BTR-70 APC, have been deemed unsuitable for modern combat altogether. Notably, survivability upgrades for older AFVs remain a critical issue for many armies operating mixed fleets of modern and aging armoured vehicles, including designs first adopted in the 1970s or even earlier. It is therefore likely that the demand for survivability enhancement packages will increase in the near future.

▼ T-80BVM fitted with the Nakidka camouflage system, Relikt ERA, RPG netting, overhead protection, and a drone jammer. [Alexey Tarasov]



Numerous manufacturers already offer such upgrades. For example, EODH provides upgrade packages that combine ERA and passive protection for vehicles such as the Leopard 1HEL, Leonidas 300 AAPC, and M113HEL. Similar solutions, combining ERA and passive armour, are offered by Turkish manufacturer Roketsan, covering a broad range of armoured vehicles, from the Leopard 2A4 and T-72 to the M113.

4) Next-generation ERA packages are currently in development or undergoing trials.

Russia has continued to develop its fourth-generation Monolit ERA designed for the Armata platform family, however, its current development status is unknown. On 19 July 2023, Russian media reported the deployment and testing of a batch of T-14 Armata MBTs in Ukraine. Later, on 23 August 2023, the TASS news agency, citing an undisclosed source within the Russian military-industrial complex, stated that the T-14 Armata would undergo further modifications based on the results of its trials in the field. This suggests that the testing of the T-14 in a real combat environment has revealed areas for improvement; however, it is unclear whether these include the Monolit ERA.



▲ T-14 MBT during a demonstration in 2021. The T-14 is fitted with NII Stali's Monolit ERA package. [RecoMonkey]

Meanwhile, India's Defence Research and Development Organisation (DRDO) has intensified efforts in domestic ERA development. On 10 April 2023, the DRDO announced the completion of work on the ERA Mk II, suitable for use on Russian T-series tanks and the Arjun MBT. On 23 November 2024, the DRDO reported finalising the development of their new ERA package, simply called: 'Next Generation Explosive Reactive Armour' (NGERA).

Despite many countries intensifying efforts on new-generation ERA packages in recent years, many research and development projects are expected to conclude only by 2030 or later, aligning with the trials of next-generation platforms. However, it is also possible that new ERA systems could be deployed earlier due to high demand or emerging threats.

APS developments

Although many countries recognised the growing need to develop and adopt APSs decades ago, the pace of implementation remained slow. High costs, the low probability of

large-scale conventional war, and, in some cases, immature technology were among the main reasons for such an approach. APSs have seen broader deployment in recent years, with several prominent trends becoming apparent.

1) APSs for medium-weight platforms are becoming an essential component of such vehicles' protection suite.

The concept of equipping medium-weight platforms with hard-kill active protection systems was already under consideration by many militaries in the 2010s. In 2016, the US military launched the expedited non-developmental item (NDI) APS programme, aimed at integrating hard-kill APSs onto the Army's M1 Abrams tanks, M2/M3 Bradley IFVs, and M1126 Stryker combat vehicles. Since the mid-2010s, APSs have been tested on many major modern medium platforms, including the AS21 Redback, M2 Bradley, CV90, LAV III, M1126 Stryker, and others.

By 2024, some APSs have been successfully integrated into medium platforms and fielded, while others are slated for deployment in the near future. The Iron Fist APS, for instance, has been integrated into the M2/M3 Bradley, CV90, AS21, and Eitan 8x8, with potential integrations into other platforms in the future. On 3 December 2019, for example, Rheinmetall reported that the US Army had awarded a contract for extensive testing of the Strikeshield APS to gather data for selecting an APS for new vehicles such as the armoured Multi-Purpose Vehicle (AMPV), Mobile Protected Firepower (MPF), and the Optionally Manned Fighting Vehi-

▼ A scale model of an AS21 Redback IFV equipped with Iron Fist APS at EDEX-2021 exhibition. [Alexey Tarasov]



cle (OMFV). Rheinmetall's Strikeshield APS is another option on the global market. Currently, only the KF41 IFV produced in Hungary is equipped with the Strikeshield, but various armed forces have expressed interest in both the platform and the APS.

Interest in integrating APSs into medium-weight platforms has revived in China and Russia. On 19 July 2024, Rostec announced that APSs designed for IFVs were currently under development, and a representative of Russia's Special Design Bureau of Mechanical Engineering (SKBM) outlined

three main areas that the manufacturer is currently focusing on: *“Our work is concentrated in three main areas: suppression using electronic warfare, protective structures, and physical destruction of drones at a certain distance. Efforts are underway in all three areas. We cannot provide more specific details, but the scope of work is broad, ranging from anti-drone shields to active protection systems,”* the representative said.

In November 2024, China unveiled a previously unknown air-droppable IFV equipped with the GL-6 APS. Notably, GL-6 uses a design similar to Iron Fist, using a traversable effector launcher with two launch tubes for grenade-type effectors, albeit the tubes are in a side-by-side configuration, rather than over-and-under as seen on Iron Fist.

Over time, it is likely that more militaries will seek integrated solutions combining both hard-kill and soft-kill APSs for a wide range of armoured and soft-skinned vehicles. Similar to passive protection, the demand for modular and customisable systems that can be adapted for various platforms – ranging from MBTs and IFVs to trucks and LMVs – could increase. A relevant recent indicator of things trending in this direction is Rheinmetall’s modular Strikeshield APS, which is able to be fitted to a wide variety of vehicle types.

2) As a response to the proliferation of top-attack threats, manufacturers are adapting APSs to counter drones, loitering munitions, and other top-attack weapons.

This development is likely the most significant in the field of APSs, with Israel in particular standing out in terms of developments aimed at countering top-attack threats. On 9 February 2023, Israeli defence company Rafael upgraded the Trophy APS with ‘silent mode’ designed to reduce the vehicle’s electronic signature. On 8 October 2024, Rafael unveiled a further upgrade to Trophy, providing it the capability to counter some forms of top-attack munitions, including drones. While the first upgrade aims to reduce the chances of the AFV being detected by enemy sensors, including those

deployed on reconnaissance UAVs, the second increases the chances of avoiding hits from loitering munitions. The manufacturer offers these upgrades for both newly produced and already deployed APSs, which is significant considering the large number of active systems in service.

Elbit’s Iron Fist APS largely follows a similar trajectory. The threat posed by loitering munitions was previously identified, prompting the system’s adaptation to counter drone attacks through a variety of countermeasures, including the platform’s remote weapon station, soft-kill disruptors, and hard-kill effectors.

Despite the fact that the Afganit and Arena-M systems were unveiled in 2013 and 2015, respectively, neither system has entered mass production to date. However, since 2022, Russia has intensified its efforts to improve and adopt hard-kill APSs. During 2022 and 2023, industrial patents were registered for T-90M and T-72B3M tanks equipped with APSs. On 5 April 2023, Russian media, citing sources in industry, reported that an Arena-M APS installed on a T-72 MBT had successfully completed live-fire trials against ‘Russian AT-GMs and captured munitions of foreign origin’. It is unclear whether Arena-M has received anti-drone and anti-top-attack capabilities; however, some observers believe that delays in adopting Arena-M and Afganit may be due to the need to upgrade both systems with these features. Importantly, in September and October 2024, T-90M and T-72B3M MBTs fitted with elements of Arena-M were filmed at UVZ’s production line. This development could indicate that the system has been sufficiently improved to enter at least low-rate initial production and limited service.

Finally, more countries are considering the adoption of APSs, or have already started research and development programmes. In March 2023, South Korea’s Hanwha began a project aimed at building an APS capable of ‘responding to multiple threats’ by developing ‘composite active protection technology’ and ‘ground-based directional interference technology’ by 2026.

- ▶ **A T-15 with the Kinzhal turret on display at the Armiya 2019 exhibition. From this angle, Afganit’s grenade-type effector launchers and box housing the radar are visible.** [RecoMonkey]



- ▶ **A scale model of a K2 MBT-M offered for Middle Eastern customers features custom components of soft-kill and hard-kill APS.** [Alexey Tarasov]



Protected Everything

The threat environment for AFVs has significantly evolved, requiring advanced protective measures to counter an increasingly complex array of threats. Additionally, the proliferation of long-range precision weapons and tactical ISR assets has expanded the combat area, demanding protection for new classes of vehicles, including IFVs, self-propelled artillery, and even logistics vehicles.

This concept aligns with the experiences of the Russo-Ukrainian conflict, which has demonstrated that nearly every armoured vehicle deployed in Ukraine, regardless of its origin, age, or class, has eventually received additional protection in one form or another.

AFVs now require multilayered protection systems capable of countering various threats and their combinations. Combat experiences from the war in Ukraine indicate that, for instance, an MBT may encounter mines, artillery fire, loitering munitions, and ATGMs within a single engagement. Conflicts in the Middle East illustrate the same pattern, where MBTs face IED threats and multiple RPG attacks from close range, or combined attacks by ATGMs and loitering munitions.

The protection suites deployed in Ukraine, for example, represent attempts to implement rapid, multilayered protective solutions. These typically include camouflage or thermal camouflage systems, advanced ERA kits providing 360° protection, passive armour screens for the hull and turret roof, soft-kill active protection systems, and electronic warfare (EW) jammers. It is likely that these measures will soon be supplemented by hard-kill APSSs.

Both existing and future protection systems are likely to move towards greater operational flexibility through modular design. This would allow for the rapid installation of various combinations of passive elements and active countermeasures based on a range of operational variables, including enemy capabilities, terrain, and specific mission objectives. This approach not only enhances the survivability of AFVs but also ensures operational flexibility across diverse combat scenarios. Greater attention will be paid to situational awareness systems and sensor packages, allowing them to detect incoming threats and react with necessary

countermeasures. Additionally, R&D programmes focused on directed energy weapons for anti-UAV defence and collective AFV protection solutions are expected to continue. Finally, more protective systems will likely be tailored to specific vehicle types and mission profiles, as each vehicle faces unique threats.

The requirements for enhanced protection of armoured and soft-skinned vehicles present several challenges – engineering, budgetary, and logistical, among others. For example, deploying advanced protection systems across a large fleet of armoured vehicles may lead to a substantial increase in expenses. The same issue applies to fleet management.



▲ **A BREM-80 ARV featuring a combination of Relikt ERA, anti-drone nets and two drone jammers on the roof at the Armiya 2024 exhibition. [Alexey Tarasov]**

Logistics is a particularly pressing challenge; armoured units require more maintenance, more storage space, and greater volume for transport during redeployments. This could lead to changes in the organisational structure and, eventually, an increase in costs. Wider adoption of complex protection systems will likely require more training or retraining of personnel, further increasing demands on resources such as time and funding. The wider adoption and serial production of new protection systems, however, could help lower production costs, making them more affordable over time. Finally, implementing new protection systems may require substantial redesigns of the AFV. In particular, this relates to rebalancing the inevitable increase in weight and power requirements.

In sum, to enhance survivability and remain mission-capable on the modern battlefield, armoured vehicles will require some form of additional protection. This need applies equally to existing designs and future systems slated for deployment in the 2030s and beyond.

Replacing the British Army's Warrior IFV fleet

David Saw

The Warrior Infantry Fighting Vehicle (IFV) and its variants first entered British Army service in 1987. Some 38 years later, it has reached its out-of-service date, but at this point there is no defined successor system. So, who are the key contenders?

That there needs to be a successor to Warrior is obvious, but defining what a successor should be or do, is not so clear. The search for clarity is made more difficult by the fact that the conflict in Ukraine has seen the emergence of new threats. However, the long-standing demand for infantry supporting armoured units to have both protected mobility and effective firepower remains unchanged.

Yet it could have been a totally different story, since the original idea was that a substantial part of the Warrior fleet would be upgraded and that its eventual out-of-service date would be 2040. To properly understand possible future British Army IFV plans, it is prudent to first understand the Warrior's development.

Where it began

The 1970s saw Britain embark on a programme that would lead to an indigenous IFV design; initially the aim was to develop a successor to the FV432 vehicle family that had entered service in 1962, with the new replacement vehicle due to arrive in the mid-1980s. Known as the Mechanised Infantry Combat Vehicle (MICV) programme, a number of different potential variants in different weight classes were evaluated. The project definition phase for what was now being called the MICV for the 1980s (MICV-80) took place between 1972 and 1976. This was followed by the issuance of a General Staff Requirement and in 1977 it came down to a choice between a British design on the one hand and the US AIFV design (based on the M113) on the other, with the decision made to opt for the British design. GKN Sankey, the company that had built the FV432, was awarded a devel-

opment contract for what was now called the Mechanised Combat Vehicle 80 (MCV-80) and this was followed by a production contract in 1984 at which point the MCV-80 became the Warrior. Production started in 1986, and deliveries commenced in 1987.

The Warrior variants acquired by the British Army included the FV510 Infantry Section Vehicle, of which 492 vehicles were acquired (of which three which were replacements for lost vehicles, giving a peak fleet of 489). This variant featured a Vickers Defence Systems turret equipped with



▲ **A British Army Warrior IFV during Exercise Iron Storm in Germany in 2023. The Warrior was originally due to be retired in 2025, now extended to 2030. However, as yet there is no firm programme for a replacement vehicle. [Crown copyright 2023]**

a RARDEN 30 mm automatic cannon and a 7.62 × 51 mm L94A1 chain gun. Alongside this, the Army acquired a total of 84 FV511 command vehicles, 105 FV512 Combat Repair Vehicles, 39 FV513 Mechanised Recovery Vehicles, 52 FV514 Mechanised Artillery Observation Vehicles, and 19 FV515 Battery Command Vehicles for AS90 Battery commanders. Later, to support operations in Afghanistan, a number of FV515 vehicles were converted to ambulances.

The Warrior saw active operations with the British Army in the First Gulf War, peacekeeping operations in the Balkans in Bosnia and Kosovo, the Second Gulf War, and subsequent operations in both Iraq and Afghanistan. Throughout their service lives, Warrior vehicles were significantly upgraded. In terms of exports, the Warrior lost out to the AIFV in the Turkish Land Forces competition in 1989. However, in 1993 it won the Kuwaiti IFV competition, which culminated in 254 Desert Warrior vehicles being delivered.

AUTHOR

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Warrior production ceased in 1997, by which point the British Army had received 791 Warriors in multiple variants, plus the 254 vehicles for Kuwait, making a total production run of 1,045 vehicles. Had the Cold War continued, it is highly likely that the British Army would have acquired more Warriors, although it is difficult to see the original objective of replacing the FV432 ever being achieved. Indeed, the FV432 is set to outlast the Warrior in British Army service!

A failed upgrade

In 2001, the Ministry of Defence (MoD) embarked on an effort to provide capability enhancements to the Warrior IFV. Central to this, was a lethality enhancement effort to provide a new armament that would offer higher performance than the Rarden 30 mm cannon. This was the start of a process that would lead to a more comprehensive upgrade programme under the rubric of the Warrior Capability Sustainment Programme (WCSP).

Under the overall WCSP heading were four separate upgrade programmes, which were: Warrior Fightability Lethality Improvement Programme (WFLIP); Warrior Modular Protection System (WMPS); Warrior Enhanced Electronic Architecture (WEEA); and the Armoured Battlefield Support Vehicle (ABSV). Regarding the ABSV, early on in the WCSP programme, the idea was to upgrade 449 IFVs and convert the remaining IFVs and support variants into the ABSV configuration in roles such as mortar carrier and ambulance, amongst others.

Turning to the WFLIP element of WCSP, the lethality enhancement seemed to be focusing on the CTA International 40 mm Case Telescoped Armament System (40CTAS). Despite the interest in 40CTAS, it was decided to hold a competi-

tion for a new gun system, evaluating both European and US solutions. The 40CTAS was eventually declared as the preferred system, but it was to take until 2015 for CTA International to receive a production order for the 40CTAS, amounting to some 515 guns for the WCSP and for the Scout SV (later Ajax) programme.

By this time Lockheed Martin UK had emerged as the prime contractor for WCSP, the scope of the programme covered 245 turreted Warriors (upgraded FV510 and FV511 vehicles), plus 135 Warriors in other variants. By 2018, it was officially admitted that the programme was running some 13 months late, with costs increasing and the anticipated in-service date (ISD) now slipping to 2023. There were a number of reasons for this, including weapon and turret integration issues, and later on the discovery that a large number of Warrior hulls had significant structural issues, leading to a suggestion that it might be necessary to produce new hulls.

Problems with WCSP continued and matters were not helped by the fact that another British armoured vehicle programme, Ajax, was also extremely troubled. Eventually, the MoD decided to give up on WCSP, and in March 2021, the programme was cancelled, having cost the MoD a little over GBP 594 million.

However, the Warrior story is not quite over yet, as in June 2023 a contract announcement was made for Rear Safety Camera Systems (RSCS) for the Warrior, described as a 'safety critical modification.' Some 359 Warriors are due to receive the RSCS, representing a contract value up to GBP 20 million, with the contract start date given as 1 September 2023 and an end date of 1 September 2025. This has, however, pushed Warrior's retirement to the right, from its originally-scheduled date of 2025. According to James Cartledge MP, the former Minister for Defence Procurement, answering a question from Labour MP Clive Lewis on 19 December 2023, Warrior was scheduled to be retired from service "by the end of 2030."

The Warrior fleet is still large, as confirmed by James Cartledge in a Parliamentary answer on 10 May 2024, that the total warrior fleet comprised 632 vehicles in all variants, of which 80 were due for near-term disposal, with a decision on the fate of nine more vehicles to be taken at a later date. With regards to the disposal of Warriors, there have been suggestions that a significant number could be transferred to Ukraine as military assistance.

- ▶ **A British Army Warrior CSP prototype vehicle in tests. This vehicle has also been referred to as 'Warrior 2'. [Lockheed Martin UK]**



- ▶ **The Hanwha Defence AS21 Redback IFV, seen here during a firing trial, won the LAND 400 Phase 3 IFV programme of the Australian Army. The comprehensive nature of the Australian evaluation process should make the Redback a contender for any future British IFV requirement. [Defence Australia]**



Beyond Warrior

While Warrior’s new retirement date of 2030 has bought some breathing room, as of yet there is no programme for a successor. A significant IFV programme will inevitably be a costly proposition and despite all the talk of new money for defence in Britain and the suggestions that efficiencies will make existing funds go further, the reality is that money is short at the MoD. Also, despite much talk of procurement reform, it would be somewhat optimistic to expect a British Army procurement programme to rapidly define a new IFV and purchase it as a successor to Warrior within the latter’s remaining service life.

Assuming that the firm intention to proceed with an IFV programme manifests itself and assuming that sufficient funding is available to support a viable IFV programme, then the search for a solution can begin. One positive regarding an IFV purchase is that there are plenty of platform solutions out there, some of which are readily available.

Filename: AS21 Redback Australia

The British Army could also draw on the experience of Australia and its search for a new IFV under the LAND 400 Phase 3 requirement. Originally Australia was looking for up to 450 IFVs and variants and 17 Manoeuvre Support Vehicles (MSV), essentially a combat engineering platform. Initially there were four contenders for LAND 400 Phase 3, including: BAE Systems with the CV90MkIV; General Dynamics Land Systems (GDLS) with a solution based on Ajax; Hanwha Defence Australia (HDA) with the AS21 Redback; and Rheinmetall

Defence Australia (RDA) with the KF41 Lynx. Rheinmetall had previously won the LAND 400 Phase 2 wheeled requirement with the Boxer. Then in September 2019, the two final bidders were announced for the programme HDA with the AS21 Redback and RDA with the KF41 Lynx. Both vehicles were put through an extensive and challenging trials process, with both vehicles also evaluated in terms of local production and sustainment of the future IFV fleet. It should also be noted that the new IFV was due to replace the M113AS3/AS4 in Australian Army service, which was to reach end of life in 2025 – an interesting parallel with the Warrior in the UK. Other factors, principally defence budgetary pressure came into play, which led to the LAND 400 Phase 3 requirement initially reduced to 300 IFVs, and then following the May 2022 election of a new government and subsequent Defence Strategic Review (DSR), reduced to 129 vehicles. Eventually in December 2023, Australia signed a contract with HDA for 129 Redback IFVs, with the combined value of the acquisition and initial support contracts some EUR 2.81 billion. Deliveries are due to commence in 2027, and be completed in 2028.

By winning the LAND 400 Phase 3, Hanwha and the Redback would be likely contenders for a Warrior replacement programme. Additionally, although Hanwha’s K9A2 self-propelled howitzer (SPH) bid lost out to KNDS’ RCH 155 for the British Army’s Mobile Fires Platform (MFP) artillery requirement, Hanwha’s bid envisioned cooperation with local manufacturers under ‘Team Thunder’, providing a potential basis to meet British industrial involvement requirements in the event of an IFV bid.

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Although it lost out in Australia, the KF41 Lynx has made progress elsewhere. Hungary is acquiring 209 KF41s in seven variants, with the first 46 vehicles being built in Germany (the first vehicle was handed over in 2022). All of the remaining KF41 will be built at a new facility at Zalaegerszeg in Hungary, with the first locally-manufactured KF41 handed over to the Hungarian Armed Forces in July 2024. Ukraine has also selected the KF41, and local manufacture has commenced with the first ten vehicles due to be handed over to the Ukrainian Ground Forces by the end of 2024. The other major development for Rheinmetall and the KF41 is that it has been downselected as one of the final two contenders



▲ **Hungary is acquiring the Rheinmetall KF41 Lynx as its future IFV, 209 vehicles were ordered, 46 were built in Germany, with the majority to be built at a new facility at Zalaegerszeg in Hungary. Ukraine is also building the KF41, with first ten vehicles to be delivered before end 2024. [Hungarian Defence Forces]**

for the US Army XM30 OMFV programme to replace the Bradley IFV.

As regards the UK, Rheinmetall is already enmeshed in the British armoured vehicle ecosystem via the Rheinmetall BAE Systems Land (RBSL) joint venture, as part of the Challenger 3 and Boxer programmes, indicating that it is capable of meeting the local involvement requirements of a new armoured vehicle programme.

The other vehicle downselected for the XM30 OMFV is the GDLS Griffin, which is actually based on the ASCOD 2 platform (now typically marketed as simply 'ASCOD') on which Ajax is based, and could also be manufactured on the Ajax line at GDLS-UK. Although it has been a troubled programme in the past, the British Army's Ajax now appears to be on track, which is positive news for both the user and the industry. The Ajax turret and its 40CTAS cannon have now been integrated, meaning the turret/weapon integration issues experienced on the Warrior WCSF need not be repeated.

As such, GDLS-UK could be in a position to meet either a near-term British IFV requirement with an Ajax derivative, or a medium-term requirement based their OMFV bid. It is also

worth noting that in November 2024, the General Dynamics European Land Systems (GDELS) ASCOD 2 platform was selected by Latvia as its future IFV.

Another proven IFV option that could be of interest for the future British requirement is the BAE Systems CV90 Mk4. The appeal of this platform is low risk, as the CV90 has been successfully exported and utilised by numerous international customers. In the Scout SV competition, it was understood that the CV90's chances were reduced by insufficient British workshare on the vehicle offered. While there may be scope for BAE Systems to adjust their workshare scope for a UK bid, there is also the possibility that, having been heavily criticised for its handling of numerous recent procurement programmes, the MoD may be willing to accept more flexibility with regard to workshare if doing so leads to rapid delivery.

Another option for a future British IFV programme is to explore alternatives to a tracked IFV. A noteworthy possibility would be for a wheeled solution, bearing in mind the British Army selected the Boxer vehicle for its Mechanised Infantry Vehicle (MIV) requirement in 2018. It has a total of 623 Boxers, with different 'mission modules' to be fitted depending on the envisaged role and mission. Since then, the selection of KNDS' Boxer 8x8 based RCH 155 SPH for the MFP requirement adds yet more Boxers (96 to 116 expected) to the British Army inventory. A turreted Boxer could therefore possibly be of interest as a future IFV. After all, the French Army uses the wheeled VBCI in the IFV role. However, the downside of this would be that wheeled vehicles cannot match their tracked counterparts in terms of trafficability across complex terrain.



▲ **A CV9035 MkIII with a D-Series turret. The CV90 family is one of the most widely-used European IFV designs, presently in service with eight users, and on order with a further two. [BAE Systems]**



▶ **A Tracked Boxer with a turret and medium-calibre armament on display at Eurosatory 2024. [RecoMonkey]**

Bearing in mind that the Boxer is generally seen as one of the few successful British Army procurement programmes of recent years and that the level of British industrial content is seen as satisfactory, it might be viewed as a disappoint-

ment that a wheeled vehicle might not be suitable for the IFV requirement. Boxer proponents need not worry, as KNDS came up with a solution back in 2022 when they unveiled the Tracked Boxer at Eurosatory. The tracked version has a higher weight rating of up to 45 tonnes, and so should provide greater flexibility with turret options than the wheeled version. As such, a tracked Boxer could be a contender for any future British IFV programme.

Closing thoughts

That the British Army should have a replacement for the Warrior IFV and variants is easily justified. Whether a replacement programme for the Warrior will actually materialise remains, unfortunately, unclear at this point in time. Had WCSP actually gone according to plan, then the Warrior fleet could have run until 2040 and any decision on a successor platform could have been postponed. As it stands, WCSP was cancelled and the end of the Warrior is due to come in 2030, with no replacement programme firmly in place. Should a realistic IFV programme for the British Army be agreed upon, numerous candidates could meet its IFV requirements. In the end, it comes down to procurement priorities and funding. Given that both are somewhat in flux pending the release of the Strategic Defence Review in approximately spring of 2025, the UK's road to a future IFV remains uncertain at this point in time.



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CAVS – rolling along, gathering strength

Tim Guest

Bolstering interoperability and collective defence amongst EU member states is at the heart of the ambitious Common Armoured Vehicle Systems (CAVS) programme, which is gaining momentum, not simply with the numbers of vehicles on order growing significantly, but also in the efficient manner in which the whole effort is being conducted and coordinated.



- ▲ The Patria 6x6 APC has a modular design allowing a wide variety of specific configurations for diverse missions, which is ideal for the respective member/national configurations required for the CAVS programme vehicle variants. [Patria]

2024 was a busy time for the CAVS programme. Funding from the EU was confirmed towards the end of the year, and additional significant vehicle confirmations were announced for at least two of its, now, four participants, with the fourth member nation having confirmed its participation formally in June, and major decisions and agreements made on life cycle management of the entire fleet of vehicles for all members. With other member states watching and Europe's threat landscape remaining perilous, the year ahead is likely to be every bit as busy as the last for CAVS programme stakeholders.

AUTHOR

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Overview

The CAVS programme was initiated in 2019 between Finland and Latvia, with Estonia also at the table at the time. Its aim was to develop a new 6x6 armoured vehicle to meet the overlapping requirements of participating nations, settle on the right design and for all participating members to then procure the platform in quantity, so economies-of-scale in its manufacturing would make it cost effective. After considering other contenders, Patria's XA-300 6x6 armoured wheeled vehicle was chosen for CAVS. (Referred to simply as the Patria 6x6 for the rest of this article).

However, before 2020 was out, Estonia had left the project, (subsequently purchasing Arma 6x6 armoured vehicles from Turkish maker, Otokar, in late 2023), but this hiccup did not prevent the programme's important R&D agreement from being signed at the end of 2020. Then, in June 2022, the third member to formally join CAVS was Sweden, a decision no doubt fuelled by Russia's full-scale invasion of Ukraine, as well as its related intentions, at that time, (subsequently fulfilled), to join NATO.

Highlighting how quickly CAVS has moved, vehicle deliveries to Finland, Latvia, and Sweden began within the project's first three years and before the programme's fourth member, Germany, joined officially in April 2023.

Fast-moving EU funding

One of the programme's most heartening developments of 2024 came when the EU announced its EDIRPA – *European Defence Industry Reinforcement through Common Procurement Act* – work programme funding awards on 14 November. This funding was created to boost defence readiness with what the EU called its 'first ever financial support for common defence procurement'. CAVS was one of 12 programmes put forward for EDIRPA support with the submission made by the Finnish Defence Administration, meeting the tight 25 July 2024 deadline. The funding programme, only established in March 2024, is a short-term mechanism with a budget of around EUR 310 million, created in response to growing Russian aggression in Europe; its premise is to support urgent and critical procurement of defence equipment through cooperation between member states and, in turn, increase military materiel assistance to Ukraine. It covers what it calls the most urgent defence materiel, namely: ammunition, air and missile defence, as well as platforms and the replacement of legacy systems, the latter is where CAVS comes in.



as C2 variants, with production using local industry capabilities in Latvia, including Patria's armoured vehicle production facility in Valmiera, which opened in May 2024. Deliveries of the 56 began by end 2024 and are due to last until 2029. Andris Sprūds, Latvian Minister of Defence, said that the new Patria 6x6 C2 vehicles will significantly improve the operational capabilities of Latvia's armed forces, as well as contributing to the development of the country's defence industry.

Patria's Mats Warstedt, senior VP, the Nordic Region, referring to the C2 vehicle, added, "We are pleased to have a new armoured vehicle variant in the joint CAVS programme and Latvia as the first customer for it." He emphasised that the intense cooperation between Patria, Latvia and other CAVS member nations was proving its benefits in terms of cost-effective and efficient R&D, thereby enabling rapid manufacturing and a rapid delivery process.

- ▲ **Suited to troop transportation and combat support roles, Patria's APC will meet a variety of needs under CAVS, including as a command post in a C2 role. [Patria]**

In short, CAVS was one of five successful programmes selected from the 12, with each awarded EUR 60 million from the EDIRPA purse in November 2024. Finland's MOD said at the time that the funds would not only be used to support cooperation between CAVS vehicle-user countries and progress of the CAVS programme overall, but would also support the domestic defence industry. The ministry also felt the funding for CAVS would also strengthen European defence and NATO cooperation overall, with Antti Häkkinen the Minister of Defence, saying in a statement, "*We managed to get significant funding for a project started by the Finnish Ministry of Defence. The Finnish defence industry is growing stronger and Finnish expertise is highly valued around the world. Joint projects of this kind are exactly what European defence industry cooperation is intended to achieve. The funding now received significantly supports the progress of the CAVS Programme and multinational defence materiel cooperation in the EU.*"

The ministry also confirmed numbers of firm orders for the Patria 6x6 under the CAVS programme, as they understood them at mid-November 2024, with Finland now having ordered 164 armoured personnel carriers (APCs) and also having signed an agreement for heavy armoured personnel carriers (HAPCs) for what it called 'crisis management use'. Latvia, it said, has now ordered more than 200 APCs, as well as having recently signed an agreement for 56 command and control (C2) vehicles. Third programme member, Sweden, had a total of 321 CAVS family vehicles on order, as of spring 2023.

Latvia's and Finland's latest tranches

At the same time as the EU's EDIPRA funding was announced in November, an agreement between Patria and the Latvian MoD was unveiled on the manufacturing and delivery of 56 additional Patria 6x6s, in a deal worth in excess of EUR 60 million. These were in addition to the already ongoing CAVS deliveries to Latvia. The latest vehicles are to be configured



- ▲ **Finnish Logistics Command has stated that the Patria 6x6 XA-300 vehicles procured under CAVS will provide Finnish Army units with increased mobility until the 2060s. [Finnish Armed Forces]**

Earlier, a September 2024 Finnish order was the continuation of a previous agreement from mid-2023, when the Logistics Command (FDFLOGCOM) of the Finnish Defence Force ordered 91 Patria 6x6 APCs, together with associated equipment and an additional purchase option for 70 at a later stage. Of the latter, 41 were ordered and delivered end 2023/start 2024. Then, at the end of September 2024, the option for a further 29 vehicles (along with equipment and spares) was exercised by FDFLOGCOM, with a total value of EUR 36.5 million, and deliveries due to be completed by the end of 2025. FDFLOGCOM stated that the Patria 6x6 vehicles will provide Finnish Army units with increased mobility until the 2060s.

Jussi Järvinen, responsible for Patria's operations in Finland, said in a statement, "Redemption of the entire domestic additional purchase option is remarkable for Patria and the whole international CAVS joint programme." Underlining the efficiency with which the CAVS programme was being conducted and the benefits it offered participants, he said, "The programme has progressed rapidly thanks to excellent cooperation between Patria and the participating CAVS

member countries.” He added the joint project had enabled cost-effective vehicle development and lifecycle support, quick procurements, and equipment compatibility, thereby strengthening European defence cooperation.

Finland and Latvia had actually signed a CAVS Life Cycle Management (LCM) agreement in August 2024, with an expectation that the other two members might join later. The CAVS LCM contract is based on Patria’s own Optime service concept, designed to meet bespoke individual customer requirements across a broad range of services and solutions required to ensure acceptable fleet availability levels at all times. By adopting the LCM contract, it brings to three, the number of CAVS framework agreements in which these two members are now involved, comprising: research & development; manufacturing and sustainment; as well as life cycle management. Mats Warstedt stated that the “CAVS Programme is entering into the sustainment phase by the signing of this CAVS LCM contract, which will secure long-term co-operation for always keeping the fleets fully operational.” He added the contract is the first Patria Optime-based agreement for the company. As to when Sweden and Germany will embark on LCM contract signing has yet to be determined.

A busy year – German moves

CAVS’ latest partner found 2024 to be a busy year. In mid-February, Germany’s industrial base for the programme set a major milestone, when Defence Service Logistics (DSL – part of KNDS group) and Flensburger Fahrzeugbau GmbH (FFG) announced their teaming with CAVS prime contractor, Patria, to enable German industry to undertake design, production, and sustainment of Patria’s 6×6 APC variants, to meet Germany’s requirements as the expected replacement for the Bundeswehr’s existing Transportpanzer (TPz) Fuchs 6×6 APC fleet. At the time, however, this remained uncertain

and there was still discussion about replacing Fuchs with Rheinmetall’s Fuchs A9 Evolution, though the economies of scale and the savings promised by the Patria 6×6 were swaying minds within the German MoD towards CAVS, though no orders or numbers were on the table.

Nevertheless, German industrial base preparations and partnership moved ahead, with Patria remaining responsible for system design and development, while local engineering, production, and life-cycle support in Germany would be provided by DSL in Freisen and FFG at its facilities in Flensburg and Kirchen (Jungenthal Wehrtechnik - JWT), with the German partners also establishing further local subcontractor support to be called upon, if things progressed nationally, which they subsequently have. Patria’s senior Vice President for Europe, Hugo Vanbockryck, said, when Rheinmetall was still hoping the Fuchs Evolution would be procured, that Patria was offering to adapt the “cost-effective, fully developed, off-the-shelf” Patria 6×6 to meet German needs, that the vehicle was already in production and fielded by NATO members, and should things move ahead, it would “be produced locally in Germany to meet the high requirements and technical standards of the Bundeswehr”. DSL’s CEO, Christoph Cords, said the partnership team brought the best of German and Finnish engineering and manufacturing expertise to the table and that such multinational industry partnerships, “are the future”. However, it fell to FFG board member and CEO at JWT, Jörg Kamper, to underline what this partnership would mean for Germany: *“This agreement establishes a powerful team ensuring a reliable and sustainable CAVS production in Germany. The main design of the vehicle system comes from Patria; the lion’s share of the manufacturing is German. For FFG and JWT, this means that skilled jobs will be created in Germany, and German industry know-how, capacity and investments can be utilised and further developed in this programme, as well as for the future in-service support.”*



- ▲ In mid-February 2024, Germany’s industrial base for CAVS was agreed to enable German industry to undertake design, production, and sustainment of Patria’s 6×6s. L to R: Michael Lausen, FFG; Christoph Cords, DSL; Jukka Holkeri, Patria; Jörg Kamper, Jungenthal Wehrtechnik. [Patria]

On 23 February 2024, less than two weeks after the Patria-DSL-FFG partnering news, Germany's Handelsblatt national business newspaper published a story by Roman Tyborski revealing that Rheinmetall would not play a part in CAVS, due to negotiations with Patria as to what roles different participating companies would play having broken down. The piece also noted that 90% of vehicles under CAVS would eventually be made in Germany, and repeated a



▲ **The Patria 6x6 meets STANAG 4569 level 2 ballistic and mine-protection requirements for protected troop transport and combat support roles and can be enhanced to meet STANAG 4569 level 4 ballistic and mine protection needs, if required, on different vehicle variants. [Patria]**

rumour from defence industry circles, that Germany could order up to 1,000 Patria 6x6 vehicles to replace the Bundeswehr's Fuchs fleet of over 800. Certainly, an order of such magnitude is exactly what the CAVS programme needs to leverage economies-of-scale advantages to the financial benefit of the programme's members. Tyborski's piece also indicated that first, initial vehicles for Germany would come from Patria, as has been the case with the other three CAVS member nations; this has been the way the programme has ensured speedy of delivery for initial vehicle batches, while local industrial capabilities are being prepared to take over production from Patria. For Germany, this is likely to be in the 2026/27 timeframe. *[ESD approached the Bundeswehr for comment on the German order situation, but no response was received by time of going to press.]*

The year ahead

At the time of writing, in December 2024, Hugo Vanbockryck told ESD that Patria's focus during 2025 will be on continuing deliveries to Finland, Latvia and Sweden, and "maintaining strong and close collaboration with the programme's countries, including Germany, on its activity gaining momentum". He added, "We also expect to see new variants contracted and developed, including variants with new weapon systems. We are also proceeding with localising the production and other programme-related activities in the

participating countries, to further support local footprints and ensure local industry and economy benefits, as well as security of supply."

Vanbockryck also confirmed that, "Patria has already received orders for over 800 Patria 6x6 vehicles from Finland, Latvia and Sweden..." and the programme "...has raised a lot of interest from many countries", concluding that, "We believe we are on the way to standardising CAVS/Patria 6x6 to be, as the programme name states, the common armoured vehicle system of European countries."

Looking forward

The way in which the CAVS' effort has progressed, thus far, is a fine example of a no-nonsense, collective approach to meeting an urgent requirement, rather than allowing protracted procurement policies to bog a requirement down in proverbial, defence industry mire. In that regard, CAVS is a breath of fresh air. It is also worth noting that the programme remains open to other European nations with similar equipment needs, with approval of current CAVS members.



▲ **When Patria's 6x6 was chosen for CAVS in 2020, the Russo-Ukraine war was nowhere in sight, although Finland's and Latvia's respective, grim, historical experiences of their dangerous neighbour were likely subconscious factors in the minds of these two CAVS founding members when they got together to jointly procure a new APC. [Patria]**

That four members have joined the programme so far is positive. Collective defence in Europe and the EU amongst member states, is not mutually exclusive to being in NATO, but in a time of greatest threat in Europe since WW2, it makes absolute sense to bolster Europe's defensive capabilities with programmes such as CAVS, which, through commonality, interoperability, simplified logistics simplification, will most certainly improve Europe's collective security.

Vehicle-mounted anti-drone solutions

Sidney E. Dean

To ensure protection against current and emerging aerial threats, expeditionary and manoeuvre forces must be accompanied by vehicles mounting anti-drone capable weapons. Various approaches to the mobile counter-UAV (C-UAV) mission are undergoing testing or development.

Small unmanned aerial vehicles (UAVs) and loitering munitions have become a major threat to military forces, as demonstrated in the Middle East and in Ukraine. They can be fielded in large numbers, and are frequently difficult to detect or target. They range from sophisticated, state-produced systems to improvised systems based on commercial and hobbyist drones. The mission spectrum includes reconnaissance and artillery spotting, delivery of small bombs, and suicide attacks by explosives-laden drones.

guns and other mounted weapons are being developed and practised. Temporary static positions such as expeditionary base camps, command posts or relay stations also require mobile C-UAV defences, although the optimal configuration may differ from that required by manoeuvre forces.

Vehicle-mounted C-UAV options for mobile and expeditionary forces can be divided into kinetic weapons and energy weapons. Kinetic options include machine guns, grenade launchers/cannons, and interceptors. Energy weapon options are divided into lasers, microwave weapons and electronic jammers.

In addition to the actual weapons, the C-UAV mission also requires corresponding sensors and fire control systems (FCS) to detect, classify, follow and engage drones in a coordinated and effective manner. Options here include radars,



▲ **BLADE prototypes shown mounted on the HMMWV (left) and M-ATV (right) during testing in 2019.**
[USAASC; Marian Popescu]

Manoeuvre forces require organic or attached C-UAV vehicles to optimally defend themselves against drone attack or neutralise surveillance aircraft. Numerous new C-UAV systems are currently being introduced, tested or developed. When dedicated C-UAV systems are not available, motorised and mechanised units must make the best possible use of their standard weapon systems. To this end, C-UAV tactics utilising standard machine

direction finders (to detect communication signals emanating from the drone), optronic day and infrared (IR) cameras, as well as acoustic sensors. Employing a combination of these technologies as a layered detection system can result in a more reliable and effective defence.

Small and medium-calibre solutions

The 7.62 mm machine guns (MGs), 12.7 mm heavy machine guns (HMGs) mounted on many vehicles can effectively destroy small and medium drones. Such capability could also be extended to 40 mm automatic grenade launchers (AGLs), when paired with a fire control system capable of tracking small moving targets, along with a suitable nature of the 40x53 mm HV (high velocity) ammunition type. These would

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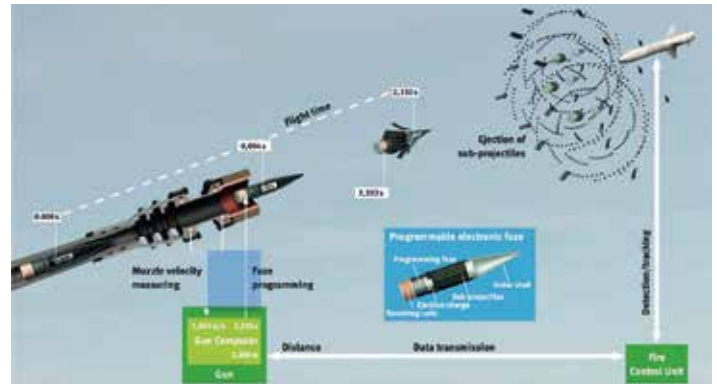
include proximity-fuzed natures such as the M684 40x53 mm high explosive proximity (HE Proximity), or programmable air-burst natures such as the Nammo NM 264 40x53 mm High Explosive Dual Purpose-Radio Frequency (HEDP-RF) or Rheinmetall DM131 40x53 mm Airburst Munition (ABM).

The United States Army has been pursuing several sensor and fire control solutions including the Ballistic Low Altitude Drone Engagement (BLADE) system. The BLADE system integrates with the Common Remotely-Operated Weapon Station (CROWS) mounted on many vehicles. It utilises the CROWS' optical sensors in conjunction with fire control software to engage small UAVs. The engagement range has been estimated at 500 m against moving targets or 800 m against stationary targets; these figures are understood to refer to when the system is equipped with the M2 HB 12.7 mm HMG, as most commonly seen used in BLADE trials.

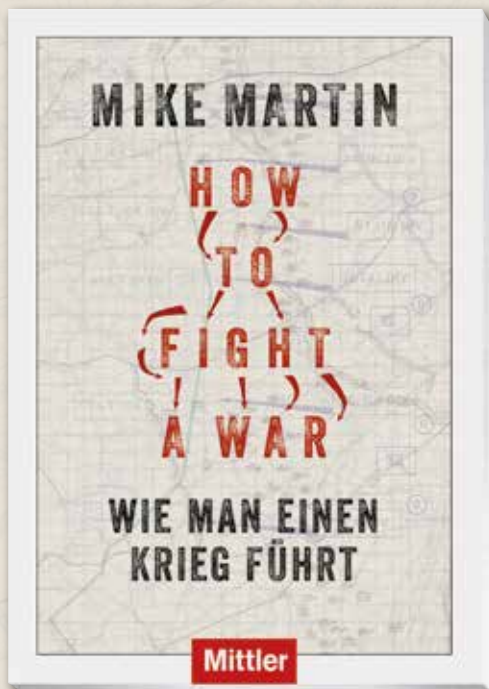
Moving up the weapon scale, medium-calibre automatic cannons deploying airburst munitions have shown considerable promise for the C-UAV mission, both against single aircraft and against drone swarms. In 2022, the US Army introduced the XM1211 30 x 113 mm high explosive proximity (HEP) ammunition. Developed by Northrop Grumman specifically for defeating small drones (including drone swarms), the rounds use an embedded radio-frequency proximity sensor to detect when the round is in the vicinity of a UAV, following it triggers detonation of the round once it has reached optimal vicinity to the target, showering the target with fragments. As described by Rylan Harris, director of

advanced ammunition for Northrop Grumman's Armament Systems unit, the embedded electronics have been ruggedised to withstand muzzle velocities up to 100,000 g.

"We're also developing an even smarter weapon system called guided medium calibre ammunition" that constitutes a "leap-ahead technology", Harris explained. These projectiles will incorporate the proximity-fused munition technologies, but also generate onboard electrical power and provide continuous trajectory guidance in a single integrated package. The guided medium-calibre ammunition is expected to provide a new level of burst-point accuracy that will increase the likelihood of hitting moving targets.



▲ Diagram showing the key phases of the AHEAD munition's flight. [Rheinmetall]



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European nations are successfully pursuing a similar approach to the C-UAV. This includes Rheinmetall's Skynex and Skyranger very short-range air defence system (VSHORAD). The mobile firepower component of Skynex and Skyranger is formed by the turreted 35 mm Oerlikon Revolver Gun Mk 3 which is integrated with onboard radar and optronic sensors. In the case of Skyranger, the turret is mounted on the Boxer 8x8 platform, while in the case of Skynex, the turret is palletised and can be either stationary or truck-mounted. The gun's rate of fire is 1,000 rounds per minute; typically, bursts of circa 24 rounds are fired. To reliably defeat small and manoeuvring targets such as drones, the cannon is provided with Rheinmetall's 35 mm Advanced Hit Efficiency and Destruction (AHEAD)/kinetic energy time fuze (KETF) ammunition. Rheinmetall offers a range of variants of AHEAD/KETF for various purposes. The PMD062 variant, is intended for engaging a broad range of aerial targets, and releases 152 cylindrical Tungsten alloy fragments in a cone into the flight path of the target. The PMD428 variant on the other hand has been specifically optimised for small airborne targets such as small UAVs, and releases over 600 Tungsten alloy fragments into the target path.

Powered interceptors

Rocket-powered and air-breathing interceptors are another means of destroying drones. However, many common surface-to-air missiles (SAMs) are not just overkill, but often cost far more than the target they are engaging. The US Army is pursuing the next-generation counter-uncrewed aerial system missile (NGCM) development programme, which aims to defeat drones up to NATO size classification Class 3 (>600 kg) using low-cost interceptors. In June 2024, the service confirmed that RTX and BlueHalo had been awarded prototyping contracts. Prototype testing is expected to be completed by the end of 2025, although the Army has an-

nounced plans to re-open the competition to other vendors currently developing C-UAV interceptors with the potential to also combat rockets and cruise missiles.

RTX's entry is based on the tube-launched Coyote Block 2+, a turbojet-powered SAM with a maximum range of approximately 15 km, which is already being used by the US in the C-UAV mission. The missile uses a small rocket booster to launch the missile from its launch tube and provide an initial boost to acceleration, at which point the turbojet engine takes over, propelling it to its top speed of around 555 km/h. The Coyote is equipped with a Ku-band active radar seeker for terminal guidance and a proximity-fuzed high-explosive fragmentation (HE-FRAG) warhead.

Raytheon has also developed the Coyote Block 3NK variant, which uses a very similar design to the older Coyote Block 1 design, likewise using wings and a pusher-prop for propulsion, and likely reaching similar top speeds of circa 130 km/h as the Block 1. The Coyote Block 3NK is advertised as using a 'non-kinetic warhead' to neutralise multiple drones simultaneously. While RTX have not provided much concrete information on the nature of the Block 3NK's warhead, it is believed to consist of a high-power microwave (HPM) effector – conceptually similar to the approach taken by Lockheed Martin with Morfius.

Also aimed at the NGCM programme, US company BlueHalo is putting forward its Freedom Eagle 1 (FE-1) design, which has also been previously marketed under the 'Next Generation Missile' (NGM) name. FE-1 follows a relatively conventional missile design scheme, and is powered by a dual-thrust solid propellant rocket motor. In terms of dimensions, appears roughly similar in length to a MANPADS missile, and wider in diameter.

In Europe, MBDA has unveiled the small anti-drone missile (SADM), based on the firm's man-portable Enforcer missile (which is deployed against ground targets) design. Compared to enforcer, SADM features an added jettisonable booster section at the rear, to increase its maximum range to approximately 5 km, compared to the Enforcer's 2 km. SADM is also fitted with an unspecified seeker type, which is capable of tracking flying targets. SADM has been shown in a notional vehicle-mounted configuration at the ILA 2022 exhibition, this comprising a turret with two nine-cell launchers mounted atop an ACS Enok 9.5 4x4 vehicle.

High-energy lasers

High-energy lasers (HELs) are considered to have great potential for the counter-drone mission. This is largely based on the ability to rapidly engage targets, as well as the fact that their 'cost-per-shot' is considerably lower than conventional cannon or missile-based solutions. Numerous developments and testing programmes for vehicle-mounted HELs are ongoing.

This includes the US Army's Directed Energy –Medium– Short Range Air Defence (DE-M-SHORAD) system consisting of a Stryker 8x8 mounting a 50 kW class laser weapon devel-



▲ **The Skywarden NNbS on display at ILA 2022. Shown here mounted on an ACS Enok 9.5, with two nine-cell launchers for SADM. [MBDA]**



▲ **A Stryker-mounted DE-M-SHORAD laser system during testing at Fort Sill, Oklahoma. [US Army]**

oped by RTX. In addition to UAVs, the system is intended to intercept artillery rounds and rockets. A prototype platoon consisting of four vehicles was fielded at Fort Sill, Oklahoma in September 2023, which was deployed to Iraq in February 2024 for a prolonged evaluation under operational conditions; the unit returned home in October 2024. Details of the evaluation have not been released at this time. According to an August 2024 Congressional Research Report, initial feedback from soldiers involved in the testing was reportedly “not overwhelmingly positive”, with officials suggesting “results from the lab environment and test ranges are very

different from the tactical environment”. The Army did report that the DE-M-SHORAD systems fared well during an Army Test and Evaluation Command (ATEC) assessment in June 2024, downing 15 of 15 target drones, it is unknown whether the test vehicles engaged any adversary UAVs during their deployment, or how they fared in the field.

Regardless of the actual results, the US military remains determined to continue HEL development. In August 2024, Lt. Gen. Robert Rasch, Director of the Army’s Rapid Capabilities and Critical Technologies Office, stated that the service plans to select several firms for a design and development competition for the Enduring HEL SHORAD programme. The competition is set to begin in early 2025, with down-select to one firm in early Fiscal Year 2026.

High-power microwave weapons

High-power microwave (HPM) weapons can damage a UAV’s electronic components including sensors, communications systems and propulsion, effectively neutralising the drone’s key systems, and/or causing it to crash. The power output and beam width of HPMs can be scaled, enabling operators to adjust their destructive power and choose whether to direct the beam at a narrow or wider portion of airspace. Most expeditionary HPM systems being developed to date are too large for deployment on smaller vehicles, but industry is working on overcoming that limitation.



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- ▶ **The Leonidas Mobile HPM is shown here mounted on a Stryker 8x8, however the manufacturer has stated it can be mounted on various user-defined platforms. [Epirus]**

In 2023, the US Army's Rapid Capabilities and Critical Technologies Office (RCCTO) awarded the technology company Epirus a contract for prototypes of the firm's Leonidas HPM system. While these prototypes – which were delivered in May 2024 and are being tested into 2025 – were trailer-mounted, Epirus and General Dynamics Land Systems (GDLS) have already demonstrated the Leonidas Mobile variant which integrates a smaller version of the HPM onto a Stryker 8x8 vehicle. Leonidas Mobile was field demonstrated at a US government testing site, where it successfully disabled individual drone targets and swarms of drones, validating the technology's ability to defend manoeuvre forces. The system has been integrated with Anduril's Lattice command and control (C2) software, to process radar track data and neutralise hostile targets while avoiding fratricide of friendly assets.

- ▶ **U.S. Marines with 26th Marine Expeditionary Unit, employ the Light Marine Air Defense Integrated System (LMADIS) during Red Sands 23.2, at the Shamal-2 Range in northeastern Saudi Arabia, on 10 September 2023. [US Army/ Staff Sgt Latasha Price]**

Electronic warfare systems

Electronic warfare (EW) systems can disrupt or 'jam' a UAV's receivers, which are used to receive instructions from the ground control station or to receive positioning information from global navigation satellite systems (GNSS). High-performance EW systems can be mounted on armoured or unarmoured tactical vehicles, including ultralight vehicles. The US Marine Corp's Light Marine Air Defense Integrated System (LMADIS) is a C-UAV system consisting of the CM262U optronic sensor; four fixed-face RPS-62 radars; the BlueHalo Titan-SV MPV3 direction finder (formerly known as the Verus SkyView-MP, until BlueHalo acquired Verus Technology Group); Sierra Nevada Corporation's Modi II jamming system; and the AN/PRC-158 radio system for communication. The components are divided between two vehicles which work as a team, one carrying the sensors and one the EW system. The USMC chose the lightweight and agile Polaris MRZR combat vehicles as the LMADIS platform.

Looking ahead

A notable recent trend is the development and testing of C-UAV systems armed with more than one type of effector. Combining multiple, complementary weapons promises the best chance of intercepting drones with different flight characteristics or which have been hardened against one-or-another type of countermeasure.

Given that the UAV threat is diversifying, it is logical that armed forces and industry will continue to pursue mobile C-UAV systems that incorporate multiple attack options that complement one another's capabilities. Even when optimised for the C-UAV mission, these systems can also address other aerial threats including missiles and helicopters. Multi-tasking weapon systems will be best suited to defending the manoeuvre force, regardless of what appears on the horizon.



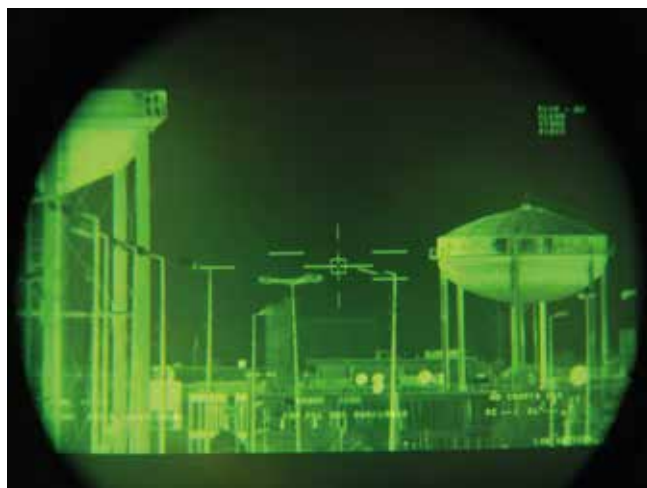
Observe, orient, decide, act: advances in AFV situational awareness

Peter Felstead

As the range of battlefield threats proliferates to include systems such as mini-UAVs and loitering munitions, AFV situational awareness capabilities are rapidly expanding to match them.

While the 'iron triangle' of armoured fighting vehicle (AFV) design – firepower, protection and mobility – still holds true, it is increasingly an AFV's situational awareness systems that are becoming crucial to both its offensive and defensive capabilities.

For the first armoured vehicles situational awareness was limited to peering through vision slits or periscopes, but during the Second World War infra-red devices began to be used



▲ **A view of western Ramadi in 2005, through a thermal imager at an observation post on Route Michigan. Situational awareness technologies have come a long way in the intervening 20 years. [Multi-National Corps – Iraq/ Staff Sgt Julie Nicolov]**

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.

for night vision. The German Fahr- und Zielgerät FG 1250 (FG 1250 Driving and Aiming Device), for example, was paired with machine guns on Sd Kfz 251 half-tracks and Pz Kpfw V Panther tanks in the later stages of the war.

Fast forward to the current day and AFVs have an extensive range of systems to enhance their situational awareness and associated offensive and defensive capabilities, including electro-optical systems, radars, laser warning systems, acoustic shot detectors, hard- and soft-kill countermeasures, network-derived capabilities and organic tactical unmanned aerial vehicles (UAVs) and loitering munitions. ESD contacted a number of the leading Western providers of the latest situational awareness technology to see what the future holds.

Thales

With a rich history in the development of situational awareness technology, beginning with the use of analogue cameras, European systems house Thales was the first company to deploy a fully generic vehicle architecture (GVA)-compliant local situational awareness system (LSAS), which was fitted onto the British Army's Foxhound protected patrol vehicle. More recently the company was responsible for designing and installing the fully integrated GVA-compliant LSAS for the British Army's Ajax tracked reconnaissance vehicle and is providing the British Army's future fleet of Challenger 3 main battle tanks (MBTs) with their primary commander and gunner sights, which feature an automatic target tracking wide-area search and detection (WASAD) capability in both day and thermal modes.

Speaking to ESD in early December 2024, Stewart MacPherson, head of digital strategy with Thales UK's Optronics & Missile Electronics business, pointed out regarding GVAs that in future all vehicles would feature "one big ethernet IP-based system where you can add cameras or effectors onto that system". By way of example he noted that the LSAS and sighting system on Ajax has 26 cameras.

"Obviously, if you've got 26 video feeds coming in, it can quite quickly overwhelm the user, so probably touching on future technology Thales are at the forefront of developing AI [artificial intelligence] and machine learning algorithms," said MacPherson, adding that Thales refers to this as the 'Digital Crew'.



▲ **A British Army Ajax armoured reconnaissance vehicle pictured during cold weather trials in Sweden in January 2024. The Ajax's local situational awareness and sighting systems feature 26 cameras. [Crown Copyright 2024]**

MacPherson noted, "Digital Crew is a collection of algorithms that reduce the cognitive burden of the user to absorb the information presented by, in that case [Ajax], 26 different cameras, but as you can probably imagine there's going to be more in the future; there's going to be an increasing amount of sensors on that vehicle."

MacPherson explained that machine learning-based algorithms, primarily based around convolutional neural networks (CNNs), offer a step change in situational awareness technology by being able to recognise imagery from sensors and contextualise it. This, said MacPherson, means that the software "now has eyes" and will thus lead to changes in how situational awareness systems are developed.

"We've designed electronic systems for 100 years across the land, naval and air domains, but previously all of our electronic systems were attuned for consumption by the 'Mark 1 human eyeball' and processed by the human brain," he said. "That's changing, and that's where this starts to evolve quite rapidly and gets really interesting because, now the software has eyes, it can take context from the content of the scene. ... So there's essentially a Digital Crew member sitting alongside the physical crew, and the role of that Digital Crew is to reduce cognitive burden on the vehicle or the platform crew because of this proliferation of sensor technologies and the rapidly changing asymmetric threats that are on the modern battlefield. The human crew can only process so much data, so the Digital Crew needs to step in at some point."

The machine-learning algorithms of Digital Crew are particularly effective with regard to object tracking – for example tracking the movement of small UAVs at distance in a way the human eye simply could not – and object classification, especially since Digital Crew is ever-present across all of the wavelengths of a vehicle's sensor technology.

"You've got television: basically your visual system that the human eye can pick up. You've also got short wave infrared. You've got medium-wave and long-wave infrared," MacPherson explained. "Obviously there's advantages to each mode of sensor, but Digital Crew is running concurrently across every video stream. So if you're an operator looking at a tel-

evision feed of a tree line, for example, in the middle of the day, you might not be aware that camouflaged behind that tree line is an enemy vehicle, but the TI [thermal imager] is picking that up. You haven't selected the TI yet, but the TI has been run through Digital Crew at the same time as the TV, so Digital Crew will alert you and say, 'By the way, you want to move to your thermal channel because there looks like there's something nasty behind that tree line.'"

Moving on to vehicle protection, MacPherson pointed out that one lesson from the current war in Ukraine is that even heavily armoured MBTs are still being penetrated by relatively low-cost weapons, such as loitering munitions. This, he said, means that a lot of effort is being focused on both soft-kill and hard-kill active protection systems (APSs).

In this area, Thales is taking the technology resident in its Elix-IR airborne multi-function passive threat warning system and looking to apply it to the land domain. While all APS capabilities require a very high-speed sensing capability to initiate hard- or soft-kill countermeasures, MacPherson noted that current APSs, which tend to rely on both optoelectronics and radar, risk giving away the position of the AFV even if the radar is used fleetingly. Thales is therefore looking at developing APS, vehicle-based artillery and rocket-launch detection systems and also counter-UAV capabilities that are completely passive in their sensing.



▲ **Thales is looking to adapt its Elix-IR aircraft threat warning system for the land domain to provide passive threat sensing. [Thales]**

For the counter-UAV mission, this, again, is an area where AI comes into its own regarding multi-object tracking and threat prioritisation. "If there's three drones in the sky," said MacPherson, "and two of them look like they're flying away from you and one of them looks like it's heading towards you at speed, then that's the one that you should be engaging. And that's not completely obvious just from a human looking at the screen because, at range, a DJI Mini or Mavic 2 drone, if you're talking about two or three kilometres away, that's only a few pixels on a screen, so it's very difficult for a human to understand which one is coming towards me and which one's going away from me. But the machine, the Digital Crew member, can pick that up and can start to classify

the three as 'This is the one that you want to engage; this is the one you want to look at first.'"

One other technology area to which MacPherson referred in relation to future AFV situational awareness capabilities was time-sensitive networking (TSN). *"If you're controlling weapon systems and effectors, you need to be able to provide safe, low-latency, real-time communications with those weapon systems,"* he explained, *"so it needs to be deterministic. It can be a message that sits on an ethernet network and waits to be picked up. It needs to be deterministic, sent to a weapon system, so we're looking at time-sensitive networking. We have an office in Belfast that falls under the integrated airspace protection systems [domain], which is anti-aircraft missile systems, and they are looking at time-sensitive networks for controlling the weapon system, so sensor to effector and having a deterministic message set that allows you to know exactly when the weapon system picks up the message."*

One last point MacPherson mentioned was in relation to the need to provide very fast video with effectively zero latency. *"Some of the issues that you get and can introduce latency is if you start to compress video and then decompress it at the other side,"* he noted. *"It can also increase if there's various network artifacts that are hogging computer bandwidth on the network. Ultimately, what we do is we try and reduce the latency as much as possible. Not compressing it is one way to do it, or sending it point to point over a very fast video format. The latency in video is still an issue, but we can get around it such that there are drivers, cameras, that have to provide video at a very high safety integrity level (SEL) rating, which basically means there's a requirement on the latency that they cannot be above."*



▲ The Thales PAAG system, installed here on a Boxer multi-role armoured vehicle, allows under-armour target designation instead of exposing a dismounted soldier to do the job. [Thales]

This is especially relevant to video used by a crewmember to drive an AFV, where even a small amount of latency can induce feelings of motion sickness, but it also affects other aspects of an AFV crew's effectiveness.

"You don't want to drive off latent video, and you don't want to fire off latent video," said MacPherson. *"You don't want to engage a target off latent video, especially if you're moving and the turret of the vehicle or the weapon system of the vehicle is moving. ... We have successfully reduced latency on many systems for driver and weapon systems. And then the next stage is reducing latency in the overall sensor system, so making sure that the video coming in is up to date, so we can run these different algorithms on it. The benefit of having a Digital Crew member is that they can process that video very, very quickly. They can process it uncompressed; the video does not need to be 'nice and human readable'; it can be very raw video coming in for a machine to process it a lot quicker."*

Moving forward, MacPherson noted that Thales is currently developing a new targeting and surveillance solution called the Panoramic Above Armour Gimbal (PAAG) system that will be installed on a telescopic mast on the Bundeswehr's Boxer multi-role armoured vehicles. The system will allow target designation from inside the safety of an AFV instead of having to expose a dismounted soldier to do the job.

Summing up his points, MacPherson stated that the future *"will be dominated by a proliferation of sensors on these vehicles; there will be a myriad of sensors on these vehicles. And in order not to overwhelm the crew, Thales and other businesses need to develop these AI algorithms, this Digital Crew, to reduce the cognitive burden on the physical crew and provide a benefit to reducing the observe, orient, decide, act (OODA) loop. How their customers will win future battles is reducing the OODA loop."*

Hensoldt

Germany's Hensoldt, meanwhile, also has a significant track record in providing AFV situational awareness systems. Noting that situational awareness is evolving rapidly as battlefield complexity increases, a company spokesperson told ESD in early December 2024 that the company *"is pushing the boundaries of situational awareness in AFVs through the integration of innovative sensor technologies and advanced AI-based systems"*. Most recently, the company's digital optics have been integrated into the German Army's Leopard 2 MBT and Puma infantry fighting vehicle (IFV) fleets.

One of Hensoldt's latest standout solutions is Ceretron: an AI-supported processing unit that analyses sensor data and provides users with significantly improved and rapid situational awareness. The company spokesperson explained that the Ceretron system *"enhances decision-making capabilities by delivering a comprehensive, real-time understanding of the battlefield environment, which is critical in high-stakes situations. The Ceretron unit processes information from multiple sensors, such as infrared and visual optics, merging them into one actionable data stream that commanders can act on swiftly."*



- ▲ **Germany's Puma IFV is one of the latest AFVs to benefit from Hensoldt's digital optics and wider situational awareness systems. [Rheinmetall]**

Ceratron, with its AI-driven sensor data processing, "is a game changer in providing a unified and coherent picture of the battlefield", the Hensoldt spokesperson said. "By fusing data from various sensors and presenting it in an actionable format, Ceratron empowers commanders to make quicker, better-informed decisions."

The spokesperson added that "Hensoldt's digital optics, particularly integrated into Leopard and Puma platforms, enhance image quality and visibility in complex environments. These digital systems allow crews to perceive and identify threats with remarkable clarity, even under low-visibility conditions, such as during night operations or in harsh weather. Together, these technologies reflect Hensoldt's

commitment to advancing situational awareness, enabling better protection and tactical effectiveness on the battlefield."

In terms of enhancing battlefield capabilities, the spokesperson noted that the "integration of digital optics into platforms such as the Leopard and Puma offers enhanced target identification – crucial for engagements in complex environments. This capability not only improves battlefield survivability but also facilitates faster and more accurate engagement of targets, supporting the rapid execution of military strategies.

"These innovations, including Ceratron and digital optics," the spokesperson added, "support a shift towards a more dynamic and responsive military doctrine. They enable forces to detect threats earlier, react faster and operate more efficiently in ever-changing battle conditions."

BAE Systems

While BAE Systems did not have a spokesperson available for interview, company representatives pointed ESD to a range of developments in which the company is seeking to provide enhanced AFV situational awareness and vehicle protection technologies.

BAE Systems' vehicle protection system offerings comprise sensors, countermeasure systems and AI-enabled autonomy functions designed to reduce the cognitive load on ground vehicle crews, allowing them to quickly respond to potential threats.

- ▼ **Coupled with BAE Systems' 360 MVP Sensor situational awareness suite, the company's BAE Systems' Terra Raven countermeasures system uses non-kinetic, infrared countermeasures technology adapted from aircraft self-protection systems to shield ground vehicles from anti-tank missiles. [BAE Systems]**



Among these is the 360 MVP Sensor system, which according to company literature “improves ground vehicles’ situational awareness, reduces crew cognitive load and integrates easily with other vehicle protection system features – all to enhance crew response time, survivability, and mission success”. Comprising high-definition, extended-view sensors built with BAE Systems’ 1920x1200 longwave infrared camera cores, the 360 MVP Sensor system delivers low-latency imagery day or night, in adverse weather and despite challenging natural and manmade battlefield conditions, according to BAE.

“The large field of view and our advanced algorithms improve situational awareness for ground vehicles and reduce the cognitive load on the crew,” the company states. “These algorithms allow the system to provide early warning of incoming threats such as anti-tank guided missiles, unmanned aerial vehicles and ground forces, allowing crews and systems to respond before the threat can engage. The 360 MVP Sensor system gives crews active vehicle protection with a ‘see first, act first’ advantage, while improving manoeuvrability and survivability in dense, urban terrain.”

BAE Systems’ Terra Raven countermeasures system, meanwhile, uses non-kinetic, infrared countermeasures technology adapted from aircraft self-protection systems to shield ground vehicles from anti-tank missiles. “Coupled with BAE Systems’ 360 MVP Sensor situational awareness suite, this infrared countermeasures system detects, tracks and engages incoming threats to armoured ground vehicles,” the company states. “Its design is customisable for any platform, mission, or budget” and “is designed to be modular, lightweight and easily integrated with other systems, including kinetic countermeasures”.

Associated with these capabilities is the company’s overall Intrepid Shield concept: a full-spectrum, multi-domain electronic warfare (EW) solution designed to create a protective

sphere around platforms in highly contested battlespaces. By leveraging the radio frequency (RF) and infrared IR parts of the EW spectrum, Intrepid Shield is designed to provide a comprehensive suite of protection capabilities while simultaneously implementing open architectures for rapid fielding and continuous system upgrades to outpace the threat.

Meanwhile, in October 2024 BAE Systems announced it had teamed with Kongsberg Defence and Aerospace to bring the latter’s Integrated Combat Solution (ICS) AFV situational awareness tool to the US market. ICS provides AFV crews with the capability to link and share video streams, metadata, target information, slew-to-cue commands and more, which according to BAE Systems reduces the typical threat response speed from minutes to seconds. The ICS capability has already been demonstrated on the US Amphibious Combat Vehicle (ACV) and Armored Multi-Purpose Vehicle (AMPV) platforms.

Closing thoughts

Future AFV situational awareness and associated technology promises to transform both the way land forces fight and perhaps also the design of the armoured vehicles they use. For example, increasingly effective APS capabilities might allow AFVs to be more lightly armoured, thus improving their mobility.

Meanwhile, developments such as the US Army’s Robotic Combat Vehicle (RCV) programme, being developed as part of the army’s Next Generation Combat Vehicle (NGCV) family of vehicles, could see the situational awareness of manned AFV formations enhanced by a forward screen of RCVs, all with their own sensors and effectors. What is already clear is that the old adage of the Second World War era, where it was deemed that if you couldn’t physically see a target then you couldn’t shoot it, is no longer an absolute truth.



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Tracked fire support vehicles: A return to 'light tanks'?

Sidney E. Dean

Attaching armoured fire support vehicles to light infantry units can enhance survival and support offensive operations. While such vehicles have been offered in various configurations for many years, recently there appears to be increased interest in acquiring such vehicles.

Several factors differentiate fire support vehicles (FSVs), whether wheeled or tracked, from other armoured fighting vehicles. FSVs are often based on existing wheeled (typically 6x6 or 8x8) or tracked armoured personnel carrier (APC) or infantry fighting vehicle (IFV) platform families, which are modified with a turret armed with a large-calibre gun. Consequently, more lightly-armoured and therefore lighter than a main battle tank (MBT), a fact which has often led to them being referred to as 'light tanks'. However, the 'tank' label can be somewhat misleading, as these vehicles lack sufficient protection to take on the doctrinal role of a 'true' tank in conducting breakthroughs or combating heavily-armoured targets. Despite often being based on a common platform to APCs or IFVs, typically FSVs lack the capability to carry a squad of mounted infantry. Historically their main armament has often tended to be lower-calibre than that of a modern MBT, but this trend has shifted in recent years, as low-recoil versions of 120 mm and 125 mm armaments have become adopted on lighter vehicles.

These characteristics reflect the FSV's primary mission, which is to provide infantry units with direct fire support (as opposed to indirect fire support via artillery). This requires the ability to deploy globally with light/medium-weight forces and to keep pace with them over difficult terrain. As a rule, FSVs are not expected to directly engage heavily-armoured combatants such as MBTs, although their primary armament may be capable of doing so, and they can be armed with turret-mounted anti-tank guided missiles (ATGMs) to augment their anti-armour capabilities.

Overall, FSVs can be considered medium-weight vehicles, primarily intended to engage stationary fortifications such as bunkers, infantry, as well as light and medium-weight vehicles. While FSVs are generally tasked with supporting light forces, they can also be attached to mechanised infantry units, freeing up MBTs for other missions.

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M10 Booker

The US Army is currently working toward fielding the new M10 Booker FSV, procured under the Mobile Protected Firepower (MPF) programme. As defined by the Pentagon, the M10 is primarily intended for providing fire support to US Army Infantry Brigade Combat Teams (IBCTs), enhancing their overall effectiveness.



▲ [A live fire demonstration of the M10 Booker marked the conclusion of the vehicle's Dedication Ceremony at Aberdeen Proving Ground, Maryland, on 18 April 2024. \[US Army/ Christopher Kaufmann\]](#)

The M10 Booker is produced by General Dynamics Land Systems (GDLS) and is based on a heavily-modified version of the ASCOD 2 (Austrian-Spanish Cooperative Development) platform. The M10 hull has been substantially modified from the original, but retains a front-mounted powerpack, comprising an MTU 8V 199 TE21 diesel engine developing 600 kW (805 hp), coupled to an Allison 3040 MX six-speed (four forward and two reverse gears) automatic transmission. The platform is equipped with hydro-pneumatic suspension in each road arm, using less interior volume than the torsion bars typically used on the ASCOD family, while the tracks are the T161 model, as used on the M2/M3 Bradley IFV. The vehicle lacks an auxiliary power unit (APU), but is fitted with 6T Li-ion batteries, which provide it with a silent watch capability, allowing it to run core systems with the engine switched off.

In terms of armament, the vehicle is armed with the XM35 105 mm L52 rifled main gun, a coaxial 7.62 mm machine gun (MG), and a 12.7 mm heavy machine gun (HMG) in a ring-mount at the commander's hatch. The gunner is provided

with a day and thermal sight on the top-right hand side of the turret, while the commander is provided with an independent panoramic day and thermal sight on the top-left hand side of the turret. Additionally, the crew are provided with a suite of cameras to provide 360° local situational awareness around the vehicle.

In terms of dimensions, the M10 Booker is actually slightly taller than the M1 Abrams MBT, but has a slightly lower width and length. The turret shares some commonality to that of the M1 Abrams in terms of line-replaceable parts, along with crew layout, and Army sources have stated that the fire control system (FCS) is similar to that of Abrams. At 38 tonnes, the M10's vehicle weight is approximately half that of the Abrams. The M10 is too large to be transported by C-130, but two vehicles will fit inside a C-17; by contrast, only one Abrams can be transported per C-17. Importantly, the M10 can cross bridges too weak for the Abrams, enabling the Army to project mobile force protection in areas not accessible by MBTs.

The M10's characteristics have led some observers to refer to it as a light tank, but the Pentagon spoke out against this characterisation. The primary objection to the light tank label is found in the vehicle's mission statement, which is to provide direct fire to neutralise obstacles typically faced



▲ [The M10 Booker displayed at its dedication ceremony at Aberdeen Proving Ground, Maryland, on 18 April 2024.](#)
[US Army/ Christopher Kaufmann]

by infantry, such as bunkers, gun emplacements or light armoured vehicles. "MPF is not designed to be able to engage enemy tanks," noted Ashley John, a spokeswoman for the Army's Program Executive Office Ground Systems, in 2022. Maj Gen Glenn Dean, Program Executive Officer for Ground Combat Systems, separately stressed that "light tanks" historically have performed reconnaissance functions, "and this is not a reconnaissance vehicle, it's an assault gun".

GDLS was awarded the low-rate initial production (LRIP) contract in June 2022. That contract covered 96 vehicles, the first of which was delivered to the Army in April 2024. In August 2024, the Army awarded the firm a second LRIP contract over an unspecified number of vehicles. The Army's acquisition objective is 504 units, although officials caution that this figure could be revised. Each infantry division is to be

assigned one battalion of 42 M10s, enough to provide each IBCT a company with 14 vehicles. Current planning calls for the first unit equipped (FUE) status to be achieved in the fourth quarter of Fiscal Year (FY) 2025. The first company is expected to be assigned to the 82nd Airborne Division at Fort Liberty, North Carolina. The Army has not stated whether that unit will be the first to receive a complete battalion, or whether the remaining companies of the first battalion set would be assigned to different divisions.

In July 2024, airborne soldiers at Fort Liberty began an intense new equipment training and test cycle on LRIP vehicles. The results of the testing, which was expected to run for three months, were not published before this issue went to press. The last known planning called for initiating the initial operational test & evaluation (IOT&E) in January 2025 if the results at Fort Liberty were positive. The IOT&E event will identify any changes GDLS needs to make to the system. A positive IOT&E report would open the path to a full-rate production (FRP) decision in the third quarter of FY 2025.

Sabrah light tank

The M10 Booker is not the only FSV based on GDELS' ASCOD 2 design. Israel's Elbit Systems offers the Sabrah FSV in both a tracked variant based on the ASCOD 2 and a wheeled variant based on the Pandur 2 8x8. Both feature an Elbit two-person turret and the 105LW rifled, low recoil 105 mm gun. The stabilised turret also mounts an FN MAG 7.62 mm MG and eight smoke grenade launchers. The tank carries 12 ready rounds in the autoloader, plus an additional 24 in the hull. A pod of two ATGMs is offered as an option, as is the Iron Fist Active protection system.

The Sabrah modification was offered in 2020 to meet a requirement of the Philippines Army for a 'light tank'. Manila placed an order for 18 tracked and 10 wheeled Sabrah FSVs in January 2021. The first nine of the tracked version formally entered service in March 2024. Elbit has stated that the approximately 30-33 tonne vehicle features a range of the firm's



▲ [ASCOD 2 Sabrah Light Tank of the Philippine Army.](#)
[Yakitaki26, via Wikimedia Commons CC-BY-SA-4.0]

subsystems, including optronic sights, a digital fire control system, TORCH-XTM battle management system, E-LynXTM software defined radio system, and life-support systems.

Kaplan MT

Türkiye's FNSS Kaplan MT is another notable in-service tracked FSV. The base vehicle is derived from FNSS' Kaplan family, using paired with a John Cockerill Defence 3105 two-person turret, armed with the Cockerill 105HP (high pressure) 105 mm L51 rifled gun, coupled to an autoloader with 12 ready rounds. Secondary armament includes a coaxial 7.62 mm MG, and a roof-mounted 7.62 MG or 12.7



- ▲ **Harimau FSVs of the 13th Satya Lembuswana Cavalry Battalion conducting a company-level tactical exercise in the Amborawang Combat Training Center (Puslatpur), on 22 November 2024. [Bataylon Kavaleri 13 (via @Jatosint), via Wikimedia Commons, Public Domain]**

mm HMG for the vehicle commander, which can be either pintle-mounted or a integrated into a remote weapon station (RWS). According to PT Pindad, the vehicle combat weight can range from 30-35 tonnes. FNSS have also offered the vehicle with the Pulat hard-kill active protection system (APS), which is a Turkish derivative of Ukraine's Microtek Zaslon APS design.



- ▲ **Test firing of the earlier CV90120-T prototype, armed with the Ruag CTG 120/L50. [BAE Systems]**

Indonesia was the first user of the Kaplan MT, which is known as the Harimau in Indonesian service, and is produced jointly by Türkiye's FNSS and Indonesia's PT Pindad. Production began in 2017, and the first batch of 10 vehicles was handed over to Indonesia's armed forces in March 2024, and the initial order for 18 vehicles was reported to have been completed by October 2024. Brazil has also been considering the Kaplan MT (as well as the Sabrah, CV90120, and Lynx 120) as part of the Armoured Combat Vehicles (VBC CC) component of its Army Armoured Forces Strategic Programme (Prg EE F Bld). Previously, in November 2022, Brazil had selected the Centauro II 8x8 wheeled FSV for its 'Viatura Blindada de Combate de Cavalaria – Média Sobre Rodas' (VBC Cav – MSR 8x8) programme.

CV90120

Since the 1990s, BAE Systems Hägglunds has developed several variants of the CV90 AFV which were equipped with larger calibre weapons, including the CV90105 and CV90120. The most recent offer in this category is the CV90120MkIV, based on the manufacturer's latest CV90MkIV platform, fitted with a two-person turret and armed with a 120 mm smoothbore gun. It is intended to provide direct fire support, and has previously been advertised by BAE as also providing a "sustained long-range anti-tank capability". While the armament would certainly mean the latter is possible, the fact that the vehicle's armour is considerably weaker than that of a typical MBT leaves it more vulnerable to return fire than an MBT in the anti-tank role.

BAE Systems have offered a version of the CV90120 for some years, even prior to their latest version based on MkIV. Originally, their 120 mm armament offering was based on the Ruag CTG 120/L50 (CTG = Compact Tank Gun) 120 mm gun, however following Ruag ceasing to offer this weapon, the primary armament was changed to the Rheinmetall Rh 120 LLR L/47 (LLR = Light, Low-Recoil) gun. The 120 mm gun accommodates all NATO standard 120 mm tank munitions as well as gun-launched anti-tank guided missiles (GLAT-GMs) and is provided with an autoloader. BAE Systems have previously advertised a maximum rate of fire of 12-14 rds/min. Secondary armament comprises a 7.62 mm coaxial MG, and additional armaments including a 7.62 mm MG or 12.7

mm HMG, or 40 mm automatic grenade launcher (AGL) can be mounted in a RWS on the turret roof.

The vehicle is also optionally offered with soft-and hard-kill APSs. The former can include laser, radar, and missile warning receivers, coupled to smoke grenade launchers, while the latter is understood to include various user-defined hard-kill APSs.

Lynx 120

Rheinmetall Defence presented the Lynx 120 FSV in February 2022. This version featured what appeared to be the two-person turret used on the KF51 Panther MBT, armed with a Rheinmetall Rh140 L/44 gun, and mated to the KF41 Lynx tracked platform. According to Rheinmetall's accompanying press release, the Lynx 120's gun was compatible with



▲ The Lynx 120 FSV variant of the Lynx KF41, shown here in the 2022 configuration, with what appeared to be the KF51 Panther turret. [Rheinmetall]

Rheinmetall's DM11 three-mode programmable HE-munition. This enables the Lynx 120 to engage targets ranging from bunkers (point detonation) to light- medium-armoured vehicles (delayed point detonation) to personnel in the open (air burst). In addition to DM11, the 120 mm is compatible with NATO 120 mm ammunition natures, including high-explosive anti-tank (HEAT) and armour-piercing fin-stabilised discarding sabot (APFSDS) rounds, enabling destruction of heavily-armoured targets such as MBTs. Secondary armament includes a coaxial 12.7 mm HMG, and a 7.62 mm MG mounted in a Natter RWS on the turret. A 360° camera system with automatic target detection and tracking assists the crew with situational awareness.

At Eurosatory 2024, Rheinmetall showed a further development of their Lynx-based FSV concept, under the name 'Lynx 120mm'. This version differed slightly from the original Lynx 120 shown in 2022, using a smaller and lighter Leonardo

Hitfact II turret mated to the KF41 Lynx hull, and armed with the Leonardo 120/45 gun. The turret is offered as a 2-person turret with autoloader or 3-person turret, and the Leonardo 105/52 gun can be selected as a lower-calibre alternative to the 120/45 gun.

Rheinmetall underscores the simplified vehicle architecture and plug-and-play design which will facilitate future up-grades. Modularity is also displayed by the vehicle's defensive suite, which includes scalable passive armour packages, and Rheinmetall's Strikeshield hard-kill APS as options.

An FSV Renaissance?

As the tactical environment continues to evolve, there appears to be a resurgence of interest in FSVs, both wheeled and tracked. Ongoing conflicts, especially in Ukraine, have demonstrated that heavy armour is often inadequate protection against new anti-armour threats such as drones and loitering munitions. Yet at the same time, there remains demand for large-calibre direct fire capabilities to support infantry or light- and medium-weight forces. Here, tracked FSVs provide a number of important advantages over traditional MBTs.

FSVs have notably lower acquisition, maintenance, and running costs than MBTs, and their adoption also allows armed forces an opportunity to increase parts commonality and reduce the logistical burden across their fleet, if their chosen FSV uses the same base platform family as already in-service IFVs or APCs. To armed forces with limited budgets, tracked FSVs offer a means to build capable armoured formations at a significantly lower cost than the – often prohibitive – acquisition of modern MBTs. Additionally, FSVs' lighter weight provides a multitude of other advantages, including reduced fuel consumption, easier recovery, the ability to traverse bridges and gaps inaccessible to MBTs, as well as being easier to transport by air. Such factors make them an attractive prospect in most tactical scenarios.

While FSVs are far more lightly armoured than MBTs, their survivability can nonetheless reach a respectable level though adoption of more 'left of boom' approaches, such as hard- and soft-kill APSs, signature reduction, and (relatively) lightweight add-ons such as bar armour and overhead protection cages. Over time, they are also likely to be enhanced with onboard reconnaissance UAVs or loitering munitions to detect and neutralise threats at beyond-line-of-sight ranges, or network with unmanned ground vehicles (UGVs). Depending on the operational scenario, these technologies could at least partially reduce the survivability gap between FSVs and MBTs. Throughout history, armies have fielded balanced forces consisting of complementary light, medium and heavy forces. The validity of this approach still resonates today.

Raining down from above

Tim Guest

The relative simplicity and effectiveness of explosively-formed penetrators (EFPs) against various types of armoured targets, has led to their use and delivery from a variety of weapon systems for more than a century. In Ukraine, top-attack EFPs, including from artillery and air-dropped systems, have been increasingly effective on both sides in defeating the relatively thin roof armour of even the most advanced armoured vehicles.

EFP threats to battlefield armour have been around for very many years and during several different conflicts, largely delivered from ground-based systems. Today, light and armoured vehicles up to main battle tanks (MBTs) continue to be at risk from ground-based EFP weapon systems, whether from landmines, improvised explosive devices (IEDs), anti-tank guided weapons (ATGW) or other means. The ongoing war in Ukraine is no exception, where such threats are numerous. One example in use with the Ukrainian Armed

Forces is the French-made HPD-2 anti-vehicle mine, which functions using a mutual inductance sensor, with its warhead delivering an EFP slug directly upwards, capable of penetrating 150 mm of underbelly armour of target vehicles from its emplaced position below.

However, the growing danger of top-attack EFPs against the relatively thin roof armour of even the most heavily armoured platforms is changing battlefield dynamics. Guided artillery rounds, for example, as well as air-dropped systems carrying EFP-based submunitions, were widely used in the Middle East during the War on Terror by US and Allied Forces. In Ukraine, however, they have been even more intensively used, this time in a peer-to-peer setting, with several such systems taking a toll on both sides and underpinning the frightening top-armour-defeating capabilities of EFPs.

While it should be noted many unmanned aerial vehicles (UAVs), including latest loitering munitions, are being used in Ukraine to defeat armour through top-attack trajectories, these largely using high-explosive anti-tank (HEAT) warheads, rather than EFPs. This article instead looks at a number of EFP basics, top-armour vulnerabilities, guided artillery and aerial top-attack EFP-delivering weapon systems on both sides in Ukraine, as well as a new top-attack innovations.

EFPs simplified

In relatively simple terms, no matter the method or weapon platform from which an EFP is delivered, this warhead is a type of shaped charge designed for use against lightly armoured vehicles, or areas of thinnest armour and other weak spots on a more heavily armoured platform, such as an MBT. Sometimes also referred to as a Misnay-Schardin effect warhead, an EFP consists of a casing containing a high-explosive (HE) filler, a detonator, and a metallic liner, often made of Copper, although other metals, including Tantalum, are also used. This liner forms the penetrator and in the case of an EFP, it differs from a HEAT charge, because its liner is often thicker; rather than a typical conical, hemispherical, or parabolic form, the liner takes the shape of a shallow dish, or bowl. These characteristics result in its collapse into a fast-moving, slug-shaped projectile, which forms within some 200-400 μ s of detonation of the HE filler. It is worth noting that variations in liner shape and material, for instance, Copper, Tantalum (today's preferred liner material), Iron, Molybdenum, and Tantalum-Tungsten alloys, as well as liner thickness, together with the explosive used and detonation points, will determine the behaviour and overall performance of the final EFP slug.

That said, whatever its parameters, in comparison with the hypervelocity jet created by a typical HEAT charge's conical liner (which is designed to perform optimally only over fairly



▲ **Hand-emplaced, XM204 top-attack EFP-delivering system, sits deployed and waiting for a target. [Textron]**

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short stand-off distances, and tends to break apart travelling over greater distances), EFPs are less penetrative, though the fast-moving EFP slug will retain its form and penetrative power over much greater stand-off distances to deliver sufficient punch to defeat its targets. In the case of top attack, that means defeating the thinner roof armour of MBTs and other AFVs. Indeed, thinner roof armour of only several tens of millimetres thickness means an EFP simply does not need the penetrative power of a HEAT jet, since it is not trying to defeat the several hundred millimetres of frontal armour of a typical tank. What it can do, however, is deliver potentially better post-penetration effects to a target than a HEAT jet, over greater stand-off ranges.

Thin on top – vulnerabilities to exploit

As to why AFV roof armour is so thin in the first place, this comes down to weight-saving and design reasons; not every part of an armoured vehicle or MBT can be as heavily protected as the front-facing parts of the hull and turret – those most likely to take a hit from ground-based weapons in battle, with attack from above seen as less likely in the past compared with ground threats. As a result, the top or roof armour of MBTs and other AFVs have typically been accepted as some of the thinnest on the vehicle. Indeed, these areas



▲ **Pictured: Rafael Trophy hard-kill active protection system (APS) on an M1 Abrams MBT. Relatively thin roof armour remains a key vulnerability, on tanks, and even the most modern tanks equipped with APSs remain vulnerable to the threat of top-attack EFPs. [Rafael]**

may even lack sufficient thickness to protect a vehicle from small HEAT bomblets, which are typically able to penetrate some 2–5 cm of rolled homogeneous armour (RHA). Multiple manufacturers have offers roof armour packages to remedy this vulnerability. To put things into perspective, the roof armour of a typical M1 Abrams, for example, is estimated to be around 25.5 mm thick; by way of comparison, the turret cheek armour of newer M1 Abrams variants is estimated to be as thick as 700–980 mm. The discrepancy between these two measurements, should clearly illustrate why new EFP-based top-attack systems are proliferating.

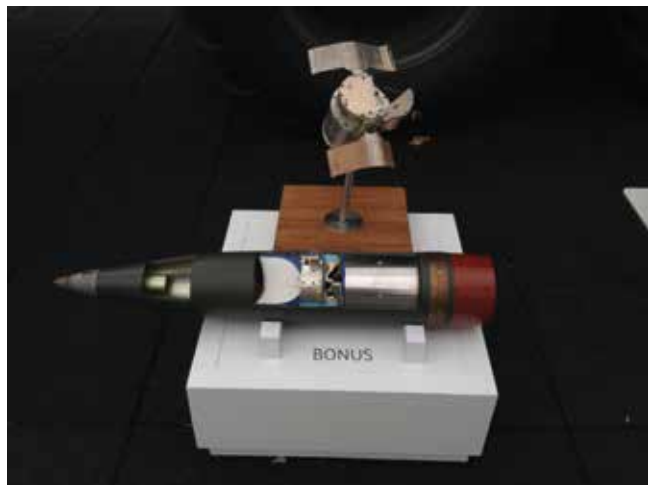
When it comes to more powerful threats such as 155 mm guided artillery, EFP submunitions from such rounds as the SMArt 155 or BONUS 155 mm guided shells, or loitering munitions (LMs) such as Libelle, which is understood to use a 155 mm diameter EFP similar to that carried by the SMArt 155 round, (both are manufactured by Diehl Defence), even a roof which has been up-armoured against bomblets would not be expected to withstand large top-attack EFPs, which pose a much greater existential threat to the vehicle and crew than a small HEAT bomblet. Though not on the battlefield, Libelle is Diehl Defence's first venture into LMs; it was a concept back in 2021, and has since been discussed in detail in ESD (see ESD 01/23). As noted, its EFP warhead is similar to that of the SMArt 155, although the rotary-winged system relies on cameras and image recognition algorithms, rather than the combination of infrared (IR) and millimetre-wave (mmWave) radar sensors used by SMArt 155 to initiate its fuzing.

Threats above the Donbas

Before looking at some of the Allied systems being used in the war in Ukraine, one Russian EFP top-attack threat on the battlefields comes from their SPBE (self-guided combat submunition), which is typically air delivered, although it can also be delivered on target using rocket-artillery. This system is similar to the US Sense and Destroy Armour (SADARM) submunitions used in the CBU-105 half-tonne cluster bomb, which carries 40 submunitions. The parachute-retarded, sensor-fuzed, anti-vehicle SPBE system employs an EFP warhead for top-attack purposes. When dropped from aircraft, the SPBE is delivered from the RBK-500 SPBE cluster bomb, which contains 15 of the submunitions, released once the carrier munition's mechanically-timed fuze initiates a pyrotechnic ejection charge. During its descent, the weapon is slowed by three small parachutes to optimise target-detection time in the air, while the submunition's dual-mode IR/mmWave sensor scans for vehicle targets below. Once the target is detected and in range, the SPBE's warhead is detonated, and its EFP is able to penetrate up to 70 mm of armour at a 100 m stand-off range. If no target is detected during that time and the submunition reaches the ground without the EFP initiating, the munition will behave as an anti-vehicle landmine, its sensors similarly responsive in such a ground-based mode. Newsreel footage during the early months of the war in Ukraine caught the mid-air terminal flight phase detonation of such carrier systems and the release of many submunitions above the car park of a residential apartment block. The submunitions, possibly SPBEs, detonated some tens of metres above the ground, and indiscriminately destroyed most, if not all, of the parked cars, including what looked like multiple strikes on many.

Gunners' preference

When it comes to Allied-supplied systems in the current War in Ukraine, already mentioned are the Bofors Nutating Shell (BONUS) 155 mm guided cluster round and Diehl Defence's SMArt 155 mm guided artillery round, which deliver top-attack EFP submunitions. Both are highly prized – when available – by Ukrainian gunners, due largely to their high-hit



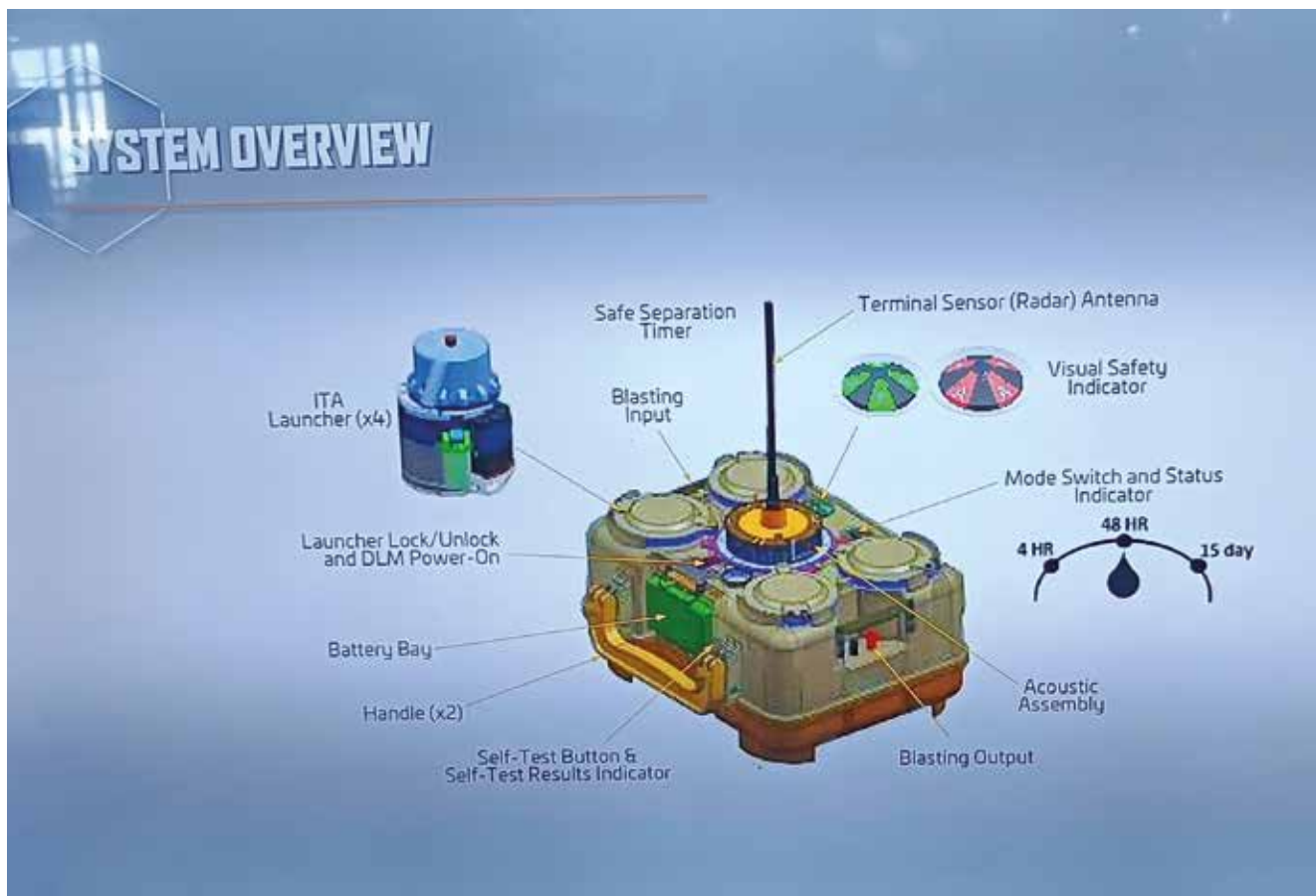
▲ **Bonus 155 mm artillery round with EFP-firing submunition.** [Tim Guest]

probabilities. Space precludes going into detail about each, but as these systems share many similarities, we'll examine one, BONUS, in more detail.

In July, Ukraine's *Militarnyi* reported that a BONUS 155 mm round's cluster submunitions had been used to destroy a Russian T-90M tank at a range of some 8 km, following its forward observation and detection by a Ukrainian Shark reconnaissance drone. The tank was struck on its turret by at least one submunition released by the carrier round; online footage clearly shows the round's detonation above the tar-

get, with a turret-top strike by one of the EFP submunitions, followed by an immediate, internal, catastrophic fire. From the outside, the vehicle appears virtually unscathed. This showed EFP top attack at its lethal best.

The BONUS round itself, according to its makers, has a dual-mode, multi-band IR and LiDAR (laser radar) sensor, which enables a hit probability of one target per shell. The round is effective out to ranges as far as 35 km, when relying on a base-bleed carrier shell, as long as it is fired from a NATO standard L52-calibre gun. The round's electronically timed fuze, set by the gun crew before firing, initiates the ejection charge to release two EFP submunitions from the carrier shell at a predetermined altitude between 800 m and 2,200 m above the battlefield, using firing data from the command post, based on targeting information and target description from the forward observer or spotting drone team. Once ejected, the two EFP sensor-fuzed submunitions then search for their own targets, each with a search diameter footprint of 200 m, and both capable of covering up to a possible 32,000 m² in total, between them, depending on the altitude from which they are released. Each EFP submunition has a descent velocity of 45 m/s, slowed by short winglets, and a spin rate of 15 rps. Once a target is chosen by a submunition, the EFP warhead is fired down into the top armour of the vehicle, the slug achieving speeds in excess of 2,000 m/s and capable of penetrating between 100 mm and 140 mm of rolled homogenous armour equivalent (RHAe); the maker claims the munition is effective against both passive and reactive armour.



▲ **XM204 system overview.** [Mark Cazalet]

Hand-emplaced, top-attack munition

Beyond Ukraine, US defence company, Textron, put out a paper in October 2024, titled 'Terrain Shaping in Modern Warfare', which discusses the tactics of controlling enemy movement and establishing defensive postures using, amongst other things, systems delivering top-attack EFPs. The paper is very obviously written in support of the emergence of the company's new XM204 (and XM250) top-attack, anti-vehicle munition systems – the XM204 having been on display at AUSA 2023/24 and Eurosatory 2024.

Already in production following a 2022 contract with the US Army, the XM204 top-attack, anti-vehicle munition system is a 38 kg, two-man carry, hand-emplaced unit, which has four sensor-fuzed, top-attack submunitions per suitcase-style, dispenser launch module (DLM). Each DLM covers a 100 m diameter strike area (50 m strike radius). Its acoustic, seismic and radar sensors monitor and can detect vehicle movement out to 1,000 m and the system then determines if the sensor data is of an appropriate target to engage. Once a target has been detected and is within range, the DLM launches a submunition, which is propelled to its target engagement altitude via integrated rocket motors. Once in the air, an IR sensor on the submunition scans for, detects the target, and initiates the EFP warhead, firing a Tantalum slug through the roof of the target vehicle. The system has been tested against a T-72 tank at Yuma Proving Grounds in Arizona, and resulted in target neutralisation. According to Textron, the XM204 is the only top-attack, counter-mobility system available to NATO. However, it is worth noting that the Russians have an equivalent in the form of the PTKM-1R, although these are deployed as individual munitions, rather than within a larger multi-submunition dispenser.

Final thoughts – protection against top-attack EFPs?

Limited space again precludes detailed discussion here about technical or operational ways, which might mitigate against top-attack EFPs. Suffice it to say though, that armoured vehicles are currently not really built to withstand this threat. There don't even appear to be easy solutions on the horizon anytime soon. It would seem unfeasible to up-armour vehicle upper hemispheres to match the threat, and existing active protection systems (APSs) were not designed with the top-attack EFP threat in mind. EFPs are able to initiate at a distance of roughly 50-100 m from the target, far out of range of known APSs' engagement ranges. Additionally, even for static forms of APS, the EFP slug is a very small projectile moving extremely fast, making it very difficult to react in time to intercept it, especially at the aforementioned short distances. On top of this, targeting top-attack EFPs would require the APS to be able to engage targets at near-vertical angles, which most APSs cannot do. By contrast, HEAT warheads are simpler to intercept, since the missile, shell, or drone carrying the warhead tend to be larger, and relatively slower-moving targets (compared to EFP slugs), and tend to approach the target at horizontal or shallow dive trajectories. Consequently, they represent a much simpler prospect for the APS to intercept.

As such, perhaps the most practical answer to such threats currently lies in very short-range air defence (VSHORAD) systems, particularly those suited for dealing with the counter-unmanned aerial vehicle (C-UAV) and/or counter-rocket, artillery and mortar (C-RAM) target sets. With demand for such systems already high due to the threat of small drones, the proliferation of top-attack EFPs will likely only increase their value to armed forces even further.

Voices from Industry: PIK-AS

Christina Polster, CEO of PIK-AS Austria GmbH, celebrates her 10th anniversary as CEO.

Under her leadership, PIK-AS Austria has become a global-leading manufacturer in high-performance connectors, LED interior lighting, and military vehicle electrical equipment.

With numerous product innovations and investments in production facilities, the company stands out as a highly reliable and quality-focused partner.

Christina Polster's exceptional leadership has not only driven growth but also highlighted the impact of female executive

▶ **Christina Polster, CEO of PIK-AS Austria GMBH. [PIK-AS]**

excellence in the industry. Latest product releases can be experienced at upcoming major events, such as the IAV Conference and IDEX in Abu Dhabi.



Just in time is dead: How European manufacturers are gearing up for land warfare

Sam Cranny-Evans

For any industry, a supply chain must balance efficiency with cost. Holding stock can be expensive and inefficient, it requires an entity to maintain and retain warehousing and storage for components and to procure them in bulk. Ideally, a production line is operated at an optimal capacity without any redundancy. This reduces waste and ensures a flexible approach to delivery and changing circumstances. Many industries pursue just in time delivery to manage their supply chains. In essence, this is a process where a manufacturer will conduct extensive planning to predict the future production needs and maintain the minimum amount of components and materials in stock necessary to meet them. When the stock falls below a certain level this will trigger the demand for replenishment that leads to frequent small deliveries. At the same time, a manufacturer will generally retain enough staff and machinery to meet the expected production outputs. Staff and machine tools, as well as the space to house them and store critical components and materials represent costs to companies. As such, keeping them 'lean' or to the minimal level required to ensure successful delivery, has become a favoured model of operations for many manufacturing industries, from microchips to cars and even food.

However, just in time delivery has vulnerabilities that primarily arise when uncertainty or variability in demand are likely. It is perhaps surprising, therefore, to find that just in time delivery has been the favoured method of supply chain management for many defence companies. "Just in time is dead," Tommy Gustaffson-Rask, President of BAE Systems Hägglunds told an audience at the Eurosatory 2024 event. He spoke in light of the aftermath of COVID and the shock of the Ukraine war. Both events have exposed fragile supply chains to some of the greatest challenges they could expect to face; from a sudden collapse of supply chains and spending, to a surge combined with changes to supplier landscapes coupled with a resurgent and very serious threat. As a

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▲ **Pictured: A CV9040C in service with Ukraine. The CV90 has always been a popular platform but orders have surged to replace those sent to Ukraine, to expand fleets, and to equip new formations. This has placed additional demands on BAE's supply chains that must be managed. [Ukrainian MoD/Oleksandr Bondar]**

result, defence manufacturers are pushing hard to increase production of essential systems as the prospect of a military confrontation with Russia hangs over the capitals of Europe.

"Just in time is dead"

For Europe's manufacturers of armoured fighting vehicles (AFVs), and indeed those abroad, just in time delivery has made some sense for a long time. Many AFVs rely on commercial powerpacks that are produced at scale and orders can be increased or decreased as required. Vehicle armour can be challenging as Europe has very few steel mills capable of producing large stocks of steel qualified for use in armoured vehicles. However, vehicle orders have tended to be predictable in size and intermittent, which allows manufacturers to prepare their supply chains for contract awards and commence production and assembly. Similarly, Europe's armed forces have limited the use of their vehicles and systems, which has allowed production capabilities of consumable components such as barrels to atrophy. With the possible exception of France, few European nations have used their howitzers enough in the past ten years to justify production of 155 mm and 120 mm barrels at scale. Orders

for new vehicles have kept these production lines alive but in a minimal form. The war in Ukraine has laid these challenges bare, since February 2022, there have been hundreds of land platforms ordered in Europe alone, an overview of some known orders for 2024 is provided in Table 1.

TABLE 1
Select major European land platform orders

Country	Vehicle family	Prime contractor	Quantity	Delivery date
Austria	Skyranger 30 on Pandur	Rheinmetall	36	2026
Bulgaria	IRIS-T SLM	Diehl Defence	n.k.	n.k.
Croatia	Leopard 2A8	KNDS Germany	50	Letter of intent
Denmark	CV9035 Mk IIIC	BAE Hägglunds	115	2026 – 2029
Denmark	Skyranger 30 turrets	Rheinmetall	16	2027 – 2028
Finland	Common Armoured Vehicle System (CAVS)	Patria	161	2025
France	Caesar Mk II	KNDS France	109	2026
Germany	UTF 5t and UTF 15t trucks	Rheinmetall	610	2024 onwards
Germany	Boxer Heavy Weapons Carrier	Rheinmetall	Up to 123	2025 onwards
Germany	Skyranger 30 on Boxer	Rheinmetall	19	2024
Germany	Leopard 2A8	KNDS Germany	105	2027 – 2030
Germany	HX Body Swap System trucks	Rheinmetall	1,515	2024
Germany	Carrier	KNDS Germany	22	2025 onwards
Italy	Carrier	Leonardo	132	2026 onwards
Lithuania	Carrier	KNDS Germany	46 (est)	by 2030
Lithuania	Carrier	BAE Hägglunds	>80 (est)	By 2030

Table 1 is far from comprehensive, and does not represent the totality of land platform orders that European manufacturers are facing. Hundreds more vehicles have been ordered since 2022 leading Tommy Gustaffson-Rask, to state, “just in time is dead, you need to plan differently, take more time, and work more proactively in the supply chain to manage it. COVID and the war in Ukraine have brought big changes to our supply chains,” in a press interview at Eurosatory 2024. At that point in June, Hägglunds had 450 CV90s on its order book as well as 700 of the BvS10 family, the company’s total order book exceeded EUR 6 billion, driving investment in its production plant with another EUR 300 million to be spent by 2027. “We need to realise that we are stretching the capacity to deliver all over Europe. There are three challenges: We have been supporting Ukraine, we have to replenish what we have sent to Ukraine, and for too long, we have had too little stock,” Gustaffson-Rask explained.

There are clues, provided in Table 1, as to how supply chain stresses can be minimised. One is a common procurement programme such as the Common Armoured Vehicle System (CAVS) 6x6 from Patria, for instance. The CAVS has been ordered by Latvia, Finland, and Sweden. Germany has also joined the consortium and may benefit from the developments put in place by the other members. Already, Patria has orders for more than 750 CAVS vehicles in different configurations and has opened a production facility in Latvia with capacity for production of around 30 vehicles per year. The CAVS vehicle is designed to be used as the base platform with user-specific additions such as a Kongsberg RS4 remote

weapon station (RWS) in the case of Sweden. However, the idea is to leave the core design of the vehicle untouched. “From a supplier point of view, it’s important to stress the fact that if you come to us with joint requirements, we can do a lot of the same. For example, Sweden is the lead

organisation in the procurement of Bvs [BvS10], and they are buying the same vehicles as the UK and Germany, they will add their own systems later,” Gustaffson-Rask said.



▲ **Pictured: Boxer Heavy Weapon Carrier. Some of the AFV procurements in Europe are now focused around a single vehicle type, as opposed to unique variants for each user. This simplifies supply chains and reduces production timelines. [Rheinmetall]**

The Boxer Heavy Weapons Carriers ordered by Germany follow this principle – they are much the same as the Australian Combat Reconnaissance Vehicle, and 100 of them will be built in Australia and exported to Germany from 2026. The Swedish and Danish orders for the

CV9035MkIIIC will come from the same production lot in the same standard, which uses the D-series turret design of the Dutch CV90 mid-life upgrade, with the same design selected for the Slovakian CV9035MkIV, 152 of which are to be delivered under a contract signed in 2022. In short, each country will receive vehicles built to a common standard that allows BAE Systems to seek out and exploit efficiencies within its supply chain – whether that is the bulk purchase of armoured steel or engines, or the expansion of warehousing facilities to store additional components and materials. The same is true of CAVS and Germany’s new Boxers, these orders mean a more simple supply chain that carries reduced risk, compared with one producing a range of different variants for different users. This is key for those European countries that would like their new vehicles to arrive in a short space of time, but it might mean compromising on requirements. “If you take 90% of your requirements, you can get your vehicles in time. But if you stick to 100% of your requirements, you might not get them until 2032,” Gustaffson-Rask added.

In a similar but connected vein, many users have settled on proven platforms in a modern format, the Leopard 2A8 is a prime example of this, with around 300 ordered in 2024 alone. They may not all be procured as Leopard 2A8s, but the base platform and turret have few differences between variants and with as many as 280 of them in the 2A8 standard, KNDS Germany will also be able to consolidate its supply chain around a single platform. However, the number of Leopard 2s that have been ordered will likely create some

Rheinmetall has expanded its production to meet the increased demand, and is expected to produce at least 100 155 mm barrels for the PzH2000 between 2024 and 2029 for an unspecified European country. The company is thought to be capable of producing up to 200 barrels in both 120 mm and 155 mm calibre per year, plenty to meet the current demand for Leopard 2 and PzH2000s, but the expansion of production into Italy will add further barrel production capacity. This is necessary to sustain the European Leopard 2 fleet, and may become critical if they must ever be used in anger.

So, it’s clear that Europe is working to boost its land platform fleets with around 1,600 vehicles ordered in 2024 from the contracts found for this article, not to mention the 2,500 or so logistics vehicles for the UK and Germany. Many are expected to be delivered by 2030, according to the initial contract announcements, which indicates that a period of intense growth must lie ahead for BAE Systems Hägglunds, KNDS Germany, Rheinmetall and Patria. “I think generally we can deliver to the customers, but maybe not in the time frame that customers are expecting,” Gustaffson-Rask said. One route to meet this need is through local partnerships, which Rheinmetall has already established in Hungary, and is in the process of doing in Romania. Similarly, BAE Systems Hägglunds has signed an agreement with Slovakian company Koval Systems for the production of D-Series turrets for Slovakia’s CV9035MkIV order. Additionally, Hägglunds has also signed an agreement with Norwegian company Ritek to produce two CV90 variants for Sweden – a forward maintenance vehicle and a combat engineer variant.



▲ **A collection of large-calibre barrels at Rheinmetall’s barrel production facility. As a consumable element of all land warfare platforms, it is essential that Europe is able to resource its barrel needs through stable domestic production from more as many countries as can be financially sustained. [Rheinmetall]**

friction within the supply chain. Barrel production is one issue that is often raised against the backdrop of the war in Ukraine. The scale and extent of the fighting led to the rapid deterioration of barrels for both howitzers and tanks, which in turn prompted an inward look at the West’s ability to replace them. Europe did not have many barrel production lines in 2022, with many reliant upon Rheinmetall for the ubiquitous 120 mm L44 or L55 gun that arms the Leopard 2 family. Many others, such as PzH2000 operators, and Poland with its Krabs, were also dependent on the German manufacturer to supply replacement barrels.

While European vehicle production is beginning to move into higher gear, other challenges remain, such as the production of sufficient quantities of ammunition. At present, meeting Europe’s ammunition demands very much requires new production lines, how is Europe meeting that demand?

‘Artillery is heaven falling to earth’

In 2022 a social media account run by a US veteran started posting accounts of the war from Ukrainian soldiers. One post recalled words to the effect that ‘Russian artillery was

like heaven falling to earth.' The soldier explained how terrifying a Russian bombardment was, how paralysis would descend over the most experienced soldiers as Russian shells crashed into their trenches. The Ukrainians fought back with their own massed artillery, expending thousands of shells and rockets stockpiled from the Soviet era and purchased from their neighbours. This helped stem the Russian advance and counter the massed fires of Russian divisions as they shifted from a war of manoeuvre to one where attrition was the order of the day. However, Ukraine quickly depleted its stockpiles of Soviet ammunition which led the West to begin supplying its NATO calibre systems and ammunition. War stocks were quickly emptied across Europe and the attendant supply chains groaned into life in a bid to replenish them. International efforts were quickly initiated to find suitable ammunition of both Soviet and NATO calibres abroad.

The matter was critical for Ukraine, the figures vary but Russian artillery has caused, and continues to cause up to 80% of Ukraine's combat casualties depending on where combat is focused. Ukraine in return has caused extensive damage to the Russian forces with its own artillery; it has destroyed thousands of Russian howitzers and prevented hundreds of advances. Suffice to say, artillery and the ammunition that enables it has been a critical tool in Ukraine, and resourcing that need has stressed the West's supply chains as it was found that there was insufficient capacity to increase production to meet dramatically increased needs.



▲ **The production of 155 mm artillery ammunition has come to be one of the main talking points of the war in Ukraine. The inability to fully meet Ukraine's need for the munition has contributed to the steady decline in the country's combat capabilities. [Office of the President of Ukraine]**

In response, Rheinmetall has opened or is working on at least three artillery ammunition factories as it works to meet the huge demand placed upon it for 155 mm ammunition. A new factory at the company's site in Unterlues is scheduled to be complete by early 2025 and due to provide an initial annual output of 50,000 shells, rising to 100,000 the year after and 200,000 thereafter, as well as 1,900 tonnes of RDX explosive per year, along with rocket motors and warheads. In 2024, Rheinmetall conducted the official takeover of

its 30 mm ammunition factory in Várpalota, Hungary and announced the start of construction of a new facility in Baisogala, Lithuania set to be operational by mid-2026, and planned to produce "tens of thousands" of 155 mm shells each year. The company is also working to establish an ammunition plant in Ukraine, and received a EUR 8.5 billion framework agreement from Germany in 2024 for artillery ammunition to replenish the country's stocks of 155 mm shells. Spain added to the order book with a framework agreement valued at EUR 205 million for up to 500,000 artillery charges. These developments, and many others mean that Rheinmetall has assessed the operating result of its weapons and ammunition business from Q1 to Q3 of 2024 to be EUR 339 million; for comparison, it was just 175 million euros for the same time period in 2023.

The French company Eurengo, which produces modular charges, nitrocellulose, and explosives for large calibre ammunition is expanding its production facilities in France. It is expanding production at many of its facilities with plans to produce up to one million modular charges per year from its Bergerac site. The company restarted production of nitrocellulose after an accident in 2022 shut production down,

▼ **Nitrocellulose production is key to many munitions, as it is used to make propellant. It requires cotton or wood pulp as the cellulose source, as well as Nitric and Sulphuric acid to turn the fibres of those materials into energy-dense nitrocellulose. [Eurengo]**



which will reduce European reliance on foreign suppliers in a supply chain that also feeds Russia's war machine. Eurengo has also stockpiled 18 months' worth of cotton to support nitrocellulose production, alongside additional supplies of wood pulp from France.

Meanwhile, BAE Systems in the UK is expanding its industrial footprint with an additional explosives filling facility at Glascoed in Wales subject to planning approval. The new facility will expand artillery ammunition output by eight times, according to BAE, although the starting point is rumoured to be relatively low. A new 155 mm shell machining line is being built in Washington in the UK, and BAE is also reinstating production of 30 mm ammunition – all under a GBP 2.4 billion partnering agreement signed with the British government in 2020.

In the Nordics, Nammo is to increase production of 155 mm shells, 120 mm tank rounds and rocket motors for AIM-120 AMRAAM missiles, for a minimum of 15 years under a EUR 86 million contract signed with the Norwegian government in July 2024. Nammo's Swedish factory has received funding from the EU's ASAP initiative as well as the Swedish government to triple its production of 155 mm ammunition, and the Finnish entity has also received funding to increase its output of 155 mm shells, nitrocellulose, and explosives. Also in Norway, Kongsberg has announced EUR 55 million in funding to support increased missile production, a move validated later in 2024 by the company's largest ever Naval Strike Missile (NSM) order, valued at EUR 850 million. Although the NSM order is for the US, increased production at Kongsberg will also benefit European states.

Missiles and complex weapons are of course a critical component of land warfare. Europe's decision to establish local production of Patriot PAC-2 GEM-T surface-to-air missiles (SAMs) at COMLOG (a joint venture between Raytheon and MBDA) is therefore a welcome one, with MBDA's Bayern-Chemie set to produce the first PAC-2 rocket motors by the end of 2026, returning a capability that was lost in 1996. Diehl is also working to expand its IRIS-T missile family footprint in Europe, and broke ground on a new facility at Nonnweiler at the end of October 2024, which is expected to be operational by the end of 2025. However, with all this expansion, companies must find raw materials and components, which will also come under pressure as the lower tiers of the defence supply chain adjust to new levels of demand. This is where synthetic environments may offer new benefits in supply chain management.

Synthetic environments and the future of supply chains

"There is an existential threat facing organisations from a lack of supply chain visibility. This threat is multifaceted, affecting operational efficiency, financial stability, ethical compliance, national security, and environmental sustainability," Hadean, a defence AI company specialising in synthetic environments told ESD via email. The company believes that 'supply chain situational awareness' can be established, allowing manufacturers to plan ahead and anticipate supply chain shocks caused by events at lower tiers. They could, for example, stockpile certain components if a risk to supply is identified

in time, or identify an alternative source. "Synthetic environments can handle the vast context of modern supply chains, allowing for comprehensive modelling and analysis without being limited by data volume or network complexity," Hadean said. These environments can also be used to run parallel simulations and conduct predictive analysis of the potential impact of any given disruption.

Many companies will have the capacity to conduct supply chain analysis in some form or another, but this will typically depend on human resources, and thus be inherently limited by the speed at which those humans can reply to any given request. The scale of a supply chain matters here – some microchip companies can sell millions of chips every week, making any comprehensive analysis impossible in a useful timeframe. "Synthetic environments can resolve this by both rapidly shortening the process time of question to answer, sometimes by removing, replacing or augmenting the Request and Analysis steps with AI, and in most cases, reducing the need for further questions through visualisation and enhanced understanding of insights," Hadean explained. The potential for synthetic environments is relatively clear; many industries failed to appreciate the impact that COVID 19 would have on their supply chains, because predicting 'black swan' events is essentially impossible. However, building the tools to conduct analysis as a disruption emerges would be beneficial.

However, there's a catch, "sharing data (a proprietary asset) with your extended supply chain would ultimately be beneficial but companies are often reluctant to do so due to concerns about data security, confidentiality, and competitive advantage. Sharing proprietary information with external partners can expose sensitive business insights, intellectual property, and strategic plans to potential risks such as data breaches or misuse," Hadean said. This means that companies in the synthetic environment space must build trust with their potential stakeholders and develop clear and secure frameworks for using company data. If, however, it is possible for Europe's supply chains to be simulated, then it may prove a worthy investment. Recent analysis from Ukrainian think-tanks indicates that Russia is increasingly reliant on China for much of its defence needs, especially for machine tools and microchips. If Europe has similar dependencies, it would do well to identify them through data-sharing, and at least simulate the potential disruption should those dependencies come to be exploited or disrupted by an adversary.

Overall, there is plenty to inspire hope in Europe's defence production. Billions of Euros have been invested into new vehicles, replenishing ammunition stocks, and standing up production lines that fell dormant in the 1990s. It seems likely that at this pace, Europe will be well-placed to meet most of its land warfare needs by 2030 – at least in a material sense. Much will depend on the political will to maintain cohesion between states, and to provide ongoing support for these new supply chains or face losing them once more.

◀ **The IRIS-T SLM air defence system has been ordered by several European countries under the European Sky Shield Initiative (ESSI).** [Diehl Defence]



Finland and CBRN Defence

Dan Kaszeta

As Europe's geopolitical landscape shifts, Finland stands out not just for bringing crucial conventional capabilities to the NATO alliance, but also as a key player in mitigating chemical, biological, radiological, and nuclear (CBRN) threats, with a comprehensive network of military, civil, and industrial capabilities in this sphere.

NATO's new member in the far north, Finland, spent decades being somewhat ignored in European defence. For decades, defence issues in Finland did not get much coverage in the West, aside from the perennial presence of Finns in UN peacekeeping operations. With the accession of Finland (along with its neighbour Sweden) to the North Atlantic alliance, there have been awakenings. Finland is keenly aware of the threat posed by its Russian neighbour, both directly and collectively to the EU, of which it is a member. The rest of Europe is awakening to the fact that, with Sweden and Finland now in NATO, the Baltic Sea is practically a NATO lake and that the alliance has now added over 1,300 km of land frontier with Russia.

Far from being a liability that needs to be defended, the addition of Finland brings massive capability to the West. Finland operates on a national mobilisation scheme whereby much of the population does military service and serves as reservists, supporting a smaller but highly professional regular cadre. It can put nearly 300,000 troops into the field if a national mobilisation is declared. Standards of training and equipment are very high and there is a national culture of supporting defence. Brave and skilled resistance to Soviet invasion in the 1939-1940 Winter War is part of the national memory. Finland practices a 'total defence' strategy and is prepared to make any invader (and, geopolitically, there's only one realistic candidate) pay dearly for every inch of Finland. Yet how well does Finland take CBRN threats into consideration? Fairly well, as it turns out.

Finnish Defence Forces and CBRN

The Finnish Army is equipped and trained to modern European military CBRN standards. The foremost battlefield threat in the CBRN spectrum is likely to be chemical attack, and Finland's cool climate mitigates that threat substantially for much of the year, as many chemical threats become solids at

low temperature, with little tactical use. However, the ethos of total defence does not permit the threat to be relegated, so CBRN equipment and training permeates both the active and reserve forces to a degree better than many other militaries. Training and equipment at the individual troop level is generally good, and CBRN officers and NCOs are of a high standard in NATO. Accession to NATO has not meant that Finland needed to come up to standard in CBRN; rather, its accession has likely raised the NATO average.



▲ **Finnish soldiers assigned to the Satakunta Jaeger Battalion, decontaminate a U.S. Soldier assigned to the 4th Squadron, 10th Cavalry Regiment, 3rd Armored Brigade Combat Team, 4th Infantry Division, during Finnish CBRN defence training at Säkylä, Finland, on 13 July 2022. [US Army/Sgt Andrew Greenwood]**

The Finnish Defence Forces maintain the Centre of Excellence for CBRN Defence serves as the CBRN school, promulgator of procedures and doctrine, and the centre of military CBRN expertise. As well as the Centre, there are two main operational units. One of two main deployable military CBRN defence units is the CBRN company that is assigned to the Finnish Army's Pori Brigade. The Pori Brigade is one of the primary combat formations of the Finnish Army. The other deployable asset is a mobile CBRN laboratory. It was developed to NATO standards long before Finnish accession to NATO was being seriously considered. Both the company and the laboratory have deployed internationally on exercises. Finland's Centre for Military Medicine provides medical expertise for CBRN scenarios and Finland's defence research centre PVTUTKL provides technical support as well, such as testing and evaluation.

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Finnish CBRN defence capability is routinely demonstrated in national and international exercises. Long before joining NATO, Finland was part of NATO's Partnership for Peace and frequent observer at and occasional participant in multilateral CBRN exercises over the years. In recent years, Finland has hosted the RECCEX series of Nordic military exercises with Sweden, Norway, and Denmark. These have had a strong CBRN component. Finnish CBRN elements have been present at NATO exercises. For example, Finnish CBRN specialists were at the Precise Response 2020/4 NATO CBRN exercise in Canada.

Civil resilience and CBRN threats

The Finnish military CBRN posture is part of a broader national context. Finland's 'total defence' strategy is not just a military defensive strategy; it is a broad over-arching framework that embeds crisis management into public institutions. The same frameworks that can mobilise the country for war can also mobilise for civil response. The Finns have made it national policy to consider CBRN threats. A national CBRNE policy was announced in 2017 by the Finnish Ministry of the Interior. By the standards of such things, and your correspondent has spent decades reading such documents, it is reasonably coherent and a good statement of policy. Furthermore, Finland has a deservedly good reputation for governance, so there is a high probability that sound practices have been implemented following promulgation of this national strategy document.



▲ **Finnish medical staff practicing on a dummy patient while operating in a mock CBRN environment in Oulu, Finland, during April 2024. [Dan Kaszeta]**

It is important to note that terrorism and warfare are not the only scenarios of concern to Finland. Finland remembers all too well the nuclear accident at Chernobyl in 1986 and certainly some nuclear power plants are closer to Finland than Chernobyl. Various measures have been taken to implement relevant nuclear and radiological countermeasures. As one example, the Finnish Police Board announced procurement of radiation detection instruments in 2021. In another example, Finland has robust radiation detection and identification technology in use at its various borders and ports. As well as taking due regard for nuclear and radiological incidents, accidents involving hazardous materials in commerce, industry, and transportation are considered a significant risk as well. Given Finland's role as a hub in international air freight logistics, this is a reasonable consideration. Finland's border control agency contains the country's coast guard and is responsible for hazardous materials incidents in Finland's Baltic water.

▼ **Finnish ambulance crews and hospital staff demonstrating medical tasks in CBRN environments in Oulu, Finland, during April 2024. [Dan Kaszeta]**



Civil CBRN response relies heavily on medical providers. Emergency medical care, at the ambulance and paramedic level and at the hospital level, is very important in response to many kinds of CBRN incidents. In April 2024, your correspondent was privileged to attend and observe civil-sector CBRN training at the FINNEM emergency medicine conference in Oulu, Finland. The training and discussions at the conference left an overall impression that CBRN scenarios are taken seriously in the medical sector, and the hospital exercise (pictured) was excellent. For example, CBRN PPE and hospital decontamination procedures were well-demonstrated. There have been significant efforts to get training, awareness, and equipment out to police, fire, and emergency medical responders across the country. In early 2024, a grant of over EUR 400,000 went to the Helsinki fire and rescue department to help preparedness efforts in Finland's capital and largest city.

Another aspect of CBRN resilience is the intensive programme of civil defence shelters. Unlike many other countries who abandoned plans to shelter their population in the event of catastrophic warfare, such as nuclear war, Finland has maintained a robust shelter programme for protection of the broader population. Finnish statistics indicate (as of early 2022) a staggering number of shelters still in service – over 50,000, together capable of sheltering over four million people. Most are dual-use facilities, such as sports centres, parking garages, and storage. Readiness varies, but government policy is to ensure that shelters, which are largely the responsibility of building owners, are ready with 72 hours of notice. Many shelters, but certainly not all of them, have various types of CBRN filtration installed in them. Sources in the Finnish private sector claim that perhaps a fifth of the shelter capacity requires some serious upgrades.

Finland and international CBRN support

Finland has other useful capabilities which have helped out in CBRN-related issues on the world stage. For example, Finland assisted the world community's efforts to remove chemical weapons from Syria. This was based in part on the repository of knowledge at a venerable research institute. The oldest and possibly most significant of Finland's CBRN capabilities is the chemical laboratory VERIFIN, located in Helsinki. VERIFIN's full name in English is 'The Finnish Institute for Verification of the Chemical Weapons Convention', and it was spun off from the chemistry department of the University of Helsinki in the early 1990s. It is

part of the Organisation for the Prohibition of Chemical Weapons (OPCW) network of laboratories and represents a gold-standard level of analytical support for investigating possible incidents of chemical weapons use. Scientists at VERIFIN have helped with a number of chemical weapons investigations. VERIFIN develops and promulgates the 'Blue Book', a widely-respected handbook on chemical weapons forensic procedures. The Blue Book is now into its 23rd edition. Furthermore, VERIFIN has provided training for experts from other parts of the world. As of the end of 2023, VERIFIN has provided training to 1,910 trainees from 141 countries. The bulk of these students have been from the developing world. VERIFIN is also an active participant in collaborative international research projects relevant to CBRN defence such as Horizon 2020 and Horizon Europe projects.

An example that combines both international cooperation and domestic preparedness was the Toxi-Triage Horizon 2020 project. It was led by the UK's Loughborough University, but had three Finnish partners. The capstone was 'Exercise Disperse' in Mikkeli, Finland. This demonstrated numerous incident management technologies and techniques at a mass-casualty exercise of a Chlorine disaster in Mikkeli, Finland in 2019.

Another internationally-significant Finnish capability is the RescEU project. RescEU is an EU-funded project to stockpile emergency supplies for a variety of contingencies and disasters, including CBRN scenarios. The CBRN element of RescEU, which cost EUR 242 million over several financial



▲ Finnish paramedics use Lego to practice fine motor skills while wearing CBRN PPE. [Otso Ollikainen]

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▼ **Finnish-made Environics chemical warfare agent detector in service with Turkish CBRN responders.**
[Dan Kaszeta]



years, is located in Finland. This stockpile is intended for international deployment, either within EU states or around the world. It contains protection, detection, medical treatment, and decontamination items and has been one of the largest CBRN equipment procurements in Europe in recent years. Strikingly, and in one of the more useful developments CBRN response, Finland also has over 60 deployable instructors and experts who can deploy with the equipment to provide training on its use.

The CBRN industry in Finland

Decades of official neutrality meant that Finland devoted significant effort to development of a defence-industrial complex that was independent from both East and West in the Cold War. This spirit of independence extended to most segments of the defence market, including CBRN protection goods. Not all of this effort has survived into the modern era. For example, Nokia, famous in prior decades for mobile phones, produced the venerable M61 CBRN mask, itself a reasonable copy of the USA's M9 mask, throughout the Cold War. However, the M61 was replaced in the 1990s by the Scott M95. In a similar vein, Kemira, the chemical firm, had previously produced mask filters. Yet now Finland buys its masks from outside Finland.

CBRN remains a niche market well served by Finland, with several Finnish companies still very active in the CBRN space. For decades, the Finnish company Environics has been

a major player in chemical warfare detection, fielding a family of ionisation-based detectors. For decades, Environics has vied with its rivals Bruker Daltonics (Germany) and Smiths Detection (UK) in this competitive market segment. For decades, their ChemPro handheld chemical warfare agent detector has been a stalwart competitor in the military chemical warfare detection space. By volume, it has lost out to the Smiths Detection LCD series (which is bought by the tens of thousands of units as the US JCAD), but it is a viable competitor for second place in that market.

Environics has a fair bit of integration experience and has put its systems into naval and armoured vehicle platforms. Their 'X-system' is designed to put chemical, biological, and radiological detection onto naval vessels. In 2023, Environics merged with Bertin, the long-respected French CBRN company, and they are now known as Bertin-Environics. The combined company is a serious player on the European CBRN stage.

The lengthy experience with development and construction of government and public shelters meant that an industry developed to support this activity. A key actor here is Temet Oy. Based in Helsinki and Espoo, they are one of the world's leading companies for the various components of shelter and bunker systems. As well as the various blast protection and support systems for shelters and bunkers, such as blast valves, blast doors, and ground shock isolation, Temet produces CBRN filtration and the necessary accessories. Verona Shelters, based in Helsinki, is also active in this segment. Clearly, the domestic shelter programme has produced industrial players than can also export these capabilities.

Other Finnish companies, many of which are SMEs, are also active in the CBRN space. Millog, the Finnish logistics company, provides CBRN logistics, equipment maintenance, and specialist calibration services. For example, they service protective masks made by Scott and Avon. IC2 Feenix, based in Kuopio, is active in CBRN textiles and produces items such as storage containers and patient isolation pods. The latter are designed for moving patients in CBRN situations. Gasmot produces gas and vapour analysis equipment, useful in hazardous materials incidents. Mavatech operates in the decontamination space. On a per capita basis, Finland has a robust CBRN industry.

Although it is not a CBRN company, it is nonetheless worth mentioning Patria. The largest component of Finland's defence industry and a keen exporter of armoured vehicles, Patria wheeled APCs are in service with many countries. CBRN recce variants of Patria vehicles have been produced, and Patria has worked with CBRN industry firms to incorporate systems into Patria platforms.

The rest of the world could do far worse than to look at Finland as an exemplar in CBRN. While, like everywhere, there is certainly room for improvement, your correspondent has been looking at Finnish CBRN affairs for 15 years, and has fewer worries there than in much of the rest of the world.

Nightmare scenario

Thomas Withington

With the re-election of US President Donald Trump, questions regarding the transatlantic relationship between the US and Europe have once again come to the forefront, including the extent to which the US needs Europe. A sober reading shows that the US has good reason to remain engaged in Europe; most notably, US security depends on various military facilities in Europe to provide detection, tracking and interception capabilities for its ballistic missile defence.

The Continental United States (CONUS) faces potential ballistic missile threats from the Democratic People's Republic of Korea (DPRK), the People's Republic of China (PRC) and the Russian Federation. Elsewhere, other US interests face ballistic missile threats from the Islamic Republic of Iran, as noted in a Stratfor analysis summarising the estimated maximum ranges of Iran's ballistic missiles. The analysis noted that Iran's Khorramshahr-4 medium-range ballistic missile (MRBM) has a possible range of almost 2,000 km. While insufficient to hit CONUS targets, such a missile could still threaten US interests in the Middle East, with US ally Israel well within range.

The American Security Project, a Washington DC-based think tank, assert that the US deploys forces to approximately 30 bases spread across Bahrain, Djibouti, Egypt, Iraq, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. All these bases are at potential risk from attack by weapons such as the Khorramshahr-4, as well as other types of ballistic missile possessed by the DPRK, PRC, and Russia. For example, the Centre for Strategic and International Studies (CSIS), another Washington DC think tank, estimates the DPRK's KN-22 Hwasong-15 to have a range of 13,000 km. CSIS assesses the PRC's DF-5 intercontinental ballistic missile (ICBM) having a similar range. Russia's RS-28 Sarmat (NATO reporting name SS-X-29/30) has a range of 10,000-18,000 km, CSIS estimates.

A general rule-of-thumb states that ICBM flight trajectories follow the so-called Great Circle Route which exploits the shortest distance between two points on Earth. It would take another article to explain the trigonometry of the Great Cir-

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cle Route but to understand how the route works, consider this example. Russia has an ICBM base at Yoshkar-Ola in the West of the country. According to the March 2022 *Bulletin of the Atomic Scientists Nuclear Notebook*, this facility is home to the 14th Missile Division. The division comprises the 290th, 697th and 779th Missile Regiments. Each regiment has nine MZKT-79221 heavy trucks capable of deploying and launching RT-2PM2 Topol-M (NATO reporting name: SS-27 Sickle-B) ICBMs. Open sources state these missiles have a range of 11,000 km and travel at a top speed of 27,100 km/h.



▲ **A Russian Strategic Rocket Force RT-2PM2 Topol-M ICBM on its 15U175 transporter erector launcher (TEL). Being based on a mobile wheeled platform allows Russia to launch these missiles from remote locations, making the precise launch location difficult to predict. [RecoMonkey]**

Suppose that the US and Russia were on the brink of nuclear war. The 14th Missile Division's regiments would be deployed into the Russian countryside from their base. This is a standard tactic to reduce the chances of the division being destroyed should a pre-emptive nuclear strike on the facilities in Yoshkar-Ola occur. Deploying the regiments in this way keeps the trucks mobile, making them easier to camouflage and harder to locate. Once the trucks have launched their missiles, they can relocate to a safe area to reduce the chances of being destroyed in a retaliatory attack. Let's assume that one SS-27 launcher has deployed to Pizhma, around 141 km north-northwest of Yoshkar-Ola. The missile's target is McGuire airbase, New Jersey. The ICBM must travel 7,844 km to reach its target. The Topol-M is thought to carry a single 800 kt warhead, equivalent to 800,000 tonnes of TNT. The aimpoint is between the base's north-south runway 18/36 and northeast-southwest runway 06/24. The missile is fuzed for a surface burst with the intention of causing



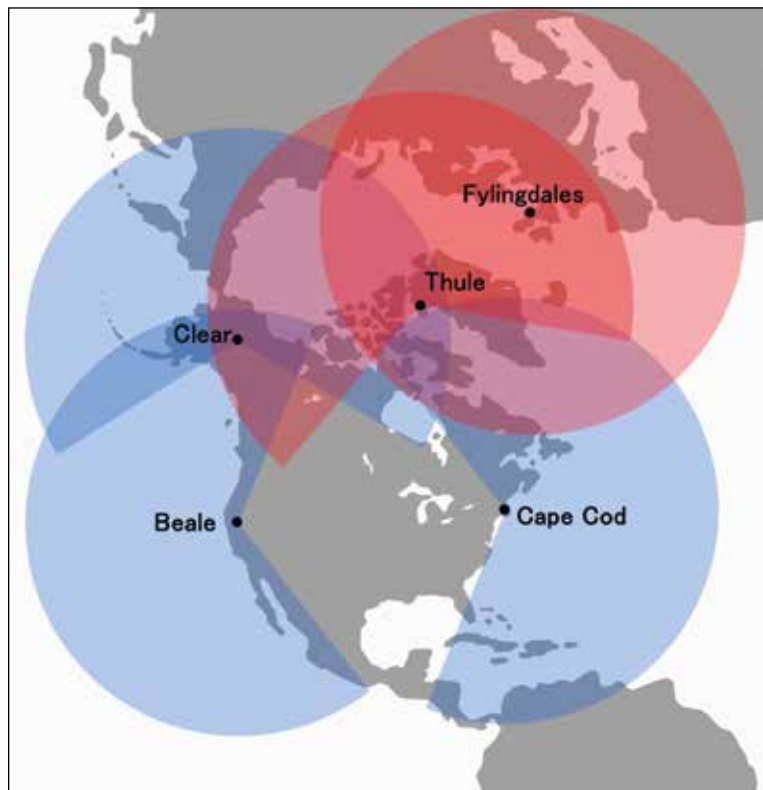
- ◀ The hypothetical trajectory of the Topol-M ICBM from its launch near Pizhma in western Russia to its target of McGuire Air Base, New Jersey. The flight would probably take around 20 minutes. [Google Earth]

maximum destruction at the base. According to a simulation performed using the nuclearsecrecy.com website, the detonation would immediately kill approximately 10,640 people and injure 14,530. The resulting fireball would have a radius of almost 1.3 km. Anyone within a 9.7 km radius of the fireball would suffer third-degree burns and those within 2.4 km of ground zero, who had survived the initial attack, are likely to perish through acute radiation sickness within one month. Radioactive fallout could drift as far as Boston, around 388 km (241 miles) northeast of ground zero.

Receiving early warning of such an incoming attack against a target in the CONUS is obviously paramount. The Topol-M in this scenario would cover the 7,844 km range in approximately 20 minutes. The missile would likely follow the shortest route between launch point and target. The route would see the missile heading into space and flying across north-western Russia, following a trajectory across Finland, Sweden and Norway, and between Iceland and Greenland. The missile would then fly over the Canadian province of Newfoundland and Labrador, skirt southeastern Quebec and cross Maine, Vermont and Connecticut before reaching its target.

Initial detection of the incoming missile would be made by the US Space Force's SBIRS (Space-Based Infrared System), which is a constellation of satellites designed to detect the hot exhaust plume of a ballistic missile as it heads into space. Once the constellation has detected the Topol-M's plume, the target would need to be confirmed by radar. The Royal Air Force (RAF) has a Raytheon AN/FPS-132 ultra-high frequency (UHF) 420-450 MHz ballistic missile detection and tracking radar with a published range of 4,800 km and is located on Fylingdales Moor in north-east England. According to the RAF's website, the AN/FPS-132 at Fylingdales provides "a continuous ballistic missile early warning service to the United Kingdom and US Governments ensuring a surprise missile attack cannot succeed". RAF Fylingdales shares its radar picture with the US-Canadian North American Air Defence Command (NORAD), which protects Canada and the CONUS against air and ballistic missile attack. The AN/FPS-132 is likely to be one of the first radars to see

the Topol-M as it appears above the horizon on its way into space. Next, a US Space Force AN/FPS-132 based at Thule, western Greenland, will provide additional confirmation on the ICBM some minutes later. NORAD is then likely to activate the US Ballistic Missile Defence (BMD) infrastructure in an attempt to engage and destroy the Topol-M before it reaches McGuire. With a flight time of around 20 minutes, every second counts.



- ▶ This graphic produced by the US Missile Defence Agency gives a useful indication of the footprint of the AN/FPS-132 ballistic missile early warning radars at RAF Fylingdales and Thule in Greenland. [MDA]

Naval ballistic missile defence

American kinetic BMD assets include US Navy *Ticonderoga* class cruisers and *Arleigh Burke* class destroyers, equipped with Lockheed Martin's Aegis BMD variant of the well-known Combat Management System (CMS). These ships possess one surface-to-air missile (SAM) type which could notionally intercept the Topol-M during the midcourse phase: Raytheon's RIM-161D Standard Missile-3 Block IIA (SM-3 Blk IIA); though it should be noted that the manufacturer only announced that the missile had entered full-rate production on 15 October 2024, and as such it is likely that most vessels lack the SM-3 Blk IIA in their loadout for the time being. The missile uses infrared (IR) homing for terminal guidance, supplemented by a combined global positioning system (GPS) and inertial navigation system for the flyout.

Europe is also advancing its missile defence capabilities as evidenced in October 2024, when the first successful launch of Eurosam's Aster-30B1NT SAM was reported to have taken place in France. The reports continued that the Aster-30B1NT can engage ballistic missiles with ranges of up to 1,500 km – this category would include short-range ballistic missiles (SRBMs) and some medium-range ballistic missiles (MRBMs). Furthermore, the missile's Ka-band (33.4-36 GHz) radar seeker can be reported to be capable of differentiating between ballistic missile warheads and decoys. Aster-30B1NT SAMs will equip the Horizon class destroyers of the French and Italian navies, and the Royal Navy's Type-45/Daring class destroyers. French and Italian Eurosam SAMP/T NG long-range, high-altitude SAM batteries will also receive this new missile.

Aegis Ashore

Upon receiving confirmation that the Topol-M is incoming, US decision-makers have another option to intercept the missile beyond naval vessels. The Aegis BMD CMS forms

the basis for the command and control system for the US Aegis Ashore facilities in Europe. Much like the aforementioned US Navy warships, Aegis Ashore uses Lockheed Martin's AN/SPY-1 series S-band (2.3-2.5 GHz/2.7-3.7 GHz) naval surveillance radars to detect and track ballistic missiles as they appear above the horizon, and is armed with SM-3 series SAMs for interception. Two Aegis Ashore facilities are based in Europe, the first located in Deveselu, southern Romania, which was declared operational in May 2016. The second is located at Redzikowo airbase in northern Poland, which was declared active in June 2024. The elements of the US BMD system are networked using secure fibre optics, conventional telecommunications and satellite communications. In a hypothetical scenario such as the aforementioned Topol-M attack, it is possible that the Aegis Ashore facility in Redzikowo would be among the first assets to detect the launch, and could be used for an initial attempt to intercept the Topol-M. Should this prove unsuccessful, BMD-capable naval assets could be used downrange for additional attempts.

US ballistic missile defence assets are also deployed to Türkiye, another NATO member and home to a Raytheon AN/TPY-2 X-band (8.5-10.68 GHz) ground-based air surveillance radar. Publicly available sources state that the radar has a range of circa 1,000 km. A single system is deployed by the US Army at Kürecik Radar Station in south-eastern Türkiye, with the radar keeping watch for ballistic missile launches from Iran against US targets in the Middle East. It is worth mentioning that additional protection can be provided by Aegis BMD CMS US Navy vessels in the Mediterranean and Black Sea. The US maintains a deployment of such ships at the *Armada* (Spanish Navy) base at Rota on Spain's southern Atlantic coast. Forward-deployed BMD assets such as the AN/TPY-2 in Romania, along with a similar system deployed in Israel, could confirm a ballistic missile launch from Iran. An initial interception could then be attempted by US Navy vessels in these bodies of water.



◀ **Aegis Ashore Missile Defence System Poland at Naval Support Facility Redzikowo, on 15 May 2024. [US Navy/Ashleigh Whitney]**

Weighing the benefit

As outlined, US ballistic missile defence benefits heavily from facilities in Poland, Romania, Spain, Türkiye, and the United Kingdom. All these bases play a vital role in providing the early detection of ballistic missile threats, including those heading toward targets in CONUS, and provide an early opportunity to deal with such threats kinetically. Remove any one of these elements, and the BMD protection of the eastern US will be degraded.

The European-US defence relationship came under scrutiny during the previous Trump administration between 2017 and 2021. related to what President Trump saw as an imbalance between US spending on defence, compared to that of other Alliance members. Trump arguably had a point, because at the time only a few NATO members met the non-binding requirement to spend a minimum of 2% of their GDP annually on defence. According to NATO's own figures, as of 2024, 23 of the Alliance's 32 members now meet or exceed this figure. This is a step in the right direction and it would not be surprising if further increases occurred in the future. Regardless of the path of the war in Ukraine, the threat posed to NATO by Russian revanchism is not dissipating. As a result, defence budgets across Europe show little sign of reducing.

However, the hard work of several European nations to meet these GDP targets appears to have done little to assuage Trump's anger. In February 2024, he revealed that during his first term he had argued with an unnamed NATO ally, adding that he told that head of government he would encourage Russia "to do whatever the hell they want" to "delinquent" Alliance members not spending their dues. Arguably, his comments undermined NATO's collective security pledge enshrined in Article 5 of the 1949 Atlantic Treaty, which stipulates that "if (an ally) is the victim of an armed attack, each and every other member of the Alliance will consider this act of violence as an armed attack against all members and will take the actions it deems necessary to assist the Ally attacked." Article 5 was famously declared by NATO in the wake of the 11 September 2001 Al Qaeda attacks against New York and Washington. European NATO Allies later deployed to Afghanistan and Iraq in support of subsequent counter-insurgency campaigns there. A total of 1,145 Allied troops would lose their lives fighting in Afghanistan alone.

The danger is that any threat to leave the Alliance or actual withdrawal by the US could have a profound effect on US security, notably in the ballistic missile defence realm. What happens if the Trump Administration had a major disagreement with some Alliance members, or the Alliance as a whole? Would countries hosting key elements of the US BMD infrastructure ask for those facilities to be removed, or refuse permission for them to be used in times of crisis? This is no idle threat. In 1967, French President Gaulle took his country's military out of NATO's integrated military structure and also demanded that NATO and US units on French soil leave the country. Although not a NATO operation, the governments of France and Germany refused to deploy troops to Iraq in 2003 to help the US oust Iraq's dictator Saddam Hussein. Likewise, the UK refused to deploy forces to aid the US in the Vietnam War between 1965 and 1975. Trump may have said he would encourage Russian aggression against those not paying their dues in a fit of pique, but his administration should be cautious that any weakening of the Alliance by the US, could trigger a response in kind from Europe's NATO members. In such a situation, the loser would not just be Europe, but potentially the US' fundamental ability to protect itself.



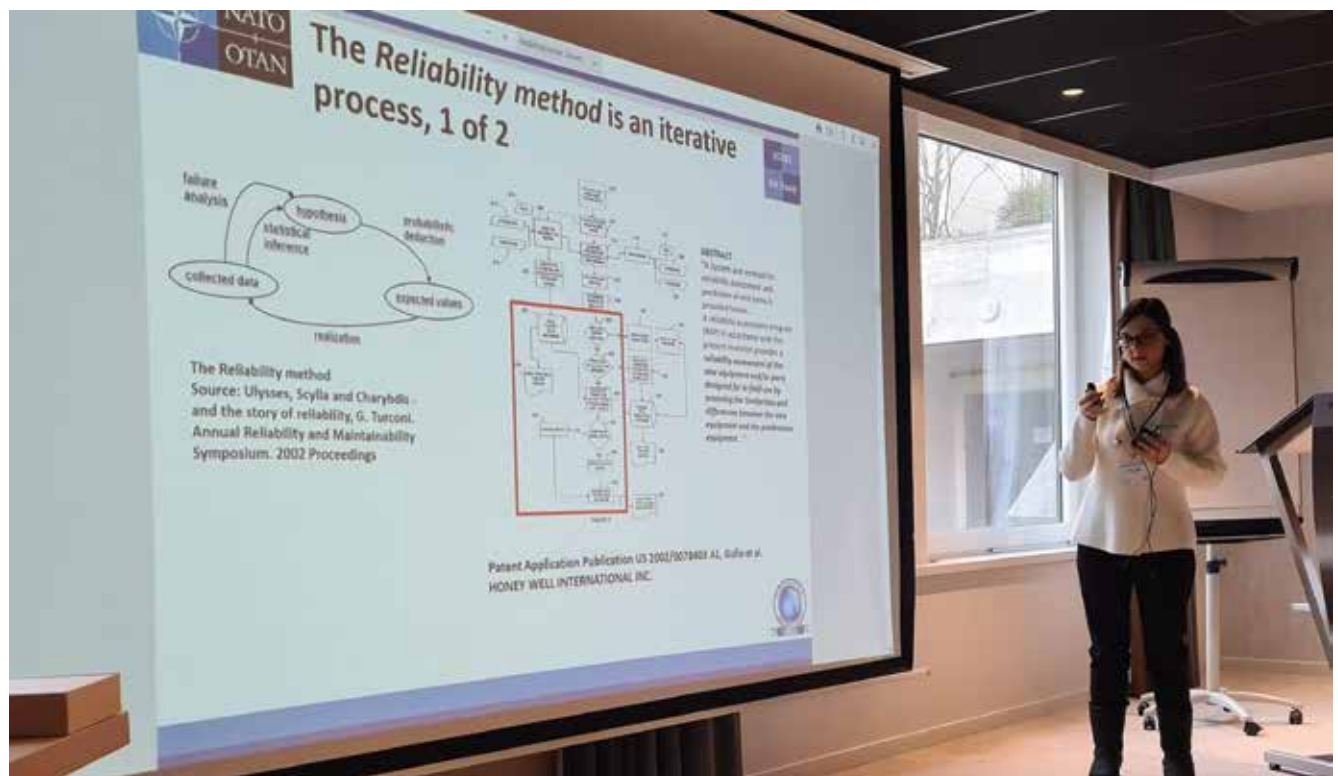
▲ Aegis Ashore Missile Defence System Romania, at Deveselu, on 14 October 2021.
[US Navy/GM] Andrew Brown]

20 years of NATO Life Cycle Management: Looking back, moving forward, facing new challenges

Manuela Tudosia

Marking 20 years of NATO Life Cycle Management (LCM), the 20th edition of the NATO LCM Conference will be held on 21 and 22 January 2025 in Brussels. Gathering numerous government and industry representatives, and chaired by Thomas Espelund Pedersen (Danish Defence Acquisition and Logistics Organisation) and J. Bo Leimand (LEIMAND Freelance Consultancy), the conference has evolved to become a major reference for NATO-industry dialogue on LCM.

The creation of the NATO Life Cycle Management Group (NATO AC/327) in 2003 and the definition of a System Life Cycle Management (SLCM) policy in the years that followed was emboldened by the major NATO transformation process launched at the 2002 Prague Summit. Guided by a capability-based approach: "The aim of SLCM is to optimise defence capabilities over the life cycle of the system by taking into account performance, cost, schedule, quality,



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▲ A speaker at the 2024 edition gives their presentation. [MRV]

operational environments, integrated logistic support, and obsolescence. It facilitates interoperability, communication, collaboration, and cooperation, while minimising total life cycle cost."

Besides dialogue with the NATO Strategic Commands and the NATO agencies, dialogue with and input from industry

to support development of LCM standards has also matured during the 2000s, thanks to the mechanisms of interface with the NATO Industrial Advisory Group (NIAG), as well as with other organisations and fora that can inform about industry standards and practices.

At a time when – as highlighted in the NATO 2024 Washington Summit Declaration – security is crucial, and two decades have passed since the first LCM conference, the 2025 edition will host discussions on current LCM improvements and innovations that address both constant SLCM objectives and evolving LCM approaches enabled by technology and digital transformation.

Updates from NATO and NATO agencies

Taking stock of current LCM approaches and key activities in NATO and beyond, the conference will feature not only high-level representatives from the NATO Support and Procurement Agency (NSPA), the NATO AC/327, the Allied Command Transformation (ACT), but also academia.

Allan McLeod (Director, NSPA) will provide an overview of LCM at NSPA in a keynote speech while Deniz Gizem Özkan (Chair, AC/327) will update on the AC/327 group's activities. Andreas Kirchhofer (Vice Chair, NIAG Industry Interface Group to AC/327) will elaborate on the mechanisms of interface with industry and the role of the NATO Industrial Interface Group (NIIG).

Barbara Craib (ACT) will address ACT's progress in establishing Requirements Traceability through life for NATO common funded capabilities.

The quest to optimise life-cycle costs and maximise operational availability

Alongside development of the NATO Programme Management Model (AAP-20) – providing the framework for the NATO life cycle model – and the NATO System Life Cycle

Processes (AAP-48) in the 2000s, the importance of forecasting Life Cycle Costs to inform important procurement decisions emerged as a key topic during the same period. Tools, best practices and processes to collect life cycle cost data started to develop, and industry shared knowledge and experience on this topic since the very beginning.

As computing power and technology have enabled the transition from collecting data to analysing, modelling and optimisation, especially in the last decade, the ability to offer increasingly sophisticated and innovative solutions is commensurate. This ability, expected to be exponentially increased by fast-growing use of AI, empowers a lifecycle perspective, including more accurate predictions of system performance throughout the life cycle and corresponding cost optimisation. Data modelling and simulation also enables a paradigm shift in the development of new systems, making it possible to predict performance and optimise life cycle costs right from the design phase.

This year's anniversary conference is rich in insights regarding optimisation of system performance and life cycle costs.

Setting the tone for a life cycle perspective, Leo Vanhatalo (Insta ILS OY) will share experiences from the strategic partnership between the Finnish Defence Forces and industry in the field of avionics MRO services. He will show how performance of systems means more than just repairing and how Insta's life cycle services start at the time of system acquisition by planning with the acquirer a maintenance concept and the security of supply requirements.

Cost effectiveness through the life cycle will be addressed by Younes Lousseief and Oskar Tengö (Systecon) with an approach of integrated analysis capabilities. They will share how integrated modelling and analysis can facilitate a holistic perspective on LCM. Looking at the path from data to decision, they will also explain how information from different sources and formats can be ingested, tweaked and merged to form a model which can be used in different analytical approaches for different purposes through the life cycle.

Dr Sanathanan Rajagopal and Del Roberts (Sirius Analysis) will remind about the importance of adopting a total cost of ownership approach and present innovative ways to undertake cost estimation from the early stages of the project life cycle to the end of the project, including sustainment and disposal. They will elaborate on Parametric, Bottom up, Analogy and use of Artificial Intelligence and Machine Learning, as well as its advantages and disadvantages.



- ▲ The conference provides ample opportunity for sharing knowledge and networking. [MRV]

Integrated Life Cycle Support and multinational cooperation

The NATO Guidance for Integrated Life Cycle Support (ALP-10) has always been a key enabler of interoperability in NATO. Every revision has added another brick to this important SCLM objective, which is all the more critical for complex multinational programmes.



▲ The LCM conference highlights cutting-edge trends in the world of life cycle management. [MRV]

During the first day of the conference, Hannu Kenttämies and Atte Hytönen (Patria Oy) will share how Multinational Life Cycle Management is implemented in the Common Armoured Vehicle System (CAVS) programme, and Ian Knight (Ilias Solutions) will provide insights on how the company's support for Ukraine's F-16 fleet management is being expanded to other platforms.

Focusing on obsolescence, Dalila Onorati (Elettronica S.p.A.) will present the development of an in-house tool for Digital Obsolescence Management named DOM.

Inspired by greater data collection capabilities, LCM discussions during the last decade have tackled the emergence of Product Life Cycle Support (PLCS) data models presented as a concept, later as use cases, and then as a natural tool in presentations and discussions regarding exchange and use of data.

Representing Eurostep AB, known for its contribution to "designing and delivering major parts of the STEP/PLCS standard", Mattias Larsson will address the challenge of "data debt" – or availability of reliable product data – and how this impacts decision-making and, ultimately, the achievement of a coherent and unified view of a product's definition throughout its entire life cycle. Sharing experiences on working with Integrated Life Cycle Support, he will convey how his organisation believes that cooperation-related issues should be addressed to streamline LCM operations.

Emerging trends

Digital transformation enables ever more sophisticated, interconnected and integrated systems-of-systems, and complex operations in the multi-domain space. LCM processes need, therefore, to keep up with the opportunities but also the challenges brought about by these developments, for example, transitioning from managing stand-alone systems to managing interconnected systems. Considering today's context characterised by collaboration across nations, industries and technology disciplines, and the multi-domain environment, Alex Perkins and James Wood (Deloitte) will introduce Deloitte's vision for Digital Engineering across the Defence Asset Delivery Enterprise and full life cycle. Referring to key technologies, use cases and case studies, the presentation will show how Digital Engineering and a connected Digital Thread are the key to unlocking a leap in LCM efficiency.

Complementing these considerations, the importance of Configuration Management to data quality and traceability for digital threads will be addressed by Jose Rosa Dias and Pedro Cunha (NIAG Study Group 306).

Environmental and sustainability considerations, and their effects on supportability, have grown in the last decade to be important and irreversible variables in LCM decisions. Two presentations will tackle these aspects.

Using examples from the Royal Canadian Air Force, Gabe Batstone (Contextere) will show how AI can enhance skill development and boost productivity through "sustainable AI" made possible by the use of smaller data models that reduce computational footprints, as well as of emerging techniques such as retrieval-augmented generation (RAG).

Fergus Hawkins and Simon Pethick (TFD Europe) will inform about the findings of a recent research project to evaluate the sustainability, viability and cost implications of alternative propulsion methods for a light aircraft used in a flying training environment. Their presentation will highlight the key support considerations for each of the alternative options considered, before revealing the benefits and drawbacks of each propulsion source, as shown by the analysis performed.

Building on the findings collected from the two-day conference, Holger Ziegler (Head Capability Delivery Section, NATO) and Manuela Tudosia (Chair NIIG to AC/327) will facilitate concluding discussions, setting the tone for the 21st edition of the LCM Conference.

We are looking forward to welcoming you on 21 January 2025!

SITREP on Ukraine – end of 2024

Alex Horobets

In late 2024, the prospects for ending the war in Ukraine or at least suspending hostilities remained unclear; however, officials from both Ukraine and its partners in the West are increasingly discussing the possibility of such a scenario.

The inauguration of US president-elect Trump on 20 January 2025 is considered the starting point for the transition of the war in Ukraine toward a lower-intensity phase and ultimately its end. Trump assured his voters of his resolve to end the war in Ukraine in the short term, hoping to exert influence on both Kyiv and Moscow. Accordingly, it is time to assess the situation of Russia and Ukraine as they begin the new year, and what tentative plans could be drawn for ending the war.

The situation on the front

As of December 2024, the Russian armed forces continued exerting pressure on Ukrainian troops on several axes at once. In the first days of 2025, the situation remains tense in the Pokrovsk, Kurakhove, Lyman, Vremivka, Toretsk, Zaporizhzhia, and Kursk directions. Obviously, the Russian



▲ **Operators of the 24th Mechanized Brigade practicing the use of first-person view (FPV) drones in the East of Ukraine. [Ukrainian Ground Forces]**

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command continues to disregard the high casualty toll, throwing more manpower into the meat-grinder in order to capture as much Ukrainian land as possible by the time Trump is inaugurated. This strategy aims to secure a more advantageous position for the potential onset of settlement negotiations, allowing Russia to assert stronger demands. As if to confirm this, a significant intensification of hostilities along the frontlines has been observed since mid-December. The total number of clashes along the entire front is roughly 300, although in November and early December, the number varied between 153 to 227, demonstrating that Russia is pursuing assaults practically along the entire front line.

In the Pokrovsk direction, the Russians have concentrated the forces of two army groups, reinforced by other units. According to estimates from the Ukrainian military operating in the area, a single Ukrainian brigade is facing four Russian brigades, and Russia is amassing reserves in order not to slow down the pace of the offensive. Due to the huge casualties on the Pokrovsk axis, the Russians have even changed the tactics of assault operations, reducing the number of fighters in assault teams from 50 to 10. At the same time, the Russians are using new assault tactics; after the now familiar meat-grinder attacks, small sabotage groups involving better-trained troops are deployed to spot Ukrainian firing positions. Although the Russian army managed to advance roughly 6 to 10 km towards the fortress town of Pokrovsk, the Commander-in-Chief of Ukraine's Armed Forces, Oleksandr Syrskyi, said Ukrainian troops would do their utmost to prevent the capture of the town. This will be a significant challenge, since Russia continues to deploy reserves to the area, confirming that capturing Pokrovsk is currently one of their priority goals, while defending the town is one of Ukraine's main priorities.

The Russian army is also becoming more active in the Zaporizhzhia region, in particular, on the Orikhiv axis. According to Ukrainian intelligence, the enemy is amassing troops and hardware in the area for assault operations. Also in the Zaporizhzhia direction, the Russian armed forces have increased the number of artillery strikes and air raids. The situation around Kurakhove remains tense as the Russians maintain their assault momentum. According to Ukrainian military estimates, the Russians have massive superiority in terms of hardware and manpower in the area while their advance enjoys constant air support. Capturing this town is also among Russia's priorities.

Intense infantry battles are also continuing near the town of Toretsk, in Donetsk region. Russia has moved a massive force to the area to seize the town, applying the same tactic of small-unit assaults without armoured support, only backed

by unmanned aerial vehicles (UAVs) and artillery. It has been observed that the Russian command applies several tactical solutions in their attacks on Ukrainian positions, including pincer movements to encircle settlements or certain areas in order to force the withdrawal of defending troops or otherwise face encirclement, as well as assaults using small infantry units, which, apparently, the Russian regular army adopted from the Russian private military company, Wagner Group.

Such approaches primarily aim to capture as much territory as possible, rather than to minimising casualties and equipment losses. According to the spokesman for Ukraine's Luhansk Grouping of Troops, the Russians on the Toretsk axis saw a mechanised battalion's worth of soldiers killed or wounded in action, that is, around 500, during one week of assaults. However, these tactics yield results only if command has a constant supply of reserves to make up for



▲ **FAB-500 bomb fitted with a UMPK glide and guidance kit. Such weapons have been a continuous threat to Ukrainian forces, and have increased in number since early 2024. [Russian MoD]**

casualties. Consequently, containing such an offensive by the Russians is a formidable challenge. As observed in the Toretsk area, continuous shelling and UMPK glide bombs turn defensive positions in urban settings into ruins, rendering it infeasible to hold them for much longer.

Ukrainian command is aware of the complexity of the situation. According to the recently appointed commander of the Ground Forces, Mykhailo Drapatyi, commanders will do everything possible to stop the Russian offensive. The main efforts will be concentrated precisely on the areas where the threat of the enemy capturing civilian populations is greatest. After being appointed, Drapatyi announced a large-scale transformation of the Ground Forces, which will affect recruiting, military training, combat management, administrative transformation, logistics, and which should make the force more flexible and adaptive.

The situation in Russia's Kursk region, where the Ukrainian Armed Forces continue to hold the captured bridgehead from constant Russian attacks, should be considered separately. It is likely that the Russian command will try to dislodge Ukrainian troops from these areas as quickly as possible in order for these territories not to become a bargaining chip in potential peace negotiations. Although the Russians are transferring

individual units to this area from the Pokrovsk and Zaporizhzhia directions, over 11,000 North Korean soldiers were also deployed there. As expected, on 14 December 2024, the first group of DPRK troops, with fire support from the Russian Army, were involved in infantry attacks in the Kursk region, near Sudzha. As can be seen from the first published videos of such attacks, Russian commanders are throwing North Koreans into battle using the tactics of mass infantry assault across open terrain, which logically leads Ukraine to intensively employ artillery and cluster munitions. Yet despite casualties and the language barrier, Russia continues using North Korean soldiers in assault operations.

Long-range strikes inside Russia and missile attacks on Ukraine

In parallel to the active hostilities in multiple areas of the front, both Ukraine and Russia pursue missile and drone attacks on targets far behind the frontline with Russia continuing its systematic strikes on Ukraine's energy infrastructure. In particular, the Russian missile strike on 13 December 2024 was one of the largest attacks to date, forcing five of Ukraine's nine operating nuclear reactors to reduce its generation capacity. Aside from missile attacks, almost every night, Russia launches dozens of Shahed one-way attack (OWA) drones, causing hours-long air raid alerts across Ukraine. Along with the Shaheds, which are armed with an explosive warhead, Russia has also modified its tactics to employ decoy targets – Parodiya and Gerbera UAVs – which might make up half of the drones launched in each barrage. However, since the military effect of such attacks is dubious, their main goal is most likely to inflict further psychological pressure on the civilian population.

In November 2024, Ukraine finally received support from the United States to strike targets inside Russia using ATACMS missiles. Washington took the decision immediately after it was confirmed that North Korean troops were being dispatched to the Kursk region. In response, Moscow announced the possibility of strikes on Ukraine using a new weapon that had not been used before. As of mid-December, several ATACMS missile strikes successfully hit targets inside Russia, notably two strikes in the Kursk region, one on the Bryansk region, and one on a military airfield in Taganrog, Rostov region. The very fact that such strikes are occurring is painful for the Kremlin and inconvenient for its propaganda machine to explain, since it is a challenge for Russia to effectively intercept ATACMS missiles. It is also nigh impossible to protect all important targets in the relevant range with air defence systems capable of shooting down ballistic targets.

► **Remains of US-produced ATACMS missiles, launched by Ukraine's Armed Forces on 25 November 2024, according Russia's Ministry of Defence. [Russian MoD]**



As such, Russia found a different form of response to Ukrainian deep strikes. On 21 November 2024, Russia hit the Pivdenmash enterprise in Dnipro with an Oreshnik intermediate-range ballistic missile (IRBM), whose production had not been previously reported. Such missiles were prohibited from being developed until 2019 due to the Intermediate-Range Nuclear Forces Treaty (INF). Therefore, Russia either continued developing the weapon in violation of the INF, or worked on older models to create a new missile after 2019. Oreshnik is understood to be based on the RS-26 Rubezh IRBM. One way or another, after the strike on Dnipro, Russian propaganda started using it to further intimidate Ukraine's allies, hinting at further strikes involving the missile on Ukrainian territory, and in the future, on European soil as well.

This trend of intimidation continued at the level of Russia's leadership. Describing the test of the new missile as a response to "NATO's aggressive actions against Russia", Vladimir Putin announced plans to establish serial production of Oreshnik, emphasising the development of non-nuclear deterrent forces. However, the question remains regarding the combat effectiveness of a non-nuclear IRBM that is significantly more expensive and complex than the Iskander, Kalibr, or Kinzhal missiles already in service, which are capable of achieving similar effects. The Kremlin probably needed to showcase the new weapon to further intimidate Europe and NATO, since Russian media immediately began to calculate the time it would take for the Oreshnik to reach European cities.

One way or another, European countries will have to take this threat into account, since it is considered unlikely that PATRIOT systems will be capable of dealing with this threat, and other options such as THAAD or Aegis Ashore ballistic missile defence (BMD) systems may be required to this end. It is also questionable whether the intimidation worked with Ukraine, where the population has already suffered many thousands of attacks. After the Oreshnik strike, the Ukrainian Defence Forces continued hitting military targets in Russia, including using unmanned systems, whose combat range is constantly increasing. Recently, a modified OVA drone successfully struck targets in Grozny, the capital of Chechnya, namely the barracks of the Akhmat Kadyrov regiment and a SWAT base. According to estimates, the flight range of such a drone can reach 1,300 km, which puts even more military targets and defence firms on Russian territory at risk.



Plans to end the war in Ukraine

As we can see, the improvement of military tech and methods of countering them remain an ongoing race. However, politicians in Ukraine, Russia, Europe, and the United States are making more and more statements regarding the possibility of holding negotiations to settle the war. Preliminary versions of peace conditions revolve around security guarantees for Ukraine, from allowing the country to join NATO, to deploying a European peacekeeping force.

It was previously reported that the Alliance plans to increase military assistance to Kyiv to strengthen its negotiating position. A similar stance has been voiced by the Biden administration, which in the last weeks of its term is working to increase arms supplies to Ukraine. At the same time, US President-elect Trump has hinted that he will also continue supporting Ukraine once in office, and it is likely he will use this support as leverage in talks with Putin and Zelenskyy.

However, while the fine details of a possible Trump peace deal remain to be seen, the basic idea being discussed thus far involves freezing hostilities along the present line of contact. To provide a security guarantee for Ukraine, there are voices in the EU which favour deploying a peacekeeping contingent from NATO countries along the line of contact. However, it is still unclear how such a scenario could be practically implemented. Therefore, most likely, such a force could consist of troops from individual allies, rather than under the auspices of the NATO, since that would likely serve as a red line for Moscow. Perhaps, to make such a scenario even more realistic, Collective Security Treaty Organisation (CSTO) troops could be deployed on the other side of the ceasefire or demarcation line.

Naturally, Ukraine joining NATO, at least without the territories occupied by Russia, would be an optimistic scenario and a valid guarantee that the war will not spread farther. However, Trump's team thus far does not appear to be showing real interest in this option at the moment. It is also difficult to imagine a consensus among all allies regarding Ukraine's accession in the current situation. At the same time, it is obvious that the goal of the Ukrainian side on the eve of a possible settlement will still be to obtain effective security guarantees in order to deter Russia from attacking again. Additionally, improving Kyiv's military capabilities should probably be the focus of this formula. In turn, the lack of such capabilities will weaken the overall ability of European nations to hold Russia back in the future. Meanwhile, according to the latest statements by the Russian defence chief, Russia is eyeing the possibility of direct military confrontation with NATO on European soil in the coming decades.

- ◀ [President of Poland Andrzej Duda gives a speech during the ribbon cutting ceremony for the transfer of authority of the Aegis Ashore Missile Defense System at Naval Support Facility Redzikowo, Poland, to NATO, on 13 November 2024. \[US Navy/MC 2nd Class Novalee Manzella\]](#)

European Security: The OSCE at 50

Lincoln Gardner

Almost three years since Russia invaded Ukraine, the rules-based order that once governed security on the European continent lies entirely in shreds. Yet, one European security organisation, the Organization for Security and Cooperation in Europe (OSCE) was created during the Cold War to deal with precisely the threats that the European continent is faced with today.

Under its catchy tagline ‘From Vladivostok to Vancouver’, the OSCE has worked to advance peace and security in its 57 member states throughout Europe, North America, and Central Asia for almost 50 years. During the Cold War, it was known as the Conference on Security and Cooperation in Europe (CSCE), founded on 1 August 1975, becoming the OSCE on 1 January 1995, and aimed at handling new security challenges following the collapse of the Soviet Union and the break-up of Yugoslavia.



▲ **A convoy of the OSCE Special Monitoring Mission in Ukraine, on 18 February 2016. The SMM was launched in March 2014 in response to the crisis in and around Ukraine. [OSCE/Evgeniy Maloletka]**

When Russia launched its full-scale invasion of Ukraine in February 2022, no security body or international organisation proved itself capable of averting the conflict, with the UN, NATO, and the EU all but helpless. However, the Vienna-based OSCE – with Russia and Ukraine as members – was established during the Cold War with the singular objective of preventing conflicts and resolving crises among its participating states; the OSCE too failed to intervene in the months prior to the invasion. The OSCE’s consensus-based decision making, always regarded as its most prized asset, had now become its principal disadvantage. Looking ahead to Trump’s second term, as well as the uncertainty surrounding Ukraine joining NATO, this article assesses the impact of the current situation on the OSCE and its mandate to maintain peace and security across the European continent.

The OSCE’s approach to security

Three ‘dimensions’ comprise the OSCE’s comprehensive security approach, in which it takes pride: the political-military, economic-environmental, and human dimensions. This broad-brush approach still seeks to prevent tensions, handle and mediate crises, and encourage dispute resolution.

- In the **politico-military**, or First Dimension, the OSCE contributes to arms control, confidence- and security-building measures (CS-BMs), and military transparency. Adopted mechanisms that include the Vienna Document and the Open Skies Treaty illustrate the efforts undertaken over the decades to reduce tensions and avoid armed conflict.
- With its **economic and environmental** programmes, the Second Dimension, primarily through the Coordinator of OSCE Economic and Environmental Activities (OCEEA), the OSCE addresses issues such as preventing and combatting corruption, connectivity, water management and energy security.
- Respect for the rule of law, freedom of speech, and human rights are all promoted by the **human**, or Third Dimension. The OSCE’s Warsaw-based Office for Democratic Institutions and Human Rights (ODIHR), is arguably the Organisation’s most well-known body, thanks to its election monitoring role, overseeing elections throughout the OSCE region.

50 years on

The OSCE faces a multitude of obstacles as it marks the 50th anniversary of the signing of the Helsinki Final Act, a set of ten core principles (the so-called ‘Decalogue’) that established the framework for its later operations. These principles include respect for territorial integrity and sovereignty, abstaining from the use or threat of force, and protecting human rights. The OSCE’s role and added value are now called into question due to ongoing geopolitical tensions, not least thanks to Russia’s actions in Ukraine and elsewhere.

This 50th anniversary might therefore offer a glimmer of hope, a chance to consider the accomplishments of the Organisation, its guiding principles, and the many difficulties



▲ Two monitors assessing the situation in the Donetsk region, on 30 August 2016.
[OSCE/Evgeniy Maloletka]

it faces. It could also offer a chance to discuss the OSCE’s very relevance in a tumultuous geopolitical landscape that is continuously changing.

In short, the OSCE’s effectiveness and very survival are being questioned, a situation made worse by the following three considerations:

- **Geopolitical divisions:** The OSCE faces increasing polarisation among its members, especially between Russia and Western ‘like-minded’ countries, exacerbated, but not exclusively, by the Ukraine conflict. Elsewhere in the OSCE area, the unsettled (or ‘frozen’) dispute in Moldova over Russia’s support for the breakaway Transnistria region remains unresolved, despite OSCE’s formal mediation role and presence of one of its 12 field missions. Russia’s spoiler role inside the OSCE is further cemented by Moscow’s support for the two Georgian separatist republics: Abkhazia and South Ossetia. Elsewhere in the Caucasus, following Azerbaijan’s military action to regain sovereignty over its ethnic Armenian enclave of Nagorno-Karabakh in 2023, resulting in the entire population of roughly 120,000 ethnic Armenians fleeing to Armenia proper, this long-running

conflict — for which the OSCE also had a long-standing mediating role under the 1992 Minsk Process has largely vanished from international attention.

- **Institutional weakness:** The OSCE operates without any formal legal personality and unlike most international organisations, it has no agreed charter, meaning it relies on the political (good)will between its members and of course, its consensus-based approach. The lack of a vigorous enforcement framework restricts its ability to implement agreements reached or react effectively to emerging tensions and crises.

- **Funding:** 2025 is also pivotal due to budgetary and operational challenges the OSCE faces. Since the consensus-based approach applies equally to financial matters, this means that the adoption of its budget routinely faces delays due to disagreements among its members. In fact, no budget has been adopted since 2021, with expenditure since then being dispensed on an allotment basis – hardly a secure or stable footing for robust and impactful engagement.

To survive therefore, the OSCE must urgently address its structural funding issues as a matter of priority. Since 2021, successive OSCE ‘Chairs’ (presidencies), with Malta presiding over the Organisation in 2024, have unsuccessfully sought consensus to overcome the impasse; options on the table, but not agreed upon, might include reforming the consensus rule itself (a dangerous opening of the Pandora’s Box) to prevent budget

blocking or exploring alternative funding models, such as voluntary contributions or partnerships with other international organizations. Without meaningful and decisive action, the OSCE’s financial uncertainty could undermine its overall mandate, leaving it ill-equipped to address Europe’s pressing security challenges. In 2025, its capacity to adapt and secure sustainable funding will likely determine its long-term viability.

The impact of a second Trump presidency

The second Trump presidency could significantly alter the dynamics of European security and by extension, any meaningful role for the OSCE. US support for the OSCE may decline as a result of Trump’s ‘America First’ policy, which places a strong – declaratory at least – focus on potentially cutting back US participation in international organisations such as NATO. This change could worsen already-existing financial issues and make it more difficult for the OSCE to react to security threats. However, less US engagement could also present an opportunity for European countries to assert more leadership within the OSCE, fostering a more unified European approach to security issues.



▲ Monitors for the Special Monitoring Mission to Ukraine patrolling in Yasynuvata–Avdiivka area, in the Donetsk region, on 30 August 2016. [OSCE/Evgeniy Maloletka]

Ukraine's NATO aspirations and potential OSCE role

Ukraine's 'non-membership' in NATO presents a unique dilemma for both the OSCE and European security overall. In a classic 'Catch-22' situation, without the overarching protection of NATO, Ukraine will remain exposed and vulnerable to Russia's aggressive actions, while Kyiv's ambitions to join NATO only heighten tensions with Moscow. The OSCE, once so heavily invested in Ukraine through its now defunct Special Monitoring Mission from 2014 until 2022, has seen its role in Ukraine massively diminished since the invasion in 2022. As a result, the OSCE's ability to fill the security vacuum in Ukraine is limited, given its dependence on consensus among its members, including Russia and Ukraine.

Strategic reflections for an OSCE future

As the OSCE navigates these complex challenges, several approaches could enhance its relevance and effectiveness:

- 1) **Strengthening European Unity:** A more unified European approach to security would reinforce the OSCE's credibility and safeguard a stronger response to emerging threats.
- 2) **Engaging with Russia:** Despite the obvious challenges, preserving a constructive dialogue with Russia is key to preventing further geopolitical escalation.
- 3) **Varying Funding Sources:** To decrease dependency on a few key member states, the OSCE should seek other fund-

ing mechanisms, including through partnering with other international organisations.

Looking ahead

The OSCE held its 31st Ministerial Council meeting on 5-6 December 2024 in Valletta, Malta, with its foreign ministers, including Russia's Sergei Lavrov, meeting to discuss current challenges, including the lack of senior leadership and the aforementioned budgetary crisis. In a positive move, however, a rare sign of consensus was reached on the appointment of the OSCE's four top-level positions, including senior Turkish diplomat, Feridun Sinirlioğlu as the new Secretary-General, though no agreement was reached on overcoming the budgetary crisis.

With the OSCE's future place in European security far from certain, there are still many observers that see a role for the Organisation, given its broad membership and mandates provided by its 57 states. With a smart approach, drawing on its extensive Balkan post-conflict experience, and building on positive steps coming from the Valletta meeting, the Organisation could role to play in promoting and fostering dialogue above all, but also on the ground when a ceasefire is ultimately reached to end the war in Ukraine. In 2025, under Finnish leadership, the OSCE has an opportunity to reaffirm its core principles, strengthen its capabilities, and navigate the complexities of a fragile geopolitical landscape, ensuring its continued relevance in the 21st century.



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