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Ukraine Will Soon Have Western Tanks, What Next?

Photo: author



As Western-made main battle tanks (MBTs) begin to drip-feed into Ukraine, expectations among many observers are that these should soon begin to make a difference on the battlefield. While this isn't an unreasonable expectation, it requires some tempering.

So far allied countries have committed to sending 116 Western MBTs that can be thought of as 'modern' designs. These are summarised by family and variant in Figure 1, with numbers derived from the Oryx Blog:

Figure 1

Donor	Tank Family	Variant	Quantity
Canada	Leopard 2	Leopard 2A4	8
Germany	Leopard 2	Leopard 2A6	18
Norway	Leopard 2	Leopard 2A4	8
Poland	Leopard 2	Leopard 2A4	14
Portugal	Leopard 2	Leopard 2A6	3
Spain	Leopard 2	Leopard 2A4	10
Sweden	Leopard 2	Leopard 2A5 (Strv 122)	10
UK	Challenger 2	Challenger 2 TES (est.)	14
USA	M1 Abrams	M1A2 (Export)	31
Total:			116

These figures have been greatly exceeded by the quantity of older-generation Soviet and Western MBTs for Ukraine, with 635+ such vehicles either pledged or already delivered – a difference of almost 550% by quantity. Since some of these vehicles were delivered in Spring/Summer of 2022, many of them have already been lost, and added to the Oryx Blog's tally of Ukrainian tank losses, which presently stands at 470.

The influx of 'modern' NATO tanks will be significantly smaller, and the key question is whether or not these tanks will fare all that better than their older counterparts. This is a more complex question than it may seem on the surface, in part because there are a lot of factors to consider. The most numerous of Ukraine's NATO tanks will be the Leopard 2A4 at 40 vehicles, and the M1A2 Abrams at 31 vehicles, so these will be examined first. While it is positive that Ukraine has been confirmed to be receiving the M1A2 variant instead of the older M1A1 as had been initially suspected, the baseline M1A2, although very capable, is no longer that new, having entered service in 1992. Although questions have been raised about fuel compatibility, with the US typically running their tanks on JP-8 fuel, the Abrams' Honeywell AGT1500 gas turbine engine is relatively flexible fuel-wise and can use DF-1, DF-2, DF-A, JP-4, JP-5, JP-8, and F-24 fuels. A bigger question mark is probably survivability, since the US forbids exporting the Abrams' Depleted Uranium (DU) armour package, it would be replaced by an export armour package. This would roughly make Ukraine's M1A2s comparable to those exported to Saudi Arabia, at least three of which have been lost to ATGMs during engagements with Houthi forces near the Yemeni border.

The Leopard 2A4 is fairly dated by modern standards, having entered service with Germany in 1985, and retired from German service in 2004, replaced by more modern variants. Despite this, it has remained in service with many other users who haven't upgraded their tanks as often as the Germans. This variant lacks the turret cheek appliqué armour introduced from the Leopard 2A5 onwards, and depending on the donor nation, may have come from one of the early production batches of Leopard 2A4, which used first-generation armour technology and were not all upgraded to second- or third-generation armour package. Around 8-10 Turkish Leopard 2A4TRs were lost in Syria from 2016 onwards, during the Turkish Army's Operation Euphrates Shield in Northern Syria.

This is not to say people should expect donated NATO vehicles to perform badly – quite the opposite, in the hands of a skilled crew, they have the potential to perform with distinction. However, there is a tendency to assume that 'modern' Western tank designs will simply inherently perform better than the more recent domestically-developed or upgraded tanks Ukraine already uses. This may be true in some areas, such as crew survivability, but less true for others. In practice, some of these Western tanks may not have more modern night vision systems or communications systems, or may not be supplied with better ammunition than that Ukraine is already using. Many of them also lack explosive reactive armour (ERA), making them arguably more vulnerable to modern ATGMs than some of Ukraine's upgraded tanks, such as the T-64 (2017) and the T-64BM Bulat. It should therefore not come as a major shock to observers when some of these 'modern' tanks get knocked out or heavily damaged by enemy fire. It will be interesting to see which lessons will be gained through Ukrainian operational experience with these vehicles in a peer context.

Mark Cazalet

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Masthead

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Cover Photo: A US Special Forces Soldier, attached to Special Operations Task Force-Afghanistan, waits for nightfall prior to starting a nighttime operation in the Alingar district, Laghman province, Afghanistan, 5 September 2016.

(Photo: US Army/Sgt. Connor Mendez)

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■ Putin Calls Halt to New START

(pf) Russian President Vladimir Putin used the occasion of a 21 February 2023 State of the Nation address, just three days prior to the first anniversary of his invasion of Ukraine, to announce that Russia was suspending its participation in the New Strategic Arms Reduction Treaty (New START).

In his two-hour address to Russia's national assembly, delivered at the Gostiny Dvor building near Red Square in Moscow, Putin blamed the Western powers not just for the Ukraine conflict but for acting "just as shamelessly and duplicitously when destroying Yugoslavia, Iraq, Libya, and Syria". Regarding the Ukraine conflict specifically Putin claimed that it was a project that "is not new. ... The Austro-Hungarian Empire and Poland had conceived it for one purpose, that is, to deprive Russia of these historical territories that are now called Ukraine. This is their goal. There is nothing new here; they are repeating everything."

Declaring it "unacceptable that the United States is rebuilding the world order exclusively for itself", Putin said, "I have to say today that Russia is suspending its participation in New START. I repeat, not withdrawing from the treaty, no, but merely suspending its participation."

He also added that Russia "must be prepared to test new types of weapons if the US does. ... No one should be under the illusion that global nuclear parity can be destroyed."

New START, which was signed by US President Barack Obama and Russian President Dmitry Medvedev on 8 April 2010 and entered force on 5 February 2011, was the sole remaining nuclear arms control agreement between the two countries. Extended in 2021 but due to expire in 2026, the treaty limited the number of deployed strategic nuclear warheads to 1,550; the number of deployed and non-deployed intercontinental ballistic missile (ICBM) launchers, submarine-launched ballistic missile (SLBM) launchers and strategic bombers to 800, and the number of deployed ICBMs, SLBMs and strategic bombers to 700.

Washington had already claimed Russia was non-compliant under New START for refusing to allow inspections of its nuclear facilities under the terms of the treaty. Putin responded in his speech that, in the context of Western support for Ukraine, "This is a theatre of the absurd", adding, "The West is directly involved in the attempts of the Kyiv regime to strike at our strategic aviation. And now they also want to inspect our defence facilities. This sounds like bullsh*t."

The Intermediate-Range Nuclear Forces (INF) Treaty, originally signed by the United

States and the Soviet Union on 8 December 1987 and ratified on 1 June 1988, was suspended by the United States on 1 February 2019 and Russia the day after amid arguments over Russian non-compliance and redundancy, given that the treaty did not include China.

The Anti-Ballistic Missile (ABM) Treaty, signed by the United States and the Soviet Union on 26 May 1972, ended in June 2002 when the United States withdrew from it, arguing that the treaty prevented the creation of effective missile defences and left Washington potentially open to nuclear blackmail by a rogue state.

■ IDEX 2023: ADSB secures EUR 1 Bn Angolan corvette contract

(pf) Abu Dhabi Ship Building (ADSB) has signed a EUR 1 Bn contract with Angola to supply a fleet of BR71 MKII corvettes to the Angolan Navy, parent company EDGE Group announced at IDEX 2023 on 20 February 2023.

Although the number of corvettes was not mentioned by EDGE in its press release, ADSB CEO David Massey told Shephard News at IDEX 2023 that the deal covers three BR71 Mk II corvettes and an undisclosed number of smaller boats.



Photo: ADSB

The BR71 MKII corvettes will be 71 m long and thus similar to the six Baynunah-class corvettes ADSB supplied to the UAE Navy in conjunction with France's CMN. According to EDGE the Angolan corvettes will feature "advanced mission systems including a 3D radar, electronic warfare suite, secure communications, a main gun, and surface-to-surface and surface-to-air missile systems".

The largest vessels currently operated by the Angolan Navy are two 62 m long Damen 6210-class offshore patrol vessels delivered in 2012, so the three ADSB-supplied corvettes will significantly enhance the Angolan Navy's offshore capabilities.

Khalid Al Breiki, President of EDGE's Platforms & Systems division, was quoted by the company as saying, "Signing a EUR 1 billion defence export deal represents a momentous achievement for EDGE as well as ADSB. This demonstrates our strategic approach and steadfast

commitment to increasing national exports in line with the UAE leadership's directive."

ADSB's Massey added that the BR71 MKII corvette "is a highly advanced vessel capable of performing multiple missions to secure Angola's 1600 km coastline. We look forward to fulfilling the Angolan Navy's operational requirements and strengthening their naval capabilities while expanding ADSB's avenues of growth."

■ Norway Firms Up Tank donation to Ukraine

(pf) Norway is to donate eight main battle tanks (MBTs) and up to four 'special-purpose tanks' to Ukraine, as well as earmarking funds for ammunition and spare parts,

Photo: USMC



the government in Oslo announced on 14 February 2023.

The tanks will come from the Norwegian Army's current inventory of Leopard 2A4NO MBTs, while a spokesperson for the Norwegian armed forces confirmed to ESD that the 'special-purpose tanks' would be armoured recovery or armoured engineering vehicles (ARVs/AEVs). The exact type of these has not yet been decided, said the spokesperson, and will be determined based on Ukraine's needs.

Norway first announced its commitment to send tanks to Ukraine on 26 January 2023. It is not yet known when they will arrive in Ukraine, the spokesperson said.

"The decision to donate Leopard 2 tanks and ARVs/AEVs has been made after close dialogue with both the chief of defence and other European countries," Norwegian Defence Minister Bjørn Arild Gram was quoted as saying on 14 February.

"The war in Ukraine is nearing a critical phase and they are dependent upon timely and substantial support. We will also contribute with educating and training Ukrainian tank crews in Poland, along with other allied countries. This donation is an important and much needed contribution," he added. The Norwegian government has also recently communicated to the Norwegian parliament that a support package for Ukraine for the next five years will be set up with a value in the region of NOK 75 Bn (EUR 6.89 Bn).

On 3 February 2023 Norway announced that it would order 54 new Leopard 2A7

MBTs from Germany's Krauss-Maffei Wegmann to upgrade its MBT force, with an option for a further 18 tanks. The first of these are due to be delivered by 2026.

Meanwhile, in Brussels on 14 February, shortly before the latest meeting of the Ukraine Defence Contact Group, German Defence Minister Boris Pistorius said that Portugal would donate three Leopard 2A6 MBTs to Ukraine. He added that it is currently unlikely that any more Leopard 2A6s would be donated to Ukraine beyond those Portuguese tanks and the 14 Leopard 2A6s that Germany pledged on 25 January. If this is the case then only countries operating 2A4 or older Leopards are likely to send more tanks to Ukraine.

■ AM General Swoops in to Secure JLTV Recompete Programme

(pf) Spurning the incumbent provider, on 9 February 2023 the US Army awarded AM General a five-year contract (plus five-year option) worth USD 8.66 Bn to produce up to 20,682 Joint Light Tactical Vehicles (JLTVs) and up to 9,883 JLTV Trailers for the US armed forces and Foreign Military Sales customers.

The contract, awarded under what is known as the JLTV A2 Program, came as something of a surprise because the provider of JLTVs to the US military since 2015 has been Oshkosh Defense, which in August of that year was chosen as the winner of the initial JLTV contest with a vehicle solution based on its Light Combat Tactical All-Terrain Vehicle (L-ATV). The company was at the time awarded a contract worth up to USD6.75 Bn, which covered two years of low-rate initial production and five years of full-rate production, and has since delivered more than 19,000 JLTVs and 3,500 of their associated trailers.



Photo: Oshkosh

However, soon after the initial JLTV contract was awarded the US government purchased the data rights to the JLTV Technical Data Package from Oshkosh and re-affirmed in a press release on 9 February, "This competitive follow-on production contract has been part of the JLTV acquisition strategy from the beginning and focused on a best value

determination that includes retaining the capability of the JLTV today, while ensuring that it can be upgraded in the future with the latest technologies."

Responding to its contract win, AM General cited its "proven transformative commercial manufacturing initiatives" and JLTV technological enhancements that include "enhanced corrosion protection and improved fuel efficiency in addition to continuous developments for an updated next-generation vehicle architecture".

AM General noted that the JLTVs are to be produced at a dedicated military production facility at its Mishawaka Manufacturing Campus in Indiana, which includes an onsite test track to trial JLTVs in a dynamic operating environment. The company cited its "readiness to execute a smooth transition for JLTV production" and said JLTV deliveries would begin 17 months after the contract award.

In a 9 February statement in response to the follow-on award, Oshkosh remarked, "We were disappointed to learn the government's decision. As the incumbent manufacturer, only Oshkosh's JLTV proposal leveraged substantial JLTV experience and established infrastructure, while providing best-in-class upgrades to the JLTV platform."

On whether it would protest the decision, Oshkosh stated, "We are pursuing a debriefing from the government on the basis of the source selection decision in the very near future and cannot comment further at this time."

Oshkosh had, in fact, recently won more JLTV business just prior to the A2 award. On 6 February 2023 the company announced it had received a USD84.9 Mn JLTV order from the army that was the third such order in two months, with those contracts having a combined value of USD 730 Mn and covering more than 2,000 JLTVs.

The US Army stated of the A2 award, "The JLTV follow-on contract request for proposals, in accordance with the Army Climate Strategy, sought to incentivize offerors to propose fuel efficiency technologies that targeted on-the-move fuel economy improvements and anti-idle capability in support of optimizing combat effectiveness. The JLTV A2 design is the first tactical wheeled vehicle with baseline architecture utilizing lithium-ion batteries, which is a key enabler for anti-idle capability.

"Effective competition is the critical element for controlling cost and maximizing buying power for the government," the army statement noted. "The JLTV engagement strategy with industry has been very successful in establishing executable timelines, adding

mature technology insertions, and providing transparency throughout the process to allow contractors to make individual business decisions."

As AM General and Oshkosh Defense set to work in addressing these requirements for the follow-on JLTV programme, both companies actually went further and have in recent years been developing hybrid electric drive (HED) solutions for light tactical vehicles; AM General has been working with QinetiQ to produce a HED-powered version of its High-Mobility Multipurpose Wheeled Vehicle (HMMWV, or Humvee: the vehicle the JLTV is replacing), while Oshkosh has produced a HED-powered eJLTV. However, the US Army did not stipulate a HED-powered JLTV as part of the A2 recompete.

■ Spain to deploy NASAMS unit to Estonia

(pf) Spain is to deploy a National Advanced Surface-to-Air Missile System (NASAMS) unit to Estonia in April 2023 for an initial period of four months.

The deployment was agreed between the two countries' defence ministers, Margarita Robles and Hanno Pevkur respectively, at the NATO defence ministers' meeting in Brussels on 14 February 2023.



Photo: Estonian MoD

"The Eastern flank of NATO has grown its muscle significantly over the past year," said Pevkur. "Considering the need to fill this critical gap in our medium-range air defence capabilities, I am very glad that we reached an agreement with Spain on the deployment of their NASAMS medium-range ground-based air defence system for four months, starting this April."

Pevkur noted that this was a short-term fix while the country prepares a more sustainable solution in conjunction with its Baltic neighbours.

"With Latvia and Lithuania we made a proposal in NATO to establish an air defence rotation model, similar to the Baltic Air Policing mission currently in place. Therefore, hopefully subsequent rotations in co-operation with allies will also become possible," Pevkur added.

"It is also very important that, thanks to the deployment of the NASAMS unit in Estonia, we will learn the tactical specifics of a medium-range air defence system. In addition, it will give our defence forces and air force the experience of integrating a medium-range air defence system with other defence systems." The objective of the Spanish NASAMS unit in Estonia will be to defend Ämari Air Base, which is used by NATO fighters to fulfil the alliance's Baltic Air Policing mission in the absence of the Baltic states having their own fighter capabilities. The unit will be deployed to Estonia under the command of NATO's Supreme Allied Commander Europe (SACEUR). A Spanish NASAMS unit has already been deployed to Latvia; it arrived in Lielvarde in mid-June 2022 and completed its readiness certification in November 2022. The two systems in Latvia and Estonia will be linked and form part of NATO's Eastern flank air and missile defence.

The procurement of Estonia's own medium-range air defence system is in the final stages, according to the Estonian Ministry of Defence, with the aim of finalising a contract before the summer of 2023.

■ Norway Firms Up Order for 54 Leopard 2A7 MBTs

(pf) The Norwegian Defence Materiel Agency (NDMA) placed an order with Krauss-Maffei Wegmann (KMW) for 54 Leopard 2A7 NOR main battle tanks (MBTs) on 17 February 2023, after the Norwegian government indicated such a purchase was coming on 3 February. Announcing the contract had been signed on 17 February, KMW said the tanks are scheduled for delivery from 2026 to 2028, adding that the deal includes an option for an additional 18 Leopard 2A7 NORs.

The value of the deal has previously been put at NOK 19.7 Bn (EUR 1.79 Bn).



Photo: Norwegian Army

"This signing is a strong signal for European co-operation," KMW CEO Ralf Ketzel was quoted as saying after the conclusion of the contract. "It also underscores the tank's performance and future viability and its importance for joint defence efforts in Europe. KMW is grateful for the confidence. We look forward to the project and thus to long-term international industrial co-operation with Norwegian industry."

Norway had also considered buying the K2 Black Panther MBT produced by South Korea's Hyundai Rotem, but selecting the Leopard 2A7 aligns the Norwegian Army more closely with its neighbours and NATO allies in terms of co-operability, logistics and industrial relations. On 14 February 2023 Norway firmed up its plan to donate tanks to Ukraine and announced it would send Kyiv eight Leopard 2A4NO MBTs and up to four armoured recovery or armoured engineering vehicles, depending on Ukraine's needs. It is not yet known when these will arrive in Ukraine.

Prior to this decision Norway operated a fleet of 36 Leopard 2A4s, with another 16 in storage, according to The Military Balance 2023 published by the International Institute for Strategic Studies. The purchase of at least 54 Leopard 2A7s will thus increase the Norwegian Army's armoured capability in both quality and numbers.

■ Construction work initiated on UK's third Dreadnaught-class SSBN

(pf) Work on construction of the UK's third Dreadnaught-class nuclear-powered ballistic missile submarine (SSBN) has begun, prime contractor BAE Systems announced on 9 February 2023.



Foto: BAE Systems

To be called Warspite, the boat is the third of four SSBNs due to enter service with the Royal Navy from the early 2030s and operate for at least 30 years. Construction of the first two SSBNs, Dreadnaught and Valiant, is already underway. The boats are being constructed at BAE's Barrow-in-Furness site in northwest England.

The Dreadnaught class will replace the Royal Navy's fleet of four Vanguard-class SSBNs, which were commissioned from 1993 and currently provide the UK's continuous at-sea nuclear deterrent. As with the Vanguard class, the Dreadnaught-class SSBNs will be armed with Trident D5 submarine-launched ballistic missiles (SLBMs), which are built by Lockheed Martin and also arm the US Navy's SSBNs.

BAE Systems has stated that the Dreadnaught programme will involve an estimated GBP 7.7 Bn being spent with UK suppliers, supporting at least 11,800 jobs in the supply chain. The overall delivery phase of the Dreadnaught programme is planned to cost around GBP 10 Bn.

Alongside production of the Dreadnaught-class SSBNs, BAE Systems is also responsible for delivering seven Astute-class nuclear-powered attack submarines (SSNs), four of which – HMS Astute, HMS Ambush, HMS Artful and HMS Audacious – are already in service. HMS Anson, meanwhile, was commissioned on 31 August 2022 and is working towards operational status, while Agamemnon and Agincourt are under construction.

■ German defence minister sees NATO's 2% target as lower limit

(oh) German Defence Minister Boris Pistorius believes Germany should spend at least 2% of its gross domestic product (GDP) on the Bundeswehr. For the 2024 financial year (FY24), implementing this demand would mean a defence budget of EUR 84 Bn.

Speaking prior to the start of a meeting of NATO defence ministers in Brussels on 15 February 2023, Pistorius said: "I think just wanting to get closer to 2% target will not be enough." This can only be the basis for everything else, the defence minister added.

With this statement Pistorius agrees with the demands of NATO Secretary General Jens Stoltenberg, who has been advocating for some time that member states should not regard the 2% target as the maximum fulfilment of their NATO commitment but as a minimum. In 2014, at the NATO summit in Wales, the member states committed to spending 2% of their GDP on defence. So far, only a few countries meet this target; Germany is not among them.

In the FY23 the German Ministry of Defence (BMVg) will have approximately EUR 50 Bn at its disposal out of a federal budget of almost EUR 476 Bn. This means that the defence budget takes up about 10.5% of federal funds. In addition, the BMVg has at its disposal the EUR 100 Bn special fund of the Bundeswehr, the actual purchasing power of which continues to dwindle.

In the course of the coming years, the special fund is to be used in particular for the procurement of major programmes, since the normal budget does not contain



Photo: NATO

sufficient financial resources to cover the Bundeswehr's declared needs. Of the EUR 50 Bn in the defence budget, only EUR 7.7 Bn is available for military procurement. The majority of Section 14, as the defence budget is also called, is needed to cover the running costs of personnel, material and infrastructure. With the planned increases in personnel and the new weapon systems to be acquired, the cost of these will also continue to rise, which will have to result in an increase in Section 14 if the Bundeswehr is to become fully operational again.

Against this background it is not surprising that Pistorius is advocating an increase in the defence budget. Earlier in February 2023 German newspaper Der Spiegel reported that Pistorius called for an increase of EUR 10 Bn in Section 14 for the 2024 budget. This would make the defence budget for 2024 about EUR 60 Bn. The level of funding to be added from the special fund would depend on how quickly the Bundeswehr Procurement Office (BAAINBw) could conclude the necessary contracts with industry.

According to the Federal Ministry of Finance, the predicted German GDP for 2024 has a nominal value of approximately EUR 4.2 Tn. If the German government wanted to meet NATO's 2% target as early as 2024, total defence spending would accordingly have to amount to EUR 84 Bn: a sum that, according to Pistorius, would have to be the basis for financing the Bundeswehr.

It is not very likely that Section 14 will reach this figure in 2024. For one thing, according to Der Spiegel, Pistorius will not be granted an additional EUR 10 Bn by German Finance Minister Christian Lindner. Secondly, the BAAINBw would probably not have the capacity to convert these sums into contracts with industry, as there are already problems spending the existing funds in a timely manner.

■ Denmark, Germany and The Netherlands announce Delivery of Leopard 1A5s to Ukraine

(gh) In a joint statement on 7 February 2023 the defence ministers of Denmark, Germany and The Netherlands announced the joint delivery of at least 100 Leopard 1A5 main battle tanks (MBTs), including the necessary logistical support and training, to Ukraine.

According to the statement circulated by the German Federal Ministry of Defence (BMVg), the Leopard 1A5s will be made

available after being overhauled from industrial stocks. The first ones are to be delivered in a few months.

The initiative will contribute to a substantial and sustainable strengthening of the Ukrainian armed forces and will complement the efforts already underway to support Ukraine with Leopard 2 MBTs.

Earlier the BMVg and Federal Ministry for Economic Affairs and Climate Action officially announced the export licence to German defence companies for up to 178 Leopard 1A5 MBTs for Ukraine. The underlying decision of the German government to deliver the tanks had already become known on 3 February. The final number of tanks to be delivered depends on the necessary maintenance work, according to the BMVg. The financing and repair of the tanks, as well as the training of Ukrainian military personnel on their operation, will be carried out in close co-ordination with Germany's European partner countries.

The delivery and training schedule for the Leopard 1A5s is not yet available, but during his visit to Kiev on 7 February German Defence Minister Boris Pistorius announced the delivery of about 20 Leopard 1A5 MBTs would take place by the middle of the year, with another 40 tanks following later in the year. The total number of over 100 tanks should be delivered by the first quarter of 2024, he said. According to Pistorius, this would allow three to four tank battalions to be equipped.

■ UK Mothballs five H135s Without Even Using Them

(pf) Five Airbus H135 light utility helicopters procured by the UK Ministry of Defence (MoD) to replace ageing Gazelle aircraft are being mothballed before even seeing any active service, it has emerged. FlightGlobal, which broke the story on 6 February 2023, was told by two sources that the H135s had been procured to replace Gazelles operating in Northern Ireland, but that the improved security situation there had made the procurement redundant.

The H135s were procured under Project MATCHA, which was launched in September 2019 and described at the time as an 'urgent capability requirement'. With the UK military's fleet of Gazelle helicopters due to be withdrawn from service in March 2024, the H135s were ordered in October 2021 and delivered in 2022. It is unclear why such an urgent requirement took three years to deliver, while the cost of the acquisition has not been disclosed.

Photo: Crown Copyright



What happens to the H135s now has not yet been determined. It is possible that they could be transferred to the National Police Air Service (NPAS), which already operates the type, and Airbus is currently bidding in a contest to replace seven NPAS helicopters. However, NPAS platforms are highly customised, whereas it is understood the MoD's H135s were delivered in a standard configuration and would have been modified for their role in the UK.

H135s are also used by the UK Military Flying Training System (UKMFTS), but these aircraft, which are known as Juno HT1s, are owned by Ascent Flight Training rather than the UK government.

Alternatively, it is possible the helicopters might simply be sold back to Airbus or another buyer.

The requirement for helicopters in Northern Ireland is a historical one. During the unrest there known as The Troubles, which began in the 1960s and ended with the Good Friday Agreement of 1998, UK military personnel were frequently transported by helicopter to avoid ambushes or roadside bombs laid by republican militants. Although the Provisional Irish Republican Army had effectively disarmed by 2005, dissident republican militants continued to pose a threat for the years beyond then. However, for the year running from 1 April 2021 to 31 March 2022 the Police Service of Northern Ireland reported that "there were fewer security related deaths and a marked decrease in the number of shootings, bombings and paramilitary style attacks compared to the previous year. ... There were 33 casualties of paramilitary style assaults during 2021/22, [which is] six fewer than during the previous year (39) and the lowest number since 1985/86."

■ UK's Challenger 3 MBT Programme Passes its CDR

(pf) The British Army's Challenger 3 main battle tank (MBT) programme has passed its critical design review (CDR) ahead of schedule, the UK Ministry of Defence's Defence Equipment & Support (DE&S) organisation announced on 9 February 2023.

Photo: Crown Copyright



Passing the CDR means that the design for the tanks has been agreed and prime contractor Rheinmetall BAE Systems Land (RBSL) can now start building the Challenger 3 prototypes.

The work has been carried out under a GBP 800 Mn contract awarded to RBSL in 2021 to deliver 148 fully digitalised MBTs to the British Army as upgrades to the army's current fleet of Challenger 2s.

DE&S added in its press statement that supply chain subcontracts have now been awarded and that work to modernise and expand RBSL's production facility in Telford, UK – which will also manufacture the British Army's future fleet of Boxer multi-role armoured vehicles – is now almost complete.

The British Army originally received 386 Challenger 2 MBTs from 1994, although UK government statistics list 227 as being held as of December 2022. Since then the United Kingdom has pledged to supply Ukraine with 12-14 Challenger 2s.

Under the British Army's Army 2020 modernisation programme the service is expected to have three Challenger 2 MBT regiments plus one reserve regiment.

The key features of the Challenger 3 include: a high-pressure Rheinmetall L55A1 120 mm smoothbore main gun to replace the Challenger 2's 120 mm/L55 L30A1 rifled gun; a new suite of Thales sights to provide tank commanders with enhanced day and night targeting capabilities; a new modular armour solution incorporating what is being called 'Epsom' and 'Farnham' armour to replace the Challenger 2's Chobham composite armour; integration of the Trophy MV Active Protection System produced by Israel's Rafael; a new turret that DE&S says "can be fitted to the tanks of allies and global partners"; an upgraded engine, although it is unclear at this point whether this powerplant will be a new one or an upgrade to the Challenger 2's current Perkins 12-cylinder diesel; and a new third-generation Horstman hydrogas suspension system to increase firing accuracy on the move.

Full operating capability for the Challenger 3 is slated for 2030.

■ Aero India 2023: HAL Unveils New Fighter Trainer

(ss) Aimed at bridging the gap between existing trainers and basic fighters with supersonic capability, India's government-owned Hindustan Aeronautics Limited (HAL) unveiled a scale model of a next-generation jet trainer called the Hindustan Lead-in Fighter Trainer (HLFT-42) at Aero India 2023, which ran from 13-17 February in Yelahanka, Bangalore.

The supersonic HLFT-42, designed to train future fighter pilots in contemporary combat missions, is equipped with an ultra-modern training suite, preparing the pilots comprehensively for a fifth-generation combat environment and thereby playing a critical role in modern combat air training. The HLFT-42 features state-of-the-art avionics including an active electronically scanned array (AESA) radar, an electronic warfare suite, an infrared search and track (IRST) system and fly-by-wire controls.

Indian Air Force (IAF) Group Captain Harshvardhan Thakur, from the HLFT-42 development team, stated at Aero India, "From the conception stage to induction, it could take anywhere from five to six years for this trainer to be in service. If the need arises the HLFT-42 can be converted into a fully fledged fighter aircraft also by integrating weapons like CCM [close combat missiles] and Astra [beyond-visual-range air-to-air] missiles."

The trainer is capable of carrying a full complement of Astra-1, Astra-2 and Astra-3 missiles along with short-range dog-fighting missiles.

As of now the number of HLFT-42s ordered by the IAF is not known. Presently the IAF uses the Pilatus PC-7 and HAL HTT-40 for basic training, followed by the HAL Kiran Mk I for stage two training. According to reports the Kiran Mk I will be replaced by the HAL HJT-36 trainer. Stage

Photo: S Sharma



three training is conducted on the BAE Systems Hawk Mk I advanced jet trainer, which is licence built by HAL.

Other features of the HLFT-42, according to HAL, are its superior kinetic per-

formance suitable for twin-engine fighter training, sustained endurance for practising multiple combat situations and exercises, and embedded virtual training system for realistic combat scenarios and large-force engagements. The HLFT-42's combat sensors also feature training as well as operational capabilities.

HAL is marketing the HLFT-42 as a cost-effective platform that gives young fighter pilots comprehensive exposure to all sensors, weapons and roles executed by modern air powers.

■ Boeing E-7 AEW&C platform offered as successor to NATO AWACS

(gh) In response to the NATO Support and Procurement Agency's request for information (RFI) under the ongoing Alliance Future Surveillance and Control (AFSC) programme, Boeing has provided data on

Photo: Boeing



its E-7 airborne early warning & control (AEW&C) platform, it emerged on 21 February 2023.

The aircraft is a military version of the Boeing 737-700ER airliner featuring Northrop Grumman's distinctive Multi-role Electronically Scanned Array (MESA) radar mounted dorsally above the cabin.

Saab has also responded to the RFI with data on its GlobalEye system.

Launched in 2016, the AFSC programme seeks a replacement for NATO's fleet of E-3 Airborne Warning and Control System (AWACS) aircraft when they are retired around 2035.

Boeing describes the E-7 AEW&C platform as a combat-proven weapon system that provides multi-area surveillance, communications and networked battle management capabilities, as well as interoperability that multiplies the effectiveness of joint and coalition forces.

The aircraft has been in service with Australia, which has six E-7s, since 2000, while South Korea and Turkey each operate four E-7s. The United Kingdom is to receive three aircraft from 2023.

The United Arab Emirates and US military have also expressed interest in the platform.

■ Military aircraft deliveries lift 2022 results for Airbus

(pf) Airbus reported its consolidated full-year results for 2022 on 16 February 2023, reporting revenues of EUR 82.5 Bn: an increase of 13% on 2021's figures.

Consolidated adjusted earnings before interest and taxes (adjusted EBIT) for the year increased to EUR 5.627 Bn on 2021's figure of EUR 4.865 Bn.



Photo: Airbus

Revenues at Airbus Defence and Space increased by 11% to EUR 11.26 Bn compared to EUR 10.2 Bn for 2021. This was mainly driven by a higher volume in military aircraft deliveries – 10 A400M airlifters were delivered in 2022 compared to eight in 2021, for example – as well as the ramp-up in the European Medium Altitude Long Endurance Remotely Piloted Aircraft System (MALE RPAS, or Euro-drone) programme.

Adjusted EBIT at Airbus Defence and Space decreased to EUR 384 M, compared to EUR 696 M in 2021, mainly reflecting the impairment related to the loss of two Pleiades Neo satellites in December 2022, when the Arianespace Vega C rocket that was carrying them into orbit failed, and to delays on the Ariane 6 launcher, as well as the impact of rising inflation. This was partly offset by the higher volume in military aircraft deliveries, Eurodrone ramp-up and the positive impact related to retirement obligations booked in the first quarter of 2022.

On the A400M programme, development activities continue towards achieving the revised capability roadmap, Airbus reported. "Retrofit activities are progressing in close alignment with the customer. In 2022 an update of the contract 'Estimate at Completion' was performed and an additional charge of EUR 0.5 Bn recorded. This mainly reflects updated assumptions, including inflation and risks related to the remaining SOC3 [final operational standard] contractual development milestones to be achieved," stated the company, adding, "Risks remain on the qualification of technical capabilities and associated costs, on aircraft operational

reliability, on cost reductions and on securing export orders in time as per the revised baseline."

Meanwhile, Airbus Helicopters delivered a combined 344 military and civil units in 2022, compared to 338 in 2021, with revenues rising by 8% to EUR 7 Bn compared to EUR 6.5 Bn in 2021. This mainly reflected growth in services and a favourable mix in programmes, Airbus reported.

Airbus Helicopters' adjusted EBIT increased to EUR 639 M compared to EUR 535 M for 2021, reflecting higher services and programme execution.

■ Work Begins on New Shipbuilding Hall at Govan

(pf) Work has already begun on a new shipbuilding hall at BAE Systems' shipyard at Govan, Glasgow, after planning permission for the new facility, submitted to Glasgow City Council in 2022, was secured this month (February 2023).

The new hall – which will be around 170 m long, 81 m wide, and 49 m high – will significantly modernise the yard and allow major warships to be constructed indoors, whereas ships longer than 75 m currently cannot be built under cover at Govan and have to be constructed in sections.

News of the planning permission approval was first broken by the UK Defence Journal on 12 February.

Although BAE Systems has not disclosed the total cost of the new facility, it is un-



Photo: BAE Systems

derstood to represent an investment in excess of GBP 100 M. The hall is scheduled for completion by December 2024, a BAE Systems source confirmed to ESD on 14 February.

Construction of the UK Royal Navy's first three Type 26 frigates is currently underway at Govan: Glasgow was launched in November 2022 and is currently fitting out, while Cardiff and Belfast were laid down in August 2019 and June 2021 respectively and are currently under con-

struction. Glasgow is expected to be commissioned in late 2026.

The UK's second batch of five Type 26 frigates – Birmingham, Sheffield, Newcastle, Edinburgh and London – was ordered on 15 November 2022. It is likely that Birmingham will be the first Type 26 to benefit from Govan's new facilities.

■ André Denk Appointed as Deputy Director General of the EDA



Photo: EDA

(gh) German Brigadier General André Denk took up his post as deputy to European Defence Agency (EDA) Chief Executive Jiří Šedivý on 1 February 2023. He succeeded Finland's Olli Ruutu, who left office after more than five years in the role.

Gen Denk was most recently Director of Logistics at the EU Military Staff and before that Commander of the Bundeswehr Logistics School.

During his long career Gen Denk also worked as a desk officer and deputy head of department for planning issues at the German Federal Ministry of Defence. He also completed numerous international missions within the framework of EU, UN and NATO mandates, most recently as chief of staff of the EU Training Mission in Mali.

Land Mobility for Special Operations Forces

André Forkert

The return to national and alliance defence in the Western Hemisphere has consequences for training, personnel, materiel and tactics and this is not just limited to any one troop category. As a result, many countries are currently reviewing the capabilities that their Special Operations Forces (SOF) require in order for them to be ready for national and alliance defence in the future..

Overall, a shift in the focus of SOF can be expected, with counter-terrorism an additional component in the matrix. SOF will again have to conduct conventional warfare against peer opponents, but will need to do so in a flexible and unconventional manner. The focus will be on the tasks of Military Assistance (MA), Direct Action (DA) and Special Reconnaissance (SR). SOF units must be fast and highly mobile on land, as well as airmobile, and the SOF community therefore needs highly mobile vehicles with reduced visual, noise and electro-magnetic signatures. Additional needs include connection to a Battle Management System (BMS) at higher command levels, as well as an appropriately integrated power supply to accommodate the necessary radio equipment, sensors and effectors. Future motorisation also plays an important role in the current development of land vehicles. For example, test vehicles are being developed and built that use classic combustion engines, but also incorporate a hybrid-electric or a purely electric drive. In the case of hybrid and purely electric drives, care will have to be taken to ensure that they can still be transported as internal and external loads in aircraft, including helicopters, despite the potential hazards posed by batteries. In this regard, US Special Operations Command (USSOCOM) is developing a number of concept vehicles, including the Purpose-Built Non-Standard Commercial Vehicle (PB-NSCV), a hybrid-electric

Photo: Arquus



Arquus Patsas 4x4, shown here with a ring mount fitted with a 12.7 mm HMG.

tric ground mobility vehicle (GMV) 1.1, a hybrid-electric version of the Light Tactical All-Terrain Vehicle (LTATV), the LTATV MRZR X military hybrid vehicle, and an autonomous LTATV. All are expected to feature lower weight and more payload. The NSCVs will include current models found in Asia and around the world, including pick-ups and sport utility vehicles (SUVs) such as the Toyota Hilux, Toyota Land Cruiser, Mercedes-Benz G or Volkswagen Touareg.

Innovations

During Eurosatory 2022, a number of new SOF vehicles were on display, including the Merlin 4x4 from General Dynamics European Land Systems-Mowag (GDELS), and an open Eagle V as a commissioned study for the Danish Special Forces. The Merlin is based on the proven Duro vehicle family and was planned to be offered as a candidate for the German-Dutch airborne platform (LuLa), but GDELS decided against submitting a tender. Thanks to this platform, and a version with a length of 5.1 m (height 1.86 m), the vehicle can be produced in multiple variants. For LuLa, among other things, a transport variant with a payload of 1.7 tonnes is required, as well as a

troop carrier for 2+8 soldiers. This is what the Merlin offers. The airmobile, rugged, compact, lightweight and robust platform gives military users superior multi-purpose and payload potential, as well as (adaptive) protection, as stated by GDELS at Eurosatory 2022. In the future, LuLa will form the backbone of airmobile forces, including paratroopers, but will also be used by SOF. Overall, LuLa is planned as a family with up to 15 variants.

Also shown for the first time in Paris was the Rheinmetall Caracal, a platform offered for the LuLa tender. The Caracal is based on the Enok Airborne (AB) from ACS Armoured Car Systems GmbH, already in use in the Czech Republic, Hungary and Cyprus for their SOF and airborne forces. The chassis (model series G 464), engine and drive train are from Mercedes-Benz. ACS has built a modular aluminium frame onto the special Mercedes-Benz chassis, intended to provide the necessary weight reduction as well as flexibility for the different weapons fits. The system was previously developed by ACS for the Swedish Armed Forces, at which time it was used for an LAPV 6x6. The vehicle, combining a steel floor with an aluminium frame, is air-loadable as either an internal or external load. The frame solution offers a high degree of modularity and, according

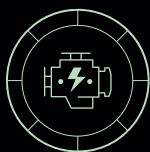
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ARQUUS

Photo: André Forkert



Defecture GRF 4x4, shown with a Rheinmetall ROSY smoke launcher on the front and Optronic mast on the rear.

to the company, is simple, robust, scalable and cost-efficient. The vehicle has a maximum weight of 4.8 tonnes and can accommodate four soldiers in its basic configuration. At EnforceTac 2022, ACS presented the Enok AB with a launcher for the MBDA Enforcer missile. According to ACS, however, other anti-tank and anti-aircraft missiles, such as Rafael's Spike, can also be integrated into the launcher and on the lightweight roof structure. ACS Managing Director Sebastian Schaubek explained: "The requirements for future SF vehicles will change as the orientation of the military changes again. Instead of Internationales Krisenmanagement (IKM; ENG: International Crisis Management), the focus will be on national and alliance defence. Mobil-

ity will remain very important for SF. At the same time, they will need modular mobility solutions to be able to take on a broad mission-specific range of tasks. Ideally, these vehicles will blur into the regular force."

For the airborne platform tender, Dutch manufacturer Defecture is also offering the Ground Force (GRF) 5.12. Defecture had already delivered a study model to IABG, at that time as a flatbed, on which a six-seat configuration could be built. The vehicle has an empty weight of 2.5 tonnes, with a maximum gross weight of 4.7 tonnes, and is already being used by the Dutch SOF as the Air Transportable Tactical Vehicle (ATTV) Vector, with whom it is currently undergoing final testing and adaptation. The GRF 5.12

has a fording depth of 750 mm and a ground clearance of 340 mm. In cooperation with Krauss-Maffei Wegmann (KMW), they offered an adapted variant for the LuLa requirement. At the KSK Symposium 2022, Defecture showed the Vector in an open version and a variant protected to STANAG 4569 Level 1+. The protected vehicle has the EOS R400S Mk2 light weapon station integrated, with two anti-tank guided missiles and a Northrop Grumman M230LF automatic cannon chambered in 30 × 113 mm.

The German Kommando Spezialkräfte (KSK) will replace its obsolete AGF (Aufklärungs- und Gefechtsfahrzeug – reconnaissance and combat vehicle) Serval and has awarded a development contract to Defecture based on the Mammoth. At the turn of the year, a wooden prototype was used for positioning tests, and three prototypes are due to be built for testing by the end of 2023. In total, the "medium special forces vehicle family" is to consist of three vehicle types: the reconnaissance-combat vehicle (AGF-2) as a protected carrier vehicle for at least four command soldiers; a fire support vehicle (AGF-2-MK with 20 mm MK armament); and the command support vehicle (UFG). All are based on the same platform. The Swiss KSK still uses the Serval, while the Austrian Jagdkommando has a similar model in the form of the Puch G 290/LP Sandviper, also based on the Mercedes-Benz G-model. The G-model is used by SOF all over the world, including Australia, the USA (USSOCOM), the British Special Air Service (SAS) and many other countries.

In Paris, GDELS-Mowag showed the prototype of an Eagle V in an open variant for SOF. This stems from an order from Denmark, which had an in-service Eagle V converted. In the Danish Armed Forces, it is known as Eagle Recce Open, featuring a gross vehicle weight of up to 11.5 tonnes, with an extremely high payload. Despite the open roof design, the vehicle has a rotating ring mount for heavy weapons.

Germany, Sweden, the Netherlands and Great Britain will jointly procure the Collaborative All-Terrain Vehicle (CATV) as a successor to the Bv206 and Viking over-snow vehicle. In addition to mountain troops, the SOF of many nations also use the BAE Systems Hägglunds Bv206. Bearing in mind possible missions in the Arctic or on NATO's northern flank this vehicle is once again gaining importance.

At Eurosatory 2022, IVECO Defence Vehicles (IDV), together with Dutch Military Vehicles (DMV), presented the Anaconda

Photo: André Forkert



Iveco Defence Vehicles Anaconda 4x4.

4x4 SOF vehicle, based on the Military Utility Vehicle (MUV) family. The platform can be adapted to the needs of different SOF applications, including for fire support, as a rapid attack vehicle, materiel or personnel transport, ambulance, etc. It can accommodate a maximum of 2+8 soldiers, has an empty weight of 4,000 kg and a payload of 3,700 kg.

Market Movement

Almost all countries have recently renewed their ground vehicle fleets, or are in the process of doing so. Australia, for example, has just replaced its Land Rovers with Supacat Jackals, also used by Britain's SAS, among others. The open vehicle is protected, has underbody mine protection, and weighs 5.5 tonnes. Thanks to its size and capabilities, long-range patrols of two weeks or more can be carried out. The SAS also use Ocelot Foxhound vehicles.

Belgium recently procured the Light Tactical Transport Vehicle (LTTV) from British manufacturer Jankel. It is based on the Unimog U5000 and will replace the ageing Mercedes Unimog 1.9T 4x4 Jacam vehicles. Jankel offers a protected cab (including a split windscreen) and a multi-functional flatbed to accommodate various "mission modules" on the Mercedes-Benz chassis. These modules can be integrated quickly and easily as pallet or container variants, thanks to standard ISO fastening. The vehicle has protection Level



Photo: André Forkert

Polaris MRZR D4, shown fitted with an acoustic gunshot detection system on the roof and RWS on the rear.

1 (STANAG 4569) and can be upgraded to Level 2, according to the manufacturer. The empty weight is 6.5 tonnes, and it can carry up to 3 tonnes of payload. It is intended for use as a long-range reconnaissance or mother-support vehicle; 199 have been ordered for the Belgian SF. Other countries use the standard Mercedes-Benz Unimog in protected or unprotected variants as a mother-support vehicle, to follow smaller combat and reconnaissance vehicles with additional equipment, ammunition, water and food.

Belgium also has the Jankel Group's Fox Tactical Utility Vehicle (TUV) in use, which is based on the Toyota Chassis Land Cruiser 79 and serves SOF for covert operations. With the air-transportable Fox RRV (Rapid Reaction Vehicle), Jankel is also supplying 100 lighter SOF vehicles to Belgium's Special Forces. The new platform will have full interoperability with the Fox RRV fleet, procured since 2015. The Fox RRV uses a reinforced Toyota Hilux chassis.

The Polaris Defence vehicles MRZR D2/4, MRZR Alpha and Deployable Advanced Ground Off-Road (DAGOR) are in service with SOF worldwide. The latter two variants in particular are currently being tested by other European nations. The first airborne Utility Terrain Vehicle (LL UTV) MRZR D4 has just been delivered to the German airborne forces, where KSK and Fernspäher (Long-Range Surveillance Unit, LRSU) are already using them. All German Polaris vehicles are tactically and road-legally converted by Diederich Engineering Systems Defense (D.E.S.).

The DAGOR is used by USSOCOM and Canadian Special Forces, among others. On the sidelines of Eurosatory 2022, it was revealed that Polaris Defence will soon present a three-axle MRZR-Alpha vehicle with additional payload capabilities.

In addition, US Special Forces will receive the GDELS Pandur Evolution 6x6, designating it the Armored Ground Mobility System (AGMS). They are set to replace the Pandur 6x6, which has been in use for more than 20 years. Weighing about 18.6 tonnes, the Pandur Evolution, including additional armour, provides pro-



Photo: André Forkert

The Jankel Light Tactical Transport Vehicle (LTTV) is based on the Mercedes-Benz UNIMOG design.



Photo: SWORD International

The Aerolite Drop Pallet from SWORD International.

tection rated at STANAG 4569 Level 3 ballistic and more than Level 3 mine protection. By using the same turret as the demonstrator of the German Air Mobile Weapon Carrier (LuWa) from Slovenian company Valhalla, a vehicle of this class can be equipped with autocannon (for example, chambered in 25 mm x 137 mm) and loaded into the C-130 Hercules without dismantling the turret. According to sources in the sector, the German KSK and the Austrian Jagdkommando are also considering the procurement of vehicles in the same weight class.

For Europe, Messer Waffenhandel, based in Germany, is the new distribution partner for US manufacturer BC Customs, which builds the lightweight SRTV-SXV (Search and Rescue Tactical Vehicle Side by Vehicle). This vehicle has been in use with US Air Force Special Forces since 2021, mainly because it can also be transported as an internal load in a Bell-Boeing MV-22 Osprey alongside the Boeing CH-47 Chinook and Sikorsky CH-53. So far, 300 vehicles have been delivered, and another 300 are under contract. In addition, it is highly mobile and can be dropped by cargo parachute. According to the manufacturer, the vehicle also has a convincing payload of around 1.5 tonnes, with an empty weight of 1.5 tonnes. Variants can fill the breacher or assault vehicle roles (with a weapon station up to 30 mm MK) or for the pararescue teams of the USAF Special Operations Command (AFSOC) with four stretchers for prone wounded. Messer will offer sales, including workshop service, in Europe. A hybrid version with diesel-electric drive will also be offered, which considerably increases the

range of the troops. Caterpillar tracks are also available for difficult terrain.

At SHOT Show, 2023 the SRTV-SXV 4x4 vehicle was shown with the 'Aerolite 12 ft' inflatable aerial delivery platform from SWORD International. This is a multi-mission Aerial Delivery System, created in conjunction with the SRTV-SXV for the USAF SOF. However, the drop pallet can be used with basically any ATV/UTV, as well as watercraft such as jet skis, rigid inflatable boats (RIBs), etc. It can also be used as a life raft if needed. It is a made-to-order product so it can be customised, within reason, to the end-user's needs. According to SWORD, it is the lightest and most versatile air delivery system of its kind. The system is designed to bring the payload safely to the area of operation with minimal build-up and breakdown time. The system will roll up and can be recovered or left pressurised and attached behind a waterborne vehicle as an additional floating work platform. It can also be repressurised using the exhaust fill system and utilised as a lift bag for rescue/recovery. The total system weight is 90 kg (198 lb) with a maximum payload of 2,268 kg (5,000 lb).

Meanwhile, Sweden is interested in the Arqus Patsas 4x4, a light armoured (STANAG 4569) vehicle with an open body, specially designed for SOF. The 12-tonne vehicle can carry 2+3 soldiers, can be transported in a C-130 Hercules, and can carry up to three 7.62 mm MGs, a 12.7 mm HMG on the rotating ring mount and an anti-tank guided missile (ATGM) launcher. Sweden has been using the Arqus Bastion for the SOG (Särskilda Operationsgruppen – Special Operations Task Group) for about five years. The Patsas and Bastion are actually the same platform, the former being an open vehicle and the latter an Armoured Personnel Carrier (APC) variant.

The Spanish Special Forces took 24 units of Einsa's Neton 4x4 vehicle into service in 2021. It too is based on the civilian Toyota Hilux chassis with an open architecture. However, the vehicle has a new engine, transmission and parts of the chassis have been modified to offer a new vehicle that meets SOF mobility and firepower requirements. Neton weighs 2,300 kg, and can transport four soldiers and their equipment, equating to a payload of 1,078 kg.

France

In France, the ACMAT and Mercedes-Benz G-model (Panhard VPS/SOF) SOF vehicles are replaced by the Arqus Areg (240 units) and Arqus Sabre 4x4 (202

units). The latter is a patrol vehicle used by SOF around the world, designed to remain as undetected as possible and to offer extremely high mobility and range. This allows it to be used behind enemy lines, according to the manufacturer. It accommodates five soldiers, weighs 11 tonnes and features the Battlenet system. It can also carry three 7.62 mm MGs, one heavy MG .50 BMG, auxiliary tanks and extensive radio equipment.

Due to delivery delays with the Arqus vehicles, an interim solution was also procured, in the form of the VPS (Véhicule de Patrouille Spéciale) 2 Patrol Vehicle. Based on the British Fox from Jankel, it is manufactured under licence by French company Technamm. The procurement was based on immediate operational needs and the vehicles were swiftly deployed to Africa. VPS 2 offers space for up to six soldiers and is designed for long-range reconnaissance missions. It is also based on the Toyota chassis with a total weight of 4.2 tonnes and a maximum payload of 1,700 kg. The maximum range is stated to be 1,500 km. On top of the vehicle is a ring-mounted weapon station that can be swivelled through 360°. This can be armed with a 7.62 or 12.7 mm heavy machine guns, a 40-mm automatic grenade launcher or a Dillon Aero M134, a 7.62 x 51 mm NATO Gatling gun with six barrels, firing at a fixed rate of 3,000 rounds per minute. Another 7.62 mm FN MAG machine gun is mounted on a swivelling station in front of the commander's seat. In 2021, Techmann also introduced the Land Tech 3.5 tactical vehicle, which uses a Peugeot Landtrek pick-up as its base and is thus more cost-effective than comparable Toyota-based vehicles. With this, Techmann wants to score points, especially in the African market.

In parallel, the P4 Aspic (Mistral) will be converted to the P4 VIPAIR configuration. The product improvement includes new guidance equipment, weapon mounts (for MGs up to 12.7 mm), roll bars, improved stowage facilities and a new paint scheme. The contractor is ACS from Germany and initially, 19 vehicles will be converted and delivered to the Brigade aérienne des forces de sécurité et d'intervention (BAFSI – Air Force Security and Intervention Brigade) with the commandos parachutistes de l'air (Air Force Special Forces).

The Rider from UNAC is a French ultra-light SOF vehicle, which can be dropped by cargo parachute or transported as an internal or external load. The vehicle itself offers a payload of 900 kg, and can tow a trailer with a further 400 kg payload, or a 120 mm mortar. The empty mass is

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Photonis is the world leader in the design and manufacturing of image intensifier tubes. With over 85 years of experience, Photonis provides cutting-edge image intensifiers to meet the needs of operators, and is the forerunner in the innovation and development of intensifier tubes.

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PHOTONIS

REVEAL THE INVISIBLE

Photo: André Forkert



Rear View of Safran's aerial delivery system for the lightweight 'Rider' vehicle.

1,890 kg. Safran showed a corresponding aerial delivery system for the Rider at Eurosatory 2022.

Also from France is the HUTP from Hautlotte, competing in the same segment as the Polaris MRZR series or the Polaris DAGOR. HUPT is supposed to offer the same payloads as larger vehicles, at a smaller size and is thus suitable for smaller aircraft. Different variants are foreseen: HUTP-Reconnaissance (HUTP-R); HUTP-Logistics (HUTP-L); and HUTP Xtra-Logistics (HUTP-XL). The HUTP-R has a total weight of 2,800 kg, a payload of 1,200 kg and can carry four soldiers, with a stated range of 1,300 km. HUTP-L is a flat-bed, has a payload of 1,400 kg and offers space for two persons. HUTP-XL is a longer 6x6 vehicle with a total weight of 3,500 kg and a payload of 1,750 kg.

The trial bikes from Electric Motion also come from France. ACS has taken over the exclusive military distribution and adapts the electric motorbikes to the tactical demands of SOF. Silent rides combined with extreme acceleration bring tactical advantages. An approval with a higher payload was obtained for the Bundeswehr. The e-bike is dubbed 'Emu', and can be ridden with a 125 cc driving licence. The battery has a range of 40 km and can be easily replaced in seconds. Thanks to its 80 kg dead weight, it can easily be carried at the rear of a 4x4. Other suppliers of military electric motorbikes are Zero Motorcycles from the USA and SurRon from Austria.

Sensors, Effectors & Camouflage

All these vehicles fulfil a single function: serving as mobility platforms. They are only a means to an end, being effective only through the cargo they transport – first and foremost, commandos as the most important (weapon) system. In addition, there are sensors for reconnais-

sance or electronic combat and, finally, effectors to achieve a direct effect. The market is enormous, so only a few examples can be mentioned here.

First of all, SOF and their means of transport should remain undetected. For highly effective camouflage, there are systems such as the Barracuda Camouflage System from Saab, customised for each platform. These systems are used in more than 24 countries, including France and Germany. The local industrial and distribution partner for France is Solarmtex in Vierzion. The 3D material consists of a textile matrix in order to fully use the properties of the active materials. The design creates a non-snagging, easy-to-use system, supporting fast and safe operation. Saab's camouflage solutions offer multispectral capabilities against a wide-range of sensors: visible, IR, thermal imager, etc., and reduce the heat inside the vehicle, which is an important factor in mission areas such as Africa.

Another supplier of multispectral 3D camouflage is Saro with its GHOSTHOOD brand from Germany. In addition to camouflage nets, it also offers systems for vehicles. The solutions protect against vision (VIS), near-infrared (NIR) and far-infrared (FIR) detection. The mobile vehicle solutions can be applied to platforms from motorbikes to IFVs or battle tanks. There are different versions, such as static systems with a turning function and two different camouflage patterns (e.g. 12 kg for 5.8 m

Photo: GHOSTHOOD



A demonstrator vehicle shown covered with GHOSTHOOD 3D camouflage.

× 8 m), or an ultra-light version with a total of four camouflage patterns and a weight of 5 kg for the same size. These can be attached in less than 2 minutes, or removed in less than 30 seconds in an emergency; they also offer a very small pack size. Similar versions also exist as a "mobile system," which can then be used on the move once attached. There are light (4 kg for a G-Class) or heavy (12 kg) versions, each with a turning function. GHOSTHOOD customises the mobile systems to fit a specific vehicle. "Modern 4x4 vehicles are fully equipped with a lot of high-tech equipment, but the space in aircraft as well as the vehicle itself is limited. Since classic camouflage is heavy and bulky, a new generation of camouflage is needed. Ultra-light and compact solutions replace old school systems while offering the same or even better camouflage. Soldiers in direct surroundings or dismounted also need to be camouflaged. Therefore, vehicle camouflage solutions for SF should be a multipurpose tool with the thread of drones and thermal devices in mind", says Konstantin Möller, Development & Sales Manager at GHOSTHOOD.

In order to be able to approach the target even more closely and quietly, electric bicycles and motorbikes are now carried by 4x4 vehicles. Close to the target, the commandos can switch from four-wheel to two-wheel mode, and cover the last few kilometres quietly. Some manufacturers have already been mentioned above, but the market is now quite large. D.E.S. from Germany, for example, designed an electric bike that can be delivered by parachute. This idea is not entirely new – the British Welbike, developed in 1942 and used by airborne forces from 1943, was a light single-seat folding motorbike that could be dropped by parachute when packed in a container. Many were used by airborne troops around Arnhem during Operation Market Garden in 1944. Another important aspect of the equipment is the inclusion of various sensors and command devices. In terms of sensors, the spectrum ranges from optical, through electro-optical, to acoustic or radar devices. It is becoming increasingly important to reduce the size and weight of sensors in order to make optimum use of available vehicle payload. To increase the range of the sensors, mast systems are now also being integrated into the vehicles. This is a challenge, especially for smaller, lighter platforms. As heard at the KSK Symposium 2022, the integration of mast systems as sensor carriers has been decided or is planned for almost all KSK

vehicles in the future. Zippermast has recently conducted tests in the Alpine operational area on the MRZR D4, together with the KSK. Mast systems must show flexibility by being used on different vehicles with different sensors (Optronic sensors, radars, etc.) as well as in remote use (dismounted) with an effector for drone defence. The range of sensors that can be integrated must include the systems already available in the respective armed forces. Acoustic shot detection, such as that of Microflown Aviso or the APV (Acoustic Protection for Vehicles) shot detection system from Rheinmetall Electronics, are also included.



Photo: André Forkert

The DAGOR 4x4, shown here with an RWS and a four-round launcher for Spike NLOS ATGMs.

Therefore, an open interface is indispensable. In remote operations, the mast and sensors must also be remotely controllable. The sensor network is ensured via a tactical ad-hoc mesh network and corresponding radio links. The Zippermast mast system is currently in the qualification process, to prove that the military requirements from current and upcoming orders are met. Another supplier of corresponding systems is Will-Burt. A further trend in SOF vehicles is heavier armament and thus greater assertiveness. Whereas in the past, light and medium machine guns were the main weapon of choice, today HMGs, 40 mm automatic grenade launchers (AGLs), 20 mm automatic cannons, Gatling guns, as

well as anti-aircraft and anti-tank missiles are the weapons of choice. The MBDA Enforcer and Rafael Spike effectors have already been mentioned. Meanwhile, vehicle manufacturers have also developed lightweight launcher systems for them, so that these effectors can also be used on the open and lightweight roofs of 4x4 vehicles.

Diehl Defence is EOS's sales partner in Europe and, together with partner D.E.S., recently showed a light, rapidly-retractable weapon system for the Polaris vehicles. An EOS R150 RWS, hydraulically retractable at the push of a button, was integrated on the DAGOR, and armed

with a 12.7 mm HMG. The rapid extension and retraction allows it to be loaded as an internally in a helicopter. Depending on the helicopter, only the barrel would have to be removed or attached, using a quick-release fastener. The forces would be ready for action immediately after landing.

At the KSK Symposium, the DAGOR was also seen with a quad launcher for Rafael Spike NLOS guided missiles. The 70 kg NLOS can engage targets at distances up to 32 km with high accuracy. The DAGOR could alternatively carry other missiles, such as Spike ER/LR, and, thanks to its lighter weight, was also able to carry a larger number. The Spike NLOS is distributed exclusively by Diehl. ■

UKP-ŽV: A New Wheeled Armoured Vehicle for the Czech Army

Martin Smisek

This year, the Czech Ministry of Defence plans to launch an acquisition programme to purchase a new wheeled platform for the Army's engineer troops.

Within the project known as UKP-ŽV (Univerzální kolová platforma ženijního vojska; ENG: Universal Wheeled Platform for Engineer Troops) the Army of the Czech Republic (Armáda České Republiky; AČR) intend to acquire 50 vehicles in three versions for route clearance (MRAP RCP, 12 units), explosive ordnance disposal (UKP-EOD, 22 units) and engineer support (UKP-ŽEN, 16 units).

Baseline Vehicle

All three variants will have a common arrangement based on a wheeled armoured vehicle with a gross weight under 20,000 kg (44,090 lb) and at least in a 4x4 configuration. At a minimum, the vehicle must meet STANAG 4569 Level 3 for kinetic energy threats and Level 3a/3b for grenade and blast mine threats.

The AČR requires a vehicle capable of crossing water obstacles with a depth of at least 1.3 m, vertical obstacles at least 0.4 m high and trenches at least 0.7 m wide. The minimum required cruising range on roads is 750 km (466 miles). It must also be air-transportable in a C-130 Hercules aircraft.

The rear hull of the vehicle will contain a large door or ramp for loading and unloading heavy objects. The front section of the vehicle has to be equipped with a universal attachment for the installation of a mine plough, roller, manipulator arm, blower and ground penetrating radar with control from the cab of the vehicle.

The armament will be composed of a 12.7 mm machine gun (plus a 7.62 mm machine gun as an option) installed in an electrically operated manned gun turret (with the possibility of manual control in case of failure of

Photo: US Army



The General Dynamics Medium Mine Protected Vehicle (MMPV) Type II is considered a possible contender for the UKP-ŽV requirement.

Photo: Excalibur Army



Excalibur Army's PATRIOT II is a possible domestic contender for the UKP-ŽV requirement.

Author

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the electrical system) equipped with a ballistic protection kit for the gunner.

The sensor suite must have the ability to observe the vehicle's surroundings using augmented reality image sensors with a horizontal field of view of 360°. The image signal from these sensors will be displayed at the commander and gunner's workstations.

The sensor equipment will also include a stabilised observation camera on a telescopic mast or alternatively a reconnaissance unmanned aerial vehicle.

The equipment of the UKP-ŽV will comprise an obscuration smoke generator, a central tyre inflation system, radio-controlled improvised explosive devices jamming suite,

an automatic fire protection device and an NBC protection system. Removable slat armour or a net screen providing protection against RPG warheads are also among the requirements.

Versions

The MRAP RCP will have a crew of three (commander, driver, gunner) and the transport capacity for six soldiers of the engineer team. In addition to the installation of a manipulator arm, mine plough, roller or ground penetrating radar, the vehicle must be also equipped with a lane-marking system. The inside of the MRAP RCP has to allow for the transportation of up to two TALON Unmanned Ground Vehicles (UGVs) remotely operated vehicles. External and internal cargo boxes with an overall payload capacity of 140 kg will be used for the transport of materiel, explosives, igniters and manpack jammers.

The UKP-EOD version has the same crew of three with transport capacity for two members of the EOD team. The internal layout should allow for the removal of special equipment and the installation of removable seats for an additional four soldiers. The vehicle must be equipped with an external cargo box with a loading platform for one TALON UGV. Additional external and internal boxes will allow for the transport of 140 kg of materiel. The hull should be able to transport two TALON UGVs along with specialised EOD equipment such as mine detectors, portable X-ray system, tool kits for remote movement and remote handling operations and blast suits.

The UKP-ŽEN variant also has a crew of three and the capability to transport an engineer squad of six soldiers together with their equipment. By removing the seats in the rear of the vehicle, the mine-laying system and storage racks for anti-tank mines can be installed. This will allow for the quick conversion of the UKP-ŽEN under field conditions into a mine-laying vehicle.

The Boost of Capabilities

The introduction of UKP-ŽV vehicles into the inventory of the AČR will significantly expand the capabilities of the Czech Army's engineer troops. Although the Czech EOD teams participated in the route clearance patrol missions in Afghanistan using the JERRV MRAPs of the US Army, this capability is basically non-existent in the current AČR due to the complete lack of suitable vehicles in the 15th Engineer Regiment. The EOD teams of its subordinate units, 151st and 153rd

Engineer Battalions, use LOV 7,62 B light armoured vehicles (a variant of the IVECO LMV with the ZSRD 07 weapon station), which are essentially an interim solution due to their lack of adequate transport capacity.

When selecting the future UKP-ŽV platform, the AČR prefers a vehicle already in service with other NATO armies. However, the potential also exists for Czech manufacturers able to offer variants of their wheeled armoured vehicles such as the MARS 4x4, manufactured by SVOS or the PATRIOT II 4x4 from Excalibur Army. ■

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Indian Navy Takes Major Step Forward

Suman Sharma

India made history recently when two fixed-wing fighter aircraft made back-to-back maiden landings on board the nation's first indigenous aircraft carrier INS Vikrant. The landings were made by an indigenous Indian fighter, the Light Combat Aircraft (LCA) Navy and a MiG-29K jet in early February this year at the Indian Naval Air Station (INAS) Hansa, Goa, in western India.

Former Indian Naval Chief Admiral Karambir Singh (retd.), himself an aviator, said: "The indigenous LCA landing on the indigenous Vikrant was indeed a proud moment for all of us. It goes to prove that the design of our carrier deck with associated wind-flow calculation was spot on."

The historic landings mark one step further towards making INS Vikrant fully operational. The carrier, which is currently in the middle of critical flight and sea trials, was commissioned in September 2022, and is expected to become fully battle-ready by the end of 2023. Both flights, by the LCA and the MiG-29K, were basic in nature, and the complete envelope of the complex flight trials is expected to be concluded in the next three-four months. Most weapons testing and rotary wing trials have almost been concluded. Indian Navy's Vice Adm Shekhar Sinha (retd.) stated: "Large number of sorties are required to develop the Operating Data Manuals which form the basis of future operations. Each weapon configuration with different wind on deck has to be flown and the flight envelope has to be plotted." The maiden flight was carried out by the single-engine LCA Navy technology demonstrator, currently incapable of full operations, is considered the precursor to the indigenous twin-engine deck-based fighter (TEDBF), presently awaiting Government sanction. Admiral Karambir (retd.) adds, "The LCA Navy was to be a technology demonstrator and a platform that would help in the design of our operational deck fighter, the TEDBF. The Government should not delay sanction of the TEDBF anymore as we need to have the first prototype out by 2026."

As Indian and foreign naval fighters carry out landings and evaluation trials, the state-run defence agencies such as the Defence Research and Development Organisation (DRDO), Aeronautical Development Agency (ADA), Hindustan Aeronautics Limited (HAL) and the Indian Navy are quietly working on the TEDBF, their most ambitious and most advanced naval fighter project. With DRDO

Photo: DRDO



LCA Navy making its historic maiden landing onboard India's aircraft carrier INS Vikrant, in early February 2023.

as the lead agency, the Indian Navy is preparing a Cabinet draft note for the development and design of the TEDBF. Before any Cabinet sanction, the Navy is required to carry out design drawings and simulations, after which the ADA will inform the Government that it is feasible to operate such an aircraft.

The principal agencies for this twin-engine, medium-weight, short take-off but arrested recovery (STOBR) aircraft with Delta-wing platform and canards, include HAL, ADA and DRDO, all three of which will join together for prototype fabrication, integration and testing. According to the Indian Navy, the first TEDBF prototype is expected to be ready around 2026, and its production is likely to begin by 2032. The Indian Navy's requirement is for over 100 TEDBF fighter jets. On the sidelines of the recently concluded biennial Aero India air show, DRDO Chairman Dr. Samir V Kamat said: "We are waiting for the Government sanction for the TEDBF."

As TEDBF is still on the drawing board and LCA Navy is only taking baby steps forward, the Navy is looking at importing deck-based fighters as an interim measure. After successfully executing exhaustive evaluation trials last year between Boeing's F/A-18 Block-III Super Hornet and Dassault Aviation's Rafale-Marine, the Indian Navy is awaiting an official announcement of the winner for

a 26 aircraft deal valued at USD 6 Bn. Unofficial reports point towards Rafale-M as the choice for the Navy's deck-based order. These 26 imported fighter jets, for both the carriers, INS Vikrant and INS Vikramaditya, will serve as a stopgap, as the TEDBF is almost a decade away from entering service. The 26 fighters would be split into 18 single-seat and eight twin-seat aircraft, in a deal to be processed through the government-to-government (G2G) route, so that further production can be carried out in India under licence, in order to facilitate the Indian Government's flagship initiative of 'Self-Reliant India', popularly known as 'Atmanirbhar Bharat'.

TEDBF

The TEDBF is a twin-engine, single-seat, carrier-borne fighter aircraft, designed for operations on board Indian carriers. The aircraft is 17 m long, with a folded span of 8.3 m and spread span of 11.6 m, has been envisaged by the Indian Navy as a replacement for the MiG-29K. With a height of 5.65 m, this homemade fighter has a maximum all-up weight of 26 tonnes, with a service ceiling of 16,764 m (55,000 ft). The aircraft will have 'g' limits from +8g to -3g, and will come equipped with 12 hardpoints and a maximum speed of Mach 1.3.

The TEDBF will operate in roles such as combat air patrol, air-to-air combat, maritime strike, escort jamming, deck-launch interception, land-attack strike, anti-ship strike and buddy refuelling. It will operate in the STOBAR concept and is designed for superior mission capability to accomplish the primary roles of air defence and maritime strike.

Regarding the TEDBF, ADA's TV Vinod Kumar, Project Director LCA (Navy) Mk-2, says: "Initially there will be four prototypes produced. The EW suite, sensors, radars and weapons will all be indigenous."

LCA Navy

In a landmark moment, the LCA Navy Mk-1 successfully demonstrated 'Atmanirbhar Bharat' by realising its ambition of becoming India's first indigenous combat jet to have an arrested landing on India's first indigenous aircraft carrier INS Vikrant. Other milestones that have been achieved by LCA Navy are successful demonstration of carrier compatibility by arrested landing and taking off from INS Vikramaditya.

LCA Navy's other accomplishments include numerous high sink-rate landings at the shore-based test facility (SBTF) located at INAS Hansa, Goa. A ski-jump take-off and arrested landing with a Derby missile has also been demonstrated successfully. The LCA Navy also boasts a successful data link functionality demonstrated with a Sea Harrier.

Other features of the LCA Navy are its ability to conduct operations from an aircraft carrier using the STOBAR concept. The fighter takes off from a ski-jump ramp in about 200 m, and is recovered on board at 90 m by engaging its arrester hook with the arresting gear wire on the carrier. LCA Navy with its primary role of air defence and secondary roles of anti-ship strike and interception will complement other aircraft on board Indian naval aircraft carriers in the future.



Photo: Suman Sharma

The TEDBF scale model on display at Aero India 2023.

The primary objective of the LCA Navy Mk-1 programme is to design and develop a naval variant of the LCA capable of operating from an aircraft carrier. The scope of the programme includes the development of a two-seat trainer, a single-seat fighter, a structural test specimen and development of a SBTF, replicating an aircraft carrier.

The two LCA Navy aircraft developed are technology demonstrators for carrier compatibility and weapons integration. The first LCA Navy prototype carried out its maiden flight on 27 April 2012, and the second prototype, in the fighter version, flew on 7 February 2015. Presently, both aircraft are undergoing extensive flight testing for carrier compatibility, ski-jump technology towards take-off from the carrier, which has been mastered. The LCA Navy successfully completed carrier trials on board the Russian-built carrier, INS Vikramaditya in January 2020.

The SBTF, a unique facility for naval fighter jets established at INAS Hansa, Goa, has also been used to train Indian naval pilots on the MiG-29K fighter jet, prior to embarking on INS Vikramaditya.

Carrier compatibility testing (CCT) is a major challenge for any naval aircraft. After initial testing in a typical up-and-away flight envelope, CCT is carried out at the SBTF. This facility replicates an aircraft carrier with restraining gear and ski-jump for take-off.

Maritime Challenges

The Indian Navy's persistent demand for a third carrier is not misplaced, when considering that the Chinese People's Liberation Army Navy (PLAN), with its 355 naval assets, is onto its fourth aircraft carrier after commissioning its third in June 2022, the 80,000-tonne Fujian.

In December 2022, Indian Naval Chief, Admiral Hari Kumar announced that the Indian Navy would aim for a repeat order of the 45,000-tonne INS Vikrant, instead of a more powerful 65,000-tonne carrier, which was initially planned, due to budgetary constraints.

Aside from helping Pakistan with submarine and warship construction, China's PLAN is reported to be considering increasing its maritime footprint in the Indian Ocean Region (IOR), by having more naval bases, followed by the deployment of carrier battle groups in the IOR.

To counter the challenge posed by delays in India's naval aviation assets, government clearances need to be expedited, coupled with speedy manufacturing and design efforts, about which ADA's Vinod Kumar says: "A defence production ecosystem has come in place in the past decade or so, which was not there earlier, that includes private players like Tata Advanced Systems Ltd (TASL) and Larsen & Toubro (L&T). This will help bolster production and development for a speedy delivery within timelines."



Photo: DRDO

LCA Navy in the two-seat configuration on display.

The World of Saint Javelin

Doug Richardson

In the course of 2022, an unofficial new female saint joined the Ukrainian pantheon. Her halo was not the traditional gold colour used in Orthodox iconography, but used the colours of the Ukrainian flag. Her hands were not raised in gesture of blessing, but cradled the recognisable form of a Raytheon/Lockheed Martin FGM-148 Javelin anti-tank missile. While the religious authorities did not approve of this image when it began appearing on websites or as 'street art', its arrival and the fact that it was dubbed 'Saint Javelin' reflected the vital role that the US missile was playing on the battlefield as Ukraine fought to contain then drive back the Russian forces that had invaded it.

History has shown that 'kill' claims are often inaccurate, and TV pundits have suggested that Ukrainian claims for numbers of enemy soldiers killed, and enemy tanks knocked out should be sharply scaled back. Yet if the Ukrainian claim that Russia had lost around 3,300 tanks in just under a year is scaled back by two thirds, the revised total would still rival the losses that the German armoured forces suffered during the Battle of Kursk in 1943 – the biggest tank battle in history, and one which tilted the military balance on the Eastern front and allowed the Red Army to begin an unstoppable advance westwards.

The London-based International Institute for Strategic Studies (IISS) recently estimated that Russia has lost around half of its pre-war fleet of modern T-72B3 and T-72B3M tanks, so is having to replace these with older tanks that had been in storage. Many of these losses are likely to have been inflicted by Javelin missiles provided by the US and Saab Next Generation Light Anti-Tank Weapon (NLAW) missiles delivered by the UK.

Direct versus top attack

If the benevolence of a saint can traditionally be thought as descending from above, the same can be said for the destructive effects of many modern anti-tank missiles. Until the early 1990s most operated in direct-attack mode, relying on a forward-firing warhead intended to penetrate the



Saint Javelin rapidly gained popularity following the 24 February 2022 Russian invasion of Ukraine, becoming a symbol of resistance and support for Ukraine.

armour of an enemy tank. The efficacy of this approach was downgraded by the introduction of composite armour and explosive reactive armour (ERA), so some missile designers opted to create weapons that would overfly the target and detonate a downward-firing warhead, or would make a diving attack. Both approaches were intended to attack the upper surfaces of a tank's turret or hull, areas that were considerably less well-protected than the vehicle's frontal arc.

A competitive evaluation of rival weapons that used direct and top-attack respectively was conducted by the US Army in the early 1990s, when it sought an interim anti-tank weapon for use until its planned Javelin

– originally known as the Advanced Anti-Tank Weapon System-Medium (AAWS-M) – was ready for service. The chosen candidates were the McDonnell Douglas Dragon II and the Bofors Infantry Light and Lethal (BILL). Both were wire-guided semi-automatic command to line-of-sight (SACLOS) weapons, but while Dragon II followed the gunner's line-of-sight to the target, BILL flew above the gunner's line-of-sight and over the target. Dragon II made a conventional attack against its target, using a warhead detonated by an impact fuze, but BILL detonated its warhead as it overflew its target, so that the resulting penetrating jet struck from above. The US evaluators concluded that Dragon II had the higher hit probability, but BILL had a higher probability of kill.

The evolution of Javelin

The earliest infantry-operated anti-tank missiles used manual command to line-of-sight (MCLOS) guidance, a scheme that was simple to implement, but had a low hit rate under combat conditions. By the 1970s, semi-automatic command to line of sight (SACLOS) was the preferred solution, but one which required the gunner to maintain a track on the target until the engagement was over.

In 1986 the US Army began its Advanced Anti-Tank Weapon System-Medium (AAWS-M) programme by awarding competitive contracts to what were then Hughes Missiles (now Raytheon), Texas Instruments (now Raytheon), and Ford Aerospace (now Loral Corporation) for the development of a next-generation anti-tank weapon for infantry use. While Ford Aerospace opted offer a SACLOS solution based on the laser-beam riding principle, Hughes and Texas Instruments took a more ambitious route by adopting imaging infra-

Author

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



Photo: US Army

A minimal launch signature and the fire-and-forget capability available from a nose-mounted imaging infra-red seeker make the Raytheon/Lockheed Martin FGM-148 Javelin a formidable weapon on the battlefield.

red (IIR) guidance schemes that would offer a fire-and-forget capability.

In June 1989, a full-scale development contract for what would become the FGM-148 Javelin was awarded to Texas Instruments and Martin Marietta (now Lockheed Martin). Low Rate Initial Production (LRIP) began in 1994, followed by full-rate production in 1997, and the first multiyear contract in 2000.

Javelin uses a missile supplied in a disposable launch tube assembly (LTA). This is mated with a reusable CLU incorporating day and night sights for surveillance and target acquisition, and connecting to the missile within the LTA to control target lock-on and missile launch. While the primary task of Javelin is to destroy vehicles, it can also be used to attack enemy personnel within fortified positions or in the open.

By early 2023, the US is thought to have transferred around 8,600 Javelin missiles to Ukraine. In a report published in January 2023, the US-based Center for Strategic and International Studies (CSIS) warned that the supply of some weapons systems and munitions directly from US inventories had "depleted some stockpiles that could be used for training, future contingencies, or other operational needs. For example, the quantities of Javelins transferred to Ukraine through late August 2022 represented seven years of production at fiscal year (FY) 2022 rates before recent reprogramming actions."

Two programmes are currently under way to create an improved version of Javelin, reducing the size and weight of the hardware, addressing component obsolescence issues, and meeting or exceeding current performance. The first of these is developing a new LTA, electronic battery unit, guidance electronics unit, and uncooled

missile seeker, creating a new production version designated FGM-148G. The second involves a new lightweight and physically smaller CLU that will exploit the latest daylight and infrared camera technology in order to provide better camera resolution and higher zoom capability.

Old and new hardware will be compatible, allowing the new CLU to be used with older LTAs, while the existing CLU will be compatible with the new FGM-148G missile. However, this new hardware will require the development of a new Basic Skills Trainer and Outdoor Trainer. The programmes to develop the new CLU and LTA are not running on the same timescale. Flight testing of the G-model missile began in Fiscal Year FY22, but development and testing are expected to take a further three years. A decision to begin full-rate production of the LW CLU is scheduled for the second quarter of FY24,

The results from early testing have shown that the new CLU allows target detection, recognition, and identification faster and at longer ranges, while live-fire trials have shown that the new seeker does not affect the performance of the missile warhead. Operational testing the new LW CLU is due to begin in the second quarter of Fiscal Year 2023, but follow-on testing will be needed once the FGM-148G missile is ready.

NLAW – The Seekerless Solution

Originally developed by what was then Saab Bofors Dynamics (now Saab Dynamics AB) to meet the demand for a light anti-tank weapon able to defeat enemy tanks over their frontal arc, the Next Generation Light Anti-Tank Weapon system (NLAW) is the second Western anti-armour weapon being used by Ukraine.

NLAW was based on the company's earlier experience with the Bofors Infantry Light and Lethal 2 (BILL 2), and uses Predicted Line of Sight (PLOS) guidance. If the target is moving, the user must track it for several seconds before firing. The missile's on-board inertial guidance electronics will record the soldier's aiming movement, then compute the required flight path. The user does not have to estimate and compensate for factors such as range, target speed and wind speed, but must select whether to use overfly top attack (OTA) mode or direct attack (DA) mode. After launch, the missile flies autonomously to the target. The warhead is initiated by a dual-mode laser/magnetic proximity fuze in OTA mode, or by an impact fuze in DA mode.

Photo: Saab



The Saab Next Generation Light Anti-Tank Weapon system (NLAW) uses Predicted Line of Sight (PLOS) guidance, so will fly a pre-calculated trajectory after launch.

A UK order was placed in 2002, with final assembly to be conducted by Thales UK at its facility in Belfast, Northern Ireland. In 2005 NLAW was ordered by the Swedish Defence Materiel Administration for delivery to the Swedish armed force under the designation 'Robot 57' (Rb 57). In 2008 Finland became the first export customer for NLAW, and since then a further four

countries have chosen this weapon. Anticipating a possible Russian invasion of Ukraine, the UK supplied 2,000 NLAWs to Ukraine by 19 January 2022. By mid-March of that year, the UK had delivered over 2,000 more, and promised a further 6,000.

On 7 December 2022, Saab announced that it had received an order worth approximately SEK 2.9 Bn from the UK for a further tranche of NLAWs. Deliveries will run from 2023 to 2026. The latest reported deliveries had been to Switzerland in 2018-2021, but "deliveries remain ongoing by Saab", Saab told ESD. Asked whether the new batch ordered by the UK would be exactly identical to the hardware delivered earlier, it stated "At this time we are not disclosing details related to production build standards."

Alternatives to Javelin

While the US was developing Javelin, a similar timescale was envisaged for the development in Western Europe of next-generation anti-tank missiles intended to replace the then-current MILAN, HOT and Swingfire systems. Following studies conducted in 1986, France, Germany, and the UK launched the Euromissile Dynamics Group (EMDG) TRIGAT Medium Range (MR) and TRIGAT Long Range (LR) systems. For the long-range version, which weighed about 40kg, passive imaging infra-red guidance was adopted, but TRIGAT-MR relied on a more conservative solution in the form of laser-beam-riding SACLOS, a choice that was thought to pose a lower risk than next-generation technology solutions.

Despite this choice of a less-complex guidance technique, progress was slow, with technology-proving and troop trials of the resulting missile getting under way until 1997. In 2000 several of the participating nations, including Belgium, the Netherlands and the UK, left the TRIGAT-MR programme, bringing about its collapse. In 2003 the UK selected Javelin as its next-generation anti-tank weapon, while France ordered a batch of Javelin in 2010 to meet an urgent operational requirement (UOR).

China's equivalent to Javelin is the China North Industries Group Corporation (NORINCO) HJ-12, also known as the Red Arrow 12. First shown in 2014, it can be used against tanks and other AFVs, bunkers, and even slow-flying helicopters. An uncooled focal plane array infrared seeker provides lock-on before launch and fire-and-forget capability, but a lower-cost variant developed for the export

Photo: Doug Richardson



China's HJ-12 fire-and-forget missile is being marketed internationally as the Red Arrow 12.

market uses a television seeker, so is only suitable for daylight use.

Russian has no Javelin-class weapon. Its Tula KBP Kornet (AT-14 'Spriggan') uses laser beam-riding SACLOS guidance, but in an interview given to the Russian military newspaper Krasnaya Zvezda in 2004, General of the Army Nikolay Kormiltsev, a former commander-in-chief of the Russian Ground Forces, claimed that new fire-and-forget versions had been developed. These were third-generation variants of the missile, and could be equipped with "a thermal or radio-locating homing head", he stated, so the gunner would only need to aim the missile, then launch it once lock-on had been obtained. Almost two decades have passed since General Kormiltsev's statement, but no fire-and-forget version of Kornet is known to have entered service.

Improved Guidance Capability

Javelin has only a single seeker, which operates in the IR region of the spectrum, but a useful tactical advantage can be obtained by adding a second sensor that operates in the visible range so can be used against targets that do not have a distinct heat signature. India's Bharat Dynamics Limited (BDL) Amogha-III is based on a dual-mode terminal seeker that combines an IIR and optoelectronic assembly. The system is tripod-mounted, and combines a tube-launched missile with a command launch unit (CLU) that can be operated remotely. It is able to fly top-attack or direct-attack trajectories, and is armed with a tandem warhead.

One problem with fire-and-forget missiles is that the user has no further control of

Photo: Russian MoD



A Russian military cadet fires a Tula KBP Kornet (AT-14 'Spriggan'). Note the absence of a nose-mounted seeker – Kornet is a laser-guided SACLOS missile, and reports of a fire-and-forget version have never been corroborated.

them following launch. If the seeker loses lock for any reason, such as target obscuration by terrain or buildings, or as a result of the enemy using screening smoke or active optical countermeasures, the shot is wasted. Nor does the user have the ability to redirect the missile towards a target of opportunity, or break off the engagement if the risk of collateral damage becomes unacceptable. For this reason, some armies prefer to rely on 'man-in-the-loop' guidance techniques such as SACLOS.

Rafael Advanced Defense Systems' Spike-LR missile gets the best of both worlds, by using an IIR or a charge-coupled device (CCD) seeker able to give fire-and-forget capability, but incorporating a fibre-optic datalink which gives the gunner a 'missile-eye view', allowing them to monitor the engagement, switch the missile to an alternative target, or use the round's lofted trajectory to locate and attack targets masked by trees or other terrain features. The Spike-MR variant uses the same launcher hardware, but its missile does not carry the bobbin of optical-fibre. The downside to eliminating the trailing optical fibre is that missile range is limited to 2.5 km, due to having to lock targets prior to relying on the seeker's target acquisition range pre-launch.



Photo: Danish MoD

Denmark selected the Rafael Spike-LR2 as its next anti-armour weapon. This version uses a multispectral seeker that allows the gunner to swap between IR and visible-light imagery while the missile is in flight. It can also attack its target at impact angles of up to 70° in order to counter vehicle-mounted active protection systems (APSSs).

When Rocketsan decided to include a datalink in its OMTAS (Orta Menzilli Tanksavar Sistemi), a medium-range weapon that has the same guidance and warhead as the larger and heavier UMTAS (Uzun Menzilli Tanksavar Fuze Sistemi) it opted for a du-

plex RF data link able to provide uplink and downlink functions.

MBDA selected dual-mode (uncooled IR plus low-light TV (LLTV) imaging) for its MMP (Missile Moyenne Portée), but also included a fibre-optic link that would allow

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Photo: Doug Richardson



Displayed at defence exhibitions by Yugoimport, this cutaway of the Bugar missile shows a close resemblance to the internal layout of the MBDA Eryx.

man-in-the-loop and lock-on after launch (LOAL) engagements. It also carries an Inertial Measurement Unit (IMU) based on MEMS (Micro-Electro-Mechanical Systems) technology. The two imaging sensors are mounted on a reversible axis, allowing the operators to select which sensor to use before launching the missile. A GPS receiver mounted in the firing post can be supplemented by a laser rangefinder, allowing target co-ordinates to be exchanged via tactical datalinks. This allows third-party target designation. The missile can be commanded to fly either a low-altitude direct attack trajectory, or a lofted flight path that will end in a top attack. Following competitive trials against Javelin and Spike, the French MoD selected MMP (subsequently redesignated as 'Akeron-MP') in 2013, and first deliveries took place in 2017. The missile will also form the basis of at least two other systems – a fifth-generation ATGM to be developed as a joint venture with the Indian company Larsen & Toubro, and variant to be known as RBS-

58 that will be developed in conjunction with Saab.

Bargain-Basement Copies?

One factor that complicates the marketplace for anti-tank missiles is some countries' creation of weapons based on foreign systems, or even unlicensed copies. The US McDonnell Douglas Dragon short-range anti-tank weapon was purchased by Iran prior to the revolution, but Iran has successfully copied it, and now manufactures it under the designation Saeghe 1. A follow-on Saeghe 2 version carries a tandem warhead, while Saeghe 4 is reported to use a thermobaric warhead. Russia's Tula KBP 9K113 Konkurs (AT-5 'Spandrel') has been copied by Iran under the designation Tosan, and was followed by the Dehlaviyeh, a reverse-engineered version of the 9K129 Kornet-P. North Korea's Bulsae series of anti-tank missiles are all thought to be based on Russian or Chinese designs.

Iran and North Korea are not the only countries offering copies or derivatives. A close similarity between the Yugoimport-SDPR Bugar wire-guided SACLOS missile and the MBDA Eryx has led to suspicions that the Serbian missile is based on the latter design. A cutaway example displayed in 2014 showed a close similarity to the internal configuration of the Eryx. Combat use of any high-technology weapon inevitably brings the risk that some examples might fall into enemy hands. During the 2006 Lebanon War, Hezbollah is reported to have captured at least one example of the Spike-MR missile and launcher. These seem to have passed to Iran, which in 2021 revealed what seems to be a reverse-engineered copy designated Almas. In its current conflict with Ukraine Russia has captured examples of Javelin and NLAW, and is believed to have passed some of this hardware to Iran, so the creation of Iranian 'rip-off' versions of both seem likely.

A Quest for Countermeasures

The threat posed by tanks has always spurred the development of anti-tank weapons, so the current generation of top-attack and fire-and-forget missiles has inevitably triggered countermeasure programmes. The use of bar armour consisting of a rigid metal grid intended to disrupt PG-7V-style fuzes dates back to the early 1940s, and screens of this type are often used to provide a degree of protection for lightly-armoured vehicles such as personnel carriers. In 2021 Russia was seen to be experimenting with top-mounted slat armour as a potential method of protecting tank turrets from downward fire. In May 2022 the Russian newspaper Moskovskij Komsomolets quoted a Russian tank crewman as saying that these improvised screens were had not proved very practical, since they interfered with radio com-

Photo: Doug Richardson



MBDA's Akeron MP (formerly Missile Moyenne Portée (MMP)) combines visual and IR seekers with a fibre-optic datalink.

munications if touched by an antenna, made it near-impossible to use the commander's roof-mounted machine gun, and would hinder the crew if they needed to abandon the tank in an emergency. As a result, they were being removed, the newspaper was told.

Having captured examples of Javelin, Russia will presumably try to develop and field countermeasures able to counter the US missile and other fire-and-forget threats. Fast-deployed smoke or other obscurants will try to deny the incoming missile the visual or infrared image on which its seeker depends, while an active optical jammer could attempt to dazzle or confuse the seeker. However, the effectiveness of an active solution may be blunted by the arrival of FGM-148G version of the Javelin missile. NLAW uses PLOS guidance, so is not vulnerable to optical countermeasures.

Down through history, the fielding of a new weapon has inevitably spurred the search for a counter-weapon. In the early 14th century, the armoured knight was a war-winner, but at the battle of Crecy in 1346 these aristocratic warriors were defeated by the arrow-storm produced by



Photo: Ukrainian MoD

Abandoned by its crew, this Russian tank still carries top-mounted supplementary armour intended to blunt the effect of downward fire.

the longbows of the massed ranks of English archers – soldiers whom the knight would have regarded as being little better than peasants. For a century, France struggled to find a suitable counter-weapon. But when a solution emerged, within a few years France not only won

the Hundred Years War, but was able to bring to an end some three centuries of English rule of French provinces. Today the battle between the armoured threat and the infantryman is still under way, and once again, the future of a country may be at stake. ■



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The 155 mm Artillery Marketplace Evolves

David Saw

With the collapse of the Soviet Union and the end of the Cold War, the strategic landscape of Europe was totally changed. Eastern European nations that had been part of the Warsaw Pact or even the Soviet Union now found themselves emerging as democratic states. For the first time in more than 40 years the threat of a major conflict in Europe appeared to have evaporated. In those circumstances where was the logic in sustaining the large military establishments that had been considered necessary in the Cold War?

As far as strategic analysis went, the belief was the role of the military in the 1990s and beyond, would be focussed on peacekeeping operations and missions such as disaster relief. Nobody was expecting world peace to suddenly emerge and conflict to disappear from the world stage. What they did expect was that the time of high intensity mechanised conflict was over. In those circumstances European land forces, which had spent years preparing to fight and being equipped to fight high intensity mechanised conflict, would have to change their focus, structure and equipment strategy to meet the demands of the new European security ecosystem. The consequence of this was a defence capability build-down over much of Europe.

Another aspect of this build-down was the cascading of equipment deemed surplus by one country to another, as we shall see in certain cases, some of this cascaded equipment has gone on to serve with a third country and even a fourth. In the context of 155 mm artillery if the end of the Cold War marked the start of a period of capability decline across much of Europe, recent events have totally transformed the European artillery landscape. Since the Russian invasion of Ukraine in February 2022, efforts to supply Ukraine Ground Forces with artillery systems unearthed a profusion of different systems. Initially these were Soviet calibre systems, but then the majority of systems arriving in Ukraine were NATO 155 mm calibre. Beyond Ukraine, the key artillery trend has been Western nations seeking to boost their own artillery capabilities, resulting in some enormous acquisition programmes. Even so, the artillery picture across Europe remains difficult to fathom.

Photo: Ukraine Ground Forces



Norway has supplied 23 M109A3GN self-propelled guns (shown here) to Ukraine Ground Forces. Italy has supplied more than 20 M109L, Britain purchased 28 M109A4BE for Ukraine, Latvia is supplying six M109A5Ö and the US is to supply 18 M109A6 Paladin.

The British Artillery Crisis

The British Army has a 155 mm artillery problem, it had been hoped that there was finally a path to resolve this situation and on paper there was, unfortunately real life intervened. The roots of the British artillery problem date back to the 1960s, and start with a number of acquisition programmes for self-propelled artillery, with two main systems being introduced into service. The first of these systems was the FV433 Abbot, based on the chassis of the FV432 APC, this was 16.2 tonne system mounting a 105 mm L13A1 gun. Work on the design started in the late 1950s and some 12 prototypes were built by the early 1960s, the first Abbot vehicles were delivered to the British Army in 1965 by Vickers and eventually 176 systems would be acquired. Vickers also proposed a less complex and expensive export variant of the system known as the Value Engineering Abbot. India acquired 68 of these, while the British Army

acquired 20 for use as training vehicles at BATUS in Canada. Also arriving in the mid-1960s were the first of some 140 M109 155 mm self-propelled guns from the US, these would be upgraded to M109A1/A2 standards during their service lives.

With both the Abbot and the M109 destined to reach the end of their service lives in the early 1990s, work started on the design and development of a successor in the 1980s, that eventually led to the arrival of the 'Artillery System for the 1990s,' more commonly known as the AS90. In total 179 AS90s were built for the British Army, but unfortunately for the AS90, it arrived after the end of the Cold War, when its capabilities were no longer seen as a priority for the British Army.

With the arrival of the AS90, the story of the Abbot and the M109 came to an end in Britain. However, a large proportion of the British M109 fleet would go on to find a new life elsewhere. In 1994, 83 of these British M109s were sold to

Austria, some of these were converted to the M109A5Ö gun configuration, others to a command and control version and others to a driver training vehicle. The M109A5Ö still remains in service in Austria, but in 2017 the Latvian Land Forces were able to acquire 35 M109A5Ö gun systems, 10 command and control variants and two driver training vehicles from Austria. Then in 2021 Latvia acquired a further 18 M109A5Ö gun systems from Austria. That is not the end of the story though, in August 2022 Latvia donated six M109A5Ö guns to Ukraine.

Ironically in 2022, Britain found itself actually purchasing M109 systems, albeit for Ukraine. When Belgium decommissioned its M109 fleet, it had 64 upgraded M109A4BE guns, of these 36 were sold to Indonesia in 2017. The remainder were sold to a private contractor and Britain purchased the remaining 28 M109A4BE for refurbishment and onward supply to Ukraine. Other M109 donations to Ukraine include 23 M109A3GN from Norway, supplied in May and November 2022, and more than 20 M109L from Italy arriving from October 2022. More recently, the US has said that it will be supplying Ukraine with 18 M109A6 Paladin guns and 30 M992 Field



Photo: British Army

Following the AS90 Donations to Ukraine, the UK's self-propelled 155 mm artillery capability will have effectively disappeared. This leaves the self-propelled M270B1 MLRS (227 mm), towed L118 (105 mm) howitzer, and the L16A1 (81 mm) mortar to take up the slack until a replacement is purchased.

Artillery Ammunition Support Vehicles (FAASV) for ammunition supply to gun systems in the field.

The course of the conflict in Ukraine has shown that artillery is absolutely essential for ground operations, this has resulted in a prodigious demand for artillery, both towed and self-propelled. To assist Ukraine, the British government offered

to supply 30 AS90 systems, the current British Army AS90 inventory is 89 guns according to the official data contained in 'UK Armed Forces Equipment and Formations' released by the Ministry of Defence (MOD). However, while Britain has 89 AS90s on paper, it does not have 89 AS90s which are actually ready for operational use.





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The third and final batch of 12 K9PL self-propelled guns ready for shipment to Poland in January. The first batch of 24 K9PL guns was rolled out in October 2022 and arrived in Gdynia, Poland, on 5 December. In total Poland ordered 48 K9PL guns for delivery in 2022/2023.

Obviously nobody is going to provide an exact number of workable guns, according to British sources there are certainly ten guns that work, the majority of which are deployed to the artillery battery supporting the British Battlegroup in Estonia. It total there are only thought to be 20 AS90 guns that are truly viable at this point. So, where were the British government going to find 30 guns for Ukraine? The short answer was that they could not, the offer of 30 guns then became an offer of 24 guns. Of these, eight AS90 could be supplied, while a further 16 were in a situation where they would gradually be made operationally ready and presumably be supplied to Ukraine at some unspecified point in the future.

Where Next?

This situation with AS90 for Ukraine demonstrated just how dire the artillery

situation had become for the British Army! There was an artillery programme on the horizon that was supposed to resolve the artillery problem in the shape of the Mobile Fires Platform (MFP). This was to be the successor to AS90, with AS90 to reach its out of service date in 2030, although there were suggestions that this could have been extended to 2032. This is a classic example of the strange world of British defence procurement, where a critical replacement for an artillery capability that has been diminished to the point of insignificance, has an in service date seven to nine years into the future! On the positive side, MFP is a funded programme, up to 116 guns were due to be acquired, as well as a range of different ammunition natures, and the contract was expected to be awarded in 2026. It was expected that the MFP programme would officially get underway at the start of this year, possible industrial contend-

ers were many and varied, including BAE Systems with Archer, Elbit with ATMOS, KMW with Remote Controlled Howitzer 155 mm (RCH 155) mounted on the Boxer platform, the Nexter offering the Caesar, and Hanwha along with their British partners in 'Team Thunder' offering the K9A2 system.

MFP was gearing up to be a fascinating programme, then all of a sudden everything changed. It appears that those in positions of power noticed that Britain did not have a viable 155 mm tube artillery capability and that something should be done about this. To that end there is now talk of an interim 155/52 mm artillery capability being acquired, with the MFP supposed to happen at some as yet to be decided time in the future. The obvious risk to the programme here is that if the interim gun system is satisfactory, why proceed with MFP? It seems that the system being suggested for the interim artillery programme is the Archer from Sweden, which presents a rather intriguing scenario. Sweden was somewhat reluctant to supply artillery to Ukraine, then it changed its mind, the next step being deciding on how many Archers to send from the 48 systems in storage and then getting them prepared for operational service in Ukraine. Once the number for Ukraine is determined, that opens up the path for negotiating on the number of systems that the British might want and then defining a timeline when they could be delivered and how much they would cost.

Archer seems to have emerged as the favoured interim artillery solution despite the fact that there appears to have been very little thought given to other possibilities. It is believed that Hanwha proposed a K9A1 solution for the interim artillery requirement and that there was very little response from the British MoD. All of which is somewhat surprising as Hanwha have proven as part of their major contract with Poland that they can rapidly supply equipment.

Under the terms of the contract with Poland, an initial batch of 48 K9PL (K9A1) guns were to be supplied in 2022/23, the first 24 guns were rolled out in October 2022 and subsequently shipped to Poland, arriving in Gdynia on 5 December 2022. The third and last batch of 12 K9PL were ready for shipment from the Republic of Korea (ROK) in January 2023. This is truly rapid delivery, the official Polish government announcement was in July, commercial contracts were inked in August and first deliveries were made in December and it is estimated that deliveries ought to be complete by March. The abil-



Poland has been a major source of defence equipment for Ukraine, supplying 18 AHS Krab self-propelled guns. In addition, Ukraine has placed an order for 54 more systems with Poland. Poland's future self-propelled gun capabilities will be based on the Hanwha K9, with many hundreds to be acquired.

ity to draw K9s from ROK Army stocks, prepare and deliver them, within such a short timescale is noteworthy.

All things considered, it has been a lucrative period for Hanwha and the K9. In December 2021 they signed a contract with Australia for 30 AS9 Huntsman (the Australian configuration of the K9) gun systems and 15 AS10 armoured ammunition resupply vehicles. February 2022 saw the signing of a contract for an undisclosed, but large number of K9 gun systems, K10 ammunition resupply vehicles and K11 fire direction centre vehicles by Egypt. Hanwha will supply the first batch of systems by the second half of 2024, while in parallel a technology transfer programme will see local production of the three vehicle types in Egypt to complete the order.

Elsewhere, the contract with Poland could eventually amount to 672 K9 systems, in November Norway added to its K9 and K10 inventory with an order for four more K9 and eight more K10 systems. While in January 2023, Estonia opted to acquire an additional 12 K9 systems, previously they had ordered 24 K9 systems, with 18 systems delivered by December 2022.

The French Connection

The Nexter Caesar system found itself at the centre of a multinational effort to support the defence of the Ukraine, France supplied an initial batch of 18 Caesar 6x6 MkI systems to Ukraine from May 2022 onwards. As of January 2023, it has agreed to supply an additional 12 Caesar 6x6 MkI systems to Ukraine. Denmark was due to take delivery of 19 Caesar 8x8 systems (mounted on a Tatra T-815 chassis), but has announced that it would be transferring these systems to Ukraine. In December 2022, Lithuania announced the purchase of 18 Caesar 6x6 MkII systems, thus becoming the second MkII export customer after Belgium, which ordered nine vehicles. The MkII system is based on a new Arquus-designed chassis. The Czech Army, which had 52 Caesar 8x8 systems on order, has now placed an order for 10 additional systems to bring their eventual Caesar inventory to 62 guns. Meanwhile France continues to order Caesar systems, the DGA, the national armament agency, ordered 18 Caesar 6x6 MkI systems to replace those transferred to Ukraine. At the end of 2021, the DGA started work on the Cae-

sar 6x6 MkII programme for the French Army, with the in-service date slated for 2026.

It would be fair to say that 2022 was the year that many in Europe rediscovered the importance of 155 mm artillery and that the conflict in Ukraine was the cause of this rediscovery. Apart from the artillery transfers noted above, we should mention the other 155 mm artillery either delivered or on order for Ukraine. These include: 22 PzH 2000 from Germany and the Netherlands, with Italy adding six more, 18 AHS Krab from Poland with 54 more on order, eight Zuzana 2 from Slovakia with 16 more on order, and finally 18 RCH 155 on order from Germany.

While it is highly unlikely that many countries will be placing artillery orders of the size that Poland has, it is now inescapable that self-propelled 155 mm artillery, whether based on a truck, wheeled armour or a tracked platform has, once again, been shown to be a critical operational capability for peer warfare. Unfortunately, following the defence capability build-down at the end of the Cold War, rebuilding such a capability remains a hostage to competing defence budgetary priorities. ■

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Advancing Battle Management Systems

Tamir Eshel

Unlike the armoured vehicles of the past that featured weapon-centric crew-operated platforms focused on mobility, protection, and firepower, modern combat vehicles have become data-centric systems of systems, loaded with sophisticated electronics comprising of sensors, vehicle, and weapon control systems, integrated into a cohesive combat system designed to survive, thrive in and dominate the battlespace by combining information, firepower, and manoeuvre. With the increasing number of electronic systems, automation and autonomy are imperative for Battle Management Systems (BMSs) to enable the crew to deal with the workload and improve the combat capability of the individual vehicle and the entire formation.

Modern combat vehicles rely on sensors for situational awareness. These include video cameras and thermal imagers providing peripheral surveillance at short and long distances, threat warning receivers for lasers, radars, and gunshot detectors, for detecting threats and employing countermeasures against them. Sensors also monitor the primary and secondary weapons to inform the crew what sectors are covered and initiate an automatic response when required. Other systems determine the platform position and orientation, supporting blue force tracking information systems.

Since each system was developed separately, their integration is a daunting, risk-prone, and expensive process. Moreover, without a high level of automation, operating a system-rich platform faces significant challenges in crew training. It poses a cognitive burden on the crew resulting in poor performance under a stressful combat situation.

For laymen, the digital displays represent the BMS in combat vehicles, but this is a superficial view. In previous articles, this author examined armoured vehicles' situational awareness trends, particularly for crew members under armour, using digital displays, helmet visors with augmented or virtual reality, digital walls, and virtual windows. Whatever the display used, the BMS is responsible for providing the information projected to the crew using an optimised human interface and ergonomic design. The goal is to filter, simplify and optimise the information displayed to the junior commanders leading the squad and platoon while presenting a more comprehensive view of the same information to the commander at the company and battalion levels.

Photo: US Army



The commander and crew of the M1A2 obtain a situational picture from multiple screens feeding sight, sensor, and BMS information in a graphical and visual display.

BMS Basics

Introducing BMSs in combat vehicles requires integrating hardware, software, communications, and displays. Different interfaces are required to connect the vehicle systems, such as turret and fire control, gun laying, remote weapon station, and active protection system, to name just a few. Key hardware elements also include power distribution and computer systems designed to operate in harsh operational environments.

Communications systems are used to provide data connectivity over wireless networks. Such systems can rely on legacy combat-net radios, specialised data radios designed to transfer high data rates or new Software-Defined Radios (SDR) that employ specific waveforms

to adapt to specific services and support both voice and data or establish Mobile Ad Hoc Networks (MANET). Other communications systems include cellular networks employing LTE and 4G/5G networks adapted to military uses. Position, Navigation, and Timing (PNT) services are also required for network synchronisation and position reporting, essential to maintaining friendly forces' situational awareness and blue force tracking systems.

The software part of BMSs includes specific services such as a digital map and Geographic Information System (GIS) applications, with services providing terrain analysis, processing a Digital Terrain Model (DTM) to calculate the line of sight and area coverage for position and route planning, Blue Force Tracking (BFT), intel-

ligence pictures depicting known hostile forces. Chat, text messaging, graphics, and freehand drawing help users communicate, dispatch orders, and easily draft reports with minimal reliance on voice communications.

The Power of Standards

Integration of a system at such a scale represents a complex task, especially when it is introduced as part of vehicle upgrades. New vehicles or those undergoing comprehensive electronic systems upgrades often adhere to modern Ground Vehicle Architecture (GVA) standards (such as the US Army VICTORY or NATO-wide NGVA, also known as STANAG 4754). Such architecture offers more efficient integration with common standards, contributing to improved system integration, reducing development time, risk, and costs, saving power and space inside vehicles, and ensuring frequent upgrades are undertaken. Systems supporting open standards also help users avoid vendor lock-in, enabling easier migration to new systems as they become available. By providing system services, GVA also eliminates redundancy, for example,

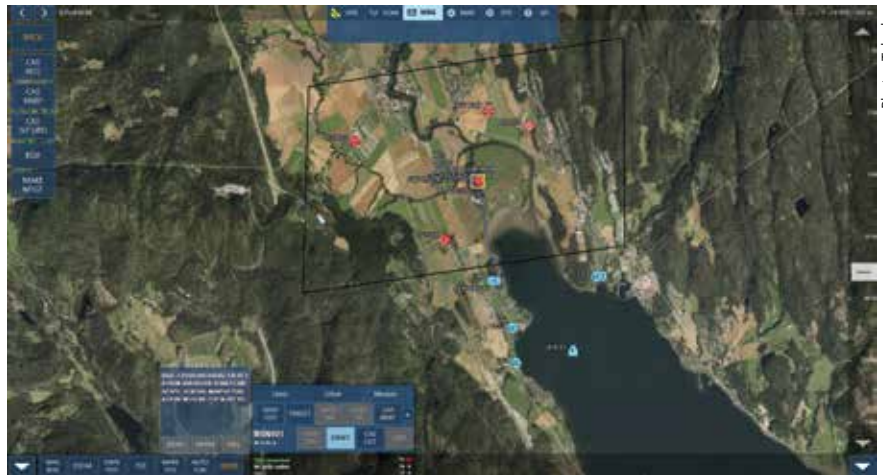


Photo: Teleplan

A map-based display of the FACNAV FIRES, the BMS system providing digitally-aided targeting and Fire Support at the Norwegian Army battalion level.

providing centralised PNT, handling digital mapping and video processing, and optimising performance through load balancing between sensors and signal processors, cloud-based and edge processing, etc. The Netherlands has been a pioneer in this field, with the integration of NVGA-Compliant Vehicle Infrastructure Demonstrator (NCVID). Implemented in a FENNEK scout vehicle

and YPR Armoured Personnel Carrier (APC), the system uses a modern mobile data infrastructure developed by TNO and Thales.

Delivering the situational awareness picture to inform the vehicle and unit commanders requires integrating information obtained from multiple sources including from on board, nearby vehicles, lower echelons, and higher command levels.

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Photo: ATOS



The Scorpion Combat Information System integrates all elements in the modern French Army Battlegroup into a cohesive, interoperable, and synchronised combat formation.

Operating at the battalion level, the BMS often manipulates this information for presentation to commanders at platoon, company, and battalion levels, as well as vehicle commanders throughout the platoons. Different formats are tailored for the individual user at each level to prevent information overload. Such systems were introduced by several European software developers addressing specific concepts of operations in each nation. Typical examples are the French SCORPION Combat Information System (SICS), developed by Thales and ATOS, and adopted by the Belgian and Spanish Armies; the FACNAV, developed by Tel-

eplan Globe in Norway; the Danish Sitaware FRONTLINE system from Systematic and Elbit Systems' TORCH-X. The Turkish company Aselsan has also developed the BATUR system, soon to be deployed with the new Altay tanks of the Turkish Army.

Vulnerability of Connected Systems

Another example is the combat-proven DELTA. In development by the Centre for Innovation and Development of Defence Technologies of the Ukrainian Ministry of Defence since 2016, DELTA was designed as an intelligence collection and management system.

The system provides comprehensive real-time information with high-level integration of multiple information sources on a digital map to provide commanders at all levels the situational awareness they need. Adapting the system to current technologies and techniques, the system taps Ukraine's 'army of drones' developed and deployed by the non-governmental volunteer group Aerorozvidka. DELTA runs on commercial electronic devices, from laptops to smartphones. The system meets relevant NATO standards to enable close cooperation with allied forces. The system was presented at recent NATO events including Tide Hackathon, Coalition Warrior Interoperability Exercise, and Tide Spirit 2023, demonstrating interoperability with current NATO systems.

Originally designed to utilise Ukrainian military communications, DELTA was placed in cloud storage outside of Ukraine to protect it from Russian cyberattacks. However, that move did not prevent Russian attempts to penetrate the system. The most recent attack was reported by the Ukrainian Computer Emergency Response Team (CERT) on December 22, 2022. The attack included massive spear-fishing attempts using email and instant messages with fake warnings directing users to update the DELTA certificates to continue using the system securely. The attack aimed to steal information from the compromised units, including internet browsing data and passwords stored on web browsers.

Relying on commercial equipment such as tablets and smartphones could have attracted this attack. That is why most BMSs and other networked military command and control systems often employ specially hardened militarised equipment that relies on comprehensive supervision and configuration management by military cyber security experts. The networks use secure mechanisms to monitor system behaviour, and distribute software keys and upgrades. These 'zero-trust' procedures enable commanders and operators to access information from any device and security level.

Evolving the Digital Landscape

BMSs are part of a broader development trend of Command, Control, Communications, Computers, and Information (C4I) capabilities for battle command in a multi-domain environment. In the US Army, progress has been made with the continued development of the Joint Battle Command Platform (JBC-P), used as the core BMS for the battalion level. The system is expected to receive a major update this year, with the introduction of Mounted Mission Command Software (MMC-S), currently in development. MMC-S will replace JBC-P as a software upgrade. As such, the new system will be installed on existing hardware and networks, introducing a more intuitive graphical User Interface (UI) based on the smartphone-styled Android Tactical Assault Kit (ATAK) that most soldiers already use and like.

Apart from the new UI, messaging, graphical, and mapping services, the MMC-S implements Over-the-air (OTA) updates for maps, software, security patches, and network keys, simplifying information management and distribution. The



Photo: Elbit Systems

TORCH-X battle management systems run on computers tailored for operation in the GVA standard.

agile software development process allows for deploying new capabilities to the Operational Force approximately every 12 months. The system provides a Software Development Kit (SDK) framework and infrastructure that enables an application hosting environment for all Warfighting Functions (WfF) and rapid third-party software integration.

European armies will also see the introduction of new generations of BMS, leveraging terrain modelling, Artificial Intelligence (AI), advanced networking capabilities featuring combat clouds, edge computing, and the introduction of robotic and autonomous systems. One such system is the Combat Digital Cloud, a cloud-ready digital platform architecture developed by Thales for the French Army to enable dynamic information exchange and analysis in real time. Utilising rich data compressed into small segments, the system enables efficient transfer over tactical networks, shortening decision-making processes from minutes to seconds.

These techniques enable continuous information sharing and augmented situational awareness shared by all levels of command. Thales' digital combat platform will leverage the integration of sensors and effectors on board and integrate unmanned aerial and ground vehicles and dismounted troops, thus broadening the reach and utilisation of BMS across the battlegroup. UI will also embrace modern trends, including augmented reality, for a more intuitive handoff of target information and enable commanders to collaborate over a virtual networked 3D 'digital sandbox' for mission planning and debriefing.

The Israeli Army has also embraced advanced digital tools. Fielding the new generation of TORCH-X enabled the accelerated introduction of efficient decision-support tools, targeting, and employment of firepower in a multi-

domain environment. TORCH-X is now configured to optimise battle command from the division to platoon level, supporting different applications, including mounted, dismounted, joint fires, and manned-unmanned warfighting environments. Each configuration utilises task-optimised hardware, software, and communications equipment.

The systems configured for dismounted operations feature decision support tools to reduce the soldier's cognitive load by improving orientation, recommending movement routes for navigation, resupply, casualty evacuation, and locating optimal vantage points for observation. The system collects and stores the soldier's physiological data and alerts the soldier and chain of command when the unit approaches its combat effectiveness threshold.

Other systems are optimised for the operation of manned-unmanned formations. Designed to support a wide range of manned-unmanned teaming (MUM-T) operations, TORCH-X RAS enables connectivity and control of Robotic and Autonomous Systems (RAS) in the air, sea (surface and sub-surface), and land (terrain and sub-terrain), extending the range and reach of warfighters and enhancing their performance in all domains. With the evolution of Artificial intelligence (AI), systems are becoming more authoritative in presenting options and suggesting best practices for operators and commanders to choose from. An example of such system is the Israeli Fire Weaver developed by Rafael and adopted by the IDF. The system is employed as a software layer with existing BMSs to provide the ability to maximise available combat power in GPS-denied environments. It networks sensors and formations, using augmented reality to present intelligence over the battlefield scene or map to provide a digital common operational picture (COP) shared

Photo: Israeli MoD



Israel's project Carmel demonstrated innovative operations of armoured fighting vehicles by two crewmembers, using large digital screens and helmet-mounted displays.

by all participants. The result is intuitive situational awareness and common visual language between sensors and shooters, reducing the latency of sensor-to-shooter loops to a few seconds. The German Army is presently evaluating the system under its 'Glass Battlefield' study. Rafael has also demonstrated the system to the US Army.

Another trend resulting from AI capabilities is improving the use of heterogeneous firepower in a multi-domain environment. The US Army is interested in optimising the ability to employ heterogeneous weapons in salvos, coordinated to deliver effects on target in a synchronised manner. Deploying indirect weapons in such dynamic contexts is beyond human cognitive abilities. The Army could turn to AI-based decision support tools to weigh the relative value of numerous options, calculate the predictive success of each option, and perform the required tasks under extremely short timescales.

The tactical environment can become highly complex depending on the threat, the operational tempo, and unexpected events. With BMSs connected to the combat cloud, systems are informed of operational plans, enemy positions and can monitor the situation of combat formations, down to the individual vehicle level via sensors and warning systems. AI decision-support tools can reduce cognitive load. Embedded in BMS systems, AI can help commanders make the right decisions in complex military tactical environments by evaluating thousands of options and recommending the few with the highest potential gain. ■

Photo: US Army



The Mounted Mission Command Software (MMC-S) uses the graphical user interface driver from the android tactical assault kit (ATAK) which is very familiar to military users.

Connecting the Force

Thomas Withington

The US Army's Handheld, Manpack, Small Form Fit (HMS) programme is the most ambitious tactical communications modernisation programme the United States armed forces have ever seen.

The US Army is supervising an acquisition that delivers new radios to itself, the US Navy, US Marine Corps (USMC) and US Air Force (USAF). The initiative falls under the purview of the army's Programme Executive Office for Command, Control and Tactical Communications (PEO C3T). Eight separate radios are being delivered, all of which will equip land forces manoeuvre units in these respective services.

As an official US Department of Defence (DOD) document makes clear, new radios being delivered via the HMS programme provide Line-of-Sight (LoS) and Beyond LoS (BLoS) voice and data communications. LoS communications are provided using Very/Ultra High Frequency (V/UHF; 30 MHz – 3 GHz) links. BLoS communications are provided using Satellite Communications (SATCOM) and High Frequency (HF; 3-30MHz) links. The radios will carry both classified and unclassified traffic.

The Radios

HMS encompasses the delivery of handheld systems for dismounted troops and backpack radios for vehicles and platforms, dismounted troops and static bases. Production contract awards for the handheld radios were made in April 2015. Similar contracts for the backpack systems followed in February 2016. Details of the radios being delivered are presented in Figure-1. An Initial Operational Capability (IOC) for the Thales/General Dynamics AN/PRC-154A Rifleman handheld radio was declared in 2012. The IOC for the General Dynamics AN/PRC-155 backpack transceiver was declared two years later. US DoD documents from 2019 state

Author

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Photo: Thales



The AN/PRC-154A Rifleman Radio is a single channel system for use by dismounted troops. The radio is manufactured by both Thales and General Dynamics.

that 100,000 AN/PRC-163 Leader handheld radios will eventually be acquired. These will be joined by 21,579 AN/PRC-154A and 104,496 Combat Net Radio (CNR) single-channel systems. A total of 73,064 backpack radios of all types will be delivered, 65,622 of which will equip the army.

Thales is providing the CNR along with L3Harris. The company told the author that deliveries of its two-channel AN/PRC-148 Improved Multiband Inter/Intra Team Radios (IMBITR) began in 2018. These already equip US Army Security Force Assistance Brigades (SFABs). SFABs provide training and advice to foreign militaries overseas. The company expects the Leader radio component of the HMS programme to conclude in 2025. That said, Thales anticipates follow-on contracts as fielding of the radios continues. "Thales has currently delivered over 10,000 two-channel IMBITR systems and anticipates that number to

be three to five times higher prior to the completion of the HMS programme," it disclosed in a written statement. Although the handheld Leader radios are particularly suitable for dismounted team leaders, they can also be used in a vehicle-mounted configuration. This usually occurs when a vehicle is not required to use SATCOM. A written statement provided by the PEO C3T adds that "the Leader radio is fielded largely at and below company level down to team leader level."

Thales also provides the AN/PRC-170 Javelin single channel data radios. The PEO C3T's written statement added said these will equip the army's Integrated Visual Augmentation System (IVAS). The army is working with Microsoft to deliver a head-up display for troops under the IVAS programme. The radios will let soldiers upload imagery to a tactical cloud during operations. The office estimates that up to 120,000 single channel

data radios could eventually be acquired to support IVAS.

Backpack radios "are deployed across the formation," the PEO C3T written statement says. They are furnished in a "variety of configurations including single vehicle mounted backpacks, dual vehicle mounted, dismounted and Tactical Operations Centre (TOC)," the latter example would include headquarters. Backpack radios deployed with the lowest echelons "are typically (used by) the radio telephone operator, at company and above, as well as above brigade. Manpacks are also mounted into many fires, airborne, and other specialty platforms across the army."

As they have two channels, the backpack radios can host at least two networks. For example, a battalion commander could have their subordinate company network on one channel, the brigade network on another. This lets them share voice and data traffic between these two networks. From a command perspective, this is imperative. Two backpack radios are being procured via HMS: General Dynamics provides the AN/PRC-155 while Collins Aerospace furnishes the AN/PRC-162. Basic specifications for both these radios are presented in Figure-1. Preston E. Johnson II, business development director for tactical communications at Collins Aerospace, said that full rate production deliveries of the AN/PRC-162 commenced in 2021. These radios are delivered under the terms of an Indefinite Delivery/Indefinite Quantity (IDIQ) contract that concludes in 2025. However, Johnson stated that "the army's acquisition objective will not have been met by that point, so we are anticipating they will have another IDIQ contract to follow the current one." He adds that "we don't have an estimate of when deliveries will conclude at this point. That depends entirely on the army's assessment of how many radios they ultimately want to procure."

AN/PRC-162 radios are currently being deployed with the army's active-duty manoeuvre brigades, said Johnson. These comprise the circa 23 armoured, mechanised infantry, light infantry and air manoeuvre brigade combat teams (BCTs) fielded by the army. He adds that some limited AN/PRC-162 deliveries are going to army Multi-Domain Task Forces (MDTF). The MDTF concept addresses regional Anti-Access/Area Denial postures (A2/AD) such as those of the People's Republic of China. Primarily expeditionary in their nature, they comprise

strategic fires and air defence battalions, alongside a brigade support battalion. The MDTF's intelligence, information, cyber, electronic warfare and space battalion includes two military intelligence companies, a signal company, information defence company and an extended range sensing and effects company.

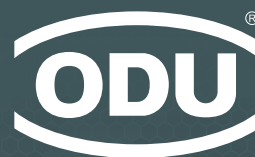
Waveforms

Waveforms are at the heart of the HMS initiative: "HMS radios will carry secure voice and digital data through SINCGARS (Single Channel Ground and Airborne Radio System), ANW2 (Army Networking Waveform-2) data including Position Location Information (PLI). Clear voice, secure voice, and imagery data (is carried) through TSM (Tactical, Scalable, Mobile Ad-Hoc Network), WREN TSM (Warrior Robust Enhanced Network Narrowband TSM), and WREN NB (WREN Narrowband), as well as PLI and secure voice/data through SATCOM waveforms," the PEO C3T statement continued.

A waveform is essentially an instruction from a software programme. It instructs the radio to behave in a particular way to perform a specific task. For example, the signal for ground communications from one radio to another across a LoS range may need less power than one used for communications with an aircraft overhead. The latter may need more amplification to reach the pilot who is comparatively far away. Using software to configure the radio saves the operator the fiddly task of having to manually tune their radio to do this.

Since the early 1990s, the standard waveform in use with US land manoeuvre units for ground communications is SINCGARS. The new HMS radios entering service will carry the SINCGARS waveform despite the eventual phase out of SINCGARS radios. HMS transceivers are not being procured and implemented in a 'switch-off/switch-on' fashion. New radios are entering service as legacy systems reach the end of their lives. Having the SINCGARS waveform in the new radios ensures they can communicate with legacy systems and vice versa. This is imperative to preserve interoperability.

Despite SINCGARS' eventual sunset, the waveform still has a lot of life left. One of the lessons of the first Russian invasion of Ukraine in 2014 was SINCGARS' resilience. The US government supplied L3Harris RF-7800V Falcon-3 radios equipped with the SINCGARS waveform



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Thales' AN/PRC-170 Javelin radio forms a key part of the US Army's Integrated Visual Augmentation System and will be used to connect dismounted troops to tactical combat clouds.

Manufacturer	Radio	Type	User	Frequencies	Selected Waveforms
Thales	Combat Net Radio	Single channel handheld radio	Individual soldier radio	V/UHF: 30-512MHz	SINGARS, HAVEQUICK, IW, APCO-25
L3Harris	Combat Net Radio	Single channel handheld radio	Individual soldier radio	V/UHF: 30- 512MHz	SINGARS, HAVEQUICK, IW, APCO-25
Thales	AN/PRC-154A Rifleman Radio	Single channel handheld radio for individual dismounted troops	Individual soldier radio	UHF: 225-450 MHz L-band: 1.250-1.390 GHz; 1.750-1.850 GHz	SRW
General Dynamics	AN/PRC-154A Rifleman Radio	Single channel handheld radio for individual dismounted troops	Individual soldier radio	UHF: 225-450 MHz L-band: 1.250-1.390 GHz; 1.750-1.850 GHz	SRW
General Dynamics	AN/PRC-155 Generation-1	Two channel backpack radio	Vehicle mounted, dismounted, fixed site	HF: 2-30 MHz V/UHF: 30 MHz-2.5 GHz	SRW, MUOS, SINGARS, SATCOM, WNW, HAVEQUICK, IW, HF SSB with ALE, WNW
Collins Aerospace	AN/PRC-162 Generation-2	Two channel backpack radio	Vehicle mounted, dismounted, fixed site	V/UHF: 30 MHz-1.850 GHz	SRW, MUOS, SINGARS, WREN TSM, IW, MUOS, SATURN, HAVEQUICK
L3Harris	AN/PRC-163 Leader Radio	Two channel handheld radio for team leaders and above	Team, squad, platoon leaders.	V/UHF: 30 MHz-2.6 GHz	SINGARS, APCO-25, SATURN, HAVEQUICK, MUOS, TSM, UHF SATCOM
Thales	AN/PRC-148C/D MBIRT/IMBITR Leader Radio	Two channel handheld radio for team leaders and above	Special operations forces	V/UHF: 30-512 MHz	HAVEQUICK, SINGARS, WREN-TSM
Thales	AN/PRC-170 Javelin Single Channel Data Radio	Single channel handheld radio to support IVAS	IVAS	V/UHF: 225 MHz- 2.6 GHz	TSM

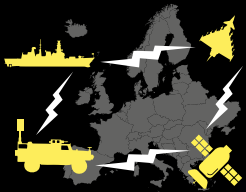
Figure-1 – HMS Radio Procurements

to Ukraine. The Russian Army had deployed significant electronic warfare assets into theatre. Systems like the army's B-301B Borisoglebsk-2, RB-531B Infauna and R-330Z Zhitel electronic warfare platforms are designed to detect and jam V/UHF radio signals. SINCGARS held up well despite the levels of jamming thrown at it. No doubt taking lessons learned from the Ukrainian theatre, the PEO C3T has embarked on the waveform's modernisation. SINCGARS FH3 supersedes the existing SINCGARS FH2/CT2 waveform variant. SINCGARS FH3 underwent evaluation at the US Army's Yuma proving ground in Arizona. Modifications earmarked for the waveform include improvements to its transmission and communications security. This comprises the implementation of the US National Security Agency's Advanced Encryption Standard-256 (AES-256). SINCGARS will eventually make way for the WREN-TSM waveform. This carries voice and data traffic to support the army's Nett Warrior dismounted situational awareness system. "Recent upgrades to the TSM waveform include WREN,



Photo: Collins Aerospace

Collins Aerospace' AN/PRC-862 is one of a pair of two channel radios being procured via the HMS programme. The other is General Dynamics' AN/PRC-155 system.



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

Figure 2 – HMS Radio Waveforms

providing up to Secret voice and data and WREN-NB, providing spectrum efficient, EW survivable voice and data in contested environments,” says the PEO C3T’s written statement.

Procurement methodology

The PEO C3T told the author via its written statement that the HMS programme achieved full rate production in August 2021 for the backpack and Leader radios. This followed the completion of testing during an Initial Operational Test and Evaluation event in January 2021. The radios are fielded to active units on a year-by-year basis according to available funding, the statement continued. “Industry competes among multiple vendors for each product line on a yearly basis.” This is to “both increase capability based on upgrades from objective to threshold requirements, while decreasing cost.” Moreover, although the programme is

led by the army, its sister services, primarily the USMC, have also procured new radios via this route.

An analysis of publicly available figures drafted by the US DoD reveals an estimated circa 300,000 radios of all types could eventually be acquired by navy, army, USAF and USMC. The lion’s share will, unsurprisingly, equip the army. Around 290,000 radios should eventually be delivered by the time these are expected to conclude in circa 2033. The next biggest recipient is likely to be the USAF acquiring almost 5,000. The US Marine Corps is expected to acquire over 2,300 radios, with the Navy receiving about 200. An analysis of the programme’s overall costs, including research and development activities, plus testing, production and deliveries gives an average unit cost of USD 88,300 per radio. The actual ‘fly away’ cost of purchasing each radio from its manufacturer is likely to be much less. Costs

will also vary according to whether the radio is a single or two-channel handheld or backpack radio.

The HMS programme has come a long way since the days of the Joint Tactical Radio System (JTRS) initiative. JTRS, or ‘Jitters’ to the tactical communications community, became a programme of record to overhaul army tactical communications. However, it suffered significant problems leading to its cancellation in 2011. Contemporary reports said JTRS had delivered no radios but had cost the taxpayer USD 6 Bn. Despite the cancellation the army and America’s forces writ large still needed new tactical communications. As a result, the HMS programme was born to learn the mistakes of the past and get the forces the radios they needed. Lessons have clearly been learned. New radios are in soldier’s hands equipped with legacy and state-of-the-art waveforms. The future looks bright for US army tactical communications. ■

Ajax Has “Turned a Corner”, Claims UK Defence Secretary

Peter Felstead

The British Army’s troubled Ajax AFV programme, which has been plagued by excessive noise and vibration issues, is back on track, according to UK Defence Secretary Ben Wallace.

Following a visit on 22 February 2023 to Bovington Camp in Dorset, where he met Ukrainian troops training on Challenger 2 main battle tanks but was also shown an Ajax vehicle being out through its paces, Wallace said of the programme, “We think the remedies are in place, we are now going through the normal trials. ... I am confident we have turned the corner on this troubled programme.”

Wallace added that the aim now was for Ajax vehicles to be active in military units soon after the test programme is completed in about 16 months.

However, questions remain among military analysts as to what extent Ajax’s noise and vibration issues have been mitigated as opposed to actually solved amid concerns that the programme is ‘doomed to succeed’ at any cost.

Asked by ESD to outline what measures have been taken to solve the Ajax’s noise and vibration issues, manufacturer General Dynamics UK (GDUK) declined to comment on 27 February. However, it has been widely reported in the UK media and military-focused blogs that the improvements include new ear defenders for the crew that incorporate hearing pieces for better communication, along with remounted seating with better cushioning and improved joysticks and controls. Assuming this reporting is accurate, the concern among observers is that the vehicle’s underlying problems have not been directly addressed and will inevitably lead to more problems down the road. Excessive vibration, for example, is likely to reduce the mean time between failures of onboard systems, reducing serviceability and increasing maintenance costs.

After selecting GDUK’s vehicle solution, which was based on a developed version of GD’s ASCOD platform, in 2010 over a rival bid from BAE Systems based on the CV90 infantry fighting vehicle, the UK Ministry of Defence (MoD) ordered 589 Ajax vehicles from GDUK in September 2014 under a fixed-price GBP 5.522 Bn contract. The 589 Ajax AFVs are divided into what became seven variants: 245 turreted re-



Photo: Crown Copyright

An Ajax vehicle undergoing cold weather trials at Tame Ranges in Sweden in February 2019. Despite persistent issues with excessive noise and vibration, it may be that the large amount of money already spent on the Ajax programme make it a programme that is ‘doomed to succeed’.

connaissance, surveillance and joint fire control vehicles (with these three types known as Ajax variants); 93 Ares armoured personnel carrier variants; 112 Athena command-and-control variants; 34 Ares formation reconnaissance overwatch variants; 51 Argus engineer reconnaissance variants; 38 Atlas armoured recovery vehicles; and 50 Apollo repair vehicles.

However, in June 2021 it emerged that issues with excessive vibration and noise had led to trials of Ajax variants being halted from November 2020 to March 2021.

A statement by the UK National Audit Office in March 2022 referred to 136 issues with the Ajax programme and noted that the UK MoD’s original capability requirements for Ajax were highly specified, “making Ajax more complex than other armoured vehicles”. Although many of the issues identified with Ajax could be put down to the usual developmental challenges encountered with producing a new AFV – and the numerous additional requirements from the UK MoD

have not helped the situation – the noise and vibration issues have persisted.

On 3 June 2022 a report published by the UK House of Commons Public Accounts Committee (PAC) said the Ajax programme had “gone badly wrong, with no deployable vehicle delivered to date”.

Noting that the MoD “initially expected to bring Ajax into service in 2017 but subsequently missed a revised target of June 2021”, the PAC pointed out that by December 2021 the MoD “had paid General Dynamics GBP 3.2 Bn but received only 26 Ajax vehicles, none of which it can use. The programme remains in turmoil because the Department still does not know whether the noise and vibration problems – which since July 2020 it has known may have injured soldiers – are fixable.”

Despite the recent optimism expressed by the UK defence secretary, it still remains doubtful whether the noise and vibration issues in Ajax have, indeed, been fixed. ■

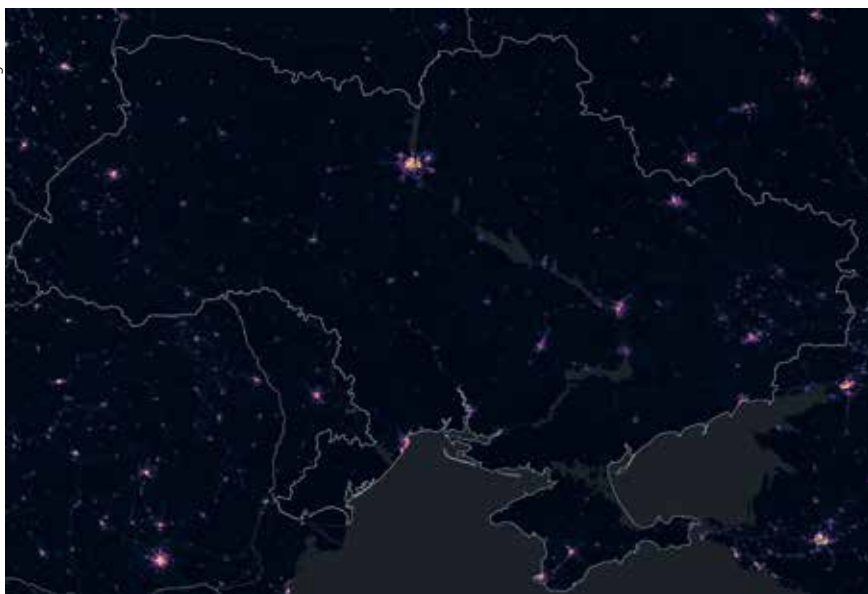
Protecting Critical Infrastructure

Tim Guest

Threats to critical infrastructure (CI) and the need for nation states to protect such assets have been brought to the fore with Russia's invasion of Ukraine and its relentless attacks, both physical and via cyberspace, on the country's vital assets.

Critical infrastructure, the services and utilities essential to the well-being, proper functioning and cohesion of a society or nation state, need protecting. Whether facility, network, service or system, CI includes public and private organisations involved in critical sectors such as energy, food and water supply, transportation (rail, road, air, sea) medical services, telecommunications, finance, and more. There's also acceptance that democratic nations' electoral systems and processes also fall under the CI banner and are equally threatened by hostile state actors. Such interference has been proven in recent years with Russian cyber-attacks at both state and fed-

Image: NASA



Night lights, Ukraine, January 2022 prior to the Russian invasion.

eral, electoral-system levels in the US, as well as in European states, including Spain and the Netherlands. Interference in the UK's Brexit Referendum remains a matter of debate, but the bottom line is that it is happening.

This article takes a look at attacks on Ukraine's CI, underlining the threat, how cyberattacks have played a major role, and looks at some of the ways in which nations, public and private organisations, as well as other corporate entities involved in the running of CI, can protect against such attacks.

Ukraine Attacks Highlight the Need to Protect CI

Russia's physical attacks on CI began in the early stages of the war following the invasion; its forces recklessly shelled and occupied the Zaporizhzhya nuclear power plant and its surroundings, though keeping the staff inside to run the facility. Ballistic and cruise missile attacks rained down on Ukraine's electricity generation and distribution facilities, the railway network, and more, and cyberattacks against almost every sector of the country's critical infrastructure, which had actually started weeks

before the invasion, reached new levels. Europe's energy dilemma, with Russian use of its gas supplies as a means of economic warfare, also rose to the fore as a way to undermine the cohesion of NATO partners and their support for Ukraine, highlighting why belligerents, whether terrorists or nation states, target CI for their purposes, or in such a conflict.

The attacks go on – Russian missiles hit power facilities on Friday 10 Feb across Ukraine, cynically coinciding with President Zelenskiy's return to Kyiv after a tour of Western capitals. The latest attacks, (at time of writing), were even cynically confirmed by the Russian Ministry of Defence the following day, when, in its daily update, it said it had carried out "massive strikes on critically important energy facilities of Ukraine's 'military-industrial complex' on Friday". It did not, of course, identify the facilities targeted as civilian infrastructure in nature, and went on to claim that the transport of foreign weapons and ammunition by rail to battlegrounds in Ukraine had been "blocked" as a result of their attack. Such an announcement was a fairly typical example of Kremlin attempts to justify attacks on civil CI.



Photo: Kostya Golinchenko, via Unsplash

Critical infrastructure across Ukraine has been targeted by both conventional and cyber attacks since the start of the war.

On 23 November 2022, at the UN in New York, Under-Secretary-General Rosemary DiCarlo made a statement about attacks that had taken place the night before against civilians and critical infrastructure across Ukraine. The attack concerned a wave of missile and drone strikes targeting Kyiv, Odesa, Lviv, Mykolaiv, Kharkiv, and Zaporizhzhia, which contributed to the already dire circumstances in which the population found itself at the time, as it faced the start of the freezing winter ahead with

These examples of what's taking place in Ukraine are a hard lesson for the rest of the West to learn from, but this clarity as to the threats and CI's true vulnerabilities will help drive discourse between public-private sector partnerships to secure CI, using latest approaches, technologies, collective thinking, including through means of resiliency and redundancy to sustain CI if and when attacked. A good example of such has been Ukraine's ability to keep its railways running and to restore, at least

For NATO and its allies, the current conflict also highlights the need to understand where vulnerabilities exist in the respective national infrastructures of member states, which could undermine the overall collective defence of the alliance unless any weaknesses are addressed.

Cyber Threats, Prophylaxis, and Response

The cyber assaults waged against critical Ukrainian infrastructure since even before the invasion have been linked to Kremlin-associated actors, and are in total violation of Russia's cynical pledge to comply with international law in cyberspace – no surprise there. Intended to incapacitate critical services, including government institutions and private companies active in such as financial, IT and energy sectors, these cyberattacks are often now coordinated as precursors to conventional strikes.

Back in January 2022, more than 70 Ukrainian Government websites were disabled by a coordinated cyberattack blamed by the authorities on cyber criminals linked to Belarusian intelligence services. During the same period Microsoft uncovered wiper software masquerading as ransomware across dozens of Ukrainian public and private computer networks, that was designed to disable computer systems and again was attributed a Belarusian group linked to the Kremlin. The largest denial-of-service (DoS) cyberattacks in the country's history followed in the days prior to the invasion targeting banks, government departments, all identified by Ukrainian, US and UK agencies as attributable to Russia,

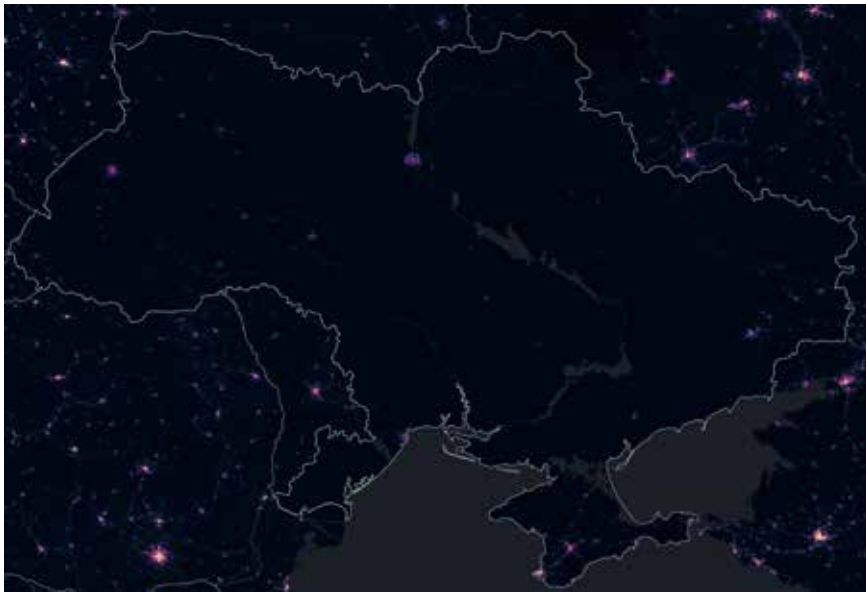


Image: NASA

Night lights, Ukraine, May 2022. Degradation effects to national grid can be seen following three months of hostilities, including attacks on electrical CI.

much of the country without heating, electricity, water, or other basic utilities. Apparently, even before the latest strikes, Ukrainian officials said that practically no large thermal or hydroelectric power plants had been left intact in the country; the latest barrage only added to the worsening situation. Indeed, on the day of the DiCarlo's statement, Ukraine was forced to introduce emergency shutdowns in all regions of the country, with some, including Lviv, Zaporizhzhia, Odesa and Chernihiv, completely disconnected from the grid.

In Kyiv, the missile and drone strike hit the Darnyts'ka thermal power plant leaving the whole of the Kyiv region without electricity; the approximately three million people in the capital were also left without running water. However, that Russian strike extended well beyond Kyiv; the Ladyzhyn power plant in the Vinnytsia region was also hit, as well as energy infrastructure in Kremenchuk, Lviv and Odesa also being damaged. Three nuclear power plants still operating at Rivne, South Ukraine, and Khmelnytskyi, were disconnected from the national grid as a result of the attacks.

some power supplies after attacks, including with the use of generators – resilience in practice.



Photo: Markus Spiske, via Unsplash

No amount of preparation can stop attempts to infiltrate a network; the key is to know what to do when a potential intrusion is detected.

and on the 23rd February 2022, destructive software was uncovered that had infected hundreds of computers in Ukrainian ministries, as well as financial institutions not only in Ukraine, but also in Latvia and Lithuania; Microsoft was able to block the software, which was named FoxBlade, sharing anti-virus code with a number of allied European countries to prevent its wider spread. These attacks have escalated throughout the conflict, including the targeting of satellite broadband aimed at degrading Ukraine's military communications capabilities, but which have also impacted civil and neighbouring nation communications.

Microsoft actually identified preparatory cyber activities a year before the invasion, when Russian troops were concentrating on the Ukrainian border. At this time, frequent malicious probing activities were uncovered and seen as intelligence-gathering attempts on Ukraine's military and its allies.

Photo: Alexandr Popov, via Unsplash



Retaliatory hacking against the aggressor managed to slow down transportation trains carrying Russia's war materiel through Belarus to the front lines early on in the invasion

Protective Response and Retaliation

Ukraine now has some of the world's most experienced IT engineers seasoned in cyber-attack prevention and response. Attacks against the nation's power grid have occurred, not only as part of the current situation, but even as far back as 2016, so multiple cyber operations have added to the nation's expertise. Yet, effective responses in the current, intense scenario have benefitted from the cooperation between allied states and leading players like Cisco, Microsoft, and Google from the private sector, whose software is often targeted by malicious activity.

The US has actually been helping the country strengthen its cyber defence for many years, including in the latter months of 2021 when soldiers from the US Army Cyber Command were deployed to Ukraine to help detect and neutralise Russian malware, potentially embedded in Ukrainian institution and company networks.

One method of response to Russia's cyber-attacks has also been to hack the attackers, which has seen hackers from inside Ukraine and elsewhere retaliate against the Russian state as well as Russian companies with attacks aimed at publishing data to compromise and counter the Kremlin's state propaganda. Anti-war messages have been posted to public institution and media websites, as well as some attacks being aimed at CI to degrade Russian military capabilities. In one instance, hacking managed to slow down transportation trains carrying Russia's war materiel through Belarus to the front lines early on in the invasion.

With such cyber resilience shown by Ukraine and its collaboration with allies in this regard, there are allied concerns that Russia might launch larger scale cyber-attacks on allied companies outside the conflict area, as well as against non-Ukrainian CI. The message here is the need to prepare for such a worst-case eventuality and even if no such attacks materialise at this time, to be prepared is to be forearmed and is imperative. Knowing what we now know, unilateral, collaborative, coordinated cyber protection are all needed in earnest with effective exchange of information and teamwork between specialised private companies and the public institutions to protect CI across NATO member states, its many allies and partners.

Protecting CI from the Threat of Cyber-Attack

Russia's attack on Ukraine has already impacted players beyond the borders of the conflict and malicious cyber activity must be assumed as a manner in which hostile players may seek to damage western and allied interests and CI without actually entering into physical confrontation.

This makes it imperative for government and private organisations of all sizes to protect and prepare to respond to the prospect of disruptive cyber incidents. While there are guidelines across the alliance by national departments, the EU and others, one agency which has set out very clear methodologies of preparing against cyber-attack is the US' Cyber and Infrastructure Security Agency, (CISA). Its approach will help CI organisations, and others, prepare for, respond to,

and mitigate the impact of cyber-attacks, which, when reported quickly, will enable assistance to be rendered quickly and warnings to be disseminated to prevent other organisations from falling victim to a similar attack; the importance of sharing information about an attack as swiftly as possible cannot be understated for the benefit of the collective whole.

Regardless of size, CI organisations, facilities, departments, should adopt a heightened posture when it comes to cybersecurity and protecting their most critical assets and while it will be challenging for many companies to identify resources for urgent security improvements, state CI players will have little choice but to implement stringent security protocols and processes. That said, there are a wide range of protections that can and should be put in place by all players to reduce the likelihood of a damaging cyber intrusion. Companies should validate that all remote access to the organisation's network and privileged or administrative access requires multi-factor authentication. IT departments must ensure that software across their networks is up to date, prioritising updates that address known, exploited vulnerabilities identified by national cyber agencies, and all ports and protocols that are not essential for business purposes should also be disabled by IT departments – 'bring your own device' should be carefully controlled in this regard so that employees do not, unknowingly, introduce malware onto a corporate network from their own tablets or phones if they connect for work purposes. If an organisation is using cloud services, IT personnel must review and implement strong

controls, many of which will be published in official government guidelines.

That said, no amount of preparation can stop attempts to infiltrate a network – the key is to know what to do when a potential intrusion is detected. Here, an organisation's cybersecurity/IT personnel should be focused on identifying and quickly assessing any unexpected or unusual network behaviour. At the same time, ensuring that an organisation's entire network is protected by cyber security software must be confirmed, and that signatures in such tools are updated. In the case of companies or agencies working with Ukrainian organisations, now and in the future, these must take extra care to monitor, inspect, and isolate traffic from those organisations, closely reviewing access controls for any such traffic. Even visiting websites for Ukrainian media and state organisations can lead to the unwitting downloading of malicious cookies that have been placed into seemingly innocent pages of news and information.

As far as protective preparation to cyber-attack is concerned, ensuring an organisation is ready and able to respond at a moment's notice if an intrusion occurs offers a degree of peace of mind, which can be achieved by designating a crisis-response team with main points of contact in the event of a suspected cybersecurity incident. Roles and responsibilities should be clear, and likely involvement should be from technology, communications, legal and business continuity departments, with the availability of key personnel assured and a means whereby surge support can be provided

in response to an incident determined, if needed. To ensure such a response works smoothly if the real thing occurs, rehearsal exercises should be conducted to ensure all participants understand their roles in an incident.

In terms of maximising the resilience an organisation has to a destructive cyber incident, back-up/business continuity procedures to ensure that critical data can be rapidly restored if the organisation is impacted by ransomware, or a destructive cyberattack, should be regularly tested, but they must also always be isolated from network connections. Where Industrial Control Systems (ICS) or Supervisory Control and Data Acquisition (SCADA) are involved, tests of manual controls to ensure that critical functions remain operable if the organisation's network is unavailable or compromised, must be carried out.

Worst-Case Conclusion and Ransomware Checklist

All the aforementioned precautions, protections, preparations will help improve the overall cybersecurity and resilience of any organisations involved in CI, though it is also advisable for all CI stakeholders and management involved in cyber/IT aspects of their organisations to review the latest guidelines from respective national government, as well as allied agencies about current Russian state-sponsored cyber threats to critical infrastructure and threats from ransomware attacks.

One key message from CISA is to 'plan for the worst-case scenario', so that senior

management of any CI entity ensure that urgent measures can be taken to protect the most critical assets in case of an intrusion, including disconnecting high-impact parts of the network if necessary.

In the case of ransomware, a joint CISA/ Multi-State Information Sharing and Analysis Centre (MS-ISAC) guideline offers a check-list of what to do to protect an organisation in the event of an attack, which is worth repeating as a useful 'detect, contain, eradicate' conclusion to this discussion on protecting critical infrastructure.

- First, determine which systems were impacted and immediately isolate them.
- Second, only in the event of being unable to disconnect devices from the network, power them down to avoid further spread of the ransomware infection.
- Third, triage impacted systems for restoration and recovery.
- Fourth, consult your incident response team to develop and document an initial understanding of what has occurred based on initial analysis.
- Fifth, engage your internal and external teams and stakeholders with an understanding of what they can provide to help you mitigate, respond to, and recover from the incident.
- Sixth, take a system image and memory capture of a sample of affected devices, such as workstations and servers.
- Seventh, consult federal law enforcement regarding possible decryptors available, as security researchers have already broken the encryption algorithms for some ransomware variants. ■



Photo: Maryna Nikolaieva, via Unsplash

The Kyiv Metro and Odessa Airport were disrupted by a ransomware attack as far back as 2017, attributed to Russian state actors, which encrypted hard drives across the organisations.

Ukraine's Favourite Dish

Thomas Withington

It is one of the most famous capabilities to make a difference in Ukraine's ongoing war, but how applicable is SpaceX's Starlink satellite communications system to future military operations?

On 28th February 2022, four days after Russia's second invasion of Ukraine, mercurial billionaire Elon Musk, sent Starlink Satellite Communications (SATCOM) terminals to Ukraine. Starlink is SpaceX's satellite broadband internet service. Musk is the company's chief executive officer and founder. Ukraine experienced significant telecommunications problems as Russian attacks pounded their critical national infrastructure. As well as affecting traditional landline communications, Russia's aggression also disrupted internet services. Maintaining internet coverage and access became an understandable top priority for Ukraine's government.

Since these first deliveries, an estimated 23,000 terminals have been delivered to Ukraine, according to local media reports. These have been donated by SpaceX, financed by the US Agency for International Development, donated by foreign governments and purchased privately. Starlink has made its presence felt as hostilities have continued. The New York Times reported the terminals helped besieged Ukrainian troops maintain contact during Russia's siege of Mariupol. The city on the south-eastern Ukrainian coast held out against Russian aggression for almost three months until its occupation on 20 May. Starlink terminals let troops stay in contact with their commanders, journalists to send their stories and relatives to keep in touch. The role of the SATCOM service in the siege earned Russian ire. It was sufficient for the then head of Russia's Roscosmos space agency Dmitry Rogozin to publicly warn Musk he would "be tried as an adult" for his actions, though it is doubtful this warning will have caused its recipient much concern.

Starlink has not been perfect. In October 2022, the Financial Times reported that the service had experienced connection failures

Photo: Kyiv City Hall



The mayor of Kyiv, Vitali Klitschko, and his brother Wladimir Klitschko are seen here with boxes of Starlink terminals shipped to Kyiv during the 2022 Russian invasion of Ukraine.

and outages. The reason for these failures was not clear, and the report said SpaceX had refused to provide any information to this effect. Such issues notwithstanding, it still appears that Starlink has made a valuable contribution in Ukraine.

Performance

Starlink terminals provide broadband internet access in a small, easily portable, package. The package includes the antenna and its base, a router and cabling. The whole lot can be fitted in a 2.3 m² (24.9 square ft) box weighing 10.5 kg (23.2 lb). The dish is a relatively small 1.5 m² (16.1 square ft), making it easy to conceal. SpaceX has stated the terminals provide between 20 and 220 mbps depending on the user's tariff. Individual customers get between 20 and 100 mbps, while business customers get between 40 and 220 mbps. Household internet users typically get download speeds of circa 100 mbps and upload speeds of around 10 mbps. Thus, Starlink is already matching the data rates one might find in

their own home, although latency may be slightly higher. The company says the terminals cost around USD 1,000 each.

The link between the satellites and terminals are providing via Ku-band frequencies of 12 to 18 GHz and Ka-band frequencies of 26 GHz to 40 GHz. The terminals use an electrically-scanned antenna steering the beam automatically ensuring continued connection with at least one satellite overhead. The space.com website said that, as of November 2022, 3,236 operational Starlink satellites are in orbit. The satellitemap.space website details the coverage these provide, which includes the United States, most of Europe (sans Scandinavia), and parts of the North African coast.

These satellites are in a Low Earth Orbit (LEO) around 550 km (297 NM) above Earth. This is typically much closer than standard military communications satellites. The United Kingdom's Skynet-5 military communications satellite constellation has a mean altitude of 35,794 km (19,327 NM) during its orbits. Nonetheless, this still means the Starlink signal can be compara-

Author

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tively weak by the time it reaches a terminal on Earth. Open sources say that the signal leaves a satellite with 4.89 mW (66.89 dBW) of power. However, the terminal can receive a signal as weak as between 1.5 μ W (-58.23 dBW) and 15 nW (-78.23 dBW). Potentially, this can place the terminal at risk of jamming. A Ka/Ku-band jamming signal eclipsing these latter power levels could risk drowning out the satellite signal.

Nonetheless, the terminals have some safeguards. Ku-band and Ka-band signals have exceptionally narrow beams, hence the Starlink antennas are physically small. Anyone aiming a jamming signal at them would need a very precise aim to direct the signal into the antenna. The attacker would need to have the terminal in visual range to do this, which is not the easiest thing to do in wartime when it might require the attacker to be quite close to their adversaries using the terminal. Data carried over the network will be encrypted. Software in the terminal could be programmed to block off and ignore any signal without this encryption. As the antenna beam is electronically steered it could point away from the jamming source and towards another Starlink satellite in view.

It is noteworthy that Russian forces did try to attack Starlink. In October, space.com reported that the terminals were subjected to cyberattacks. These were quickly remedied using a software fix. The good news is this illustrates that Russian forces may not have jamming systems suited to attack the terminals. The author's analysis is that the Russian Army does not currently have the capabilities to jam the frequencies Starlink uses. The fact that a cyberattack was able to succeed, no matter how quickly it



Photo: SpaceX

Starlink SATCOM terminals are highly portable. Their small antenna can also frustrate electronic attack by presenting a comparatively small aperture that a jamming signal must hit accurately.

was remedied, does illustrate vulnerabilities. As Starlink is sending and receiving IP data the injection of malicious code into the terminals will always be a risk.

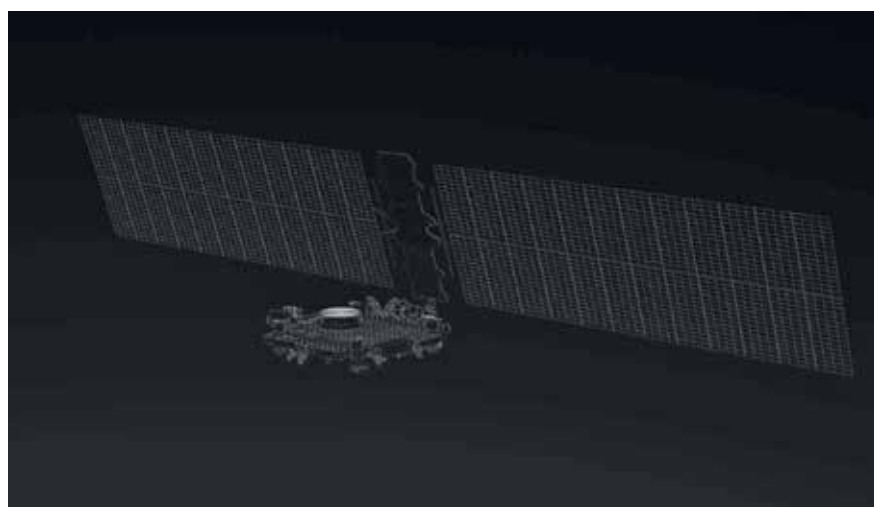
The Pentagon

What is Starlink's military potential beyond Ukraine? Dr. Bledwyn Bowen is an associate professor of international relations at the University of Leicester, in England's East Midlands. He is an expert on the militarisation of space. Dr. Bowen says the military market has always been a key part of Starlink's business model. He says that private sector SATCOM providers always have military and government clients at the forefront of their mind "to make ends meet." To date, the civilian SATCOM market has

been arguably niche, largely confined to users needing SATCOM in locations where conventional communications are unavailable: "Very few parts of the space economy are viable without military and governmental involvement," he continued.

Towards the end of 2022, SpaceX revealed plans to formalise its offerings to the military and government via its Starshield service. Details of Starshield's exact specification are sparse. Repeated enquiries to SpaceX by the author went unanswered. Media reports have said that the system will gather satellite imagery, provide communications and have additional space for unspecified government payloads. This seems to indicate that a new constellation of spacecraft will be launched to provide these services. Alternatively, future Starlink satellites may be designed from the outset with these payloads. The reports continued that the crucial 'military/governmental' part of the constellation is the encryption it will use to secure the communications. This will almost certainly be more robust than levels of encryption for the civilian Starlink service. In 2022 CNBC revealed US Air Force tests to evaluate networking aircraft, vehicles and fixed sites with Starlink.

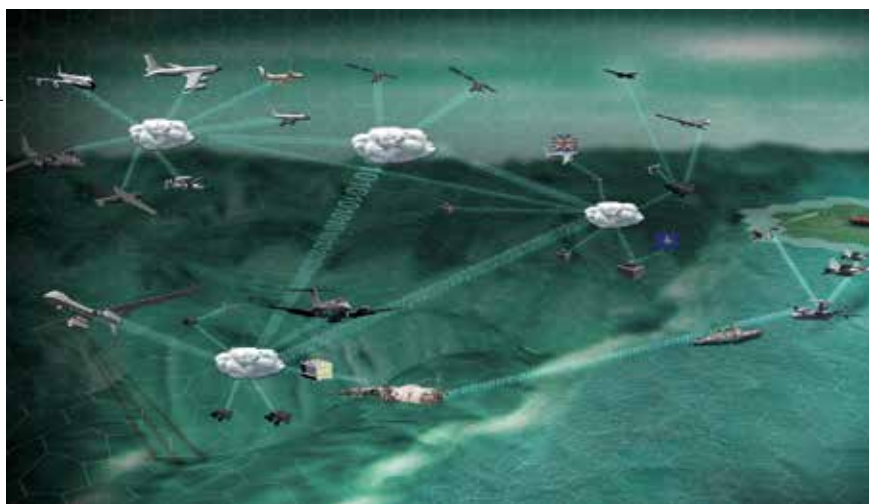
The US military has an insatiable appetite for satellite communications. The Department of Defence possesses circa 33 individual satellites reserved for military communications. Despite this, it still leases epic levels of bandwidth from the private sector. DoD use of commercial SATCOM en masse commenced in the mid-1990s with the Commercial Satellite Communications Initiative (CSCI). Mandated by the US Congress the CSCI launched studies to determine the role private sector SATCOM provision could have within the DOD. None-



Source: SpaceX

This is a rendering of the satellite element of the Starshield wideband global satellite communications architecture SpaceX is suggesting for the US Department of Defence. It could use the same basic architecture as Starlink, but including augmentations making it more suitable for military use such as robust encryption.

Graphic: L3Harris



This graphic demonstrates how the JADC2 concept will network multiple systems, platforms, personnel and bases with each other and with the combat cloud. SATCOM links will be essential to ensure that data can be efficiently and securely moved around the various networks the JADC2 concept will depend on.

theless, the DoD's uptake of commercial space services precedes this, notes space historian Dwayne Day: "The US military has been using commercial SATCOM services since the 1960s and was using them extensively by the 1970s and 80s. They have used commercial satellites in geostationary orbit for things like telephone and television transmissions to military bases around the world, and the relay of data from military weather satellites and even ballistic missile warning radars."

Fast forward to today and the DoD is looking to take the plunge in funding a LEO broadband constellation as part of the Pentagon's 2023 to 2027 spending plan, spacenews.com reported in June 2022. This seems to dovetail with precisely the type of service SpaceX is offering through Starshield. A SATCOM system using a similar architecture to Starlink is necessary if such a concept is to be militarily useful, cautions Day. "Starlink was not designed for military use, it has been adapted for that use ... There are a lot of things that are usually requirements for mobile or transportable military systems, like encryption, anti-jam capabilities, ruggedness, and so on, and Starlink doesn't have them."

Contracts for the provision of commercial SATCOM to the DoD are handled through the US Space Force's Commercial Satellite Communications Office (CSCO). In late December 2022, Space Force announced it had assumed responsibility for all military SATCOM systems possessed by the DoD. The CSCO plans to award commercial SATCOM contracts worth almost USD 2.3 Bn in 2023 and 2024. The spacenews.com report added that the contract to provide LEO broadband services is worth up to USD

875 M over ten years. The force has a strategy behind its employment of private sector SATCOM. The rationale is for existing and future Space Force-owned satellites to carry traffic, or provide capabilities, that SATCOM companies cannot. Voice or data traffic needing high degrees of protection and security could be carried over military constellations. Less sensitive or unclassified traffic could move across commercial SATCOM links: "For those frequency bands, coverage areas or specialised capabilities not offered by the commercial SATCOM industry, purpose-built constellations and payloads will be acquired." As Dr. Bowen notes, "Secure traffic takes the priority on the government-owned constellations, everything else will go across the commercial networks."

In some ways, the US has little choice but to rely on the commercial SATCOM sector. In turn, as Dr. Bowen argues, the commercial sector largely depends on US DoD SATCOM bandwidth leasing contracts. This symbiosis will only deepen in the future. A 2012 analysis written by David Furstenburg, then chairperson at NovelSat, said a single US Air Force Northrop Grumman RQ-4B Global Hawk uninhabited aerial vehicle needs around 500 mbps of SATCOM bandwidth to fly. This is five times the entire SATCOM bandwidth used by the US military during the 1991 Operation Desert Storm to liberate Kuwait. Back in 2010, estimates predicted the DOD would need 16 gbps of SATCOM bandwidth to support a large deployed joint force in a major war. In the twelve years between 1991 and the US-led Operation Iraqi Freedom in 2003, US military SATCOM demands rose from 100 mbps to 4 gbps. Increased US military SATCOM demands will be driven by two factors: The Joint All-

Domain Command and Control (JADC2) concept and the Internet of Military Things (IOMT). JADC2 was launched in 2018 via the US National Defence Strategy. It federates stove-piped C2 systems used by the navy, air force, army and Marine Corps to ease information sharing within and between services. This will trigger an exponential increase in communications traffic. Moreover, these links will need to be intercontinental to support US expeditionary operations. Starshield could be well placed to provide the wide bandwidth, long range communications JADC2 will surely demand.

The physical size of the terminal could make it easy to deploy in space-constrained environments: "Starlink provides internet capability using a small terminal," says Day: "Existing military and government systems can only provide some of that capability, but with bigger equipment." Survivability is another big attraction. SpaceX could eventually field between 12,000 and 42,000 communications satellites, according to plans articulated by the company. This gives enviable survivability: "Taking out a few satellites, or even many of them, will not severely damage the network." This is an important concern. Several nations are exploring Anti-Satellite (ASAT) weapons using modified Surface-to-Air Missiles (SAMs). India, Russia, the People's Republic of China and the United States have all performed kinetic tests of ASAT weapons. These weapons could participate in tomorrow's wars, particularly given military reliance on SATCOM. Day believes one strength of networks like Starlink is their survivability: "Taking out a few satellites, or even many of them, will not severely damage the network" given the thousands of satellites equipping the constellation.

Erratic Actor

There is a catch. What is stopping a private sector provider pulling the plug if they decide that they are not being paid enough for their service? What happens if their management or owners disagree with the political aims of a war? At best, Musk seems eccentric, at worst erratic. The same Financial Times report said that Starlink provision was expected to cost SpaceX over USD 100 M by the end of 2022. In October 2022 the Washington Post reported that Musk had threatened to stop funding Starlink provision to Ukraine. SpaceX had asked the DoD to contribute to funding the service, and Musk warned the company "cannot fund the existing system indefinitely and send several thousand more terminals that have data usage up to 100 times greater than typical households. This is unreasonable." He appeared to make the threat after Ukraine's ambassador to Ger-

many rebuked Musk's proposal to end the war on terms seen as favourable to Russia. Perhaps more concerning, in early February 2023, SpaceX decided to impose restrictions on Ukraine's Starlink access to prevent the system being used to control drones. In a statement during a during an 8 February conference in Washington D.C., Gwynne Shotwell, SpaceX's President and COO, stated that the service was "never meant to be weaponised" and that "Ukrainians have leveraged it in ways that were unintentional and not part of any agreement." Such actions raise the question of how the DoD would avoid SpaceX, or any private sector SATCOM provider, switching off the service if they no longer agreed with a particular conflict, or if they believed they should be paid more?

Beyond the US

Will services like Starshield or Starlink have military appeal outside the United States? Possibly. The US is not the only country which is pledged to significantly deepen its level of military connectivity. In January 2022 the UK Ministry of Defence (MoD) launched its Multi-Domain Integration (MDI) initiative. MDI is focused on "ensuring that every part of defence can work seamlessly together, and with other government departments and the UK's allies, to deliver a desired outcome." The MoD foresees deepening levels of integration within and between the UK's armed forces. In addition, this level of connection will be replicated vis-à-vis other government departments contributing to the UK's defence posture. These include the Foreign and Commonwealth Office (FCO), Secret Intelligence Service (SIS), and the Government Communications Headquarters (GCHQ). Likewise, robust links with external actors like the United Nations and North Atlantic Treaty Organisation (NATO) will ensure information can be easily shared. The MoD does not specify exactly what capabilities will be delivered to ensure MDI becomes a reality. Nonetheless, improving communications links between these actors will be imperative. Although the UK already possesses the Skynet-5 SATCOM constellation, is there a role for the private sector to provide additional wideband links to carry less sensitive traffic?

Dr. Bowen does not believe that Starlink will necessarily find ready customers for Starshield-style services in NATO and allied nations, even if there is a strong demand. Space is becoming democratised. The miniaturisation of electronics and reusable rockets is reducing the costs of getting communications satellites into orbit. SpaceX plans a total of at least 12,000 LEO satellites in orbit,



Photo: ESA

SpaceX's Falcon-9 rocket, shown here together with its Falcon Heavy launcher, are both instrumental in reducing launch costs. This has helped 'democratise' space for nations which had previously refrained from developing military SATCOM constellations on cost grounds.

possibly increasing this to 42,000. In 2018, SpaceX estimated the entire programme will cost \$10 billion. This gives each satellite a potential unit cost of between USD 238,095 and USD 833,333 depending on how many are eventually launched. The actual unit costs will probably be lower as the USD 10 Bn includes all costs associated with the programme. Nevertheless, a price tag of under USD 1 M for a communications satellite makes the technology attractive even for nations which do not have such capabilities. Furthermore, launch costs are reducing. The US Space Shuttle had launch costs of USD 54,500 per kg (2.2 pounds). SpaceX's Falcon-9 and Falcon Heavy rockets reduce this to USD 2,720 per kg and \$1,400 per kg respectively. This means that countries that previously refrained from developing military communications satellites on cost grounds could now develop this capacity. Having the global coverage of Starlink would require a lot more outlay. Nonetheless, if the country in question only wants a small constellation covering a specific area this would not be as expensive as in the past.

Paradoxically, this creates a challenge for SpaceX and other companies involved in private sector military SATCOM provision. As Dr. Bowen observes, some nations maybe keen to develop their space sectors and champion their own scientific endeavour and expertise by developing sovereign systems. This may now be noticeably more affordable than in the past. It could also help avoid potential pitfalls discussed regarding a private company providing, owning and operating a military SATCOM system on a nation's behalf.

Starlink has made a difference in Ukraine and continues to do so. The US military is understandably interested in what Musk has to offer. Innovations like JADC2 will rely on greater SATCOM capacity than currently available. This will be mirrored in MDI initiatives around the world. "Starlink provides new capabilities, but is really only an evolution of previous options for military SATCOM," says Day. The future will reveal the extent to which SpaceX can capture this market, as well as how far the DoD and others can rely on its services. ■

Understanding the View – Imagery in Geospatial Intelligence

Tim Guest

Relying heavily on imagery from which to elicit usable information, Geospatial Intelligence (GEOINT) can give a fighting force the upper hand in a conflict. Likewise, having access to high quality images from space can make all the difference.

Satellite and aerial imagery plays by far the biggest role in the provision of raw material from which GEOINT is derived. The war in Ukraine is a case in point and from its very start overhead images have given the world, as well as commanders on the ground, regular, near-real-time intelligence of the unfolding conflict. With a brief subject overview, this article focuses on satellite imagery in geospatial intelligence, including how such views have been playing a part in Russia's war against Ukraine.

Photo: USGS



Satellite imagery plays by far the biggest role in the provision of raw material from which GEOINT is derived. Pictured: Landsat 8 satellite.

Brief Overview

First coined in 2005 by US Government agencies, GEOINT typically combines imagery intelligence, imagery analysis, charting, and mapping to display the Earth's geographically-referenced events and physical features, as well as man-made structures. For military applications, such imagery helps a fighting force relate its operations to the exact lay of the land, so that, at the tactical level, precise mission planning can be undertaken with confidence, the force in possession of the best GEOINT, assuredly, gaining the upper hand on the battlefield; accurate, near-real-time, literal imagery – literal imagery describes things exactly as they are without hidden or symbolic meaning – of hostile forces, for example, will enable friendly-force artillery to precisely target enemy positions.

At the strategic level, GEOINT also provides governments with timely, actionable intel effective in counterterrorism ops, as well as information on weapons of mass destruction, and any unfolding global political crises and popular unrest. While literal imagery is the biggest contributor to an overall GEOINT picture, geospatial intelligence can also involve the processing and fusion of data collected from other sources, such as electro-optical (EO) systems, synthetic aperture radar (SAR), local situational awareness (LSA) systems

and more; for example, contributing to an overall GEOINT picture may be the likes of eye-in-the-sky platforms such as AWACS and UAV systems like Global Hawk all the way down to terrestrial vehicle-borne LSA electro-optical systems on an AFV, or even feedback from individual soldier-worn cameras and vision systems. Airborne reconnaissance is nothing new, with a wide range of aircraft having been used through the years, including observation balloons. With specialist platforms such as Lockheed's long-range, high-altitude, Mach 3+ strategic reconnaissance aircraft, the SR-71 Blackbird, and the company's high-altitude U-2 Dragon Lady, which previously provided some of the highest altitude GEOINT imagery, agencies and militaries are spoiled for choice today by a wealth of both government and commercial satellite imagery resources.

GEOINT Imagery

Overhead geospatial imagery fundamentally depicts the locations and character-

istics of features, both natural and constructed, on the Earth's surface. Core data includes the likes of topographic, elevation and terrain data, as well as land cover, geodetic information and more, giving decision-makers a multi-dimensional picture of the any area of relevance or interest. It is then the role of a GEOINT analyst to unpack actionable intelligence from that overhead and aerial imagery, in order to provide critical, accurate and timely information regarding enemy force dispositions and movements, potential battle areas and other information vital to friendly forces on the ground. Imagery will include likenesses, or representations of any natural, or man-made feature, or related object, or activity, together with positional data of those features at the precise time the image, or representation, was acquired. Information about the platform, or system that acquired it, such as a satellite, high-altitude aircraft or UAV, optical system/camera, etc. will also be included with analysis. When it comes to field tube or missile artillery, GEOINT imagery and cartography



Photo: Maxar

Craters in fields and roads around Bakhmut from continuous artillery bombardments, 7 January 2023.

can supplement standard map reconnaissance with greater detail about potential areas to deploy a battery or other firing and command and control assets. It can also supplement or replace forward observer target information, if such is available at all. GEOINT analysis solutions to support artillery fires include: artillery slope analysis, site/gun position selection, range fan, and line-of-sight analysis solutions, and drop-zone/fall-of-shot, weapon systems field of fire, and cover and concealment analysis solutions. Such solutions can dramatically reduce the time searching for and identifying enemy artillery positions, as well as when reconnoitring suitable gun positions for friendly forces, in addition to identifying and planning safe areas from which to mount 'shoot-and-scoot' missions, to coordinating ammunition resupply and more.

Leading Imagery Provider

One of the leading providers of GEOINT for both defence and commercial purposes is Maxar Technologies, which has a long history of working with the US Department of Defense. In late 2020, for example, under the terms of an 8-year, USD 49 M contract, the company was selected by the US Army's Geospatial Center as a sole-source, indefinite-delivery/indefinite-quantity (IDIQ) supplier to deliver multiple, highly portable, direct-downlink tactical ground systems - called the US Army Remote Ground Terminal (RGT) - to provide critical GEOINT to operatives in remote locations. Easily transported by two people, the RGT can be set up in about an hour and enables troops to rapidly downlink, analyse and disseminate imagery/data from commercial Earth observation satellites to support their mili-

tary, humanitarian and/or disaster-relief missions. The system, (which is based on Maxar's portable Tactical Architecture for Near-real-time Global Operations - TANGO - platform), downlinks data from a variety of commercial sources, including Maxar's high-resolution WorldView constellation, and is designed to be continuously upgraded with additional commercial EO and SAR sources. It is expected that the RGT system will become the commercial imagery receive node for the US Army's future Tactical Intelligence Targeting Access Node, TITAN, a scalable intelligence ground station that will leverage sensors across multiple domains to provide rapid and accurate GEOINT-based targeting data directly to precision fires assets. When the contract was awarded, Technical Director at the Geospatial Center, Matt Cro, said that times of crisis are defined by seconds and minutes, not days and months, add-

ing that the Maxar-developed RGT would significantly enhance the speed at which the Army can access critical information at the tactical edge, as well as provide an important technology advancement for enabling TITAN.

Instrumental in Ukraine

One of Maxar's latest US Government developments - and very relevant to the Ukraine conflict - came last year with a contract renewal with the US National Geospatial-Intelligence Agency (NGA) to provide mission-ready satellite imagery for the Global Enhanced GEOINT Delivery (G-EGD) programme, which has enabled military units, first responders, intelligence analysts and civil government users to tap into Maxar's 125-petabyte imagery archive and daily imagery collections for time-sensitive, mission-critical planning and operations, since 2011. The latest USD 44 M contract, which began in September, is the third of three option years for the contract, which has a total value of up to USD 176 M. The deal will see Maxar continue to provide over 400,000 US Government users with unclassified, online and offline, on-demand access to high-resolution commercial imagery. (Access to geospatial data and products from other commercial industry providers, such as BlackSky and Planet Labs PBC, are also available through the Electro-Optical Commercial Layer contract.) During G-EGD Option Year 2, NGA developed a roadmap to integrate five commercial SAR data providers into the G-EGD platform by the end of 2023. To date, Maxar has developed ingest solutions for SAR data from Capella Space and ICEYE, to include data visualisation



Photo: WorldView-3 Satellite/Maxar

Destroyed bridge in Kyiv. Damaged Bridge and road on approach towards Kyiv, Ivankiv, Ukraine, 27 February, 2022.

Photo: Maxar



Before: Town of Soledar, Ukraine, August 1, 2022, (lat: 48.663700, long: 38.091763).

and complete product discovery and delivery methods. Maxar will continue data integration efforts for Umbra and PredaSAR, a Terran Orbital Company, throughout Option Year 3.

G-EGD has more than 1.1 million km² of new imagery uploaded each day and anyone supporting a US Government mission can request authorisation to access that current imagery, as well as more than 6 billion km² of archived imagery for time sensitive, mission-critical planning and operations. Dan Jablonsky, Maxar President and Chief Executive Officer,

said last year that, "G-EGD has been instrumental in enabling NGA to provide unclassified access to satellite imagery for a wide range of US Government users and partners throughout the war in Ukraine."

Indeed, Maxar has been releasing imagery of Ukraine throughout the war, even from before the invasion began when Russian troops were massing in concentration areas over the border. The build-up to the war and Russia's ensuing attack, unlike such hostilities in the past, has been told through such images

providing essential GEOINT to relevant stakeholders. From satellite images of those troops on the border, to columns of armour and tanks moving through the countryside towards Kyiv, a convoy 64 km (40 miles) long attempting resupply, mass graves outside Mariupol, and the town's theatre, bombed into oblivion despite satellite imagery clearly showing the word 'children' written into the ground outside. And the wider world and media, too, have, like never before, also had access to the same GEOINT imagery as the military.

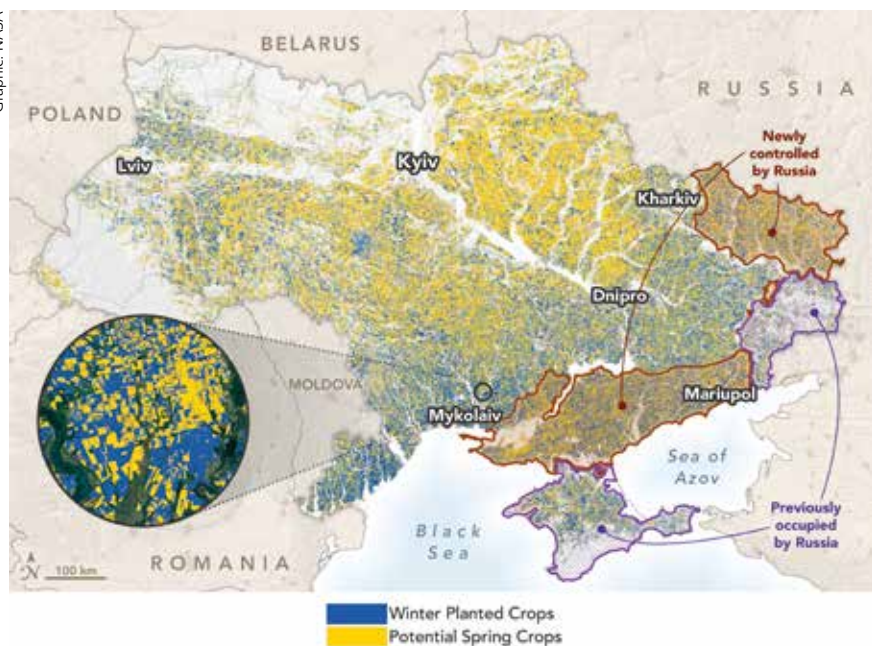
A Wealth of Information

As well as its purely defence-related work, Maxar partners with NOAA, NASA and other organisations where studies overlap into other areas, such as the sharing of Earth observation data/imagery on weather and climate patterns, agriculture and more, which can equally provide GEOINT relevant to and arising from military operations. Maxar's 1300-class satellite has been serving government and commercial missions for over 30 years in this area. In the case of Ukraine, weather-related imagery and data offer the potential to view geographical features such as lakes and waterways, as well as lines of communication, routes, tracks, that will all be affected by extremes of temperature and rainfall; iced-over, frigid land, for instance, firm and suited to the movement of heavy armour, or weather forecasting thaws turning ground into impassable muddy traps that can devour a whole tank. Weather-related imagery delivers valuable GEOINT to commanders on the ground that will dictate operational planning, including for any spring offensive.

Ukraine's Wheat

A strategically-contested aspect of the conflict in Ukraine has been its agriculture, specifically its wheat crop, and satellite imagery has provided vital GEOINT in this regard crucial for Ukraine's Government of world markets. Earth-observing satellites are constantly acquiring imagery across Ukraine's, currently, daily-changing landscape and analysts are deciphering the impacts of human conflict on the country's built, agricultural and natural environment. NASA's Harvest research team, for example, has been using GEOINT imagery and economic data to track how the Russia-Ukraine conflict is disrupting the global food system. In the early days of the conflict, food security

Graphic: NASA



NASA's Harvest research team has been using GEOINT imagery and economic data to track how the Russia-Ukraine conflict is disrupting Ukraine's crops and the global food system.

specialists wondered if Ukrainian farmers would be able to harvest the wheat and barley they had planted the previous autumn – food for the population and Army, and income to buy more weaponry... or not. There was also worry that declining grain exports from Ukraine might throw global markets into turmoil and trigger food shortages overseas. Satellite-based production data for Ukraine's 2022 winter wheat crop, however, showed the harvest was largely successful, the NASA Harvest team having been able to calculate from imagery that 26.6 million tonnes of wheat were harvested in 2022, several million tonnes higher than expected and close to the five-year average of 27.9 million tonnes. That said, they were also able to see that 22% of 2022's wheat was harvested in the occupied eastern part of the country, out of reach to the majority due to the war. The NASA Harvest team, (working for more than a decade with colleagues from Ukraine's Ministry of Agrarian Policy and Food and the Igor Sikorsky Kyiv Polytechnic Institute, as well as several

other organisations), combines satellite observations and modelling to assess the planting, growth, and harvest of key commodity crops. Data in this instance comes from the commercial satellite company Planet, NASA, and the European Space Agency. NASA Harvest's analysis showed that 94% of the winter crop was harvested, including 88% of winter crops in areas not controlled by Ukraine. And while the UN-brokered Black Sea Grain Initiative freed up vessels from a few Black Sea ports for some 5.4 million tonnes of Ukrainian grain to reach global markets, GEOINT and economic data analysis showed that Russia benefited from a large amount of the 26.6 million tonnes harvested. This represents a financial loss to Kyiv of at least USD 1 Bn. This detailed analysis would not have been possible without the use of high-quality images from space. Using satellites to observe areas left unharvested, the NASA Harvest team was able to see from GEOINT imagery that these were mainly concentrated along the front line. Wheat is largely harvest-

ed in mid-July. In natural-colour mosaic images of Ukraine, based on data from Planet, unharvested wheat fields were visible in dark brown and stand out compared to the light brown harvested fields to the north and south. The lighter brown colour is a sign of leftover plant debris covering the fields after harvesting equipment has sheared the wheat and separated grain from chaff, all of which can be deduced from high-quality imagery and analysis. The images used are a bi-weekly composite of data, based on PlanetScope imagery collected between 12-26 July 2022, by Dove satellites. Landsat images have also shown harvested wheat around the town of Berezhneuvate compared to unharvested wheat around Velyka Oleksandrivka, with natural-colour images acquired by the Operational Land Imager on Landsat 8. Using such satellite imagery to derive war-related agricultural GEOINT has enabled accurate information to reach and calm otherwise potentially uncertain and volatile markets, which, in turn, has benefited returns for the government in Kyiv. ■

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US Army Modernisation: a Mid-Term Report

Sidney E. Dean

The US Army Futures Command (AFC) celebrates its fifth anniversary in August 2023. The Pentagon created this dedicated command in the hope of avoiding the kinds of mistakes that had plagued numerous development and procurement programmes in recent decades and delayed much-needed replacement of legacy systems. Many observers see 2023 as a pivotal year for the Army's ambitious modernisation efforts.

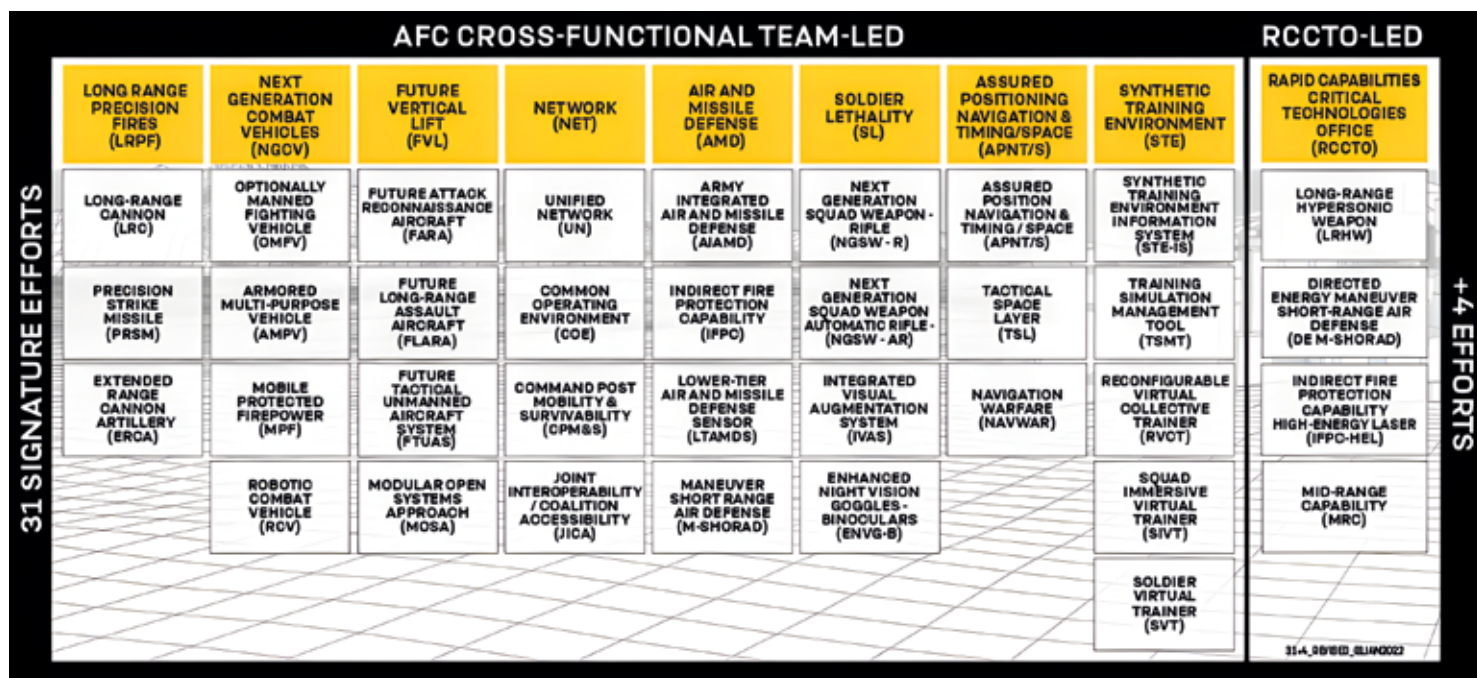
The bottom-line goal of these efforts is straightforward. The Army needs to enhance lethality, mobility and survivability in order to compete and win on the future multi-domain battlefield. A major factor will be retaining – and in some cases regaining – technological and operational superiority over peer/near-peer opponents. While US and other Western military equipment is generally considered superior to those of adversary states, some rivals – taking advantage of the Pentagon's two-decade long focus on counterinsurgency – are making considerable headway in such areas as long-range artillery, air defence, and cyber operations. The most dramatic area may be hypersonic weapons, which both China and Russia managed to introduce before the United States did.

While the US Army is planning to introduce a large number of individual weapon and support systems, a major element of the future combat capability enhancement lies with multiplier technologies which are intended to fuse the various elements into an operational system which is much more than the sum of the individual components. This will require transitioning to a more data-centric force in which individual vehicles, aircraft, robots, and even infantry soldiers and their weapons can be wirelessly connected on the digital battlefield. Other favoured innovations will include: enhanced (longer range, greater precision) firepower for combat systems; increased reliance on automation, autonomy and artificial intelligence (AI); reduced logistical footprint and improved

sustainability in the field. Technologies designed to facilitate these developments include modular open-system architectures (MOSA) to enable the seamless addition or replacement of hardware and software components; this will ensure that all platforms and systems can be kept at state-of-the-art performance throughout their service lives.

Priority Programmes

While the ongoing US Army modernisation programme encompasses more than 500 development, acquisition or upgrade efforts, the core rests with 35 new "future force" systems, which are supposed to be fielded by 2030. Army Futures Command is overseeing 31 of these programmes, which it refers to



The US Army's 35 top priority modernization programmes, by leadership team.

as “signature efforts”; the remaining four are under the aegis of the Pentagon’s Rapid Capabilities Critical Technologies Office (RCCTO). The 2023 budget document foresees operational fielding or operational testing of two dozen of these 35 systems by the end of Fiscal Year 2023 (FY23). Some of the programmes are utilising advanced prototyping and experimentation to fast-track development. The introduction of digital design and virtual experimentation processes is also shortening development programmes, sometimes significantly.

The Army has grouped its prioritised development and acquisition programmes into six capability portfolios. These are: Long-Range Precision Fires (LRPF); Next-Generation Combat Vehicles (NGCV); Future Vertical Lift (FVL); Network, Integrated Air and Missile Defence (IAMD); and Soldier Lethality.

Long-Range Precision Fires

Long-Range Precision Fires is designated as the foremost priority among the modernisation portfolios, largely as a reaction to Russian and Chinese progress in long-range tube and rocket artillery. The LRPF portfolio is scheduled to move forward across the board during FY23. Both the 155 mm Extended Range Cannon Artillery (ERCA) designed to deliver enhanced rocket-propelled shells onto targets 70 km distant, and the Long-Range Hypersonic Weapon (LRHW) with an initial 2,800 km capability, are scheduled to equip their respective first batteries this year.

During 2023, the Army also expects to receive the first of 54 Precision Strike Missiles (PrSM, 500+ km range) which were ordered in December 2021; operational testing is scheduled for 2024, with an initial operational capability (IOC) expected in FY25. The PrSM is intended to engage high-value tactical targets, and will be fired from existing M270A1 MLRS and M142 HIMARS launchers.

The Strategic Mid-Range Fires (SMRF) system, also known as the Typhon, will be fielded in FY23, only two years after development began. The first prototype battery was delivered to the Army in November 2022, with one additional battery to be delivered in each of the following three years. The concept modifies US Navy SM-6 and UGM-109 Tomahawk missiles for deployment from ground-based launchers. The 500-1,500 km operational range falls between the PrSM and the LRHW.



Photo: US Army

The ERCA is based on the M109A7 Paladin self-propelled howitzer, but mounts a 9.1-m-long gun tube versus the original 6-m-tube.

Next-Generation Combat Vehicles

Tangible progress is being made within the tactical ground vehicle portfolio. In 2022, the Mobile Protected Firepower (MPF) light tank transitioned to Low-Rate Initial Production (LRIP), with a goal of equipping the first light infantry unit in 2025. The Armored Multi-Purpose Vehicle (AMPV), intended as replacement for the Vietnam-era M113 armoured personnel carrier, overcame numerous technical issues and passed operational testing in 2022; a full-rate production decision is slated for FY 2023. Downselect for prototyping the Optionally Manned Fighting Vehicle (OMFV) is scheduled for 2023; the Army still expects to equip the first

combat unit with the OMFV in FY28, initiating the long-term transition from the Bradley Infantry Fighting Vehicle (IFV).

The fourth element of the NGCV portfolio is the Robotic Combat Vehicle (RCV) programme, which is subdivided into light, medium and heavy-vehicle development programmes (RCV-L, RCV-M and RCV-H, respectively). The RCVs are intended to support and operate with manned fighting vehicles, with roles ranging from reconnaissance to combat. The RCV-H has currently been deprioritised. Intensive evaluation of RCV-L and RCV-M surrogates began in 2022. The Army intends to award engineering manufacturing and development (EMD) contracts for the RCV-L in late FY23, with a production decision expected no later



Photo: US Army

The 38 tonne MPF has a 105 mm main gun.

Photo: US Army



Bell Textron's V-280 was selected in December 2022 as the FLRAA production aircraft.

than FY27. The decision whether to pursue an EMD for the RCV-M is expected during FY24.

Future Vertical Lift

The Future Vertical Lift (FVL) programme currently encompasses the Future Long-Range Assault Aircraft (FLRAA) and the Future Attack and Reconnaissance Aircraft (FARA). Bell Textron Inc. was selected in December 2022 to build the FLRAA, which is destined to ultimately replace the UH-60 Blackhawk. Bell's competitor Sikorsky contested the contract award in late December. The Government Accountability Office (GAO) is required to rule on the protest by the first week of April 2023. While challenges only rarely succeed, an overturn of the contract award remains possible. The Pentagon generally factors contract-related delays into its timelines. In that light, Sikorsky's challenge is not expected to significantly impede the Army's goal of fielding the new aircraft in 2030.

FARA is the intended replacement for the AH-64 Apache in the attack- and scout-helicopter role. The Army has acknowledged that its stated goal of fielding FARA by 2030 is ambitious, but continues to stand by that schedule. Government flight testing of the two competing prototypes (again being offered by Bell and Sikorsky) is expected to begin by late FY23, with a production award slated for 2028.

FVL also encompasses the Future Tactical Unmanned Aerial System (FTUAS) component, which is being procured in two increments. In August 2022, the Army awarded AeroVironment Inc. the Incre-

ment 1 contract, which will introduce the Arcturus Jump 20 UAS as replacement for the RQ-7B Shadow UAS in FY23. The service is currently reviewing competing submissions for the Increment 2 procurement, which will introduce a second type of tactical UAS.

Network

While hardware might be the most visible modernisation aspect, the digital element could well be the most crucial. Networking the many vehicles, platforms and hardware systems is considered the key to maximising their tactical performance. The establishment of a "tactical cloud" to connect disparate weapon and sensor systems remains a core aspect of US Army modernisation. This will ensure interoperability and a common operating picture for the joint force and coalition partners.

The Integrated Battle Command System (IBCS) will connect multiple offensive and defensive platforms, weapons and sensors to significantly enhance the chance to quickly and effectively engage enemy targets of all kinds. The IBCS underwent initial operational testing and evaluation in 2022 and into 2023, with a full-rate-production decision to be made later in FY23.

Other elements of the Network portfolio include the Unified Network and the Common Operating Environment. The former will encompass an integrated tactical network and an integrated enterprise network, and will facilitate networking of individual communications and data systems. The latter will integrate databases and provide mission commanders with a unified set of command applications. Finally, the Network portfolio aims to enhance mobility and reduce signature emissions of mobile command posts.

Integrated Air and Missile Defence

The Integrated Air and Missile Defence (IAMD) portfolio aims to develop a tiered, multi-layered system to defend fixed sites and manoeuvre forces against the full spectrum of short- to long-range low-altitude threats. Some programmes are under the aegis of Army Futures Command, with the remainder being pursued by the joint service RCCTO. The Lower Tier Air and Missile Defense System (LTAMDS) will serve as the IAMD's primary radar, although it will not replace all other air defence radar systems. It will be platform-independent, feeding warning and targeting data to various interceptor systems. The Army plans to field the first LTAMDS battalion, consisting of four sensors, by the end of FY23.

Photo: Dynetics



Artist concept of the Enduring Shield air defence system.

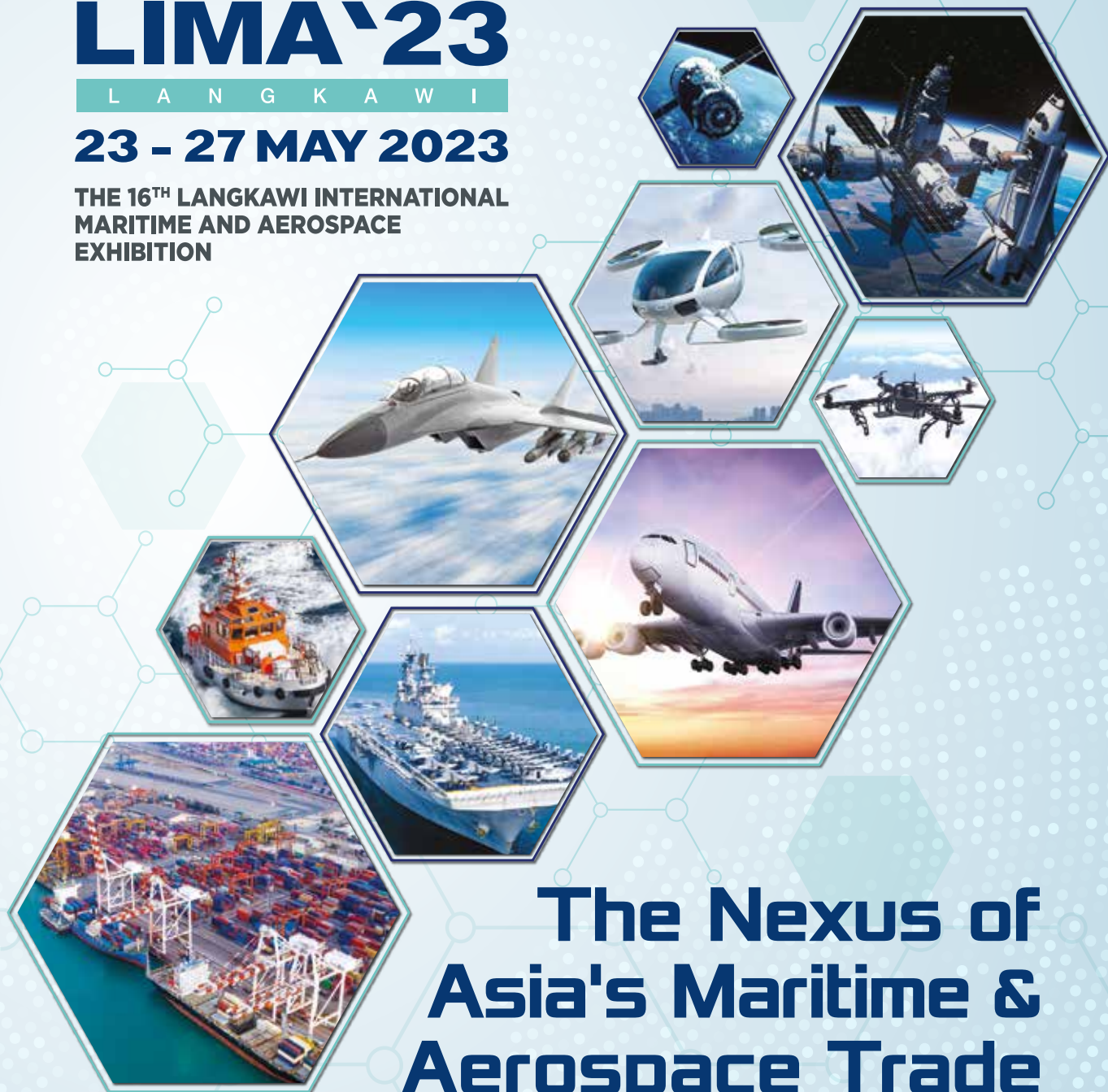


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Photo: US Army

The Sig Sauer XM7 (formerly XM5) Rifle will replace both the M4 carbine and the M249 squad automatic weapon (SAW).

New air and missile defence interceptor systems are being prepared. These include the Directed Energy Maneuver Short-Range Air Defense (DE-M-SHORAD) system, which is based on a Stryker vehicle armed with a 50 kW laser. The primary mission will be defending tactical army units from UAS and manned helicopters, as well as incorporating a counter rocket, artillery and mortar (C-RAM) capability. The first four-vehicle prototype platoon is slated for operational testing in early 2023. The Maneuver SHORAD (M-SHORAD) system, also based on a Stryker vehicle, became operational in October 2021 with a permanent overseas presence in Germany. Instead of a laser, this system employs kinetic weapons including Longbow Hellfire missiles, Stinger missiles, and a turret-mounted 30 mm gun. Targets include UAVs, cruise missiles, helicopters and low-flying fixed-wing aircraft.

Beginning in May 2019, the Indirect Fire Protection Capability (IFPC) programme (managed by the RCCTO) initially tested the truck-mounted High Energy Laser Tactical Vehicle Demonstrator (HEL TVD) developed by Dynetics, with the goal of fielding a 300 kW system to intercept UAS and other airborne threats. In January 2022, the RCCTO issued a Request

for White Papers (RFPW) from potential prime contractors for the IFPC Increment 1 procurement track, officially designated the IFPC-HEL. The RFPW's stated goal was delivery of up to four complete high-energy laser weapon systems to be delivered no later than the fourth quarter of FY24 in preparation of live range testing against operationally relevant targets. Meanwhile, in September 2021, the Army selected Dynetics' Enduring Shield system for the IFPC Increment 2 after a shoot-off against Rafael's Iron Dome. The palletised launcher accommodates multiple modified AIM-9X interceptor missiles capable of shooting down manoeuvrable airborne threats including subsonic cruise missiles and UAS; by 2026, the system is supposed to add a C-RAM capability. Citing supply-chain issues, Dynetics is currently behind schedule delivering the first four prototype launchers for operational testing, but the Army expresses confidence that system testing will still begin during FY23. The contract calls for 16 prototype launchers and 80 "fieldable" AIM-9X prototypes to be delivered through 2024, with an option to procure 400 operational launchers following testing. Transition to a programme of record is planned for FY25. In January 2023, the Army issued a contracting notice request-

ing information regarding the feasibility of augmenting the AIM-9X with a second interceptor type, this one capable of defeating supersonic cruise missiles and large calibre rockets.

Soldier Lethality

Ten-year procurement contracts for the Next Generation Squad Weapon (NGSW) programme were awarded to Sig Sauer in early 2022. The first infantry unit is expected to be equipped by the fourth quarter of FY23. NGSW replaces the M4 carbine, the M249 light machine gun, and the M240 machine gun with the M7 rifle and the M250 automatic rifle (machine gun), both chambered for newly developed 6.8 × 51 mm ammunition. Vortex Optics will build the Picatinny rail mounted firing computer (FC) for the new infantry weapons. The FC sights will provide the option of 1x to 8x magnification; more importantly, the active reticle fire control system will calculate variables such as wind and bullet drop, and automatically adjust the sight's point of aim. Overall, the NGSW is attributed with a significant improvement in range, accuracy, lethality and portability when compared to current arms and ammunition. The Integrated Visual Augmentation System (IVAS) is also classified as a Soldier Lethality tool as it provides enhanced situational awareness. The Army plans to begin fielding the augmented reality goggles to training and recruiting units in September 2023, followed by infantry units in 2024. In early January 2023, the service announced that it was already tasking Microsoft with developing a new variant dubbed IVAS 1.2, primarily to address soldier complaints regarding discomfort, fatigue and injury experienced when testing the cumbersome device.

Enhanced training capabilities designed to prepare soldiers for top battlefield performance constitute another major element of this portfolio. These training systems are collectively designated as the Robust Training Environment. Component systems to be delivered to the Army during FY23 include: the Reconfigurable Virtual Collective Trainer (RVCT), designed to enable unit collective and combined arms training for ground units and for non-rated aircrew; and the IVAS Squad Immersive Virtual Trainer. The Soldier Virtual Trainer (SVT) will round out the training systems when it achieves full operational capability in 2025; it will support individual weapon skills development, joint fires operations training, and escalation of force training at the

Photo: GDLS



The AbramsX technology demonstrator could form the basis of the US Army's next MBT, or serve as a test platform for developing technologies which could flow into the next generation MBT.



Photo: US Army

The Strategic Mid-Range Fires missile system is considered especially valuable for operations in strategic areas such as the Pacific island chains.

individual and unit level. All of these systems will utilise a Synthetic Training Environment (STE), which will portray a common three-dimensional scenario for all participants.

The Journey is the Destination

General James McConville, Army Chief of Staff, has stressed that initial fielding of a weapon does not constitute the end of the modernisation programme. “What is really important is getting to the Alpha model,” McConville said in late 2022. “If you get the capability, get it in the hands of soldiers, then we’ll incrementally improve it.” In this light, the full impact of the new systems might not be felt until well into the 2030s. By that time, the Army will be pursuing yet more new vehicles, weapons and sensors to exploit the latest technological developments and operational concepts. “Military modernisation” is in fact a constant effort, not a finite goal to be accomplished.

And while the 35 signature technologies currently being discussed are considered critical, all of the many lower profile acquisition or upgrade programmes are expected to contribute to the future force. Additionally, some projects not included among the 35 signature programmes are high profile and high impact. The Abrams M1A2 SEPv4 Main Battle Tank (MBT) upgrade is a prime example. According to the Army, the combination of new sensors and targeting systems, improved power system, the new Advanced Multi-Purpose Round ordnance, the Trophy Active Protection System and upgraded onboard diagnostics will make the SEPv4 the most lethal Abrams of all time. The

Army plans to begin fielding the upgraded variant during the first quarter of FY25. In the meantime, the M1’s developer, General Dynamics Land Systems, presented the AbramsX technology demonstrator in 2022. That design, incorporating new technologies such as hybrid propulsion, increased use of AI, and the capability to control unmanned vehicles, could bridge the gap until introduction of a completely next-generation MBT, or could simply serve to test various technologies which might ultimately flow into the next generation MBT.

Maintaining Momentum

Force modernisation is resource intensive, as is sustainment of current readiness. The Army’s 2023 budget request included USD 35 Bn for acquisitions and research, development, test and evaluation (RDT&E). This constitutes 19.7% of the total Army budget request of USD 177.5 Bn. In late 2022, the coming year’s defence budget largely appeared to be a done deal. Following the 2022 Congressional election, a vocal – and potentially influential – minority in the House of Representatives has begun pressing for defence spending cuts which could cap budgets at 2022 levels. While such an extreme scenario is considered unlikely, it cannot be excluded that the Army may need to choose between deferring one or more developmental programme, or accepting increased risk to current readiness.

The impact of the war in Ukraine on the US Army’s modernisation programme is another source of uncertainty. “It’s a little early to translate lessons learned from Ukraine into all of our requirements process for our major weapon

systems,” Army Under Secretary Gabe Camarillo told reporters on 7 December 2022. Overall, Pentagon planners postulate a need to maintain the general force structure construct, which is centred around MBTs, IFVs and artillery. Within this context, there remains room for change. As US Army Brig. Gen. Geoffrey Norman, Director of the Next Generation Combat Vehicles Cross Functional Team, asserted in late 2022, the service is monitoring which weapon systems are destroying MBTs in the current fighting. “Is it tank-on-tank direct fire engagements or is it top attack from anti-tank guided missiles [or] artillery sensor fuzed munitions,” Norman commented in October 2022. “We’re taking a hard look at that. [...] How are we protected against that? What, if anything, do we need to do differently, both from the material standpoint, but also from a tactics and a doctrine standpoint.” The same holds for tactical helicopter systems, where the Russian Armed Forces seem to have suffered significant losses and operational restrictions. The performance of current Western weapon systems and the tactical capabilities of western and Russian systems by type will certainly flow into US force structure modernisation.

Overall, Army leadership is attempting to balance confidence in the modernisation process while projecting realism. “Progress generally is going very well,” said Army Secretary Christine Wormuth in October 2022. “Given that we have 24 systems in one year that we’re either trying to start fielding or we’re trying to get prototypes in the hands of soldiers, we may hit some bumps in the road along the way. I think that is to be expected.” ■

Zelensky's Call for Fighter Jets Leaves UK Searching for Options

Peter Felstead

Ukrainian President Volodymyr Zelensky used a surprise visit to the United Kingdom on 8 February 2023 to urge the UK to supply fighter jets to Ukraine to repel the Russian invasion there. During a widely applauded speech to the UK House of Commons President Zelensky presented Sir Lindsay Hoyle, the House of Commons Speaker, with the helmet of a Ukrainian pilot on which was written 'We have freedom, give us wings to protect it.'

However, although UK Prime Minister Rishi Sunak responded that "nothing is off the table", and the UK had already that day committed to start training Ukrainian pilots on NATO-standard jets, supplying Ukraine with fighters remains problematic.

UK Defence Minister James Heappey noted to the House of Commons Defence Committee in October 2022 that it takes the Royal Air Force (RAF) 4.8 years on average to train a UK fast jet pilot to the point of joining an operational conversion unit. This has contributed to the RAF suffering a significant backlog in training its own pilots, let alone any from Ukraine. Then there is the problem of what fast jets the UK could actually supply. Most obviously the RAF is unlikely to give up any of its growing fleet of fifth-generation F-35B Joint Strike Fighters – even if the United States sanctioned that, which is unlikely. Apart from the F-35s the RAF operates a fast jet combat fleet consisting of 119 Eurofighter Typhoons (including conversion trainers), although in March 2021 the UK Ministry of Defence (MoD) announced plans to retire its older Tranche 1 Typhoons in 2025, since it is deemed not economically viable to upgrade them. At this point the RAF had 30 Tranche 1 Typhoons remaining in frontline service. While these might be considered for Ukraine, adding a new fast jet type to the inventory of the Ukrainian Air Force (Povitryani Syly Ukrainy – PSU) would bring with it significant logistics and support issues: a dilemma already being faced by the Ukrainian armed forces.

For example, the UK MoD's undertaking in mid-January 2023 to supply Ukraine with 14 Challenger 2 main battle tanks (MBTs) as part of a package that also included around 30 AS90 self-propelled guns is itself problematic; the Challenger 2 is the only major MBT that still uses

Photo: Crown Copyright



Ukrainian President Volodymyr Zelensky arriving at the UK's Stansted Airport on 8 February on an RAF C-17 airlifter.

a rifled 120 mm main gun and thus requires different ammunition to the 120 mm-armed Leopard 2 and M1 Abrams MBTs pledged to Ukraine by its Western allies.

Before the Russian invasion of Ukraine on 24 February 2022 the PSU operated a fast jet combat air fleet of about 132 aircraft, although estimates of numbers in service varied very widely, reflecting significant numbers of stored airframes.

This total included MiG-29 fighters (36-51 in use of about 100, including 10 MiG-29UBs), Su-24 attack aircraft (12-24), Su-25 close air support aircraft (17-33 including two-seaters) and Su-27 fighters (26-42, plus six two-seat Su-27UB conversion trainers). These aircraft were supported by a training fleet

that included 30-47 Aero L-39C advanced jet trainer/light attack aircraft.

However, as of February 2023 the PSU had lost at least 53 frontline combat aircraft according to the Oryx website, which tracks equipment losses in the Ukraine conflict that are confirmed by photo- or videographic evidence; actual losses can be expected to be higher.

Contributing aircraft types to Ukraine with which the PSU is already familiar would much more effectively bolster its airpower over the short term as well as minimising any training and logistics issues. This could possibly be effected by the UK engaging with allies that still operate those types in deals that might involve backfilling those air forces' fleets.

Meanwhile, a former senior RAF commander has argued that supplying Ukraine with US-made Lockheed Martin F-16 fighters would be a much better option than the RAF's older Typhoons. In an interview with the UK's Forces TV on 10 February 2023, Air Marshal Greg Bagwell (rtd), who previously served as the RAF's Deputy Commander (Operations), acknowledged that offering Ukraine its older Tranche 1 would be the UK's only viable, but noted, "There's not many of them and they are a little bit out of date in terms of their support, but that's about the only thing we've got spare – and I use that word advisedly because there's almost nothing spare right now. We do need to worry about 'What if Russia decides to do something else and is NATO ready and what is our part in a NATO defence?', so we can't afford to give everything away."

The UK offering Ukraine Tranche 1 Typhoons would "come with a huge challenge", Bagwell warned. "You're going to have to train people up, train the maintainers, provide spares packages. That aircraft has been going out of service now for many years. We keep bringing it back from the dead, but now it's going once again, which means we've stopped developing the software; we've stopped the supply chain of certain spares and avionics. And my personal view is it's not the right aircraft because there aren't enough."

The right choice of fighter for Ukraine, Bagwell argued, "needs to be something like an F-16. There are thousands of those in the world; they're still being built; they'll be upgradeable for many years; they can carry all the modern weapon systems that other aircraft can – same as the F-35, or even the F-22 for that matter."

Noting that the Typhoon has very strong air-to-air capabilities, Bagwell said, "I think one on one you might well take a Typhoon [over an F-16], but if you can get 200 [F-16s], and you know they've got a lifetime and a support network that will run them on for 10, 15, 20 years, that would be my preference [for Ukraine]."

Among Europe's air forces, F-16 users Belgium, Denmark, the Netherlands, Norway and Poland have either moved on to the F-35 Joint Strike Fighter or are in the process of doing so, which should leave a significant pool of second-hand F-16s for Ukraine. Moreover, Slovakia and Bulgaria are procuring the latest F-16V, while Romania has recently acquired second-hand F-16AM/BMs from Portugal, ensuring the F-16 as a type will operate in Central Europe for some years to come.

Photo: Crown Copyright



An RAF Tranche 1 Typhoon F2 from 11 Squadron, RAF Coningsby, pictured in flight in March 2007.

Another option for Ukraine would be older Saab Gripens. Of the Swedish Air Force's current six squadrons of Gripen C/Ds, four will transition to the Gripen E while the remaining two will remain operational with their Gripen C/Ds. Although some of the retired Gripen C/Ds will be needed for spares, others could be made available to Ukraine.

Europe's other Gripen users, the Czech Republic and Hungary, currently lease

rather than own their Gripen C/D fleets, with these aircraft unlikely to become available for Ukraine in the next few years. The Czech government announced in July 2022 its intent to buy F-35s to replace its Gripens, but its lease deal will not end until 2027. Unlike the Czech Republic, Hungary will own its Gripen C/Ds when its lease deal ends in 2026 and so is likely to opt to keep them. ■

Photo: Romanian MoD



A pair of Romanian F-16s. Ukrainian President Volodymyr Zelensky has asked for British fighters to help repel the Russian invasion of his country, but F-16s would be a better fit.

Special Operation Forces Innovations Network Seminar (SOFINS)

A Decade in the Service of the Special Forces

Jean Auran

From 28 – 30 March 2023, the sixth edition of SOFINS will be held in Martignas-sur-Jalle in Gironde, the training ground and base of the 13th RDP (13e Régiment de Dragons Parachutistes). Every two years, SOFINS provides a rendezvous for three days to the whole world of Special Forces to discover the latest products on the market.



Photo: SOFINS



Visitors can conduct test firings on the shooting ranges of the Souge Camp.

The SOFINS exhibition celebrates its tenth birthday. SOFINS stands for: "Special Operations Forces Innovation Network Seminary".

Defence exhibitions such as Eurosatory in France have long been the only opportunities to discover new equipment. However, these significant events no longer satisfy the heads of the Special Forces (SF) looking for specific products in a more confidential setting. The French Special Operations Command (COS) therefore decided to organise a show in France purely dedicated to SF. General Gomard provided the necessary impetus for the organisation of the first event. The show originated in 2010, when the European Defence Economic Network (EDEN) cluster and the SF came up with the idea of creating a crossroads between the industrial world and those working in the field, by bringing together all relevant SF

elements at the same event; SF and commando units became members of the cluster created in 2008. EDEN is a cluster of defence, security and safety SMEs, founded in 2008 in the Lyon region, which brings together 130 companies representing 9,000 employees. Since the second event, it has been organised by Le Cercle de l'Arbalète. Unique in Europe, this biennial event represents the meeting place for high-tech industry, bringing together SF and special units. There are two comparable events in the world. Jordan created the biennial Special Operations Forces Exhibition and Conference (SOFEX) in 1999 under King Abdullah II's patronage held in Aqaba. In 2022, more than 400 delegations representing 100 countries came to see more than 300 exhibitors. The other similar event is held in the United States, at the SOFIC (Special Operations Forces Industry Conference) in Tampa, Florida, which brings together the ecosystem linked to the United States Special Operations Command (SOCCOM). The command has created the SOFWERX system, which aims to facilitate exchanges between soldiers and researchers.

The Seminar

For three days, experts, SF operators and large industrial groups meet in the Souge military camp, which is transformed into a place for meetings and technical demonstrations. SOFINS is organised around three main areas: an exhibition and business meeting space for manufacturers; a product testing and demonstration area (SF, drones, vehicles); and conferences that present future challenges in terms of equipment and also display R&D programmes. Visitors can also observe dynamic equipment tests in conditions that allow innovative manufacturers to demonstrate the added value of their equipment. Aquatic demonstrations are regularly organised in the relatively close Arcachon basin. Visitors can also try out armaments at the camp's firing range. At each SOFINS event, the SF operators conduct several demonstrations such as the infiltration of a reconnaissance unit by a high-altitude jump, insertion of units on the ground, release and exfiltration of hostages, neutralisation, and capture of terrorists.

Author

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Photo: French Air and Space Force

unit that commandos can equip, as desired, with wheels to make it a land robot, rotors for a drone, floats for maritime missions, or an articulated arm. "Equipment changes are done in a few seconds, without tools", explains Vincent Marionnet, in charge of innovation for the ISR activity (intelligence, surveillance, reconnaissance) at Thales.

Startups and SF Equipment

In their quest for innovation, SF units can also count on the support of the Cercle de l'Arbalète. The association promotes technology and the innovative spirit of SF and businesses, by liaising with manufacturers. It collects the operational needs of the different SF teams, visiting many defence equipment displays worldwide in order to identify startups offering valuable new technologies. Among the highlights identified to date, Pragma Industries produces a bike with a hydrogen fuel cell that recharges in one minute. Electric bicycles or motorcycles are valuable for infiltration as they can be quickly loaded onto patrol vehicles. SEAir is a specialist in boats equipped with hydrofoils; Navy commandos have tested this semi-rigid unit with tiny, profiled hydrofoils, which allow the ship to skim the water. The result is enhanced comfort and a 30% reduction in fuel consumption. Also on show was the Escape helicopter's nacelle, designed by a member of the GIGN, which allows the rapid evacuation by a medium-size helicopter (Puma or Caracal) used by commandos. It can also be used to evacuate civilians during rescue missions.

Previous SOFINS Shows

During the first edition in 2013, 114 companies, primarily small and medium-sized companies, both French and foreign, met

Many foreign Special Forces delegations frequent the exhibition.

SOFLAB

Since 2015, the Cercle de l'Arbalète has organised a space within SOFINS reserved for selected start-ups called SOFLAB. During the first two days of the show, these start-ups have the privilege of speaking in a close setting in front of SF members to present their products, for a whole morning. In previous shows, the Pangolin company has been rewarded by offering high-performance, flexible, and lightweight ballistic protection solutions adapted in particular to level III and III+ special threats. Asvestis was rewarded thanks to its HTNB information-sharing solution, which provides communication and geolocation solutions to secure vehicle and operator communications. Additionally, Sera Ingenierie was rewarded for its expertise in the demining and counter-IED fields.

Industrial Cooperation

Commandos are often the first units chosen to test new equipment under arduous and challenging conditions. In addition to adopting the German HK416 assault rifle, the replacement for the legendary FAMAS (five years before conventional forces adopted it), they have also pioneered the use of small tactical drones, such as the Skylark from Israel's Elbit Systems. The optronic sensors of the future NH-90 helicopter, intended for SF units, will also be extended to conventional units' helicopters. Innovation rests primarily with the commandos themselves. Thus, the CPA 10 (commando Parachutiste de l'Air no 10), based in Orleans, has developed a drone called Corvus, capable of taking off vertically like a helicopter, and then flying like an aeroplane. With a range of 10 km, the equipment is easily repairable in the theatre of operations: the wings, designed from a kind of polystyrene, can be

reproduced by 3D printing, thus drastically limiting maintenance costs.

The SF units also cooperate closely with the defence industry as seen with an R&D unit specific to the COS, the CIEPCOS (Joint Commission for Practical Studies on Special Operations), which selects and finances around 60 projects annually by mixed military-industrial teams. In 2017, a sniper came up with the idea of improving Safran's JIM Compact infrared binoculars, already among the best on the market, by equipping them with a computer that corrects the aim according to the movement of the target. "On a target running at 8 km/h at 400 m distance, we reach a 90% probability of hitting the target," according to the COS officer behind the idea. After 18 months of work and tests with Safran, the equipment should enter service with the SF in the coming weeks. Thales is no exception – in cooperation with the SF, the company developed a multifunctioning robotic vehicle named BRAIN. This vehicle is a central



Photo: SOFINS

Thematic conferences allow forces to exchange experiences and outline the concepts of tomorrow.



View of one of exhibition tents.

with representatives of around 30 commando units from around the world. The second edition of SOFINS was held in April 2015 with more than 4,000 registered participants. Delegates attended from 91 countries, and for the first time, buyers from NATO were also present. The organisers also launched on-site nautical demonstrations in the town of Archacon in front of the Jetée d'Eyrac. That year, large orders were signed during the show. In March 2017, the show received 2,780 visitors and among the roughly 200 companies displaying products, around 30 were startups with innovations in the field of GEOINT. The Delta Suite is a real Geographic Information System (GIS) with a large number of protocols and equipment (encrypted transmission systems, GPS, laser designators, L16, sensors, etc...); it also allows the integration of multiple video streams from drones or any other sensor with its metadata, adopted by the COS units. Geo4i, a young startup specialising in GEOINT, displayed its innovative solutions aimed at taking advantage of spatial imagery. During the same show, the AA/ROK company presented its concept of combined arms-guided light support munition, the SSA-1108 MIGALe. In 2019, the show's organisers saw that SOFINS had already become a success story, based on its brave formula of pro-

moting a selective and confidential event while remaining professional. The 2019 show brought together 256 participating companies with one of the highlights being the participation of a Gazelle of the 4th RHFS, equipped with the M134 Minigun chambered in 7.62 x 51 mm. With a rate of fire of 4,000 rds/min (approximately 66 rds/sec), this weapon can engage infantry and vehicles up to 800 m away. The Alseamar company exhibited its Murene underwater tractor, designed for use by combat divers.

After the COVID pandemic, the 2021 show was held with participants who were either vaccinated or in possession of negative PCR tests; rapid antigen tests were carried out in the car parks if required. The most recent edition brought together 253 exhibitors, about 3,500 visitors and 49 foreign delegations. There were roughly 600 business meetings and equipment tests held in the area. Sillinger displayed the 470 SRD SUB folding boats for the first time. This was a first for the equipment manufacturer from Muret (Haute-Garonne), which will supply 2,000 rounds of .408 Chey Tac and an equal amount in .260 Remington and .300 AAC Blackout. Thanks to its British subsidiary Energetics Technology Ltd (ETL), Unitive has also managed to place a contract with the Ministry of the Armed Forces for sev-

eral batches of small-calibre ammunition. The SF are always looking for new ammunition, new effects and new suppliers too. The sixth SOFINS event will be held this year at the Souge camp in Gironde, following a year of meetings and intense work by members of the Cercle de l'Arbalète. Finally, SOFLAB will be added to this year's show, meaning there will be a space reserved for emerging companies selected by the Cercle de l'Arbalète.

Le Cercle de l'Arbalète

Le Cercle de l'Arbalète was officially launched on 25 April 2014 at the Military School in the presence of MG de Saint Quentin, the COS commanding officer at the time. The association is a federation of equipment manufacturers for SF and special units. The association is comparable to GICAT, GIFAS, GICAN and functions as an innovation hub aiming to create a link between the armed forces and the civilian world. It brings together 98 companies, including large and small businesses, research centres and schools wishing to contribute to the equipment and the efficiency of R&D dedicated explicitly to the SF. The Cercle de l'Arbalète runs several R&D workshops annually and organises visits to operational units.

The SOFINS Lottery

This year, a raffle will be held for the benefit of several military support associations. These associations include Terre Fraternité, l'Entraide FUSCO, la Fondation des Œuvres Sociales de l'Air (FOSA) and l'entraide caserne Pasquier for the GIGN. Raffle winners can choose between one of several prizes, which are all quite exceptional. The activities are open to French citizens and the activity will be available after a security check. For fans of the Navy Commandos of Lorient, you could win a tandem jump into the sea, with recovery by an ECUME, followed by a raid and assault on a ship in transit. For aviation fans, there is in-flight control of a plane from the Poitou squadron, or even a very high altitude jump with operational troops. For those interested in the Army SF, you could choose to participate in a hostage release mission, involving operational preparation right up to the action itself with 1st RPIMa, 13th RDP and 4th RHFS personnel. For GIGN fans, a tandem jump from a helicopter with skydivers and a canine team, plus a shooting session at the stand, are all on offer for lottery winners. ■



The Outfielder is a 4x4 intervention vehicle specifically dedicated to special forces. Manufacturer Soframe is a member of the Cercle de l'Arbalète.



Viewpoint from New Delhi

Photo: Suman Sharma



India, US Announce Initiative on Critical and Emerging Technologies

Suman Sharma

Deepening Indo-US ties soared to newer heights with the recent announcement of the US-India Initiative on Critical and Emerging Technologies (iCET), aimed at collaboration in key areas. Covering a wide spectrum from military, strategic, to scientific sectors, though the iCET represents an aligned positioning between both democracies. Strategic experts are largely viewing the initiative as a measure to step up defence against a rising and expansionist China.

Considered as the next big thing in fostering closer Indo-US linkages, the iCET co-led by the Indian National Security Council Secretariat and the American National Security Council represented by the National Security Advisors (NSAs) of both nations, was launched in May 2022 at the Tokyo Quad Summit in a bid to facilitate outcome-oriented cooperation in artificial intelligence (AI), quantum computing, 5G/6G, biotech, space, semiconductors and joint defence production.

Backed by intragovernmental administration, resource sharing, academia, industry outreach, ideation and setting up of an ecosystem, the iCET is likely to boost resilience into a new blueprint for technology diplomacy and statecraft.

The precursor to iCET was the Defence Technology and Trade Initiative (DTTI) established in 2012, and pushed by former US President Barack Obama to foster collaboration in critical defence technologies and promote co-production.

Supporting the initiative, former Indian Ambassador to the US, Meera Shankar, says, "India-US defence ties have strengthened in recent years. However, technological collaboration in the defence sector and in other critical technologies has been somewhat limited. The DTTI has made only modest progress so far. In this context the iCET programme for strengthening India-US collaboration in Critical and Emerging Technologies holds the promise of taking the relationship to the next level."

The China Factor

The iCET has been called out by strategic watchers as a move towards countering China, a view that was reiterated by the US NSA Jake Sullivan, "The larger challenge posed by China, its economic practices, its aggressive, military moves, its efforts to dominate the industries of the future and control the supply chains of the future have had a profound impact on the thinking in Delhi."

However, White House Press Secretary Karine Jean-Pierre said that iCET was not just about China, "The President believes this initiative, just laid out, is key for the US and India to create a democratic technology

ecosystem, so we see this as an incredibly important initiative and a partnership that we have with India."

With Beijing's support to Moscow in the Ukraine-Russia war, the Indo-China border standoff in the Himalayas, and the more recent 'balloon espionage' incidents, the technological, economic and military rise of China has undoubtedly acted as a catalyst for US to enhance and shape its strategies and bolster partnerships in the Indo-Pacific, like boosting military bases in Philippines and Japan, reviving cooperation with Pacific island countries, formation of AUKUS and invigorating the Quad with India, Japan and Australia.

The competition for technological dominance between the US and China has sharpened, while the disruption in supply chains caused by the COVID-19 pandemic has driven home the vulnerabilities caused by dependence on a single supplier. Ambassador Shankar added, "De-risking through diversification and 'friendshoring' is high on the US agenda. A partnership with India, given its technologically skilled manpower and large market, could help to strengthen America's competitive edge while advancing India's capacities in the technologies of the future."

Indo-US Ties

With the four Indo-US foundational pacts- Basic Exchange and Cooperation Agreement (BECA), Communications, Compatibility and Security Agreement (COMCASA), Logistics Exchange Memorandum of Agreement (LEMOA), and the Industrial Security Agreement (ISA) firmly in place, the defence and security cooperation between both the democracies seems to be increasing and deepening. The total defence trade with India has gone from near zero in 2008 to over USD 20 Bn in 2020. Some recent deals under Foreign Military Sales (FMS) are the MH-60R Seahawk helicopters worth USD 2.8 Bn, Apache helicopters valued at USD 796 M, and the Large Aircraft Infrared Countermeasures (LAIRCM) at USD 189 M.

India also boasts of becoming the first non-treaty partner to be offered a Missile Technology Control Regime Category-1 Unmanned Aerial System – the Sea Guardian UAV manufactured by General Atomics, a deal in its final stages, valued at USD 3 Bn for 30 MQ-9B Predator armed drones. General Atomics is reportedly scouting for an Indian partner, under the 'Make in India' initiative. Meanwhile, two American aircraft manufacturing giants, Lockheed Martin with their F-21 fighter and Boeing with their F/A-18 Super Hornet and F-15EX Eagle, are both in competition for the Indian Air Force (IAF)'s future fighter aircraft programme. Both Boeing and Lockheed have partnered with Tata Advanced Systems Limited (TASL) under 'Make in India'.

Italy's Multiyear Defence Planning Document 2022-2024

Luca Peruzzi

The release of the Italian MoD's Multi-year Planning Document 2022-2024 (Documento Programmatico Pluriennale or DPP 2022-2024) in July 2022, highlighted the highest funding support for the Defence since the mid-2000s, with a budget reaching EUR 18 Bn compared to the EUR 16.8 Bn of 2021, but expected to decline in the following years.

The Defence procurement reaches EUR 5.42 Bn with a 34% increment compared to year 2021. During 2022, the DPP 2022-2024 indicated a planned start of 46 procurement programmes in addition to the already operating 170 projects. Having responsibility for Defence procurement, the Secretariat General of Defence/National Armaments Directorate plays a key role in providing the systems and services requested by the four Armed Forces, including Army, Air Force, Navy and Carabinieri, and supporting Defence export programmes through Government-to-Government (G2G) agreements, as highlighted by the recent sales of helicopters to Austria and transport aircraft to Slovenia.

Joint programmes

Among the joint armed forces programmes which are being funded through the DPP 2022-2024, the Italian MoD has launched the Software Define Radio (SDR) EVO project regarding the technological development, new hardware and waveforms for in-service and new SDR systems, the Next Generation Fast Helicopter initiative which focuses on the national industry participation to studies on emerging technologies in the rotary-wing domain, exploiting at the same time the national capabilities in this sector through the development of a Next Generation Fast Helicopter based on advanced and potentially disruptive technological solutions.

The Italian MoD also gave the green light to the joint helicopter school led by Italian Air Force and based in Viterbo, both in terms of infrastructures and ground based training system, including a flying platform between the basic TH500 and the operational helicopters, which has been identified in the AW169 LUH. The latest DPP has also given the green light to the expansion of the infrastructures for the Pantelleria island military airport, a key forward base for joint missions in the middle of the Mediterranean, alongside the upgrading of the national network of fuel pipelines, and the upgrading of naval bases infrastructures for the accommodation of the Italian Navy ships. Among the joint programmes, there is also a study for a new joint maritime multi-mission system (J3MS) platform with sensors to conduct strategic collection of information, integrated into a joint C4I architecture. Programmes regarding the development study for a High-Altitude Platform System (HAPS) for ISR missions and a new 3rd generation optical satellite constellation will be based on two space platforms which will replace the single OPTSAT 3000 satellite, improving space-based support for ground

surveillance and communications. Communications also stand to benefit from the first two of four satellites belonging to the 2nd generation COSMO-SkyMed constellation, equipped with synthetic aperture radars, as well as the July 2022 contract award to Thales Alenia Space and Telespazio for two SICRAL 3 satellites for military and governmental applications. For national airspace protection, the Italian MoD has also launched a programme for the acquisition of four long-range radars for ballistic missile defence (BMD), as part of a wider programme to include C3 and effectors. Other key programmes in the air defence domain came to fruition in 2022-2023 with funding from previous years. In addition to the December 2022 order for new MBDA Aster family missiles including Aster 15, Aster 30 (Block 1, Block 1 NT) with France, in February 2023 the OCCAR agency, on behalf of the Italian and French MoD also awarded a contract for the procurement of the elements of the new Eurosam SAMP/T NG system, and is preparing a production contract for the Italian Air Force. The latter is due to receive five batteries, which will work aside the six batteries (one for training) of the Italian Army. The Italian Navy will also use newer Aster family missiles to deal with air-breathing and ballistic threats. On November 2022, OCCAR awarded MBDA Italia the contract for the production of the EMADS (armed with CAMM-ER) systems for the Italian Army's Grifo and Air Force's MAADS air defence programmes.

Land programmes

In mid-February 2022, during a hearing in Italian Parliament, the Army Chief of Staff, Lt Gen Pietro Serino presented the Army's most important modernisation programmes. Assessing the needs of its heavy brigades, the Italian Army is upgrading the legacy fleet of its Ariete MBTs. Industry has recently deliv-

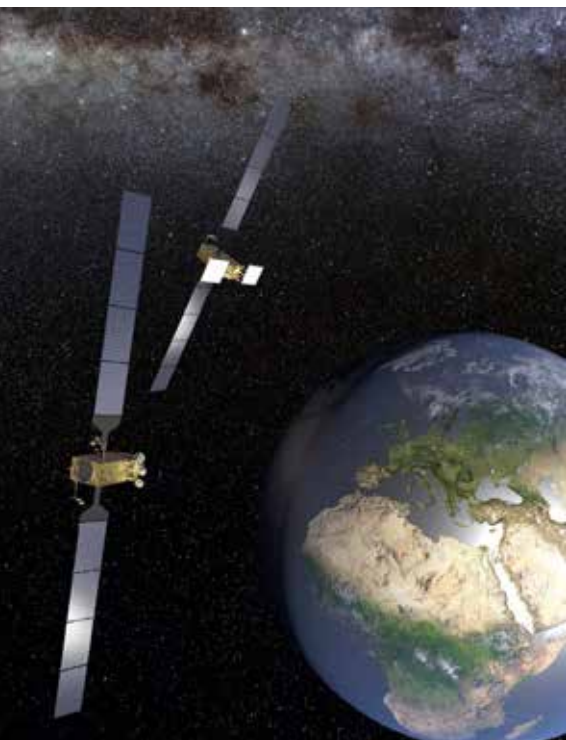


Photo: Thales Alenia Space

The SICRAL 3 constellation will comprise two satellites, dubbed 3A, and 3B.



Photo: Italian Army

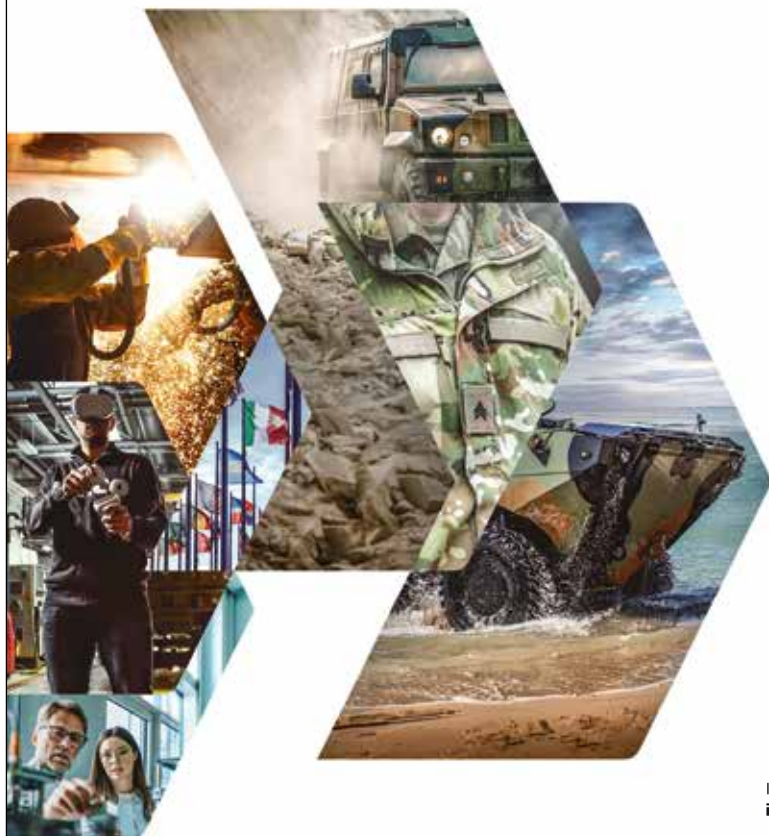
The industry has recently delivered to Italian Army three prototypes of the upgraded Ariete which features enhancements in terms of mobility, lethality, and protection.

ered three prototypes of the upgraded Ariete which features enhancements in terms of mobility, lethality, and protection. A total of 125 out of 200 originally produced Ariete MBTs will be upgraded. Looking to the future and highlighting the international trend towards the upgrading of in-service versus the development of new platform, the potential for international cooperation, and the urgent need for new MBTs, the Army's Chief

of Staff has favoured procuring new systems already in service with other NATO and EU nations, characterised by an existing logistics support chain.

Further down the list, the Armoured Infantry Combat System (AICS) will provide a family of vehicles based on a new tracked platform to replace the in-service Dardo IFV, and is due to enter service in 2035. This programme calls for the acquisition

of a completely new family of vehicles, and will draw national industrial involvement starting from the CIO consortium companies of Iveco Defence Vehicles and Leonardo. In the interim period, an initial batch of vehicles could also be procured on the market, preferably highly modern, operationally proven, and supported by a well-established and possibly multinational logistics chain.



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Photo: MBDA Italia



CAMM-ER during a live fire test.

The Italian MoD's Land Armaments Directorate (TERRARM) is continuing to procure the VBM Freccia 8x8 wheeled IFVs for the Italian Army's second Medium Brigade from the CIO consortium, introducing an upgraded vehicle and mission suite configuration. CIO also provided the first ten of 122 contracted Centauro II (out of a total requirement of 150) fire support vehicles, while Iveco Defence Vehicles (IDV) continues to supply the Lince 2 VTLM in different configurations with C3 provided by Leonardo.

Photo: ICIO



In addition to Equipping Italy, the Centauro II fire support vehicle has also been purchased by the Brazilian Army.

Under the 'Forza NEC' digitalisation and networking programme, the Italian Army is procuring deployable and digitalised command and control posts for all Brigades and Regiments as well as the enforcement of ISR capabilities through the renewal of its Electronic Warfare, Imagery Intelligence and Human Intelligence capabilities.

The recent operations in Ukraine and previous crisis have highlighted the need for longer-range precision indirect fire support systems. Aside from the procurement of extended-range rockets for the in-service MLRS systems, the head of Army has stressed the need for procuring mobile multiple rocket launching systems such as HIMARS. In the meantime, the Italian Army's self-propelled PzH 2000 and towed FH70 artillery systems will be subject to an upgrade programme aimed at making them capable of firing Vulcano family long-range guided/unguided munitions, the procurement of which was launched in 2022. Moreover, a procurement programme for 13 counterfire radars is on-going.

The Italian Army is currently upgrading its air defence capabilities, from VSHORAD to LRAD. The Italian Army Chief of Staff recently revealed the existence of a development programme for a new short-range missile system to replace the Stinger, stating that the development contract has been awarded to MBDA Italia, but not providing further details.

The Counter-UAV/Loitering Munition (C-UAV/LM) and Counter-Rocket, Artillery, and Mortar (C-RAM) role will in future go to an air defence vehicle variant from the AICS programme. MRAD will be provided by the Grifo GBAD system, for which

the prime contractor is MBDA Italia. Grifo is based on the MBDA EMADS system, and the Army's configuration will use the Rheinmetall Air Defence X-TAR3D radar, the 'Posto Comando di Ingaggio' (PCMI) command post, and will be armed the MBDA CAMM-ER missile. Higher-echelon air defence will be provided by the aforementioned SAMP/T NG system, which will be integrated with Grifo.

Another key programme being launched is the procurement of mini, micro, and light UAVs in large numbers, which according to the dossier presented in Parliament, will include 214 UAVs, logistics support, training, and spare parts.

Italian Army is also working to renew its fleet of attack and light transport helicopters, after having received the last NHIndustries NH90 TTH in November 2022. The first prototype of the Leonardo AW249 Nuovo Elicottero da Esplorazione e Scorta (NEES; ENG: New Escort and Reconnaissance Helicopter), which is destined to replace the A129 Mangusta, had its maiden flight in August 2022. 48 AW249s are due to be delivered under the programme, providing the Italian Army with a significantly more capable and network-centric platform than the Mangusta. Since July 2020, Leonardo has also been delivering initial batches of the new AW169M Light Utility Helicopter (LUH), with 40 due to be delivered. The helicopter is equipped with self-protection systems, improved take-off weight, and an optronic turret, among other enhancements.

In December 2022, the Land Armaments Directorate signed a contract with Iveco Defence Vehicles for the supply of 36 Veicoli Blindati Anfibi (VBA; ENG: amphibious armoured vehicles) 8x8s (derived from the Iveco SuperAV design) to the Italian Navy. The contract comes as part of a programme aimed at increasing the sea projection capability of the Italian Navy.

Air Force Programmes

In December 2022, the Governments of Italy, Japan and UK announced the development of the Global Combat Air Programme (GCAP), to develop a next generation fighter aircraft by 2035. Growing from the national and international activities of the three MoDs and industries of the Tempest and the F-X programmes, Leonardo together with BAE Systems and Mitsubishi Heavy Industries will collaborate in the development of the 6th generation combat aircraft, which will operate as a system of systems. In addition to Leonardo, the Italian team will involve Avio Aero, Elettronica and MBDA Italia together with the country's wider innovation and manufacturing eco-



Photo: Italian Air Force

A KC-767A of the Italian Air Force refuels an F-35.

system. In the latest DPP 2022-2024, the Italian MoD has so far put aside EUR 3.1 Bn for funding GCAP out to 2036. The latter will initially operate alongside the in-service Lockheed Martin F-35 and Eurofighter Typhoon, progressively replacing the latter, and then a major share of the former.

Under the F-35 procurement programme, the Italian MoD has invested EUR 7.06 Bn (Phase 1) for the first 28 aircraft including F-35As and a reduced number of F-35Bs. Launched in 2022, a EUR 4.2 Bn Phase 2a will support the procurement of additional 27 aircraft, while preliminary agreements were planned to be reached for the EUR 7 Bn Phase 2b, for 35 aircraft. Each phase also includes spares and logistics support. To support joint Air Force and Navy expeditionary capabilities with the F-35B, the Italian MoD's Air Armaments and Airworthiness directorate (ARMAEREO) has launched the procurement of dedicated equipment to operate and refuel from small forward air bases under a joint command and operational scheme. In total, the Italian Armed Forces will acquire 90 F-35s, consisting of 60 F-35As for the Air Force and 30 F-35Bs which will be split between the Navy and Air Force with 15 aircraft each.

For the 96 Eurofighter Typhoons remaining in service (of the original 121), subdivided between Tranche 1, 2 and 3, the Italian MoD and industry are involved in the Long-Term Evolution (LTE) multinational study programme, which was planned to be completed in late 2022, opening to the technology maturation phase in the next three years. In 2021, Italy has joined the UK in the development of a next-generation radar for Eurofighter.

In order to support its fleet of fighters, bombers, transport and special mission aircraft, in November 2022 ARMAEREO released a report on the heavy tanker fleet renewal. The report called for replacing

the existing fleet of four Boeing KC-767A with six new Boeing KC-46A, with the programme valued at EUR 1.12 Bn including integrated logistical support.

In February 2021, the Italian MoD launched a multi-phase programme for eight Joint Airborne Multi-sensor Multi-mission System (JAMMS) platforms for the Intelligence, Surveillance, Reconnaissance & Electronic Warfare (ISR&EW), and Airborne Early Warning & Battle Management Control (AEW&BMC) roles. Italy already operates two Gulfstream G550 CAEWs, and in March 2022, ARMAEREO awarded IAI/Elta a contract to supply two additional platforms, while in the same period the first of at least two G550 green airframes arrived in Italy to be converted for the ISR&EW role, with mission suite provided by L3Harris and Leonardo. The service also expressed interest in a platform such as the EC-37B Compass Call.

Italy is one of the participating countries in the European Medium-Altitude Long-Endurance (MALE) UAV programme man-

aged by OCCAR. Under the development, procurement and in-service support contract assigned in February 2022, the Italian MoD is acquiring five systems, each including three aircraft and two ground-control stations. With first flight sets for 2025, deliveries are planned from 2028. ARMAEREO also launched preliminary activities for sensors and mission system upgrades, as well as weapons for the in-service MQ-9A Predator B, having retired the MQ-1 fleet by the end of 2022.

The Leonardo C-27J transport fleet will be subjected to extensive avionics upgrades and platform life-extension works, as well as the introduction of a multi-purpose roll-in/roll-out platform payload to conduct C4ISTAR, COMINT and gunship operations in support of special forces.

The Aeronautica Militare is also reinforcing its MRAD capabilities through the upgrading and procurement of additional MAADS (Medium Advanced Air Defence System) batteries. Like the Army's Grifo programme, MAADS is based on the MBDA EMADS system, however the Air Force's configuration is slightly different, using the longer-range Leonardo Kronos Land 3D radar and the SIRIUS C2 system. However, the armament will be the same as Grifo – the MBDA CAMM-ER missile.

Naval programmes

In the last three years, the Italian Navy and the MoD's Naval Armament Directorate (NAVARM) have launched a feasibility study for the Next Generation Destroyer (DDX) and the Mid-Life Update (MLU) of Italian-French Horizon guided missile destroyers (Horizon MLU), the procurement of a second *Vulcano* class Logistic Support Ship (LSS) as well as the replacement of the two FREMMs sold abroad and the upgrade of



Photo: Italian Air Force

Two Eurofighter Typhoons of the Italian Air Force.



Image: T. Mariotti

The SDO-Surs platform is being constructed by Italy's Genoa-based T.Mariotti shipyard.

Thaon di Revel class Pattugliatori Polivalenti d'Altura (PPA) vessels.

In late 2021, NAVARM awarded Fincantieri the pre-feasibility studies contract for the DDX, envisaging a >10,000 tonne platform with an improved combat system from the PPA class (including combat management system, radars, and EW suite) as well as the Leonardo Kronos Power Shield radar for BMD. The armament package will include a more capable air defence system equipped with MBDA Aster family missiles, including the Aster 30 Block 1NT, vertical launching system (VLS) cells for cruise missiles and inclined launchers for anti-ship/land attack missiles. A procurement contract for an initial two ships batch due to be awarded in 2024.

Under the joint French-Italian programme managed by OCCAR, Fincantieri is also

working on the 9th and 10th FREMMs, which due to the changing operational environment, come in a 'hybrid' GP (General Purpose) version with the same anti-submarine warfare (ASW) suite as the dedicated FREMM configuration. The Italian MoD is also looking to procure additional FREMMs, but no final numbers have been officially confirmed. The Italian Navy Chief of Staff, Admiral Enrico Credendino has however unveiled a partially-funded plan for improving the two in-service PPA Light to the Full configuration.

In December 2022, OCCAR announced the signing of a contract with Fincantieri for the procurement of the third submarine under the U212 Near Future Submarine (NFS) programme, once funding will be available. The U212 NFS programme calls for a total of four platforms, the first of which to be

delivered in late 2027 at the earliest. The second *Vulcano* class LSS (Logistic Support Ship) is under construction while a third is planned. NAVARM, Italian Navy and Fincantieri are currently working to urgently replace the *Comandanti* class with a four OPVs aiming to finalise a contract by the end of 2023. The same programme also includes follow-on platforms derived from the EU's European Patrol Corvette (EPC) project managed by OCCAR.

Among the programmes funded and to be launched with the DPP 2022-2024 is the replacement of in-service and aging *Santi* class LPDs with the same number of larger but not flat deck LDX amphibious platforms which will add to the Trieste LHD, expected to be delivered in the first half of 2024. Intermarine is working on the new generation Mine Countermeasures Vessels (MC-MVs), to be divided into two classes, with a larger vessels for blue water operation and smaller vessels for coastal operations. Both will be equipped with unmanned vehicles of different types which are able to enter mined zones.

In July 2021, Genoa-based Mariotti shipyard has been awarded a contract to build the new Special & Diving Operations-Submarine Rescue Ship (SDO-SuRS), which will be equipped with a sophisticated suite for diving and submarine crew rescue provided by DRASS and Saipem joint team. The vessel will also operate unmanned underwater vehicles (UUVs) of different sizes. Delivery is planned for late 2025/early 2026. With the urgent need to also replace the aging *Magnaghi* hydrographic platform, in December 2022 NAVARM awarded Fincantieri a contract to build and equip the Nave Idro-Oceanografica Maggiore (NIOM; ENG: Hydro-Oceanographic Major Vessel) to be delivered in 2026. The vessel will be equipped with UUVs and ROVs for over operations at over 3,000 m in depth.

NAVARM is further improving the Italian Navy with the development of the new Te-seo Mk2/E antiship/land attack missile (assigned to MBDA Italia), alongside contracts for supplying DART guided munitions for defence against sea-skimming anti-ship missiles, as well as long-range *Vulcano* guided munitions.

On the aviation front, DPP 2022-2024 has given the green light for new rotary-wing UAV, and the Italian MoD's Air Force and Airworthiness directorate has awarded In-situ a contract for the procurement of two fixed-wing UAVs for the Italian Navy, while being involved in the feasibility studies for the mid-life upgrade (MLU) and maintenance, repair and overhaul (MRO) of the Leonardo EH101 fleet.

Photo: Italian Navy



Paolo Thaon di Revel PPA. The upgrade of the PPAs will depend on additional funding necessary for the programme to go ahead.

The EU as an International Security Institution

Bo Leimand

As to whether the EU is envisaged as a security institution depends very much on how one defines such a security body in the first place and whether it possesses the relevant tools. On the other hand, from the very beginning, NATO has very clearly been accepted as an international security institution with its well-known Article 5, the so-called “musketeer oath”. Therefore, in order to address the issue, it will be necessary to look at the EU to see if similar criteria apply.

“The road of diplomacy may appear complicated and frustrating. But progress to it requires both the vision and the courage to undertake the journey.”

Henry Kissinger:
The Spectator, December 2022

Definition

In this context, a security institution can be defined as an institutional arrangement referring to security measures and protocols mandated by a government or corporate entities. These measures shall be in place to protect strict social structures and the environment. Examples of international security institutions, besides NATO, are the UN Security Council, the North Atlantic Council, the US-Soviet Standing Consultative Commission, and the Board of Governors of the International Atomic Energy Agency (IAEA). The keyword for any security institution is to “protect” and to do so by using the necessary means available.

Considering this, it is important to note a NATO member country’s collective defence obligations according to Article 5 of the North Atlantic Treaty:

“The Parties agree that an armed attack against one or more of them in Europe or North America shall be considered an attack against them all and consequently they agree that, if such an armed attack occurs, each of them, in exercise of the right of individual or collective self-defence recognized by Article 51 of the Charter of the United Nations, will assist the Party or Parties so attacked by taking forthwith, individually and in concert with the other Parties, such action as it deems necessary, including the use of armed force, to restore and maintain the security of the North Atlantic area.

Any such armed attack and all measures taken as a result thereof shall immediately be reported to the Security Council. Such measures shall be terminated when the Security Council has taken the measures

necessary to restore and maintain international peace and security.”

This language is relatively flexible. It permits each NATO member country to decide for itself what action it should undertake to react to an armed attack on a NATO ally. It does not require any member to respond with military force, although it permits such responses as a matter of international law. A member may decide that instead of responding with force, it will send military equipment to NATO Allies or impose sanctions on the aggressor. The purpose is to restore and maintain security. In other words, Article 5 is securing maximum protection for NATO members.

Photo: EDA



From 3-14 October 2022, the EDA ran its European Spartan Exercise, hosted by Bulgaria. The exercise involved four C-27Js and 150 personnel from four participating EU Member States.

EU Lisbon Treaty Article 42.7

The Treaty of Lisbon amounts to another attempt to enhance European security and defence as it introduced the initiative of the Common Security and Defence Policy (CSDP), a policy espousing defence cooperation and coordination between EU Member States whilst creating internal political and military structures that facilitate civilian and military operations outside of the EU. Furthermore, the Treaty of Lisbon introduced several mechanisms, including a commitment to mutual assistance and Article 42.7 is the mutual defence clause. It derives from Article 5 of the Treaty of

Photo: NATO



A ceremony in 2004 marked the handover from the NATO-led SFOR mission to the EU's Operation Althea in Bosnia.

Brussels in 1948 that created the Western European Union (WEU), the first mutual defence organisation in Europe. Article 42.7 was incorporated into the Lisbon Treaty in 2011 and states that:

"If a Member State is the victim of armed aggression on its territory, the other Member States shall have towards it an obligation of aid and assistance by all the means in their power, in accordance with Article 51 of the United Nations Charter.

This shall not prejudice the specific character of the security and defence policy of certain Member States. Commitments and cooperation in this area shall be consistent with commitments under the North Atlantic Treaty Organization, which, for those States which are members of it, remains the foundation of their collective defence and the forum for its implementation."

This article was introduced at the instigation of those Member States who supported a greater role for the EU on defence matters. The French were particularly prominent amongst those advocating such an approach. In fact, Emmanuel Macron has outlined how Europe needs to finally become independent because the Russian invasion of Ukraine proves that Europe cannot depend on others. In this respect, European defence must take a new step forward. Here the EUROCORPS might come into play.

Requirements

Article 42.7 differs from Article 222 of the Treaty on the Functioning of the EU (the so-called "Solidarity Clause"), which pledges solidarity in the face of terrorism, and from NATO's Article 5.

At the simplest level, EU Member States are required to provide aid and assistance, although the provisions do not apply equally to all countries. The Article contains the provision that it:

"...shall not prejudice the specific character of the security and defence policy of certain Member States."

This means that countries with long-standing traditions of neutrality, such as Ireland, Finland or Sweden, are not required to break these traditions. Apparently, an EU mutual defence article exists, but it is linked to commitments in a NATO context and if a country has some specific caveats such as neutrality, that country can abstain from taking part in a given defence activity. Differences still exist between Member States in the interpretation of this article.

NATO-EU Threat Management

While the NATO-EU partnership is simultaneously an indispensable component of, and an emerging framework for, contemporary threat management, it is also confronted with several difficulties that undermine its remit and impact. Some issues are worth mentioning to establish a picture of the EU as a security institution.

Although the NATO-EU Declaration from 10 July 2018, which comes two years after an initial agreement made in Warsaw, states that NATO and the European Union are strengthening cooperation in a range of areas, the two Joint Declarations were issued and signed by the organizations, not by their respective members. The dynamic and degree of political will within Member States can therefore be different. States that belong to only one of the two

institutions do not always necessarily see cooperation with the other as a top priority. Indeed, 22 states are members of both institutions, and this facilitates cooperation, yet with the US and Turkey on one side, and some of the non-aligned EU non-NATO states on the other, there are divergences over the idea of a mutually beneficial partnership.

Even among the 22, there are those that are lukewarm about the virtues of cooperation as Article 42.7 states that, "Commitments and cooperation" in defence "shall be consistent with commitments under the North Atlantic Treaty Organization, which, for those States which are members of it, remains the foundation of their collective defence and the forum for its implementation". The essential partners of NATO prevail in their own security policy, and the other one is consequently less of a priority. The number of EU entities involved in EU-NATO relations makes the partnership a multi-level exercise rather than a two-player game. The European External Action Service (EEAS), the European Commission (EC), the General Secretariat of the Council (GSC), and the European Defence Agency (EDA) are simultaneously engaged in a dialogue with NATO. And even NATO is not necessarily homogeneous, with entities such as Supreme Headquarters Allied Powers Europe (SHAPE) relating to the EU in a way that may differ from interaction at political headquarters' level. This creates different layers of dialogue that tend to alter the bilateral nature of the relationship, while the EU internal coordination challenge also complicates cooperation with any third party.

Practically, this means that there can be no review or update of the existing legal arrangements between the EU and NATO outside of the implementation of the 2003 Berlin Plus agreement. Under Berlin Plus, the EU can request NATO to make available its assets and capabilities to the EU for an EU-led and directed operation. To date, the EU has conducted two operations with NATO support. Operation EUFOR Concordia in 2003 in the former Yugoslav Republic of Macedonia (fYRoM) and Operation EUFOR Althea in 2004 in Bosnia and Herzegovina, which is still ongoing.

Under the CSDP, the EU takes a leading role in peacekeeping operations, conflict prevention and the strengthening of international security. It is an integral part of the EU's comprehensive approach towards crisis management, drawing on civilian and military assets. Since the first CSDP missions and operations were launched back in 2003, the EU has undertaken over 37 overseas operations, using civilian and

military missions and operations in several countries in Europe, Africa, and Asia. Finally, the EU-NATO partnership takes place within the context of the EU's renewed efforts to develop its own defence policy and the debate which this generates in terms of compatibility with NATO. With the creation in 2017 of the Permanent Structured Cooperation (PESCO) and the European Defence Fund (EDF), the EU has tangibly upgraded its defence profile, which in turn has changed the nature of the EU-NATO dialogue. In principle, the EU defence momentum must enable the EU to better tackle threats in cooperation with, and to the benefit of, NATO. Coordination between the European Capability Development Plan (CDP) and the NATO Defence Planning Process (NDPP) is improving because of PESCO. The NDPP is feeding into the CDP and the two are different by nature. In essence, the NDPP is NATO's tool to assess member states' contributions to the forces needed to carry out NATO's military level of ambition. The CDP has been designed specifically to analyse what sort of military capabilities the EU needs in more general sense and where the major shortfalls lie.

Strategic Concerns

The narrative over the EU's strategic autonomy, which is sometimes linked to the question of a 'European Army' or 'Army of Europeans', has also stirred concerns about intended or unintended consequences for NATO and the transatlantic bond. From an EU perspective, an appropriate level of EU strategic autonomy contributes to more effective burden-sharing across both institutions and strengthens Europe's ability to promote peace and security within and beyond its borders. Yet the fact that the aspiration towards strategic autonomy might reflect a certain mistrust vis-à-vis the Alliance or the US, or that it simply takes stock of a fading US commitment to European security, has also led to some tension. The EU-NATO partnership does not exist in a political vacuum – it is to a large degree a product of political dynamics within each institution, as well as at the transatlantic level. The current tensions within the EU in the context of Ukraine and within NATO about its own internal cohesion can only foster more synergies between the two institutions.

For the EU, it is a question of whether to build a strategy taking three parameters into account; Russia, gas and oil; China, cheap high technology and the Silk Road; and the US, security. For the EU, it will be difficult to navigate in this triangle and we have already seen EU nations following



Photo: NATO

Finland in Sweden already cooperate very closely with NATO, and are in the process of accession to the alliance.

their own path in these areas. It has also been noted that one nation even remarked that NATO was experiencing "brain death", while others are striving hard to keep NATO and the US closer to the security of NATO and Article 5. In addition to this, two more EU members have signed up for NATO membership.

However, cooperation between NATO and the EU looks set to deepen somewhat, as on 10 January 2023, the two signed a Joint Declaration on EU-NATO Cooperation. This stated that "The NATO-EU strategic partnership is founded on our shared values, our determination to tackle common challenges and our unequivocal commitment to promote and safeguard peace, freedom and prosperity in the Euro-Atlantic area." The agreement also promised to "assess progress on a regular basis."

The EUROCORPS

In October 1991, the French, and the German Governments, were keen to increase the discernible signs of the reconciliation between France and Germany while nurturing simultaneously an idea of European defence. Some months later, in May 1992, both Governments decided to establish a French-German Corps Headquarters in Strasbourg, where both nations would have an equal share of the command but also the burden. The EUROCORPS was established.

Shortly after, the French and German Governments decided to open this headquarters to members of the WEU. Today there are 11 Framework or Associated Nations. Currently this might be the closest you come to the tools for a security institution in Europe. But again, when one examines the setting for the EUROCORPS, it is stated, after the creation of the EUROCORPS in

1992, that the Corps is at the disposal of NATO to show to the Allies that the EU-ROCORPS was not only a new European unit but was also complementary to the defence efforts of the Alliance. Since the signature of the SACEUR agreement in 1993, the EUROCORPS can be placed under the command of SACEUR to develop shared training and planning with NATO.

Conclusion

One might wonder why there cannot be a NATO taking care of security and threat management and an EU taking care of trade and trade management. Nevertheless, there is increasing competition between the great powers assuming the form of a global struggle for power and position. The US focus on innovation and technology means that the European NATO member countries and EU are subjected to renewed pressure. The EDF and NATO's Defence Innovation Accelerator for the North Atlantic – or DIANA – are both working with the private sector and academia, to ensure that they can harness the best of new technology for Euro-Transatlantic security. The result is that taxpayers are paying twice for the same service. Whether this is an intelligent way of doing business, only the future will show. The discussion about the wisdom in having an EU as a security institution will continue and the result might well be that EU Member States that are also NATO Allies are hedging their bets in favour of the Alliance's better defined defence mandate, rather than that of the EU, whose ambitions for common security and defence remain largely statements of intent. This should be seen in the context of the current security situation in Europe, and Finland and Sweden's pending accession to NATO. ■

Interview with Martin Krona, President EMEA at Markforged

In February 2023, ESD interviewed Markforged, a company known for their additive manufacturing platforms, commonly known as 3D Printers. Although not primarily targeted at the defence sector, the company has been making inroads as armed forces increasingly begin to experiment with the applications of 3D printers. These typically include rapidly delivering often highly-specific components, one-off designs, or being able to take concepts to a prototyping or service stage more quickly than using traditional manufacturing methods.

Answers to ESD's questions were provided by Martin Krona, President EMEA at Markforged.

Q: The applications of 3D printing are fairly extensive, as I recall, Markforged has presented its printers being used to produce a helmet mount adaptor to allow mounting night vision goggles (NVGs) to a non-standard helmet, a rifle holder for a car door, and even a part of a landing gear door for an F-35. Is it fair to say that your company aims to occupy the low-volume, urgent-requirement/high complexity space in the defence sphere?

A: In addition to customising and creating new designs in the field and at any point of need, 3D printing can also help resur-

rect legacy parts by reverse engineering. With the help of a 3D scanner, field units can reverse engineer old or obsolete parts that need replacing by creating a file of the scan and sending it to the printer to create a new one. It is quite common that parts that need replacement in the field are old and do not necessarily exist in the market. This is especially true within the defence industry with a fleet of machines spanning over 20 years in operations.

3D printing and additive technology has come a long way since it was first used in the defence industry. Its material strength, accuracy, reliability and connectivity now make it a vital tool used by military and defence organisations around the world. The reason we often see low-volume, critical components being printed on Markforged printers in the defence industry is due to complexity of the part (that additive manufacturing can solve), and the requirement on quality and strength of the part in this particular environment.

Q: When many people think of 3D printers, they typically think of plastic components. What are the high-strength materials Markforged printers can use, and how do they compare in terms of material properties to their conventionally-manufactured counterparts?

A: Markforged printers are capable of manufacturing components from the following high-strength materials:

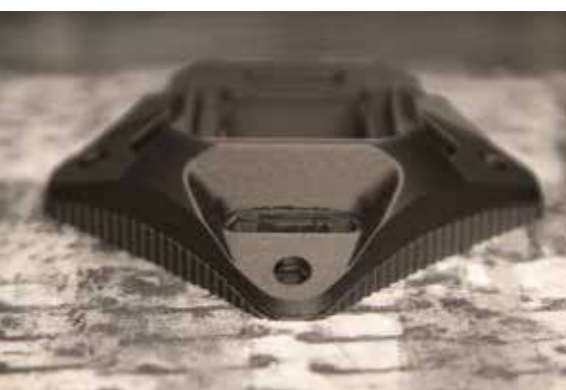
- Onyx with carbon fibre is specifically designed for strong parts and have the same strength as 6061-T6 aluminum

for use in tools, fixtures, brackets and mounts and bespoke parts.

- Onyx + Aramid fibre (Kevlar) for extreme toughness and energy absorption found in applications such as end of arm tooling, supports, and wear stops.
- Ultem 9085 with Carbon fibre for requirements of high performance thermoplastic parts that requires flame, smoke and toxicity characteristics such as aircraft interiors, aircraft brackets, handles, etc.
- Onyx FR is a certified UL94 V-0 rated flame-retardant micro carbon fibre filled material used for applications such as weld fixturing, aerospace clips and brackets or electrical brackets and fixtures.
- Metal 17-4PH stainless steel allows a variety of printed parts that are strong, robust and heat-treatable. Applications include end of arm tooling, lightweight brackets, sockets and general high-wear tooling.

Q: You have so far delivered an expeditionary-ready 3D printer to the US Marines 3rd Maintenance Battalion. What did the process of making the printer ready for expeditionary operations look like, and how did the machine fare in the field?

A: The US Marines used the Markforged X7 that prints composite material as mentioned earlier. However, they had some unique requirements and turned to Markforged for a custom version now named 'X7 Field Edition'. Through cooperation with the US Marines, we mounted the X7 into a shock-absorbing Pelican AL3232 single lid case with custom



Photos: Markforged

The USAF 27th Special Operations Support Squadron (27 SOSS) 3D printed replacement Night Vision Goggle (NVG) mounts with built-in spacers to accommodate multiple helmets for less than USD 5 in just a few hours. According to a user, their 3D printed NVG mounts are "just as strong as the commercial, off-the-shelf aluminum ones."



The Markforged X7 Field Edition printer was developed for use in a military operational environments.

foam and modules that can be deployed via airplane to remote areas. It includes the necessary materials and spare parts to be run for weeks. It is included in the MIL-STD-810 testing in support of a DoD Program of Record. Since its launch we have successfully deployed several dozen of these printers globally across several countries and military forces.

Q: What is it that most people miss when it comes to the potential of 3D printing?

A: The most common mistake or misconception about 3D printing is that everything can be printed. It is true that in the future as the machines and technology improve we will see more and more applications being supported. Saying that, 3D printing or additive manufacturing has some benefits that traditional manufacturing would struggle to support. For example, additive manufacturing provides more flexibility as it can use unique geometries and surface finishes. It allows the user to produce components in smaller batches and on demand. However, the process of additive manufacturing is more complex and requires a skill set more from the software engineering side rather than operator side as with traditional manufacturing. As such we often see failures not related to the printer but due to process and labour skill set. Markforged has taken the platform approach which means we deliver not only the printer, but also the needed Software to run the machines and material in a closed environment that allows the end user to remove the complexity in a secure way. We are also trying to bridge the skill set gap with Markforged University to enable more users to become experts in how to build parts for additive manufacturing.

Q: You also offer a design and simulation platform to design and virtually test components before printing. Aside from reducing the amount of trial and error before a part can be put to work, what are the other aims of this software platform?

A: Markforged Simulation software opens doors for engineers to save time and costs when it comes to using Additive Manufacturing to build end-use parts. The software provides the following:

- Instils confidence that your 3D printed parts will have the strength required for demanding industrial applications. Powerful simulation technology optimised for additive manufacturing lets any user virtually test parts, taking the guesswork



A hatch plug that sits on top of a vehicle used in low-light scenarios, helping the driver see at night. Unfortunately, this part is not in production anymore, and would cost roughly USD 10,000 to reproduce, not to mention the long lead time. Using a Markforged printer, the user printed one in 'Onyx' for USD 230, and then one in metal for USD 800.

out of configuring print parameters to meet performance requirements.

- Delivers parts faster by reducing design-print-test iteration cycles and rework delays. Unlike traditional simulation tools that need specialised expertise and time-consuming analysis, Simulation is integrated into Markforged's Eiger Software and streamlined for additive manufacturing so users can test parts within their familiar 'slice and print' workflow.
- Reduces the cost of 3D printed parts by automatically optimising the amounts of material and continuous fibre reinforcement needed. Avoid overbuilt parts and wasted material by effortlessly applying settings that optimise to meet your needs for strength, cost, and print speed. Replacing the typical 5 to 25 iterations of trial and error printing with virtual testing can save hundreds or even thousands of dollars per part. Ultimately, this enables expanded use of fibre-reinforced composite parts and for more metal tooling and end-use parts to be replaced

in a manner that is faster, for cheaper, and requires less effort.

Q: As a business model, you primarily make and sell 3D Printers, rather than offering services based upon printer time. However, when printer time is all that is required, do you have a network of third-party service providers military clients can go to?

A: At Markforged the product is the end part. We are on a mission to bring Industrial production to the point of need. We believe that manufacturing despite being in a defence or commercial environment has the same objective: to become more flexible and resilient. As such, our focus is to ensure the process of additive manufacturing is simplified and every single part that comes out matches the requirement of the user every single time. In some cases that part can be printed by a service provider and Markforged has several customers and partners operating fleets of printers to offer that service.



Markforged's software is provided with simulation functionality, enabling a user to test the strength of a part before printing it. Among other benefits, this reduces the amount of trial and error needed to get a component right.

Connection Protection

Thomas Withington

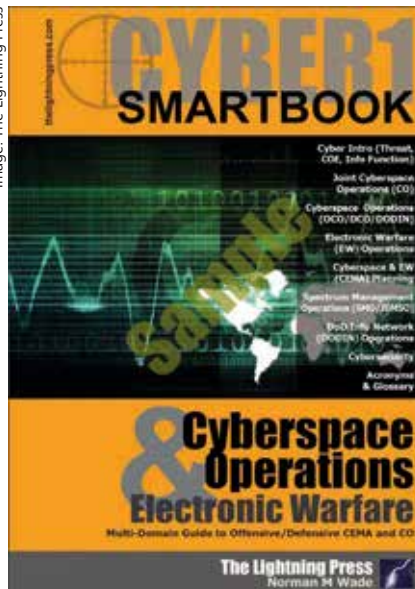
The networked battlefield emphasises the importance of cyber protection. What steps can militaries take to enhance their cyber protection at the tactical level and what steps is NATO taking to this end?

The Lightning Press, a defence and security publisher based in Florida produces a fine line of manuals explaining an array of military concepts. One of recent volumes entitled *Cyberspace Operations and Electronic Warfare* is penned by Norman M. Wade, its proprietor. The book contains excellent discussions and definitions of military cyber operations, including cyber security. This will be a deepening concern as bases, platforms, sensors, weapons and personnel on and above the battlefield, on and below the high seas, are increasingly networked.

Cyber security is preventative in nature. It exists to prevent "unauthorised access to, exploitation of, or damage to computers, electronic communications systems and other (IT/Information Technology systems) as well as the information contained therein," writes Wade. Cyber security is vital at the tactical level to reduce or eliminate "vulnerabilities that maybe exploited by an adversary and/or implementing measures to detect malicious cyberspace activities." Such steps can include everything from increasing individual password strengths, using software patches to remove vulnerabilities and encrypting data. Processes are also vital. Personnel must be aware of cyber security best practices. Access to suspicious websites must be restricted. Nicolas Razy, head of French cyber programmes for Airbus' defence and space division, says that cyber security risks at the tactical level are like those found at strategic and operational levels: "Weapons systems and IT networks are subject to cyber threats."

The problem for militaries is that battlespace Internet Protocol (IP) communications are vital. Videos, images, written information and even voice traffic is en-

Image: The Lightning Press



The Lightning Press' *Cyberspace Operations and Electronic Warfare* book provides an excellent overview of how these two disciplines converge and diverge.

coded into IP traffic. This traffic is sent across communications networks. These networks can be Line-of-Sight (LoS) conventional very/ultra-high frequency (V/UHF) radio links between personnel, platforms, bases, sensors and weapons systems. Networks can also be hosted by beyond LoS satellite communications (SATCOM) and high frequency (HF) radio links. Even conventional and fibre optic telephone lines are used, along with cellular communications. At the tactical level, IP traffic carries orders, situation reports and intelligence. Command and Control (C2) systems, regardless of where they are and at what echelon they are deployed, depend on this. To exacerbate matters, soldiers may bring battlefield devices that have been compromised at some point in the supply chain, says Razy: "This means you could have intrusions into tactical networks." Furthermore, tactical networks do not exist in isolation. "These are often connected to other networks at operational and strategic levels," he continues.

The digital battlefield's reliance on IP traffic creates a vulnerability. The enemy can use malicious code to infect these networks. Cyberattacks maybe delivered conventionally through IP networks as they are in the civilian world. They could also be delivered via electronic attack. Rather than a radio signal carrying a jamming payload, as it would in conventional electronic attack against hostile radios and communications, it carries a cyberattack as the payload. The malicious code could infect C2 systems or computers equipping weapons systems, sensors, platforms and even individual soldiers. The attack may be intended to wreck these systems for a finite time or permanently. It may work to prevent IP networks functioning. Likewise, the attack could be used to steal data, and hence intelligence, from these computers or networks. Cyberattacks at the tactical level maybe immediately apparent. Equally, they may be highly covert with the damage taking some time to appear. These risks underscore the importance of tactical cyber security on the battlefield. Cyber security is but one potential solution. Electronic protection of any equipment depending on a radio connection to the outside world against electronic attack is paramount. Fortunately, radar and radio engineers already make strenuous efforts in this regard. As Wade succinctly summarises "cyberspace risks affect mission accomplishment."

Cyber Security Fundamentals

"The emergence of IP technology and the need for near-real time information exchange have led modern tactical NATO systems to communicate with higher-level IT systems to satisfy cross-domain and interoperability requirements at all command levels," a NATO official told the author: "This presents a unique cyber security challenge as tactical networks need to be protected against a variety of both virtual and physical threats," they continued: "Implementation of static and deployed protective measures helps en-

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hance the resilience of these networks.” Cybersecurity, tactical or otherwise, rests on the pillars of confidentiality, integrity, availability, authentication and nonrepudiation, writes Wade. Confidentiality safeguards sensitive information from disclosure to unauthorised people, processes or devices. Integrity is the reliability of the hardware, software and processes of a specific information system like a computer. Availability refers to users’ ability to timely access data. Authentication security measures protect communications systems against nefarious or damaging transmissions. It does this by establishing the validity and integrity of a transmission and its sender. Finally, nonrepudiation assures the sender they receive proof of delivery, and that the recipient receives proof of the sender’s identity.

As a continuous process, cybersecurity depends on a layered, defence-in-depth approach. All systems at risk from cyberattack, no matter how small, must be safeguarded. This could stretch from the soldier’s individual ruggedised tablet or smartphone to complex systems handling battlefield logistics. Another prerequisite is redundancy – which parts of a network or which systems can a deployed force afford to lose for a short time? If the logistics computer system mentioned above suffers an attack, how quickly and easily can logistical tasks be performed using other tools, even reverting to pen and paper? Integration is vital. Tactical cybersecurity does not exist in a vacuum. Some of the deployed forces’ computer networks will be connected to operational and strategic systems, or they may connect in some way to local, civilian networks. Are there required levels of cybersecurity in these associated networks? If not, what steps will ensure the tactical networks are kept safe from potential threats affecting these third parties?

Internet of Military Things

Tactical cybersecurity is already essential, but its importance will only grow in the coming years. Most technologically savvy militaries are taking steps to deepen networking within and between their forces. Militaries want to outpace potential adversaries in their Observe, Orient, Decide, Act (OODA) cycles. US strategist John Boyd asserted that whichever individual or force navigated the OODA loop quickest would prevail in any engagement. Outpacing hostile OODA loops largely depends on moving information in the

most practical, secure and efficient way possible. Protecting this information, the networks it travels on, and the systems depending on it, is vital.

The coming decade will see the advent of the Internet of Military Things (IoMT). At the tactical level, the IoMT will net-

point. These coordinates are sent to the cloud by the C2 system in the form of a call for fires. The artillery command post, also connected to the cloud, is alerted to the call for fires and downloads the information. The command post confirms the target and tasks the howitzer best

Image: US Army



The dependence of militaries on IP moving around the battlespace at the tactical level will only increase in the future, particularly as concepts like the Internet of Military Things make their presence felt.

work computers used by all deployed personnel, sensors, weapons, platforms and bases. The goal is to ease the organisation and sharing of all information collected by all these assets. Let us suppose a platoon’s unattended radar detects a vehicle moving towards an army checkpoint. This information is immediately shared to the ‘combat cloud’. This is a cloud computing environment where intelligence, surveillance and reconnaissance data are deposited and retrieved. Other users of the combat cloud include deployed artillery and the company command post. The latter’s Battle Management System (BMS) is alerted that new data is available on the cloud, sent from the unattended radar. The commander sees the information being collected by this sensor in real-time. Automatic number plate recognition software embedded in the commander’s C2 system confirms the vehicle is hostile. Data provided by the sensor includes the vehicle’s coordinates as it approaches the check-

placed to attack the vehicle. The shell is fired, fused to explode at a specific point of aim based on the vehicle’s speed and direction. The vehicle is destroyed, and the mission accomplished in the time it took you to read this paragraph.

Following the fire mission, the howitzer’s own computer automatically sends information up to the combat cloud that one of its shells has just been expended. Logisticians connected to the cloud receive an alert on their C2 system that this howitzer will need at least one shell to be replenished. This will either be delivered to the howitzer or replenished after the mission. The howitzer’s computer has also uploaded health and usage monitoring data to the cloud. It says oil levels will need to be topped up and two suspension springs will need replacing within the next 24 hours. Once again, logisticians will either deliver these and perform the necessary repairs, or do so when the mission is complete, whichever is more pressing. Both these scenarios are

Photo: CrowdStrike



Russia's X-Agent malware developed by its 'Fancy Bear' cyberwarfare group was thought to be highly effective in locating Ukrainian artillery for targeting by counterbattery fire.

dependent on IP data moving around the battlefield across a plethora of communications networks used by the manoeuvre force. However, this can create vulnerabilities: "The use of cloud computing introduces new information threats," warns Razy: "This is a major consideration as concepts like multi-domain operations emerge."

Fancy Bear

The cyber threat, and the need to protect against it at the tactical level is not hypothetical. Ukrainian troops have already experienced of the damage such attacks can cause. Following Russia's 2014 invasion of Ukraine, Russian cyber warriors devised malware to infect Ukrainian Army artillery C2 systems. X-Agent malware targeted computers running the Android operating system used by Ukrainian artillery. CrowdStrike, a cyber security company, identified that X-Agent was developed by a Russian cyber warfare group dubbed 'Fancy Bear' (Note: not the outfit's real name, the codename comes from a designation system developed by Dmitri Alperovich, formerly of CrowdStrike). Open sources state that Fancy Bear is strongly suspected of close links with Russia's GRU military intelligence service.

X-Agent specifically targeted 'Correction D-30' Ukrainian Army fire control software. Developed to provide fire control for the army's PJSC 2A18/D-30 122mm howitzers, the software could provide artillery targeting times of circa 15 seconds. However, any artillery unit using the software had to input their own location to obtain their correct gun laying instructions. X-Agent was thought to have stolen artil-

lery unit location data from the Correction D-30 software. Stealing this information gave Russian Army gunners detailed information on where their Ukrainian adversaries were. From a counter-battery perspective this was invaluable. Experts have told the author that the software was almost certainly wirelessly inserted into Ukrainian Android devices running Correction D-30. Ukrainian Army sources have told the author the malware may have been

delivered from Russian Army electronic warfare platforms. The latter's RB-341V Leer-3 Communications Intelligence/Jamming (COMINT/COMJAM) system could have been used for this task. Leer-3 employs three Orlan-10 Uninhabited Aerial Vehicles (UAVs). These are equipped with a COMINT/COMJAM payload to locate hostile troops based on their radio emissions. This can include mobile phone signals on frequencies of 900 MHz to 1.9 GHz. Given their service ceiling of 5,000 m (16,000 ft), the Orlan-10 UAVs could have delivered this code via a jamming attack from ranges of 380 km (205 NM). X-Agent almost certainly helped Russian artillery target Ukrainian guns. Analysis written by Henry Boyd, research fellow for defence and military analysis at the International Institute for Strategic Studies (IISS), a London-based think tank, estimates that up to 20% of Ukraine's pre-invasion D-30 inventory was wiped out by Russian attacks.

"At the tactical level, the majority of cyberwarfare risks are not really different from classical threats," says a written statement provided by Hensoldt. "It is just the way the attackers try to achieve their objective ... Instead of jamming communications networks in the classical way, the attacker aims to reduce this

Photo: Airbus Defence and Space



Airbus' Tactical SOC is a cybersecurity system for use at this level of war. It has been procured by the French armed forces and is operated by the French Army's Information Systems and Communication Command.

via an attack on the operating system of the equipment.” X-Agent was primarily confined to the Correction D-30 software used by Ukrainian artillery. Nonetheless, once a threat has entered one battlefield network, there is no telling where it might end up.

Moreover, a tactical cyberattack could be indirect. Perhaps battlefield networks and systems are left alone, but personnel are instead targeted to weaken their morale. This arguably crosses into the information warfare domain. Given how much information is now delivered via the world wide web this is not surprising. Hensoldt says that online disinformation campaigns can target the morale of individual soldiers. These campaigns could extend to soldier’s families with the intention of weakening their morale or spreading lies about their relatives or the wars they are involved in. The latter has arguably more of an operational or strategic impact and is more likely to be effective over a prolonged timescale. Open source intelligence providers can often detect when disinformation campaigns maybe underway. This helps provide early warning that personnel, their families or populations at large are being targeted.

Hensoldt is taking a holistic approach to the tactical cyberwarfare risk. The company says it “addresses cyber risks early on in the development process of our products and systems independent of the level at which they are going to be used. The includes a detailed cyber risk analysis of individual components, overall system architecture and its interaction with third-party equipment.” It also helps that materiel specifications now routinely include cyber resilience as standard.

Likewise, Airbus provides tactical cyber security solutions: “We use commercial off-the-shelf technology tailored to meet the military requirements of our customers ensuring necessary levels of security and resilience,” says Razy: “The concept of operations is to be as simple to operate and fully effective for the client.” The company has delivered its Tactical SOC product to the French armed forces. It is operated by the Armée de Terre (French Army) Commandement des Systèmes d’Information et de Communication (COMSIC; ENG: Information Systems and Communication Command).

NATO’s Outlook

At the NATO level, individual members are responsible for their national cyber



Photo: Estonian Ministry of Defence

NATO’s Cyber Coalition exercise in Tallinn saw alliance officials detail a new messaging standard under development which will greatly assist the movement of cyberwarfare information around the battlespace.

defence, an alliance official told the author. This is the case at the strategic, operational and tactical levels. NATO does have a Standardisation Agreement or ‘STANAG’ pertinent to tactical cyber protection. This provides guidelines that can be shared among the allies, the official continued, “for use in deployments as they see fit.”

As the X-Agent attacks underscored, staying abreast of the threat is half the battle. “NATO and allies exchange information about cyber threats in real time, including through a dedicated Malware Information Sharing Platform,” the official continued. “We also share information on cyber threats with the European Union.” Forewarned is forearmed and this helps improve national and supranational cyber resilience and defence, whatever the level of war. Individual awareness is front and centre of this approach: “NATO attaches great importance to cyber security awareness among all its personnel. (The alliance) regularly releases cyber-related information to its staff, and provides regular security briefings and mandatory training that takes into account threats at local level.”

The cyber threat on and off the battlefield is unlikely to diminish in the coming years, instead it will most likely increase. This is driven by the relentless march of technology in the civilian and military worlds alike. “The security environment is becoming increasingly complex, and as technology advances, the cyber threat to NATO and NATO allies increases.” To this end, it is important

to be realistic, the official adds: “Cyber threats will never be fully ameliorated or eliminated. The alliance is determined to employ the full range of capabilities at all times to actively deter, defend against, and counter the full spectrum of cyber threats, including in the context of hybrid campaigns.”

Recognising and engaging these threats is not just about technology. Having the right people and processes are crucially important. “NATO and its allies respond to these threats by strengthening our ability to detect, prevent and respond to malicious cyber activities while continuously adapting to advancing/emerging technologies, tactics, techniques and procedures.” During a visit to NATO’s Cyber Coalition exercise in Tallinn, Estonia in late November 2022, the author was told about a new tactical messaging standard NATO is developing. Like the J-Series messaging protocols exchanging tactical information across NATO tactical datalinks, a similar messaging protocol will assist cyber operations. This will help easily move cyber threat information between allies. NATO experts expect the cyber messaging standard to undergo tests during alliance exercises this year. The messaging protocol may then be formally adopted as a NATO STANAG. Such developments are important. They will greatly simplify the efficacy with which the alliance can manoeuvre in cyberspace at the tactical level and beyond: “All of these steps help make NATO as strong in cyberspace as we are on land, in the air, in space, and at sea.” ■

French Special Forces Acquisitions Report – Staying in the Vanguard

Jean Auran

Conducting operations with small groups of fighters, and combining a solid skillset with a powerful impact, French Special Forces (SF) units are looking for equipment to give them a decisive advantage.

The French Special Forces, whose role has increased in the fight against terrorism, are adapting to current and future high-intensity combat situations. They comprise 4,500 men and women from the three branches of the armed forces, coming under the authority of the Commandement des Opérations Spéciales (COS; ENG: Special Operations Command).



The Special Operations Command was born in 1992 from lessons learned from the Gulf War.

Equipment Processes for French Special Forces

The fundamental needs for all SF units include operational preparation, intelligence collection, penetration and attack, protection, mobility, and communication. Today, SF units find themselves at the forefront of technological advances. As a reminder, the French SF units are trained by each branch and placed under the COS command for operational tasks. Until recently, each branch supplied equipment to its own units. If the Air Force SF used the special

patrol vehicles (VPS), based on the Land Rover, the other branches used the Mercedes G-class modified by Panhard (now Arquus). While French SF units require specific equipment, they remain subject to public actors' procedures and regulations. Nevertheless, the French Commandement des Forces Spéciales Terre (COM FST; ENG: Army Special Forces Command) Command has a certain degree of autonomy in the acquisition of equipment. In addition, the units have direct purchasing capabilities. Finally, there is the Commission Inter-armées d'Études Pratiques Concernant les Opérations Spéciales (CIEPCOS; ENG: Joint Commission for Practical Studies on Special Operations). This is a research and development body that works on many innovative projects and selects and finances around 60 ventures annually that are proposed by mixed military-industrial teams. At the Army level, the COM FST participates in the acquisition process, whether conducted by the Special Operations Command or the État-Major de l'Armée de Terre (EMAT; ENG: Army Staff).

Internal Innovation

General Delort-Laval, former French SF Commander, wrote: "if the French SF soldiers use high-tech equipment, they operate in theatres where technological superiority does not completely ensure operational superiority, in particular, because they always impose an action with physical proximity". Tinkering to enhance equipment efficiency is part of the daily life of SF operators. In 2017, an SF sniper proposed improving Safran's JIM Compact infrared binoculars by equipping them with a computer that corrects the aim according to the target's movement. As another innovation, we can mention the repositionable textile tourniquet with a simplified release, which can eventually be integrated into the uniform and easily activated. Three Navy commandos have developed a multi-function box, allowing biometric and digital data collection on the ground, and combat

divers from the 1st RPIMa have developed a waterproof GPS. This is a waterproofed terrestrial GPS with the antenna deployed on the surface.

The French Navy created the Innovation Laboratory for Marines and Commandos (FUSCOLAB) in 2019, which aims to connect the commandos to Navy stakeholders and the Defence Innovation Agency (AID). It is a project incubator open to the outside world, a privileged interlocutor for companies, particularly local ones. One recent project aims to develop a miniaturised inertial unit to navigate in areas of GPS denial access with Safran.

Directorate General of Armaments Technical Support

The Direction Générale de l'Armement (DGA; ENG: Directorate General of Armaments) is the defence procurement and technology agency responsible for project management, development and purchase of weapon systems. The DGA has a vital role because it manages the SF-specific major effects programmes (PEM), such as vehicles or the modernisation of the C-130. Regarding specific SF requirements, the DGA placed one of its personnel inside the COS HQ in order to understand the requirements better. It is important to note that the specification and certification-qualification phases are sometimes as long as, or longer than the sole contracting phase. The qualification of sophisticated equipment is sometimes an extraordinarily complex process, as illustrated in the case of the new parachute (SMTCOPS) – 750 were ordered by the DGA from Zodiac Aerosafety Systems, with the order taking six years to complete.

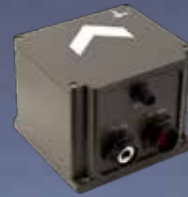
The Ministry also uses the NATO Support and Procurement Agency (NSPA), which allows off-the-shelf equipment purchases. This has enabled the acquisition of the Rover system for aircraft guidance or the multi-purpose arm for the C-130. The

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DGA, as well as the Thales and Safran, and companies of the Cercle de l'Arbalète, have established the Centurion platform. This consists of capturing innovation in positioning and navigation, observation, armament, functionalised textiles, and innovative interfaces.

Photo: French Air and Space Force

The SOFINS Seminar

The Special Operations Innovation Network Seminar (SOFINS) is an unmissable event; presentations of innovative materials and equipment are made, together with operational demonstrations. Created by the Special Operations Command, and later entrusted to the Cercle de l'Arbalète, which brings together all the companies that potentially equip SF units. Each year, the members of this association are welcomed by one of the units of the French Special Forces (naval, air, or land forces). French Special Forces Equipment

Tactical transport air capabilities

The French Air and Space Force (AAE) staff decided to withdraw the Transall C-160s from service in May 2022, including, the three aircraft belonging to ET 3/61 Poitou Squadron. These aircraft were modernised in 2019, integrating a C3ISTAR capability (Command, Control, Communication Intelligence, Surveillance, Target Acquisition and Reconnaissance) and Liaison 16. This squadron also operates two DH-6 Twin Otters and two C-130 Hercules, which recovered the C3ISTAR capability from the Transall. These have recently undergone additional ICAO renovation to meet general air traffic requirements. Some aircraft received a SABIR articulated arm, allowing

the external carriage of an optronic sensor for targeting and surveillance missions.

Developing the capability for SF to use the A400M is an ongoing process. Three crews from the 3/61 Poitou Squadron will be trained on the aircraft, and tests began in January at the Bordeaux air base with personnel and equipment drops. The French Special Forces do not have heavy transport helicopters such as the CH-47 Chinook, despite repeated requests from COS. In 2014, a Senate report went in this direction, suggesting the purchase of used CH-47 Chinooks or CH-53s. In addition to their current aircraft, the French SOF will have ten NH90 helicopters in the 'Special Forces standard' subvariant of the Tactical Transport Helicopter (TTH) variant, offering good penetration and interoperability

capabilities. The DGA launched the development in September 2020.

Nautical assets

In terms of the marine environment, Navy commandos expect a lot from the new nuclear attack submarines (SSNs) of the Suffren class, in service since June 2022. With this in mind, Naval Group developed a dry deck shelter (DDS). The DDS is an ultra-resistant steel deck hangar capable of withstanding the pressure at the immersion depths at which the Suffren vessels operate. the DDS is about 11 m long, 3 m wide and weighs around 40 tonnes. ECA Group won the Navy contract to produce the PSM3G third-generation swimmer delivery vehicle developed in collaboration with the elite Commando Hubert group. Navy commandos use the commando rapid transport craft (ETRACO), which entered service in the 1990s. The ETRACO is a 7.3-m Zodiac-Hurricane semi-rigid boat equipped with two 200 hp outboard motors, capable of carrying around ten men and reaching 92 km/h (50 knots). Ten are still in service today.

The fleet also includes 15 new-generation boardable multi-purpose commando craft (ECUME NG), a 9.3-m boat based on the ZH-930, with inboard diesel propulsion of 2x 300 hp, allowing it to exceed 92 km/h (50 knots) and the possibility of embarking up to 12 commandos. The M134D Dillon Aero Gatling gun can be installed on the ECUME NG, as can the medium-range Akeron MP anti-tank guided missile (ATGM). It even appeared that the ECUME/ETRACO tandem was complementary and made it possible to cover all types of missions. In May 2022, the



Special Forces crews start working with the A400M. Tests have recently taken place with the onboarding of specific FS equipment.

Photo: Jean François Aurant



The SF's vehicles are less-armoured but faster than those of the conventional forces, reaching a balance between protection and speed. Here is the Sherpa Light Special Forces Variant.

Ministry of the Armed Forces launched a call for tenders. The target is for 17 boats and four airdrop systems of a new "ETRACO NG" version; the first deliveries are possible from 2024. In this vein, Turgis & Gaillard developed the SSA-2001 Kraken, a hybrid craft for infiltration by SF units, and start-up SEAir launched the first semi-rigid vessel with retractable hydrofoils. The latter was carried out within the framework of the e-Flyco project, by the Agency of Defence Innovation and Fuscolab.

Special Forces Vehicles (VFS)

The French Special Forces have long been equipped with ageing vehicles. Launched in 2016 as a major effect programme (PEM), the VFS programme aims to provide 202 SF trucks (PLFS) and 206 light SF vehicles (VLFS). French company Arquus won the contract but initially failed to meet the requirements. The DGA rejected the first 25 vehicles due to unsatisfactory performance. To fill the gap, the Ministry has chosen to buy the Special Operations Vehicle – Patrol (VOS-PAT) developed by vehicle modification company Technamm. The VOS-PAT is a four-wheel drive vehicle offering excellent mobility, and is based on the Toyota Series 70. It has eight STANAG-3548 compliant air transport attachment points and a tubular structure with added baskets and boxes. It is also possible to install a 12.7 mm M530D Dillon Aero Gatling gun on the ring mount. Thirty vehicles were acquired and have been deployed on operations. The company has also developed the VOS-APP, based on a 6x6 Toyota chassis. This vehicle can be armed



Photo: Jean François Aurant

While waiting for the VLS and the PLFS, the Technamm company has delivered VOS-PAT vehicles, based on a Toyota chassis. These are currently serving operationally.

with Nexter's P20 20 mm automatic cannon, which has limited mass and a low recoil. In 2023, COS expects the delivery of the VLFS and the PLFS. The COS has also acquired MRZR for "experimental purposes", to explore new modes of action.

Armament

The armament issued to SF team members is derived from various sources and often consists of the acquisition of different equipment according to the individual component or regiments. The COS operators were the first to receive the HK 416, which has now equipped the entire French Army. This rifle is now standard SF

equipment. The 1st RPIMa and the 13th RDP bought the SIG MCX in 2020, which is used with the .300 Blackout ammunition. The SCAR-L is also in service within the units; 1st RPIMa teams are equipped with the SIG 553, a weapon particularly appreciated by combat divers.

Helicopter crews have received the HK MP7A1, and the FN P90 is also in service with protection teams. For long-distance shooting, the HK-417 remains in service, while some SP10M rifles from Seekins Precision were acquired in 2019-2020 and the Sako TRG-42 sniper rifle is also in use. The 1st RPIMa fielded the CDX-40 Shadow, with an effective range greater than 2,000 m, for medium and long-range use. Marine commandos use the Barrett M82 as part of the Target Surveillance and Neutralisation Team (ESNO). The French Special Forces acquired FN EVOLYS 5.56 × 45 mm machine guns, and still use both the Minimi and the MAG58. The patrol vehicle is also equipped with M2HB and automatic grenade launchers. The AT4CS and the M72-A8 and A10 are part of the equipment. The SF also use the Akeron MP ATGM to neutralise combatants and armoured targets day and night. Mounted on vehicles or small boats, it should be directly linked with a UAV to engage non-visible targets. In 2022, the COS also purchased Hirtenberger 60 mm mortars for the 1st RPIMa.



Photo: French Air and Space Force

Special forces team members have individual quality equipment that is constantly evolving. The armament is differentiated according to the regiment.

Night vision equipment

This type of equipment is crucial for gaining superiority over the enemy. Operators mainly use the Thales Bonie HP image in-



Photo: French Navy

In November 2022, Navy commandos carried out a parachute jump from a Breguet Atlantique 2 for the first time.

tensifier goggles, and also like to use the Thales Sophie and Safran JIM LR thermal imaging binoculars. They might be interested in the L3Harris Ground Panoramic Night Vision Goggle (GPNVG-18), which has four lenses designed to extend the operator's field of view to 97°.

UAVs

The French Special Forces use a number of drones of different sizes and models, including micro, nano, and Medium Altitude Long-Endurance (MALE) types. The range used includes the PD-100 Black

Hornet and the Delair UX11, a photogrammetric mapping drone for modelling large surfaces and hard-to-reach infrastructure. The COS is interested in acquiring Medium-Altitude Medium-Endurance (MAME) UAVs, which offer flexibility of use, endurance, and a good payload capacity. The SF evaluated the SolarXOne, which has a range of 100 km and can fly at an average speed of 50 km/h, but can also reach 125 km/h. During the first phase of an evaluation carried out in Lorient last in September 2022, the SolarXOne was observed to still have 40% of its battery left, even after

having travelled the evaluation distance. In 2022, France ordered 82 units of the Switchblade 300 loitering munition for its SF units. American company AeroVironment previously provided RQ-20 Puma (locally known as 'DRAACO') mini-UAVs.

Conclusion

Despite renewed interest in conventional forces, Sébastien Lecornu of the Ministry of Armed Forces, announced in *Le Monde* that: "we have chosen to toughen up our model by raising the ambition for their equipment, with an unprecedented effort of EUR 2 Bn." He added: "We will remain in the top three of the best Special Forces in the world". These units will have to adapt to the "hybridisation" of conflicts – the combination of conventional, irregular and asymmetrical means to create tensions to weaken a target country". That said, looking beyond budgetary issues, the SF must benefit from an appropriate governance structure and enter into dialogue with an ecosystem of institutions and industrial players – particularly with fragile start-up SMEs – since the capacity challenges to be managed are substantial. This could involve acquiring additional A400Ms, developing optronic capabilities, or financing a second Caracal squadron.

Composition of the French Special Forces

Joint Staff

- Special Operations Command (COS)
- Army
- French Army Special Forces Command (COM FST),
- 1st Marine Infantry Parachute Regiment (1st RPIMa), specialised in commando land actions
- 13th Parachute Dragoon Regiment (13th RDP), specialised in military intelligence in hostile environments
- 4th Special Forces Helicopter Regiment (4th RHFS)

Navy

- Maritime Force of Marines and Commandos Command
- Five assault commandos (Jaubert, Trépel, de Montfort, de Penfentenyo and Hubert) and two special operations support (Kieffer and Ponchardier)

Air Force

- Special Forces air brigade HQ
- Air Paratrooper Commando Nos. 10 and 30 (CPA10 and 30)
- 3/61 Poitou Transport Squadron
- 1/67 Pyrénées Helicopter Squadron ■

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Lessons Learned From Ukraine: Rocket Artillery On The Modern Battlefield

David Saw

While rocket artillery has been around for a very long time, recent decades have seen improvements to accuracy and firepower, coupled with extensive proliferation. This has resulted in the present situation, where multiple rocket launchers (MRLs) are a common and often highly oppressive presence on the modern battlefield, with significant second-order effects beyond their immediate lethality.

Past, Present and Future

The first generation of Soviet MRL systems, the BM-8, BM-13 and BM-31-12 Katyushas and the second generation BM-14 and BM-24 systems were capable, but they shared a number of limiting features. Combat ranges were not as long as required, thereby increasing system vulnerability to counter-battery fire, rockets still suffered from dispersion making accurate engagements difficult. To an extent it was possible to compensate for dispersion by increasing the warhead size to maximise the effects on target, although this would exact a penalty in range. The other option was to mass MRL systems and simply saturate the target area with rockets, thus overcoming the dispersion issue by having a statistically high probability of hitting the target.

To overcome the accuracy limitations of the time, the Soviet military tasked what is today the Splav State Production and Research Enterprise (NPO Splav) with finding a solution. Splav was essentially the centre of excellence for Soviet MRL design and production, being established at Tula in 1945. Currently part of the Ros-tec organisation, Splav remains the centre of Russian MRL industrial activity. By the early 1960s, Splav had started work on a new MRL system that would feature a newly designed 122 mm calibre rocket. By 1963 the new system had entered service with the Soviet Army as the BM-21 Grad. The BM-21 supposedly first saw combat service in March 1969 during border fighting between the Soviet Union and China. Today the BM-21 remains the most widely used MRL system globally. It has also provided the basis for

Photo: Ukraine Joint Forces Command



Some 60 years after it first entered service, the BM-21 still provides the bulk of the artillery rocket capability for both Ukraine and Russia.

Modernisation of the launch vehicle and the introduction of enhanced ammunition types will keep the BM-21 and its variants in service for years to come.

numerous indigenous MRL programmes around the world. The BM-21 continues to be a highly regarded combat asset, and some 60 years after its debut with the Soviet Army, the BM-21 remains in near-constant combat use by Russian and Ukraine ground forces in the current conflict in Ukraine.

Ukraine also has a derivative version of the BM-21 system in service, known as the RM-70, originally developed to meet the requirements of the then Czechoslovak Army. The system is mounted on a Tatra 813 6x6 truck, there is 40-tube launcher as well as a 40-rocket reload pack mounted on the vehicle for rapid reloading. Initially the system used standard Soviet 9M22 rockets, which possessed a

high explosive fragmentation (HE-FRAG) warhead, and had a range of 20.38 km, and 9M28 rockets with an HE-FRAG warhead and a 15 km range. Later there were locally developed 122 mm rockets, such as the JROF and JROF-K, both HE-FRAG natures, with a range of 20.75 km and 11 km respectively. Other natures included: Tmovnik with anti-armour bomblets, Kuš with PPMi-S1 anti-personnel minelets and the Krizhna-R with four PTMi-D anti-tank mines. Additionally, RM-70 can also launch all standard Soviet/Russian 122 mm rockets.

The Czech Republic supplied Ukraine with more than 20 RM-70 systems in April 2022 and in July 2022 supplied a number of RM-70 Vampire systems.



Photo: Czech Army

The RM-70 was originally designed to meet the needs of the Czechoslovak Army; based on a Tatra chassis, the RM-70 mounts a 40-tube launcher and a 40-rocket reload pack. The Czech Republic supplied over 20 RM-70 systems to Ukraine in April 2022 and the more advanced RM-70 Vampire system in July 2022.

These latter systems are mounted on a Tara T815 chassis, and feature various improvements, including a modern fire control system, but still keep the 40 launch tubes plus the 40-round reload pack configuration. The Czech Republic in mid-2022 also purchased an unknown number of BM-21 systems from Bulgaria that were then supplied to Ukraine. Poland also supplied Ukraine with over 20 BM-21 systems in April 2022. It is also fair to assume that Ukraine now has access to substantial 122 mm rocket stocks from its own resources, but also from within NATO Europe and elsewhere, if required. Returning to the BM-21, when it first en-

tered service it was a massive upgrade in terms of MRL performance. According to Soviet military writings from the early 1980s, the BM-21 had four times the salvo weight of the original BM-13 Katyusha and eight times the destructive capability! Bearing in mind that since that point, 122 mm rockets have been developed that feature increased range and enhanced payloads, increasing the destructive capability of the system even further.

The original BM-21 system consisted of a 40-tube launcher mounted on a Ural-375D truck, various other system configurations were also developed/proposed, but the original variant is the one most likely to be encountered. As regards ammunition, there is a diverse collection of 122 mm rockets available, both Soviet era and types more recently developed in Russia. Apart from the standard HE-FRAG natures, there are smoke, incendiary, illumination and chemical types, as well as rocket natures with different submunition payloads, including anti-tank and anti-personnel systems, there was even an RF jammer rocket payload.

In 2014 the Russian Army introduced a new evolution of the BM-21 into service in the form of the 9K51M Tornado-G system. This was a substantial upgrade, introducing the 2B17-1 launch vehicle mounted on a Ural truck chassis. The vehicle was equipped with an automated fire control system (FCS), coupled with GLONASS navigation system. This enables the crew to conduct fire missions more rapidly, since they can aim to a

grid reference point and the FCS will automatically lay the launcher onto the target coordinates. Alternatively, a battery of these vehicles can be cued to automatically engage target coordinates designated by Kapustnik-BM artillery command and fire control vehicles. The Tornado-G is also armed with a range of extended-range 122 mm rockets including the 9M521, with a 40 km maximum range, and the 9M522, with a 37.5 km maximum range, as well as various other rocket natures.

Ukraine has also sought to modernise its BM-21 fleet, with various upgrade proposals focussed on replacing the truck chassis of the system, with a Ukrainian-manufactured KrAZ chassis. Upgrades have included the Bastion-01 and Bastion-02 systems, the Verba system and the BM-21UM Berest. The latter is mounted on a KrAZ 536 4x4 chassis and features a 50-round launcher. Ukraine Ground Forces would have significantly upgraded their MRL capabilities prior to the current conflict if they were able to, but the money was not available. As such, limited numbers of upgraded systems have been fielded, but not in the quantities required.

There is often speculation that Belarus might be drawn into the conflict between Russia and Ukraine, if that unfortunate development does occur, this will see another BM-21 user enter the fray. Belarus also has its own upgraded version of the BM-21 in service, this has the BM-21A designation and is mounted on a new truck chassis, with a standard 40-round launcher and a 40-round reload pack on the vehicle.

As previously mentioned, the BM-21 is in service all over the world and this means that there are numerous manufacturers of 122 mm rockets globally. China, Egypt, Iran, North Korea and Pakistan all produce 122 mm rockets, and it should be noted that both Iranian and Pakistani tube artillery ammunition has been supplied to Ukraine since the conflict started. However, it seems likely that for Ukraine, Poland represents the best source for both standard and extended-range 122 mm rocket natures. Of particular interest will be their 42 km HE-FRAG nature and a 32 km range rocket with various different submunition payloads.

Hurricanes and More

The fact that both Russia and Ukraine operate so many of the same MRL systems and have an artillery and MRL employment doctrine based on the same his-

Photo: Ukraine Ground Forces



Providing MRL units with their own reconnaissance and targeting capability required Ukraine to take unorthodox action, they went out and acquired commercial UAVs in large numbers in the shape of these DJI MAVIC 3 systems from China and re-purposed them for military use.

torical experiences, creates a very unique situation. Such awareness of the military doctrine of an opponent and the culture associated with the formation of doctrine is extremely rare. With Ukraine receiving advanced weapons from the US and other NATO nations, it is now in a position to develop its own doctrine and base it on operational experience gained since 2014, and more specifically in the current phase of the conflict since February 2022. The BM-27 Uragan is another MRL system in service with both Russia and Ukraine, work on this system began in the 1970s as the then Soviet Army looked to field an MRL capability that could deal with a changing and more complex target array. To that end they were looking for an MRL system that had greater range than existing types, was more accurate and had greater on target effects. This led them to basing the system on a larger-calibre 220 mm rocket that had a greater payload/warhead and could offer the desired increased range. Operationally, the idea was to have a system that could accurately strike targets in the depth of the enemy position and neutralise them. The BM-27 system is based on an 8x8 ZIL-135 truck chassis, it has 16 launch

tubes and maximum range of the 220 mm rockets is 35 km. Rocket natures include HE-FRAG, bomblet, anti-tank and anti-personnel munitions and anti-tank mines. The Uragan-1M is the latest Russian BM-27 variant to be introduced into service, this is based on a new truck platform and is reportedly equipped with extended-range rockets with a maximum range of around 70 km. Ukraine has introduced its own developed version of the BM-27 in the form of the Bureviy, this is mounted on an 8x8 Tatra T815-7T3RC1 chassis, equipped with a digital fire control system, 16 launch tubes and access to an extended range rocket capable of engaging targets out to approximately 65 km.

Also in service with both Russia and Ukraine is the BM-30 Smerch system, this came into service at the end of the 1980s and continued the Soviet MRL design trends of that era, delivering more range, accuracy, payload and destructive effect. The Smerch system is based on the 8x8 MAZ-543 chassis, the system has 12 launch tubes and initially its 300 mm rockets had a range of around 70 km, rocket natures available include HE-F and submunition. Ukraine has devel-

oped an evolution of the Smerch system known as the Vilkh, the standard rocket has a range of 70 km, an extended-range rocket with a range of some 130 km has been fielded and other rockets are being developed. The successor to the Smerch system in Russian service is the 9K515 Tornado-S. The launch vehicle is based on the MZKT-79306 8x8 truck chassis, the launcher is derived from the Smerch system and it uses the standard 300 mm rocket natures, as well as the 9M542 rocket with a range of 120 km and the guided 9M544 and 9M549 rockets, also reportedly possessing a range of 120 km. Like the Tornado-G, the Tornado-S has also been upgraded with a GLONASS navigation system and an automated FCS, to enable automatic cueing and laying launchers onto the target coordinates.

Mention should also be made of the Russian TOS-1/TOS-1A systems, these are based on a T-72 tank chassis, and mount a 220 mm rocket launcher with either 30 (TOS-1) or 24 (TOS-1A) tubes. Rocket natures are thermobaric, with the system being used for relatively short-range engagements against fortified positions or in urban environments.

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Photo: Ukraine Joint Forces Command



The US supplied Ukraine with HIMARS systems from June 2022, the system was first used in combat in Ukraine on 25 June 2022. Supplied with GMLRS guided rockets, the HIMARS gives Ukraine Ground Forces a long-range precision strike capability.

Eastern Problems and Western Solutions?

The development of Soviet and post-Soviet MRL capabilities was obviously slowed by the collapse of the Soviet Union and the economic chaos and industrial decline that plagued the post-Soviet successor states. Recovering from years of systematic underinvestment in

the military and the defence industry has not been easy. Even Russia, which has been in a better position than most in the post-Soviet space to invest in defence, took a considerable time to reinvigorate its military and defence industry. The performance of Russian forces and equipment since the February 2022 invasion of Ukraine would seem to indicate that the Russian investment in de-

fence has not had the transformational effects that the Russian leadership apparently expected.

Artillery has always been seen as a strength of the Soviet Army and its Russian successor, but combat performance in Ukraine appears to demonstrate that all is not well in terms of tube and rocket artillery. A technology gap appears to have opened up between Russia and the West, particularly in terms of the broader defence electronics sector. Russia had been moving towards developing and fielding its ideal MRL solution, it could meet the range requirement and could produce the warhead/payload required, what it could not do was meet its accuracy requirements for extended range engagements, due to the fact it was not able to build guided rocket artillery munitions in quantities useful to conducting a major war. This has resulted in Russia primarily relying on unguided 'dumb' munitions for the overwhelming majority of its fire missions. Added to this, weaknesses have been exposed in Russian reconnaissance, surveillance and targeting capabilities, further diluting artillery performance.

Considering how long Russia has been working on MRL systems and the immense operational experience that it has with such systems, it must be very frustrating for them to see Ukraine using HIMARS and MLRS systems to such great effect. These systems are achieving the precision targeting that Russia has been working towards for so many years and has failed achieve at relevant scale. Furthermore, these US systems have a growth path in place to keep them in service for many years to come, introducing longer-range and even more accurate rockets.

Events in Ukraine since the Russian invasion have demonstrated that MRL systems can still neutralise area targets as successfully as they have always done. The key development in the artillery rocket sector from combat operations in Ukraine is that the MRL can now also deliver a long-range precision strike capability, allowing for the engagement of high value targets in the strategic depth of the opposing force. While accuracy in rocket artillery is generally desirable, this quality has taken on heightened importance in the present war, given that air defences on both sides of the conflict have hindered the carrying out of strikes from the air. As such, it has fallen on rocket artillery to carry out some of the tasks which in other wars might have been conducted by aircraft. This has resulted in increased pressure on MRL accuracy and availability. ■

Photo: Ukraine Ground Forces



The BM-27 Uragan system has 16 tubes for 220 mm rockets that have a range of 35 km. Both Russia and Ukraine use the system, Russia has introduced the enhanced Uragan-1M system into service, while Ukraine has deployed its own BM-27 modernisation in the form of the Bureviy system.

The Art of Logistics

Thomas L. Nielsen

How Much is Enough?

Russia's invasion of Ukraine has served as a wake-up call for much of the world, not least Western Europe and a realisation that a new, major war in Europe was less improbable than had previously been imagined. This realisation has led to much soul-searching with regards to defence funding and military preparedness, and a large part of this has been the discussion of logistics. Particularly important in this discussion is the issue of ammunition. Although this article focuses on ammunition logistics, the same or similar arguments can be advanced for any item of supply, from vehicle spare parts to toilet paper.

Much of the past and current discussion regarding ammunition logistics focuses on the issue of stockpiles. How much of which kinds of ammunition does NATO and its member countries need in order to be ready for a potential war in Europe? And what about assurance of supply, or in other words, how can this ammunition be obtained, taking into account European (and world) defence industrial capacities and Allied nations' stockpiles?

Three major factors come into play with this issue: the existing stockpiles (how much is currently in stock); the expected expenditure rate in case of war (how much is needed per day/week/month); and the rate at which resupply can be expected from industry or from allies.

As outlined in a previous article ("Ammunition in the Post-Nuclear Age" by Scott E. Willason and Thomas L. Nielsen, published in ESD), many nations abandoned national ammunition production after the end of the Cold War since, with the significantly reduced requirements for ammunition, na-



Photo: US Army

Field artillery rounds are stocked near by the guns during training of paratroopers from the 4/319 field artillery, 173rd Airborne Brigade, at Grafenwohr, Germany.

tional production was not seen as economical. The "trickle-down" effect on the European ammunition industry was a lack of development, expansion and maintenance of capabilities due to the reduced customer base (due, in part to relatively restrictive European export control laws, which limited foreign sales). Unless the European ammunition production industry undergoes a revival, both with regards to capacity and capability, this will seriously impact on the third factor mentioned above (resupply from industry). At the same time, and for the same reasons, resupply from allied nations becomes increasingly unlikely, especially in case of a major war, since the said allied nations: a) have also reduced their national stockpiles; and b) now desperately need those stockpiles themselves. As a result, the questions of the current size of, and future requirements for, national stockpiles, increase in importance.

For years even before Russia's invasion of Ukraine, NATO has been working to put the issue of stockpile levels into a more formal framework, via the work in its "Stockpile Planning Committee" (SPC). The SPC has been working to formalise and harmonise supply and stockpile planning, to achieve at least a degree of agreement as to how to determine what constitutes "sufficient" stockpile levels, what these levels are, and how they can best be achieved.

While stockpile levels are certainly a vital part of any sort of ammunition logistics discussions and planning, they are not the be-all and end-all. In fact, it could be argued, as this article will do, that the above-mentioned questions of stockpiles and assurance of supply are the last questions we need to ask, however important they are.

The argument here is that much of the past and current logistical planning has been looking at the issue "from the wrong end", so to speak. Where we ought to start is where the ammunition is needed: At the front line...

The Front Line

It should surprise no one that the front line is where ammunition is needed; for artillery, infantry, armour, air defence and a host of other weapon systems. Experiences from the war in Ukraine have amply illustrated the importance of tube and rocket artillery, so that is what we will use as an example for the rest of the article.

Ukrainian data indicates that, during heavy, high-tempo combat, the consumption of tube artillery ammunition has been approximately 300-400 rounds per tube, per day. As a counterpoint to this, the old US FM 101-10-1/2 "STAFF OFFICERS' FIELD MANUAL; ORGANIZATIONAL, TECHNICAL, AND LOGISTICAL DATA PLANNING

Author

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US Army Soldiers from Charlie Battery, 3rd Battalion, 29th Field Artillery Regiment, 3rd Armored Brigade Combat Team, 4th Infantry Division, fire 155H ammunition rounds from a Paladin Artillery System at targets during Decisive Action Rotation 15-02 at the National Training Center on Fort Irwin, California on 12 November 2014.

FACTORS" also provides planning data for ammunition quantities, although it should be stressed that this field manual is no longer used by the US Armed Forces for logistical planning. That aside, table P-16 in the aforementioned manual provides ammunition quantities per weapon (platform) per day, for planning purposes. Specifically, for the 155 mm M109 howitzer, as part of a mechanised division, the baseline is 203 rounds per howitzer for the first day of combat, and 207 rounds per day for successive days, during defensive operations.

Although US quantities are lower than currently seen in Ukraine, it should be taken into account that Soviet (and, presumably, present-day Russian and Ukrainian) military doctrine was, and still is extremely "artillery heavy". In Soviet doctrine, artillery constituted the primary means of destroying the enemy, with infantry and armour supporting the artillery in this task by engaging and "fixing" enemy units, allowing them to be engaged and destroyed by rocket and tube artillery. This is, in many ways, the obverse of Western/NATO doctrine, where artillery acts in support of infantry and armour, as the latter close with and destroy the enemy. Naturally, the Soviet/Russian/Ukrainian doctrine will lead to higher consumptions of artillery ammunition.

As such, the figures presented here should be seen only as a means of illustrating the points made in this article – not as a realistic attempt to calculate or predict actual consumption levels or stockpile requirements. Furthermore, even though Western/NATO weapon systems are generally considered to be qualitatively superior to their Russian counterparts in terms of range, accuracy and effect, it would still be reasonable to presume that the quantity of artillery ammunition not expended by a Western/NATO army would still be expended, just in the form of some other ammunition type

(aircraft bombs, tank rounds or other), thus leaving the logistics burden more or less the same.

Additionally, the figures from the war in Ukraine are specifically for heavy, high-tempo combat, which will not be the case for every day, and on every part of the front.

Incidentally, and as a second counterpoint, US experiences with ammunition expenditures during Operation Desert Storm and Operation Iraqi Freedom showed ammunition expenditures significantly lower than planned according to FM 101-10-1/2 (this being one of the reasons why the field manual is no longer used for logistical planning). However, even taking these caveats into account, the war in Ukraine, between two near-peer opponents, has amply illustrated that considerable quantities of ammunition are required. And this ammunition has to come from somewhere.



US Marines with Combat Logistics Regiment 3 on-load ammunition for Marines supporting Exercise Ssang Yong 14 onto logistics vehicle system replacement at Pier 9, South Korea, 2 April 2014.

Using one of the smaller NATO members as an example, Denmark recently purchased 19 Caesar howitzers from Nexter in France (all 19 having since been donated to Ukraine). If we use the lower consumption figure from Ukraine, each howitzer will require 300 rounds per day during heavy fighting, which for all 19 equates to a combined total of 5,700 rounds of artillery ammunition (shells, propellant charges, fuzes and igniters) per day!

Supplying the Front Line

Ammunition is typically supplied to the front line from temporary or semi-permanent rear-area supply points, or a series of them. As the situation in Ukraine has shown, these need to be close enough to the front line to be able to supply the weapon systems and soldiers in a reliable and timely manner, but at the same time far enough from the front line to, hopefully, avoid exposure to the majority of enemy weapons.

This situation also hints very strongly that the means of transporting the ammunition from these rear-area supply points to the weapon systems that need it will, at least in part, have to traverse areas that are within reach of enemy weapons, both by direct and indirect fire. Not only can this pose a direct risk to the transports themselves, but it can also mean that much of the infrastructure in the area has been partially or completely destroyed. This further indicates that the means of transportation must be protected (armoured) and all-terrain capable.



Photo: USMC

Ammunition off-loaded by a landing craft utility 1666 assigned to NBU 7 for Marines supporting Exercise Ssang Yong 14 at Pier 9, South Korea, 2 April 2014.

A quick back-of-the-envelope calculation indicates that one protected all-terrain truck with a 15 tonne capacity will be able to transport roughly 225 complete shots for 155 mm howitzers (shells, propellant charges, fuzes and primers). Continuing to use Danish artillery as an example, this means 25 truckloads per day, during heavy combat. Does the nation(-s) have this transport capacity and capability? If not, it is irrelevant how much ammunition is available in national stockpiles.

Supplying Rear-Area Supply Points:

Of course, in order for the rear-area supply point(-s) to supply the front line with 20 truckloads of tube artillery ammunition per day, that ammunition has to be available there. This means that the required quantities of ammunition have to be transported to the rear-area depot(-s), typically from national storage facilities.

The transport of the ammunition from national storage facilities to the rear-area supply point(-s) is likely to be conducted primarily with “non-military” means, in the sense that, even if the transports are operated by the armed forces, the actual means of transport will most likely be civilian trucks or trains and, for larger quantities over longer distances, by container vessel. In many situations, this part of the logistic transport will take place outside the range of enemy weapons. However, it might still be vulnerable to enemy air attack or, for sea transport, enemy warships, including submarines. In fact, for the last two major wars in Europe, attempting to intercept enemy supplies during sea transport (across the Atlantic or

across the Channel), and preventing such intercepts from taking place, required significant effort on all sides of the conflict (in WW2, for example, 3,500 allied merchant ships, 175 allied warships, 783 German U-boats and 47 German surface warships were lost directly or indirectly in this effort). Although present day warfare is, in many ways, different from WW2, especially regarding the prevalence of long-range, precision weapons, some parallels may still be drawn, including the question of whether the above-mentioned transports from national storage facilities to the rear-area supply points will need to be escorted, whether at sea, in the air or on land. Continuing with this point, if the nation(-s) involved does not possess the capability and capacity to keep the rear-area supply

points resupplied from national storage facilities including, where necessary, the capability and capacity to escort said resupply transports, it becomes irrelevant how much ammunition is available in national stockpiles.

With Denmark as our example, the Danish Navy currently possesses only one dedicated transport ship, the HDMS Sleipner (named after the Norse god Odin's 8-legged horse) with a cargo capacity of 150 tonnes. A rough calculation indicates that this is equal to approximately 2,300 complete 155 mm shots (if these would fit in the cargo hold of the Sleipner, which is unknown). And, as shown by our calculations above, this is roughly 40% of the estimated daily requirement for 155 mm ammunition! The HDMS Absalon and Esbern Snare, originally commissioned as “Flexible Support Ships”, undoubtedly have greater cargo capacity, as well as self-defence capabilities, but in 2020 both ships were re-classified as anti-submarine frigates, and it is highly unlikely that the Danish Navy would choose to withdraw one or both of these ships from submarine hunting duties to serve as transport ships. The Danish Navy, and others, of course have the option of leasing additional transport capacities from civilian shipping companies, and in many cases agreements are already in place for this eventuality, but this doesn't change the fact that the capacities to perform these transports need to be available, including the capacity to escort them if necessary.

A Question of Space:

Having now followed the logistics chain in reverse from the front line, we find ourselves back at the starting point, at the national storage facility(-ies), provided these actually exist.



Photo: USMC

The risks of attacks on ammunition stocks is high during wartime, with potentially lethal consequences. Here more than 3,266 kg (7,200 lb) of unserviceable tank rounds, mortar bombs, and 771 kg (1700 lb) of C-4 detonates near Camp Leatherneck, Afghanistan, 19 February 2011.

As part of the general drawdown of forces at the end of the Cold War, many nations significantly reduced their national stockpiles of ammunition, either through demilitarisation and disposal, or by using it for training. This left many storage facilities empty and, in order not to spend money on maintenance of empty structures, many of these facilities were decommissioned. In the specific case of storage facilities for ammunition, this also meant that the safety zones established around the storage facilities, where construction and building were prohibited in order to maintain minimum safety distances to the ammunition storage, were opened up to development, and new civilian buildings began to spring up. What this effectively means is that, in many cases, even if the storage facility infrastructure (bunkers, office buildings, roads, etc.) still exist in a usable condition, it cannot simply be recommissioned as an ammunition storage facility, due to the encroachment of civilian infrastructure over the years, and the consequent lack of safety distances to civilian infrastructure.

Therefore, in order to store sufficient ammunition (greatly depending, of course, on one's definition of "sufficient"), new national storage facilities will almost certainly need to be constructed more or less from scratch.

In the past, a regularly quoted benchmark for stockpiles was 30 days of supply. Using Denmark as the example, we calculated above that heavy fighting would require some 5,700 rounds of tube artillery ammunition per day. As previously stated, not every one of the 30 days are expected to be "heavy fighting", but this should still be taken into account.

Just as a calculated example, if we assume that ten days out of the 30 days stated above involve heavy fighting, and the remaining 20 days require only 10% (570 rounds per day) of the 'heavy fighting days', we end up with a total requirement of a whopping 68,400 rounds of artillery ammunition for 30 days. Another rough-order-of-magnitude calculation indicates that this will require some 2,000 m² of storage space; and this does not include the safety area around the depot where, for high-explosive ammunition, a radius of 600 – 1,000 m or more could easily be required. Is the capacity available nationally to store the required ammunition quantities? If not, how quickly and at what cost can it be developed?

Continuing with the points developed above, even if a small NATO nation such as Denmark, found the funds to actually contract 68,400 complete rounds of 155 mm artillery ammunition, this wouldn't do

much good if no ammunition storage facilities existed. And, at this point, we haven't begun to talk about the resources required to maintain the ammunition, to take regular samples of the propellant charges to check for ageing, to X-ray samples of the HE shells to check for cracking and cavities in the explosive, or to conduct regular test firings.

Conclusion

Circling back to the initial paragraph, when addressing the issue of ammunition, the current discussions within NATO and in nations on military readiness tend to focus on stockpiles and required quantities. The point being made is that discussions and calculations of quantities of ammunition and stockpile levels are absolutely relevant, but they need to be accompanied by planning to ensure that NATO and its member countries also have:

- The required capacity to store the ammunition nationally.
- the required capacity to transport the ammunition from national storage facilities to rear-area supply points.
- The required capacity to transport the ammunition from the rear-area supply points to the soldiers and weapon systems that need it.

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The Hazards of Aeromedical Evacuation

Ian Frain

When the COVID-19 pandemic gripped the globe, the military in many countries supported the civilian authorities in many roles, from assisting medical professionals, to enforcing the lockdown, and in general law and order support roles. In providing support to doctors, nurses, and paramedics, the military also transported patients both on the ground and in the air.

Royal Responsiveness

In the United Kingdom, the National Health Service (NHS) quickly found itself overwhelmed as cases rose, especially with hospital admissions. On 23 March 2020, Prime Minister Boris Johnson announced the country would enter lockdown, with the general public having to stay inside their homes except for essential journeys, and to isolate from all contact with others if they felt any symptoms, for a proposed period of 12 weeks. Those not restricted by these new rules were classified as 'key workers', which included medical and hospital personnel, engineers, and public sector workers. To assist in the effort to combat the virus, the Ministry of Defence (MoD) mobilised units to support the civilian authorities. The Aviation Task Force was formed in Scotland, the north of England and in the south of the country.

All battlefield support helicopters in the UK fall under the Joint Helicopter Command (JHC), be it the Army Air Corps (AAC) Boeing Leonardo (AgustaWestland) WAH-64D (and soon to be Boeing AH-64E Guardian), and the Leonardo AW159 Wildcat, the Royal Air Force Boeing Chinook (MK4/5/6), and Airbus Helicopters Puma HC2, or the Royal Navy Fleet Air Arm (FAA) Leonardo Merlin MK3 and MK4, and Leonardo AW159 Wildcat. The JHC established the Aviation Task Force COVID Support Force (ATF CSF).

Author

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Photo: RAF

Three Puma HC2 helicopters formed the Aviation Task Force for Scotland.

On the 27 March 2020, an Aviation Task Force comprising three Royal Air Force (RAF) Puma HC2 aircraft, was stationed in northeast Scotland at Kinloss Barracks (a former Royal Air Force station), near the Moray Firth. In Edinburgh, a team of military and military staff planners/liaison officers established themselves at the Scottish Government headquarters building in St Andrew's House. Their role was the coordination of Medical Evacuation (MEDEVAC)/EMS (Emergency Medical Service), moving large groups of patients for treatment, plus the transportation of important equipment and medical personnel.

At the same time, further south at RAF Leeming in North Yorkshire, a single RAF Boeing Chinook heavy lift helicopter and an Army Air Corps (AAC) AW159 Wildcat multi-mission, light battlefield helicopter, were stationed to support civilian authorities in that part of the United Kingdom. Further south, in Oxfordshire at RAF Benson, a second Aviation Task Force Headquarters was established, as a second base to cover the south of the country.

RAF Benson is home to No.28 Squadron (Boeing Chinook) and No.33 Squadron, as well as No.230 Squadron (Airbus Helicopters Puma HC2), and the newly reformed No.22 Squadron (formerly Rotary Wing Operational Test & Evaluation Unit). Another unit based at RAF Benson is the Joint Helicopter Support Squadron (JHSS), which supports all rotary wing operations occurring at this time, plus elements of a Tactical Supply Wing from a base in the West Midlands. Protecting the aircrew, medical personnel, and patients from infection was paramount, and measures included decontamination of aircraft, personnel and uniforms in accordance with medical guidelines.

The Royal Air Force is no stranger to aeromedical missions with biohazards. During the 1980s, aircraft of the Air Transport (AT) fleet, based at RAF Brize Norton in Oxfordshire, were equipped with the legacy Vickers VC-10 four-jet tanker transport aircraft, which was later used in the repatriation from Africa of a British nurse infected with a virus. With the retirement of the Vickers VC-10 K2 and the three-en-

gine Lockheed L-1011 Tristar, the AT fleet now consists of the multi-engine Airbus A330-200 Voyager Multi-Role Tanker Transport (MRTT), operated by both 10 and 101 Squadrons. The Boeing C-17A Globemaster III four-engine strategic transport operated by 99 Squadron, also at Brize Norton, carries out aeromedical evacuations if tasked, likewise with the Airbus Defence four-engine turboprop A400M Atlas.

The RAF has the Deployable Air Isolator Team (DAIT), dedicated to the transport of patients with possible or confirmed highly infectious diseases back to the UK. Since 2012, the DAIT, a joint Department of Health (DoH) and Ministry of Defence asset, has successfully transferred a case-patient with the Crimean-Congo haemorrhagic fever, five case-patients with the Ebola virus, and five case-patients with high-risk Ebola virus exposure. Currently, no UK-published guidelines exist on how to transfer such patients. The DAIT therefore has procedures from collection at point of illness or exposure, to delivery into a dedicated specialist centre.

Air Force Nightingales

In the United States Air Force (USAF), Air Mobility Command (AMC) is responsible for global airlift and air-to-air Refuelling (AAR) across the armed services of the United States and their allies. Across their fleet of multi-engine jet and turboprop transport aircraft, it is predominantly the six decade old legacy four engine Boeing KC-135R/T Stratotanker, Boeing C-17A Globemaster III, Lockheed-Martin C-5M Super Galaxy heavy strategic airlifter and the four turboprop Lockheed-Martin C-130H/J Hercules/Super Hercules which are used in the aeromedical evacuation role.

The aeromedical mission was added with the introduction of the new twin-engine Boeing KC-46A Pegasus with the first aeromedical mission conducted by a Pegasus belonging to the 22nd Air Refuelling Wing (ARW) at McConnell Air Force Base (AFB) in Kansas. The mission involved transporting patients between Joint Base (J-B) Andrews in Maryland, to Naval Air Station (NAS) Norfolk in Virginia, and across the other side of the country to Travis AFB in California.

The Distinguished Visitor (DV) Bombardier C-21A Learjet twin-engine executive transports, which are deployed at headquarters bases, such as at the United States Air Forces in Europe & Air Forces Africa (USAFE-AFAFRICA) at Ramstein Air Base (AB) in the Eifel region in Germany,

has been tasked for rapid emergency aeromedical missions. The demise of the small Beechcraft C-12 King Air turboprop fleet in the USAF leaves only a small number of available aircraft, but the C-12J in service with the 374th AW at Yokota AFB in Japan, does have a secondary aeromedical role within the Pacific region.

Up until 2005, the USAF had a dedicated flying air ambulance in the form of a four-decade old twin-engine McDonnell Douglas C-9B Nightingale (based on the successful DC-9 airliner). After its retire-

of C-130H/J Hercules/Super Hercules and C-17A Globemaster III (additionally, the C-17 is able to transport two TIS units). The infectious disease containment unit is designed to minimise the risk to AMC aircrew and medical personnel, while transporting and allowing in-flight medical care for patients infected with dangerous diseases and viruses such as COVID-19. The set-up consists of a single antechamber module (AM) complete with two isolation modules (IM), with each one on its own modified 463L air-

Photo: USAF/Staff Sgt. Justin Parsons



Capt. Rachel Enouen, 405th Expeditionary Aeromedical Evacuation Squadron flight nurse, secures a litter in the negatively pressurised Conex-Lite in Southwest Asia, 30 July 2020.

ment, the even older KC-135R/T Stratotanker has taken on the secondary mission (or third role if counting the tanker and small transport) of medical evacuation, with the cabin converted to take stretchers and equipment.

United States Air Force School of Aerospace Medicine (headquartered at Wright-Patterson AFB in Dayton, Ohio), trained medics on the use of the Transport Isolation System (TIS), which was entered service in 2014 at the time of an increased outbreak of the deadly Ebola virus on the African continent. The United States Africa Command (AFRICOM) initiated Operation Unified Assistance in response to the outbreak, to move and repatriate patients to the United States.

The TIS allows medical personnel to use all medical supplies and equipment carried by Aeromedical Evacuation (AE) crews and Critical Care Air Transport Teams, and allows for the same level of care available on any USAF AE mission. The TIS can be installed in the AMC fleet

craft pallet. In order to contain both the airborne and non-airborne pathogens, the pallets are retrofitted with watertight enclosures and high-efficiency particulate air (HEPA) filtration systems. The AM ensures that the medical personnel have an enclosed space to safely decontaminate and remove their personal protective equipment (PPE) before exiting, while the IMs are where treatment and care of the patients are conducted. Each TIS can hold two litter patients, stacked securely for evacuation, or four ambulatory patients, meaning those who can walk with little to no need of assistance.

European Responders

During the COVID pandemic, Spain and Italy were among the hardest-hit in Europe, with massive numbers of infected and dying patients. The Spanish Army (Ejército) has a specialist unit called UME (Unidad Militar de Emergencias), Military Emergencies Unit, which in normal times



Photo: Aeronautica Militare Italiana

Biocontainment system for use with Italy's HH-101s.

consists of mountain rescue teams, fire-fighters, paramedics and an operating fleet of multi-engine Airbus Helicopters AS532UL Cougar battlefield medium-lift/utility helicopters (based on the Super Puma family). The Army also has the smaller twin-engine H135 (EC135), commonly used across the globe in the para-public marketplace. The UME were out in force serving in the local communities, wearing protective Tyvek suits and respirators, while their aviation unit with the Cougar were performing medical evacuation with specialist incubator units.

In Italy, the armed forces, in particular the Army (Esercito) and Italian Air Force (Aeronautica Militare Italiana) were also hard at work. The latter was utilising the Leonardo HH-101 Caesar (AW101 Merlin family) three-engine Combat Search and Rescue (CSAR) helicopter, primarily for the Casualty Evacuation (CASEVAC) role. To deal with the emergency, a temporary hub was created at the Cervia air base, with HH-101 helicopters always ready for departure 24 hours a day, together with crews of the 9th and 15th wings, and medical and nursing personnel of the Italian Armed Forces specialised in transport and biocontainment. The activities were coordinated by the Poggio Renatico Air Operations Command, the nerve centre of the Armed Forces which, through its Air Operation Centre, receives and evaluates the requests from hospitals, prefectures and, during this health emergency, also by the Civil Protection authorities. These interventions were included in the broader framework of the support ac-

tivities of the Armed Forces in the health emergency in Italy, offering an important contribution to the plans put in place by the Ministry of Defence in support of the Ministry of Foreign Affairs, Health and Civil Protection.

An example of how one company responded to the emergency can be seen with IN MM, an innovative Italian and British medical company, established in 2013, and operating in the Emergency and Military medical sectors. According to its founder and owner, Sabrina Menghini, who is a graduate of the NATO Centre of Excellence for Military Medicine in Buda-

pest, Hungary, their company is constantly evolving with research and development to improve and invent new technological solutions. One such solution that IN MM provided in this instance was bio-isolation chambers, including stretchers and bio-isolated vehicles. The bio-isolation products are able to be rapidly deployed and provide a safe environment for patients and staff in the vicinity. The systems provide a drastically reduced risk of cross-contamination once installed.

After the experience of the recent pandemic, IN MM have modified the isolation stretcher, model IsoArk N36 (mainly intended for road ambulances), to meet the requirement to be safely loaded onto helicopters and aircraft, by creating the N36 AVIO version. This version helps to increase the capabilities of performing air evacuations of an infected patient from remote areas, or to simply guarantee quicker transportation to hospitals and medical facilities while maintaining the safety of the internal conditions of the aircraft. It is the ideal solution for transporting infected patients, or those with suspected infections, in a high level of biocontainment. Just one operator can deploy the stretcher in a few minutes, making it a perfect piece of equipment to be used in emergency conditions.

The IN MM N36 AVIO version has since been modified to be safely loaded on both fixed and rotary wing aircraft. The new internal and external configuration has been designed and produced, starting from the original OEM design, to help complete an entire system. These adaptations also include SHIELD, a protective



Photo: Ian V Frain

IN MM N36 AVIO Isolation stretcher controls on display at European Rotors.

flame-retardant and stain-resistant coating, which protects while maintaining transparency and flexibility. Internal and external restraints are installed on the OEM system bases in both directions (transversal and longitudinal), in order to withstand manoeuvring loads and emergency crash conditions. A bio system is integrated with the N36 AVIO, which is key to ensuring safety during flight in an emergency, increasing the safety of biocontainment through a series of sensors that measure (but are not limited to) negative pressure, CO2 levels, as well as ventilation and filtered air levels. Changes to these outside accepted limits triggers an alarm system. The system guarantees multi-platform transport and transfer within different scenarios, being interoperable between air, land and sea. The installation of the N36 AVIO version and its retainers does not affect the aircraft's performance. Evacuation tests have already been performed on business jets, to prove that the height increase does not affect the egress procedure. This aircraft was selected specifically in order to have as small a volume as possible in a cabin, in conjunction with a small door, a 'worst case scenario' test.

Photo: Ian V Frain



Brazilian Air Force Embraer C-390 Millennium at Paris Air Show 2019, configured for medical evacuation.

Latin American Ambulatory Airlift

In South America, Brazil was one of the countries hardest hit by COVID. At the beginning of the pandemic, the Brazilian Air Force (Força Aerea Brasileira), participated in Operation Return to the Beloved Homeland Brazil, which involved repatriating 34 Brazilian nationals from the Chinese epicentre of the virus, Wuhan itself. This involved using a pair of Embraer VC2 (E190 Legacy) twin-engine Distinguished Visitor (DV) jets flying into the Anapolis Air Base where they would be quarantined for 18 days. The Chemical Biological Radiological Nuclear (CBRN) specialist unit of the Brazilian Navy (Marinha do Brasil) set up isolation facilities and medical facilities. Thereafter, the same unit was responsible for assisting the civilian authorities with the pandemic, from providing medicinal aid to the indigenous communities, transportation of patients, and the sanitary cleaning of public areas such as schools, hospitals, medical clinics, doctors' surgeries, as well as airports, bus and railway stations. The Air Force has made use of every transport aircraft across its fleet from the newest twin-engine heavy transport C-95 (Embraer EMB-110), C-97 (Embraer EMB-120), single-engine C-98 (Cessna

C-208), C-99 and twin-engine jet VC-99 (Embraer EMB145), twin-turbo propeller C-105 and SC-105 (Airbus Defence C-295), Lockheed Martin C-130 and twin-jet engine strategic transport Embraer KC-390. These were adapted to transport patients across the large expanses of the country. A centralised call centre was created for Air Force health system users to not only provide information and psychological support (through chats and electronic messaging), to families whose relatives were hospitalised, but also training for specialised military and civilian personnel. A close liaison was developed between the Centre of Specific Acquisitions (responsible for procurement actions assigned by legislation) and the Aeronautical Chemical Pharmaceutical Laboratory (responsible for the development, manufacture, and distribution of medicines and chemical products). This led to a prompt response with the acquisition of PPE and medications, as well as a centralised distribution of these materials for the entire Brazilian Air Force (BAF) health system. Additionally, a network focused on COVID-19 was created, linking infectious disease professionals at the higher levels in the BAF hierarchy, with remote and less

prepared units, to coordinate bed distribution, personnel rotation, and common solutions to day-to-day problems by sharing lessons learned.

Preventive Future

While there is currently no cure for COVID-19, the global vaccination programme has been ongoing since the end of 2020. Military air arms around the world have played their part by helping to transfer patients in a safe manner for all concerned, from aircrew and medical personnel, to the patients themselves. All militaries, especially in North America and Europe, and the majority of civil authorities, are also constantly training to meet the threat of radiological, biological and chemical warfare. While these traditionally include exercise drills on an air base or a forward location, for example, it has been airborne exercises, especially those concerned with transporting patients with infectious diseases, and personnel needed in the event of such attacks and catastrophes, that have had the most impact on the smooth operations during the pandemic. The experience gained dealing with the pandemic now informs future training and preparedness. ■

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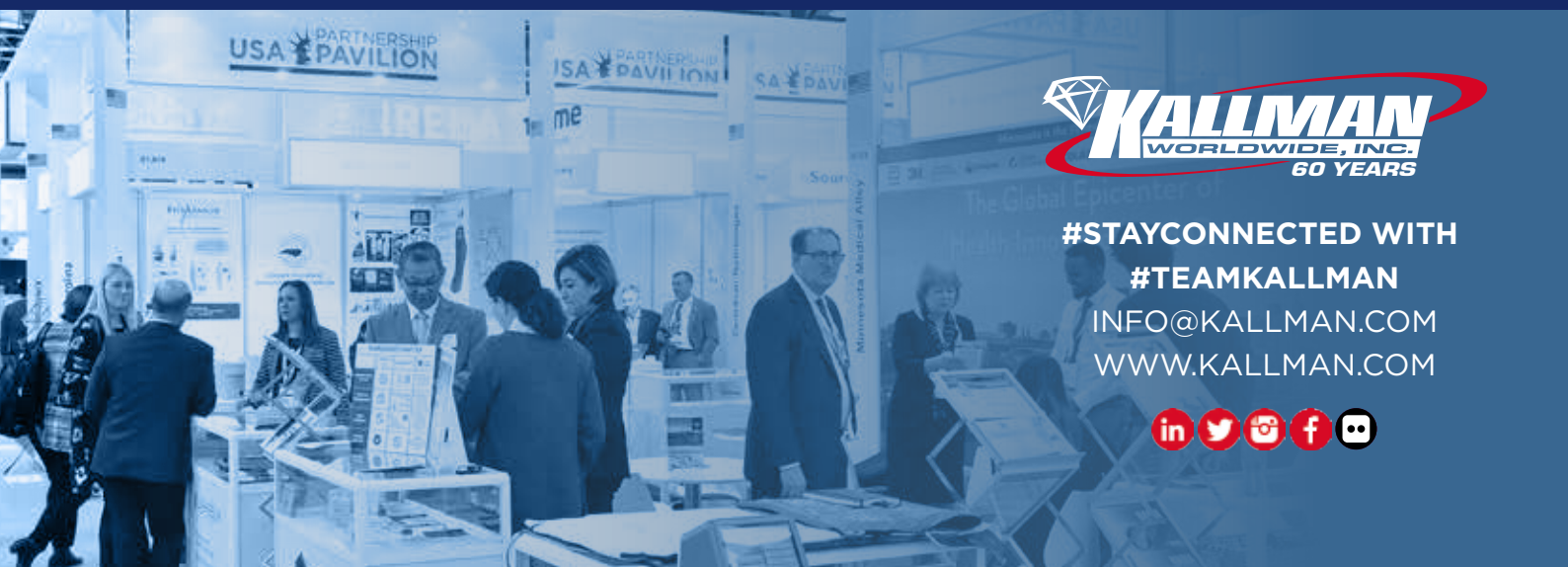
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